



**Naval Facilities Engineering Command Southwest
BRAC PMO West
San Diego, CA**

FINAL

**PARCEL G REMOVAL SITE EVALUATION
WORK PLAN**

**FORMER HUNTERS POINT NAVAL SHIPYARD
SAN FRANCISCO, CA**

June 2019

Approved for public release: distribution unlimited

DCN: CH2M-9000-FZ12-0013



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Prepared for:



**Department of the Navy
Naval Facilities Engineering Command Southwest
1220 Pacific Highway
San Diego, CA 92132**

Prepared by:

**CH2M HILL, Inc.
San Diego, CA**

**Contract Number: N62470-16-D-9000; Task Order No. FZ12
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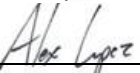
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Quality Assurance Manager

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Radiation Safety Officer

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Project Manager

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Executive Summary

Background

Radiological surveys and remediation were previously conducted at former Hunters Point Naval Shipyard (HPNS) as part of a basewide Time-critical Removal Action (TCRA). Tetra Tech EC, Inc. (TtEC), under contracts with the Department of the Navy (Navy), conducted a large portion of the basewide TCRA, including Parcel G. Data manipulation and falsification were committed by TtEC employees during the TCRA. An independent third-party evaluation of previous data identified additional potential manipulation, falsification, and data quality issues with data collected at Parcel G (Navy, 2017, 2018). As a result, the Navy developed this work plan to investigate radiological sites in Parcel G. Future work plans will address soil and buildings in the other parcels (B, C, D-2, E, UC-1, UC-2, and UC-3), including the North Pier and Ship Berths.

Project Purpose

The purpose of the investigation presented in this work plan is to determine whether current site conditions are compliant with the remedial action objective (RAO) in the Parcel G Record of Decision (ROD) (Navy, 2009). The RAO for radiologically impacted soil and structures is to prevent receptor exposure to radionuclides of concern (ROCs) in concentrations that exceed remediation goals (RGs) for all potentially complete exposure pathways. Additional reference background areas (RBAs) will also be identified to confirm, or update as necessary, estimates of naturally occurring and man-made background levels for ROCs not attributed to Naval operations at HPNS. A statistical comparison of site data to applicable reference area data will be conducted.

Scope

The radiological investigation will be conducted at the following sites:

- Former Sanitary Sewer and Storm Drain Trenches
- Former Buildings 317/364/365 Site
- Building 351A
- Building 351
- Building 366
- Building 401
- Former Building 408 Concrete Pad
- Building 411
- Building 439

The sites and the locations of work are shown on **Table ES-1** and **Figure ES-1**.

Soil Investigations

Soil investigations will be conducted at the following areas:

- Former Sanitary Sewer and Storm Drain Trenches
- Former Buildings 317/364/365 Site
- Building 351A Crawl Space

Soil investigation areas will be divided into trench units (TUs) and surface soil survey units (SUs). The size and boundary of the TUs and SUs will be based on the previous plans and reports.

Former Sanitary Sewer and Storm Drain Trench Units

For the TUs associated with former sanitary sewers and storm drains (from 1 to 22 feet deep), a phased investigation approach was designed based on a proposal by the regulatory agencies to achieve a high level of confidence that the Parcel G ROD RAO has been met for soil (Attachment 2.1 in **Appendix A**). For Phase 1, 100 percent of soil will be re-excavated and characterized at 33 percent of TUs in Parcel G. Soil sampling and scanning at the remaining 67 percent of TUs will be performed as part of Phase 2 to increase confidence that current site conditions comply with the Parcel G ROD RAO. The Navy will re-excavate 100 percent of Phase 2 TUs if contamination is identified in Phase 1 TUs. For both Phase 1 TUs and Phase 2 TUs, the durable cover (including asphalt, asphalt base course, concrete, gravel, debris, or obstacles) will be removed to expose the target soils.

Phase 1

Phase 1 includes the radiological investigation on a targeted group of TUs. Twenty-one of the 63 former sanitary sewer and storm drain TUs were selected for the Phase 1 investigation.

The radiological investigation of soil includes the following:

- Collection of systematic soil samples from each TU
- Gamma scan of 100 percent of the soil
- Collection of biased soil samples, where necessary, based on the gamma scan measurements

The targeted TUs were selected based on the highest potential for radiological contamination. The following information was used to select the units:

- Historical documentation of specific potential upstream sources, spills, or other indicators of potential contamination (NAVSEA, 2004)
- Signs of potential manipulation or falsification from the soil data evaluation (Navy, 2017, 2018)

All of the soil (100 percent) will be excavated to the original TU boundaries, as practicable, and gamma scans of the excavated material will be conducted. Excavated soil will be gamma scanned by one of two methods. Soil may be laid out on Radiological Screening Yard pads for a surface scan, or soil may be processed and scanned using soil segregation technology. Following excavation to the original TU boundaries, additional excavation of approximately 6 inches of the trench sidewalls and floors will be performed to provide ex situ scanning and sampling of the trench sidewalls and floors. The excavated soil from within each trench and the over-excavation will be tracked separately, and global positioning system (GPS) location-correlated results will be collected.

Systematic and biased samples will be collected from the excavated soil from the TUs and from the soil surrounding the TUs. A minimum of 18 systematic samples will be collected from each excavated soil unit and TU. The soil samples will be analyzed for the applicable ROCs by accredited offsite laboratories. Soil sample locations will be surveyed using GPS. If the investigation results from the gamma scan surveys and results from analysis of systematic and biased soil samples of the over-excavated material demonstrate exceedances of the RGs that are not attributed to naturally occurring radioactive material (NORM) or anthropogenic background, the material will be segregated for further evaluation. An in situ investigation and/or remediation of the trench sidewalls and floor will be performed prior to backfill.

Phase 2

At the remaining 42 TUs, 100 percent radiological surface gamma scan of accessible areas and soil sampling will be conducted. Subsurface soil samples will be collected via borings, with a minimum of 18 borings within the trench and 1 boring every 50 linear feet along the sidewalls of the trench. The borings will be advanced beyond the floor boundary of the trench or to the point of refusal. Gamma

scans of the core will be conducted. Borehole locations will be surveyed using GPS. The soil samples will be analyzed for the applicable ROC analysis by accredited offsite laboratories.

Former Building Site and Crawl Space Soil Survey Units

At the 28 surface soil SUs¹ from the Former Buildings 317/364/365 Site and Building 351A Crawl Space, the radiological investigation of soil is based on a proposal by the regulatory agencies (Attachment 2.1 in **Appendix A**) and includes the following:

- Collection of a minimum of 18 systematic soil samples from each SU
- Gamma scan of 100 percent of the soil
- Collection of biased soil samples, where necessary, based on the gamma scan measurements

For all the surface soil SUs, a surface gamma scan of 100 percent of surface soil will be conducted as walk-over or drive-over surveys. GPS location-correlated results will be collected. Systematic and biased samples will be collected from the surface soil SUs. The soil samples will be analyzed for the applicable ROCs by accredited offsite laboratories. Soil sample locations will be surveyed using GPS.

Building Investigations

Investigations of interior surfaces will be performed for the following buildings:

- Building 351A
- Building 351
- Building 366
- Building 401
- Former Building 408 Concrete Pad
- Building 411
- Building 439

Buildings will be divided into SUs, and the size and boundary of the SUs will be based on the previous plans and reports. The radiological investigation will be conducted to include the following:

- Collection of a minimum of 18 systematic static alpha-beta measurements from each SU
- Alpha and beta scan of surfaces
- Collection of biased static alpha-beta measurement where necessary, based on the alpha-beta scan measurements
- Collection of swipe samples

Data Evaluation and Reporting

Data from the radiological investigation will be evaluated to determine whether the site conditions are compliant with the Parcel G ROD RAO. If the residual ROC concentrations are below the RGs in the Parcel G ROD or are shown to be NORM or anthropogenic background, then the site conditions are compliant with the Parcel G ROD RAO. **Section 5** of this work plan provides additional information and details on data evaluation and reporting.

¹ Previously, 32 SUs were investigated at the Former Buildings 317/364/365 Site and Building 351A Crawl Space; however, some SU areas overlapped. For the Former Buildings 317/364/365 Site, former SU 22 overlaps TU 153 and will be investigated as part of TU 153. For the Building 351A Crawl Space, former SU R, SU S, and SU U overlap SU M, SU N, and SU O and will be investigated as SU M, SU N, and SU O.

The following methods will be used to determine whether the residual ROC concentrations comply with the Parcel G ROD RAO:

- Each sample and static measurement result will be compared to the corresponding RG. If all residual ROC concentrations are less than or equal to the corresponding RG, then site conditions comply with the Parcel G ROD RAO.
- Sample and measurement data will be compared to appropriate RBA data, and multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include, but is not limited to, population-to-population comparisons, use of a maximum likelihood estimate (MLE) or background threshold value, graphical comparisons, and comparison with regional background levels. If all residual ROC concentrations are determined to be consistent with NORM or anthropogenic background, then site conditions comply with the Parcel G ROD RAO.
- Each radium-226 (^{226}Ra) sample result exceeding both the corresponding RG and the expected range of background will be compared to concentrations of other radionuclides in the uranium natural decay series (see **Section 5.6**). If the concentrations of radionuclides in the uranium natural decay series are consistent with the assumption of secular equilibrium, then the ^{226}Ra concentration is NORM, and site conditions comply with the Parcel G ROD RAO.

If the investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically-based RGs² at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a remedial action completion report (RACR) will be developed.

If the investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically-based RGs² at agreed upon statistical confidence levels and are not shown to be NORM or anthropogenic background, then remediation will be conducted, followed by a RACR.

The RACR will describe the results of the investigation, explain remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel G ROD RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.

² The RGs are statistically based because they are increments above a statistical background.

Table ES-1
Soil and Building Trench and Survey Units
Parcel G Removal Site Evaluation Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

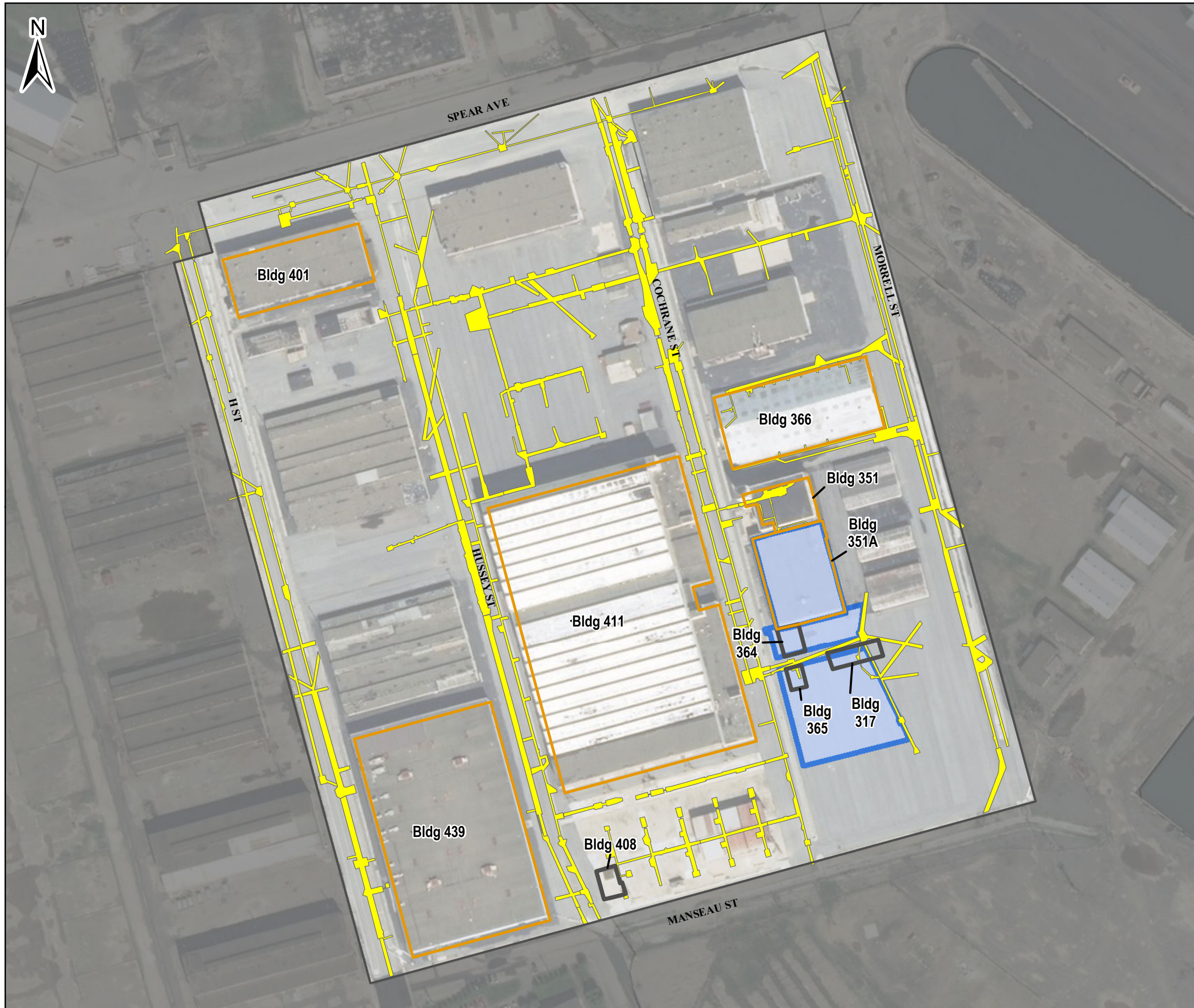
Site	Soil	Building Surfaces	Soil		Building ^a		
			Building Site Soil Survey Units	Trench Units	Class 1 Survey Units	Class 2 Survey Units	Class 3 Survey Units
Storm Drain and Sanitary Sewer Lines	X			TU-66, TU-67, TU-68, TU-69, TU-70, TU-71, TU-72, TU-73, TU-74, TU-75, TU-76, TU-77, TU-78, TU-79, TU-80, TU-81, TU-82, TU-83, TU-84, TU-85, TU-86, TU-87, TU-88, TU-89, TU-90, TU-91, TU-92, TU-93, TU-94, TU-95, TU-96, TU-97, TU-98, TU-99, TU-100, TU-101, TU-102, TU-103, TU-104, TU-105, TU-106, TU-107, TU-108, TU-109, TU-110, TU-111, TU-112, TU-113, TU-114, TU-115, TU-116, TU-117, TU-118, TU-119, TU-120, TU-121, TU-122, TU-123, TU-124, TU-129, TU-151, TU-153, TU-204			
Buildings 317/364/365 Site	X		SU-20, SU-21, SU-23, SU-24, SU-25, SU-26, SU-27, SU-28, SU-29, SU-30, SU-31				
Building 351A and Crawlspace	X	X	SU-A, SU-B, SU-C, SU-D, SU-E, SU-F, SU-G, SU-H, SU-I, SU-J, SU-K, SU-L, SU-M, SU-N, SU-O, SU-P, SU-T		SU-1, SU-2, SU-3, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-12, SU-13, SU-14, SU-16, SU-18, SU-19, SU-20, SU-21, SU-22, SU-23, SU-24, SU-25, SU-26, SU-27, SU-29, SU-30, SU-31, SU-32, SU-33, SU-34, SU-35, SU-36, SU-37, SU-38, SU-39, SU-40, SU-41, SU-42, SU-43, SU-44	SU-45, SU-46, SU-47	
Building 351		X			SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-17, SU-18, SU-19, SU-20, SU-21, SU-22, SU-23, SU-24, SU-25, SU-26, SU-27, SU-28, SU-29, SU-30, SU-31, SU-32, SU-33, SU-34, SU-35, SU-36, SU-42, SU-43, SU-44, SU-45, SU-46, SU-47, SU-48, SU-49, SU-50, SU-51	SU-39, SU-40, SU-52, SU-53, SU-54	
Building 366		X			SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-12, SU-13, SU-14, SU-18, SU-24, SU-25, SU-26, SU-27, SU-28, SU-31, SU-32, SU-33, SU-34, SU-35, SU-36, SU-37, SU-38, SU-43, SU-44, SU-45, SU-46, SU-47, SU-48, SU-49, SU-50, SU-51, SU-52, SU-53, SU-54, SU-55, SU-56, SU-57, SU-58, SU-59	SU-60, SU-61, SU-62, SU-63, SU-64, SU-65, SU-66, SU-67, SU-68	SU-69
Building 401		X			SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-12, SU-13, SU-14, SU-15, SU-16, SU-17, SU-18, SU-19, SU-20, SU-21, SU-22, SU-24, SU-25, SU-26, SU-27, SU-28, SU-29, SU-33, SU-34, SU-35, SU-36	SU-30, SU-31	
Former Building 408 Concrete Pad		X			SU-1	SU-2	
Building 411		X			SU-5, SU-6, SU-7, SU-9, SU-10	SU-8, SU-11	SU-2, SU-3, SU-4
Building 439		X			SU-1, SU-2, SU-4	SU-3, SU-5, SU-6	

Notes:

^a Building survey unit data is based on available documentation, and may not reflect current site conditions. Updated survey unit data will be provided as part of the building surveys.

TU-- Trench Unit

SU - Survey Unit



Legend

- Parcel G
- Impacted Buildings
- Demolished Impacted Buildings
- Building Site – Soil
- Storm Drain and Sanitary Sewer Line – Soil

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure ES-1
Soil and Building Sites
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

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Acronyms and Abbreviations

⁶⁰ Co	cobalt-60
⁹⁰ Sr	strontium-90
⁹⁰ Y	yttrium-90
⁹⁹ Tc	technetium-99
¹³⁷ Cs	cesium-137
²¹⁴ Bi	bismuth-214
²²² Rn	radon-222
²²⁰ Rn	thoron-220
²²⁶ Ra	radium-226
²³⁰ Th	thorium-230
²³² Th	thorium-232
²³⁴ U	uranium-234
²³⁵ U	uranium-235
²³⁸ U	uranium-238
²³⁹ Pu	plutonium-239
μCi/mL	microcurie(s) per milliliter
AHA	activity hazard analysis
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
APP	accident prevention plan
ASTM	ASTM International (formerly American Society for Testing and Materials)
bgs	below ground surface
BMP	best management practice
BRAC	Base Realignment and Closure
BTV	background threshold value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CDPH	California Department of Public Health
CFR	<i>Code of Federal Regulations</i>
CH2M	CH2M HILL, Inc.
cm	centimeter(s)
cm ²	square centimeter(s)
cm/s	centimeter(s) per second
cpm	count(s) per minute
cpm/μR/hr	count(s) per minute per microrentgen per hour
CSM	conceptual site model

DAC	derived air concentration
dBa	decibels
dpm	disintegration(s) per minute
dpm/100 cm ²	disintegration(s) per minute per 100 square centimeters
DOT	Department of Transportation
DTSC	Department of Toxic Substances Control
DQA	data quality assessment
DQO	data quality objective
ESU	excavation soil unit
GPS	global positioning system
HAZWOPER	Hazardous Waste Operations and Emergency Response
HPNS	Hunters Point Naval Shipyard
HRA	Historical Radiological Assessment
ID	identification
IL	investigation level
keV	kiloelectron volt
LBGR	lower boundary of the gray region
LLRW	low-level radioactive waste
LWTS	liquid waste transfer system
m ²	square meter(s)
m ³	cubic meter(s)
m/s	meter(s) per second
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MLE	maximum likelihood estimate
MOU	memorandum of understanding
NA	not applicable
NaI	sodium iodide
NaI(Tl)	sodium iodide activated with thallium
Navy	Department of the Navy
NORM	naturally occurring radioactive material
NRC	Nuclear Regulatory Commission
NRDL	Navy Radiological Defense Laboratory
NUREG	Nuclear Regulatory Commission Regulation
OSHA	Occupational Safety and Health Administration
pCi/g	picocurie(s) per gram

Perma-Fix	Perma-Fix Environmental Services
PPE	personal protective equipment
PRSO	Project Radiation Safety Officer
PSPC	position-sensitive proportional counter
Q-Q	quantile-quantile
QA	quality assurance
QC	quality control
RACR	remedial action completion report
rad	radiation absorbed dose
RAO	remedial action objective
RASO	Radiological Affairs Support Office
RBA	reference background area
RCA	radiologically controlled area
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
rem	roentgen(s) equivalent man
RG	remediation goal
ROI	region of interest
ROICC	Resident Officer in Charge of Construction
ROC	radionuclide of concern
ROD	record of decision
RPM	Remedial Project Manager
RSCS	Radiation Safety and Control Services, Inc.
RSO	Radiation Safety Officer
RSY	Radiological Screening Yard
RWP	Radiation Work Permit
SAP	sampling and analysis plan
SCM	surface contamination monitor
SFU	sidewall floor unit
SIMS	Survey Information Management System
SOP	standard operating procedure
SSHO	Site Safety and Health Officer
SSHPP	site safety and health plan
SU	survey unit
SWPPP	stormwater pollution prevention plan
TCRA	time-critical removal action
TtEC	Tetra Tech EC, Inc.

TU	trench unit
UBGR	upper boundary of the gray region
USEPA	United States Environmental Protection Agency
VD	virtual detector
VOC	volatile organic compound
VSP	Visual Sample Plan

Introduction

This work plan presents the tasks and procedures that will be implemented to investigate and evaluate radiologically impacted sites in Parcel G at former Hunters Point Naval Shipyard (HPNS), San Francisco, California (**Figure 1-1**). Radiological surveys and remediation were previously conducted at HPNS as part of a basewide Time-critical Removal Action (TCRA). Tetra Tech EC, Inc. (TtEC), under contracts with the Department of the Navy (Navy), conducted a large portion of the basewide TCRA, including Parcel G. Data manipulation and falsification were committed by TtEC employees during the TCRA. An independent third-party evaluation of TtEC data identified evidence of manipulation, falsification, and data quality issues with data collected at Parcel G (Navy, 2017, 2018). As a result, the Navy will conduct investigations at radiologically impacted soil and building sites in Parcel G that were surveyed by TtEC (**Figure 1-2**). Future work plans will address soil and buildings in the other parcels (B, C, D-2, E, UC-1, UC-2, and UC-3), including the North Pier and Ship Berths.

The purpose of the investigation presented in this work plan is to determine whether site conditions are compliant with the remedial action objective (RAO) in the Parcel G Record of Decision (ROD) (Navy, 2009). The RAO for radiologically impacted soil and structures is to prevent receptor exposure to radionuclides of concern (ROCs) in concentrations that exceed remediation goals (RGs) for all potentially complete exposure pathways. Additional reference background areas (RBAs) will be identified to confirm, or update as necessary, estimates of naturally occurring and man-made background levels for ROCs not attributed to Naval operations at HPNS. A statistical comparison of site data to applicable reference area data will be conducted.

The lead agency at HPNS is the Navy, and the lead federal regulatory agency is the United States Environmental Protection Agency (USEPA). The Navy will continue to work with USEPA and the State of California throughout the planning and site investigation process.

The approach for collection and evaluation of data is based on the Parcel G ROD (Navy, 2009) and the Basewide Radiological Management Plan (TtEC, 2012). For soil, a phased approach was designed based on a proposal by the regulatory agencies to achieve a high level of confidence that ROD RGs have been met for soil (Attachment 2.1 in **Appendix A**). For Phase 1, 100 percent of soil will be re-excavated and characterized at 33 percent of trench units (TUs) associated with former sanitary sewers and storm drains in Parcel G. Soil sampling and scanning at the remaining 67 percent of TUs will be performed as part of Phase 2 to increase confidence that current site conditions comply with the Parcel G ROD RAO. The Navy will re-excavate 100 percent of Phase 2 TUs if contamination is identified in Phase 1 TUs. Because the survey design and implementation methods in this work plan are based on the regulators' proposal and their comments, the Basewide Radiological Management Plan (TtEC, 2012), and compliance with the RGs in the Parcel G ROD, only applicable elements of Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (USEPA et al., 2000) are incorporated.

The activities presented in this work plan will be conducted in accordance with this work plan, the sampling and analysis plan (SAP) (**Appendix B**), and a separate accident prevention plan/site safety and health plan (APP/SSHP). Specific procedures to ensure data quality and worker safety are described in the SAP and APP/SSHP. Project requirements, including personnel roles and responsibilities, required training, and health and safety protocols are presented in **Section 6**, based on CH2M HILL, Inc. (CH2M) and its subcontractor, Perma-Fix Environmental Services (Perma-Fix), leading and conducting the field activities. CH2M and Perma-Fix will be conducting the work outlined in **Section 4** and **Appendix C**. A separate contractor, Aptim, has been selected to conduct the work outlined in **Section 3**, and this work plan and the SAP will be amended for contractor-specific information, as needed.



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- Legend:**
-  Installation Boundary
 -  Parcel G

BASE MAP SOURCE:
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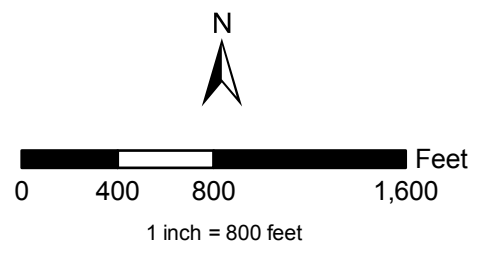
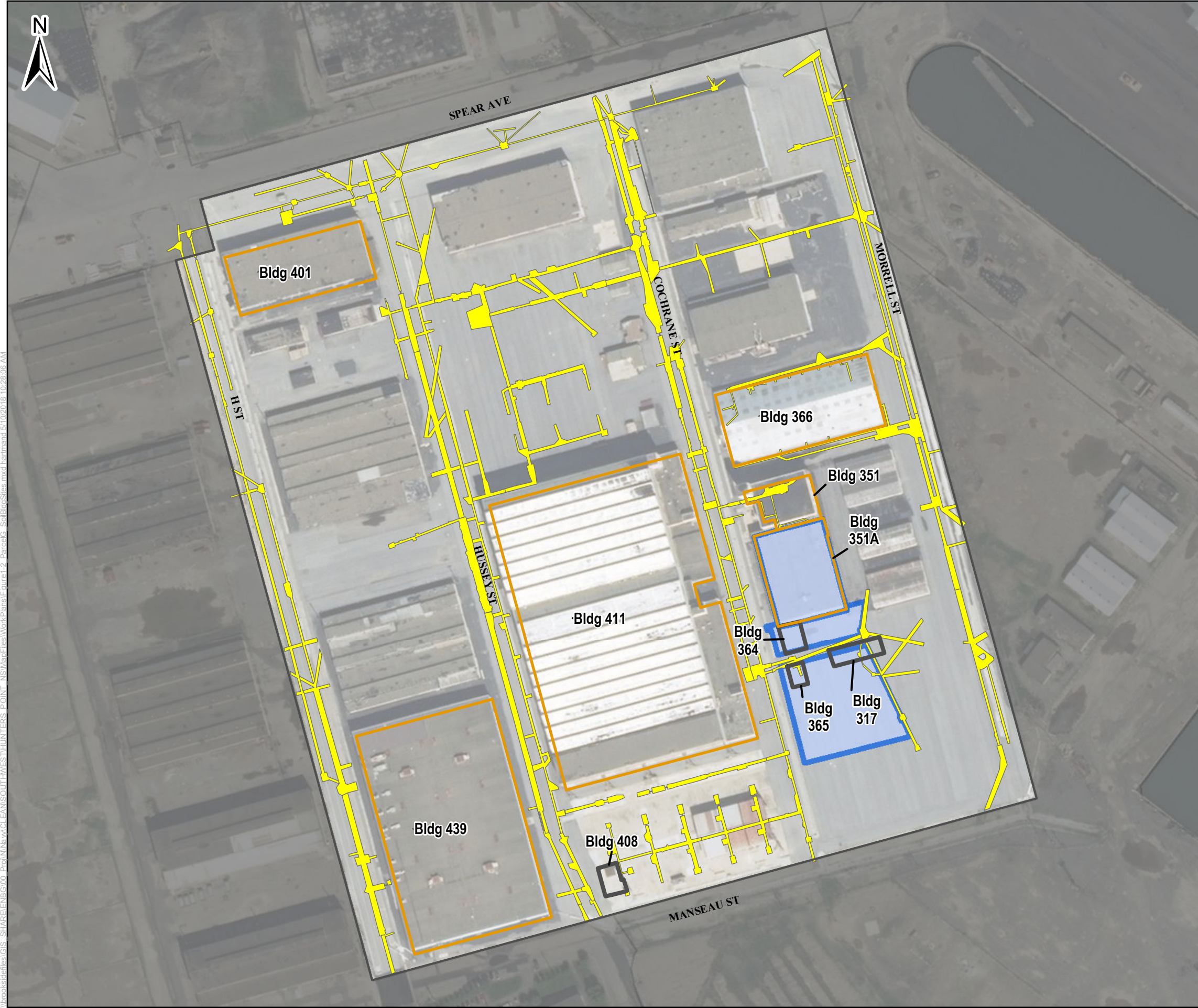


Figure 1-1
HPNS and Parcel G Location
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



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- Legend**
- Parcel G
 - Impacted Buildings
 - Demolished Impacted Buildings
 - Building Site – Soil
 - Storm Drain and Sanitary Sewer Line – Soil

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

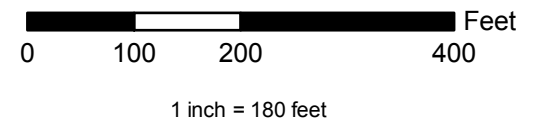


Figure 1-2
Soil and Building Sites
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

Conceptual Site Model

This section provides an updated conceptual site model (CSM) (**Table 2-1**). The CSM summarizes the site description, history, and current status related to radiologically impacted buildings and former building areas, and former sanitary sewers and storm drains identified in the Historical Radiological Assessment (HRA) (NAVSEA, 2004). The sanitary sewers and storm drains were once a combined system identified as radiologically impacted because of the possibility that radioactive waste materials had been disposed of in sinks and drains, and the potential for the surrounding soil to be impacted by leakage and soil mixing during repairs. A removal action was initiated in 2006 to remove the sanitary sewers and storm drains. The removal action included excavation of overburden soil, removal of pipelines, plugging of open sanitary sewers and storm drains left in place during the removal process, ex situ radiological screening and sampling of the pipeline, and performance of final status surveys of the excavated soil and exposed excavation of trench surfaces. Soil was removed to a minimum of 1 foot below and to the sides of the sanitary sewer and storm drain piping.

Following the investigation and removal actions, there were allegations that TtEC potentially manipulated and falsely represented data, and some allegations have since been confirmed. In addition, the onsite laboratory used a screening method to analyze radium-226 (^{226}Ra) that may have reported at levels higher than actual radioactivity. TtEC presented CSMs in removal action completion reports that were based on potentially falsified data and screening results for ^{226}Ra reported by the onsite laboratory (results were biased high).

The results of additional investigation activities presented in this work plan will be used to update the CSM as needed.

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Table 2-1. Conceptual Site Model

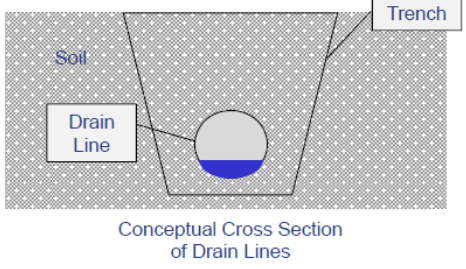
Site Name	Former Hunters Point Naval Shipyard (Parcel G)	
Site Location	Located on San Francisco Bay near the southeastern boundary of San Francisco, California. HPNS encompasses approximately 848 acres, including approximately 416 acres on land, at the point of a high, rocky, 2-mile-long peninsula projecting southeastward into San Francisco Bay. Parcel G occupies 40 acres in the middle of HPNS (Figure 1-1).	
Site Operations and History	<ul style="list-style-type: none"> • NRDL activities associated with analyzing samples from nuclear weapons tests, scientific studies (fallout, plant, animal, materials), and production and use of calibration sources. • The HRA also documents in Table 5-1 that the Navy had five radioactive licenses with the Atomic Energy Commission for ¹³⁷Cs, one for a quantity of 3,000 curies and a separate quantity of 20 curies of ¹³⁷Cs. Two licenses indicate that ¹³⁷Cs was in sources. In some cases, the Navy made its own sources with ¹³⁷Cs. • Use of radiography sources. • Use and potential disposal of radiological commodities, including discrete devices removed from ships (deck markers, radium dials) and welding rods. • Historical radiological material use documented in the HRA (NAVSEA, 2004) lists “impacted sites” – sites with potential for radioactive contamination. • Former surface soil impacted by fallout may be subsurface soil today because of fill activities. 	
Historical Site Conditions	<p>Facility created from fill with some background levels of radionuclides (e.g., NORM and fallout). Dredge spoils from local berths were used as fill for some areas. Trenches were backfilled following removal of sewer lines. Trench backfill is mixed, but documentation of source is available (onsite fill, offsite fill, or mixture). Bay mud or bedrock marks bottom extent of fill material.</p> <p>Site drainage system was designed in the 1940s to discharge to San Francisco Bay and was separated into sanitary sewers and storm drains in 1958, 1973, and 1976, but never completed.</p>	
Potential Source Areas	Potential Historical Sources of Radiological Contamination	<ul style="list-style-type: none"> • Potential spills and releases from the following: <ul style="list-style-type: none"> – Storage of samples from nuclear weapons tests at various NRDL facilities – NRDL waste disposal operations: <ul style="list-style-type: none"> ▪ Liquid waste stored in tank and processed at Building 364 ▪ Animal research at Building 364 • Incidental disposal of radioluminescent commodities (e.g., dials, deck markers) during maintenance, individually or attached to equipment. • Leaking radiography and calibration sources could affect buildings listed in HRA Table 6-1 related to production and maintenance of calibration sources. • Small amounts of low-level radioactive liquid waste were authorized for release with dilution to sanitary sewers based on regulations in place at the time.
	Release Areas in Parcel G	<p>Known Release Areas (from Section 6.4 of the HRA):</p> <ul style="list-style-type: none"> • Building 351A <ul style="list-style-type: none"> – Contaminated sinks and drain lines in Room 47 were removed • Buildings 317/364/365 Site <ul style="list-style-type: none"> – Peanut spill (small peanut-shaped spill adjacent to Building 364) – Liquid waste tanks removed – Contamination identified in yard and removed – Contaminated sinks and drain lines connected to the liquid waste tanks, not to the sanitary sewer, were removed <p>Potential Releases Identified after the HRA:</p> <ul style="list-style-type: none"> • Building 366 ventilation and potential releases to soil.

Table 2-1. Conceptual Site Model

<p style="text-align: center;">Impacted Buildings in Parcel G</p>	<p>Impacted Buildings with High Contamination Potential (from Table 8-2 of HRA):</p> <ul style="list-style-type: none"> • Building 364 (demolished) – Previously a concrete structure, measuring approximately 40 feet by 50 feet, used as an animal irradiation and research facility, for isotope processing and decontamination studies, and as a general research laboratory. Building 364 also contained a hot cell used to perform some of these processes. A liquid radioactive waste collection area was previously located at the rear of the building. Following closure of HPNS, it was leased to a laboratory company, which performed assay operations and has since been demolished. <p>Impacted Buildings with Moderate Contamination Potential (from Table 8-2 of HRA):</p> <ul style="list-style-type: none"> • Building 351 – Vacant three-story reinforced-concrete shop building with a five-story tower at the northwest corner, covering approximately 35,166 square feet of floor space. Building 351 was previously used as an electronics work area/shop, optical laboratories, Navy Bureau of Medicine and Surgery storeroom, machine shop (first floor), sampling laboratory, general research laboratories, and biological research laboratories. The NRDL also used the building as materials and accounts division, technical information division, office services branch, thermal branch, engineering division, and library. • Building 351A – Vacant one-story concrete building, covering approximately 35,166 square feet of floor space, constructed in 1952 over a crawl space that abuts the southern end of the building. Building 351A was used as a radiation detection, indication and computation repair facility and electronics shop for radiation detection equipment and a facility for the calibration, repair, and reconditioning of other instruments. The NRDL also used the building as a chemistry laboratory, applied research branch, administrative offices, nuclear and physical chemistry laboratory, and chemical technology division. • Building 366 – Vacant, one-story, raised-ceiling structure composed of an exterior “sheet metal” shell with interior room constructed of traditional wood and sheetrock materials, measuring approximately 280 feet by 130 feet. The building was built over a full-floor concrete pad with isolated areas of asphalt patching. Building 366 was used as administrative offices, applied research and technical development branches, radiological safety branch, management planning division, nucleonics division, instruments evaluation section, general laboratories, chemical research laboratory, shipyard radiography shop, boat/plastic shop, and other military/navy branch project officers station. NRDL also used the building for instrument calibration and management engineering and comptroller department. • Building 408 (demolished) – Previously a steel-framed structure enclosing two free-standing furnaces, used for smelting, that were constructed in 1947. The building was the equivalent of three stories at its northern end, dropping to one story at its southern end, and open-sided on the north. A firebrick-lined hearth occupied most of the open area at the north. Natural gas burners were present on the east and west sides of the hearth and a pair of smokestacks extended from the lower rear segment of the building. The building has been demolished, and the concrete building pad is all that remains. <p>Impacted Buildings with Low or No Contamination Potential (from Table 8-2 of HRA):</p> <ul style="list-style-type: none"> • Building 317 (demolished) – Previously a concrete structure measuring approximately 30 feet by 40 feet, used by NRDL personnel for temporary animal quarters. • Building 365 (demolished) – Previously a wooden structure with a concrete foundation that measured approximately 30 feet by 40 feet. Building 365 was used as a personnel decontamination facility, change house, and storage building. The NRDL also used the building as a small animal facility. • Building 411 – Vacant curtain-walled, steel-framed building with a flat roof and includes a saw-toothed series of rooftop monitors as well as bands of steel industrial sash and large glazed industrial doors, measuring approximately 185,000 square feet. Building 411 was used for source storage, as a civilian cafeteria, shipfitters and boilermakers shop, and ship repair shop. A leading enclosure measuring approximately 25 feet by 15 feet was in the building and housed an x-ray machine used for radiography. <p>Buildings Identified after the HRA:</p> <ul style="list-style-type: none"> • Building 401 – Vacant two-story building measuring approximately 100 feet by 250 feet. Building 401 was previously utilized as a supply storehouse, trades shop, and general stores, and by public works as a maintenance shop and offices. In 2005, the civilian tenant had been made aware of the presence of gauges and dials containing ²²⁶Ra and provided the gauges and dials to the Navy. • Building 439 – Vacant one-story building measuring approximately 250 feet by 400 feet. Building 439 was previously used by the Navy as an equipment storage facility. Following closure of HPNS, the building was leased by a skateboard company for use as a manufacturing and assembly plant. In 2002, Young Laboratories, a civilian tenant, was relocated to a 40-foot by 50-foot enclosed area in the northwest corner of the building with a separate outside entrance. Young Laboratories processed and analyzed metals and other materials containing metals as part of its assay operations. Previous investigations in Building 364 identified an old kiln that was assumed to have been used by Young Laboratories and a subsequent survey identified slag material inside containing ²²⁶Ra. Additional surveys within Building 364 identified areas of elevated ¹³⁷Cs activity. The Navy identified Building 439 as potentially impacted based on potential cross-contamination from Building 364 during relocation. <p>The Navy has found radiological contamination in portions of Parcel G, such as in the southeastern corner (associated with the buildings and the peanut spill) and in the sewers along Cochrane Street because of previous testing during the Phase I through Phase V radiological investigations/cleanups. The HRA indicates that ¹³⁷Cs was found at high concentrations in sediment from a manhole along Cochrane Street. The HRA documents that the Navy used ¹³⁷Cs, resulting in liquid waste releases in Building 364 in piping, sinks, and the peanut spill behind the building.</p>
<p style="text-align: center;">Radionuclides of Concern for Parcel G (from Table 8-2 of HRA)³</p>	<ul style="list-style-type: none"> • ²²⁶Ra • ¹³⁷Cs • ⁹⁰Sr • ⁶⁰Co (only for interior surfaces of former Buildings 364 and 365 and Building 411) • ²³²Th (only building interior surfaces of Buildings 351, 351A, and 408 and TU 115) • ²³⁵U (only for interior surfaces of former Buildings 364 and 365) • ²³⁹Pu (only for interior surfaces of Building 351A and former Buildings 364 and 365)

³ The site-specific ROCs for the soil and building investigations are listed in Table 3-4 and Table 4-1.

Table 2-1. Conceptual Site Model

<p>Potential Migration Pathways</p>	<ul style="list-style-type: none"> • Releases to soil and air. • Releases to sanitary sewer lines. <ul style="list-style-type: none"> – Buildings with known releases • Releases to storm drains. <ul style="list-style-type: none"> – Incomplete separation from sanitary sewer lines • Runoff from surface spills. • Releases from potentially leaking storm drain and sanitary sewer lines to surrounding soil (now removed). • Release of sediments from breaks or seams during power washing of drain lines. 	 <p>The diagram is a cross-section of a trench. A circular 'Drain Line' is shown at the bottom of the trench, partially filled with a blue liquid. The trench is surrounded by 'Soil'. A 'Trench' label points to the excavation. Below the diagram is the caption 'Conceptual Cross Section of Drain Lines'.</p>
<p>Potential Exposure Pathways</p>	<ul style="list-style-type: none"> • Soil: <ul style="list-style-type: none"> – External radiation from ROCs – Incidental ingestion and inhalation of soil and dust with ROCs for intrusive activities disturbing soil beneath the durable cover (only construction worker receptor) • Building surfaces: <ul style="list-style-type: none"> – External radiation from ROCs – Inhalation and incidental ingestion of resuspended radionuclides 	
<p>Current Status</p>	<ul style="list-style-type: none"> • HPNS is not an active military installation. In 1991, HPNS was selected for closure pursuant to the terms of the Defense BRAC Act of 1990. For more than 20 years, the Navy leased many HPNS buildings to private tenants and Navy-related entities for industrial and artistic uses. Current leases include art studios and a police department facility. Parcels A, D-2, UC-1, and UC-2 have been transferred to the City and County of San Francisco for nondefense use, and the remaining areas of HPNS are also planned to be transferred. • All known sources removed by Navy using standards at the time. <ul style="list-style-type: none"> – Follow-up investigations resulted in removal of small volumes of soil to meet current RGs • Sanitary sewer and storm drain removal investigation conducted at Parcel G from 2007 to 2011. <ul style="list-style-type: none"> – More than 4 miles of trench lines and 50,000 cubic yards of soil investigated and disposed of or cleared for use as onsite fill – Trench excavations that have been backfilled now contain homogenized soil from onsite fill, offsite fill, or a mixture of both 	
<p>Uncertainties</p>	<ul style="list-style-type: none"> • Lower potential for radiological contamination than originally described in historical CSMs based on the following lines of evidence: <ul style="list-style-type: none"> – Known sources have been removed. – Sanitary sewers and storm drains, and 1 foot of soil surrounding the pipe removed to the extent practicable. The sewer lines were removed to within 10 feet of all buildings. Impacted buildings had remaining lines removed during surveys of the buildings. Non-impacted buildings had surveys performed at ends of pipes, and pipes were capped. – Any residual concentrations may be modified by radiological decay (shorter-lived radionuclides, such as ¹³⁷Cs and ⁹⁰Sr) or remobilization (including weathering and migration). – Sediment data from inside pipe not indicative of a large quantity disposal or contamination (maximum ²²⁶Ra concentration of 4.2369 pCi/g and maximum ¹³⁷Cs concentration of 0.87795 pCi/g in Parcel G). – Overestimate of ²²⁶Ra concentrations in soil by the onsite laboratory using an imprecise measurement method. – LLRW bins were tested by the Navy's independent waste broker at an offsite laboratory using 5-point composites, and only 3 out of 1,411 bins had results with ²²⁶Ra above the RGs. • Data manipulation or falsification. • Data quality deficiencies. • ¹³⁷Cs and ⁹⁰Sr are present at HPNS because of global fallout from nuclear testing or accidents, in addition to being potentially present as a result of Navy activities. Because of backfill activities, ¹³⁷Cs and ⁹⁰Sr from fallout and Navy activities are not necessarily only on the surface and may be present in both surface and subsurface soil. • Potential for isolated radiological commodities randomly distributed around the site. • Trenches where scan data exceeded the IL and biased soil samples were not collected. 	

Notes:

⁶⁰Co = cobalt-60⁹⁰Sr = strontium-90¹³⁷Cs = cesium-137²³²Th = thorium-232²³⁵U = uranium-235²³⁹Pu = plutonium-239

BRAC = Base Realignment and Closure

IL = investigation level

LLRW = low-level radioactive waste

NORM = naturally occurring radioactive material

NRDL = Navy Radiological Defense Laboratory

pCi/g = picocurie(s) per gram

Soil Investigation Design and Implementation

This section describes the data quality objectives (DQOs), ROCs, RGs, ILs, and radiological investigation design and implementation for Parcel G soil.

3.1 Data Quality Objectives

The DQOs for the soil investigation are as follows:

- **Step 1-State the Problem:** Data manipulation and falsification were committed by a contractor during past sanitary sewer and storm drain removal actions and current and former building investigations for soil. The Technical Team evaluated soil data and found evidence of potential manipulation and falsification. The findings call into question the reliability of soil data and there is uncertainty whether radiological contamination was present or remains in place. Therefore, the property is unable to be transferred as planned. Based on the uncertainty and the description of radiological activities in the HRA, there is a potential for residual radioactivity to be present in soil.
- **Step 2-Identify the Objective:** The primary objective is to determine whether site conditions are compliant with the Parcel G ROD RAO (Navy, 2009).
- **Step 3-Identify Inputs to the Objective:** The inputs include surface soil and subsurface soil analytical data for the applicable ROCs and gamma scan survey measurements to identify biased soil sample locations. RBA surface and subsurface soil analytical data for ROCs will also be used to confirm, or update as necessary, estimates of naturally occurring and man-made background levels for ROCs not attributed to Naval operations at HPNS.
- **Step 4-Define the Study Boundaries:** See Phases 1 and 2 TUs and survey units (SUs) listed in **Tables 3-1 through 3-3** and shown on **Figure 3-1**.
- **Step 5-Develop Decision Rules:**
 - If the investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically-based RGs⁴ at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a remedial action completion report (RACR) will be developed.
 - If the investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically-based RGs⁴ at agreed upon statistical confidence levels and are not shown to be NORM or anthropogenic background, remediation will be conducted, followed by a RACR. Remediation will be based on the following:
 - If one Phase 1 TU does not meet the Parcel G ROD RAO, all Phase 2 TUs will be excavated.
 - If all Phase 1 TUs meet the Parcel G ROD RAO, Phase 2 will be initiated for TUs.
 - If any Former Building Site SU, Crawl Space soil SU, or Phase 2 TU does not meet the Parcel G ROD RAO, the SU or TU will be excavated.
 - The RACR will describe the results of the investigation, explain remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel G ROD RAO through the use of

⁴ The RGs are statistically based because they are increments above a statistical background.

multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.

- **Step 6-Specify the Performance Criteria:** The data evaluation process for demonstrating compliance with the Parcel G ROD RAO is presented in **Section 5** and depicted on **Figure 3-2**.
 - Compare each ROC concentration for every sample to the corresponding RG presented in **Section 3.3**.
 - If all concentrations for all ROCs for all samples are less than or equal to the RGs, then compliance with the Parcel G ROD RAO is achieved.
 - Compare sample data to appropriate RBA data from HPNS as described in **Section 5**. Multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include, but is not limited to, population-to-population comparisons, use of a maximum likelihood estimate (MLE) or background threshold value (BTV), graphical comparisons, and comparison with regional background levels.
 - If all residual ROC concentrations are consistent with NORM or anthropogenic background, site conditions comply with the Parcel G ROD RAO.
 - If any ^{226}Ra gamma spectroscopy concentration exceeds the ^{226}Ra RG and the range of expected NORM concentrations, then the soil sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , and ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra to evaluate equilibrium conditions. If the concentrations of radionuclides in the uranium natural decay series are consistent with the assumption of secular equilibrium, then the ^{226}Ra concentration is NORM, and site conditions comply with the Parcel G ROD RAO.
 - If any result is greater than the RG and cannot be attributed to NORM or anthropogenic background, remediation will be performed prior to backfill.
- **Step 7-Develop the Plan for Obtaining Data:**
 - Phase 1 TUs – The radiological investigation will be conducted on a targeted group of 21 of the 63 TUs (from 1 to 22 feet deep) associated with former sanitary sewers and storm drains in Parcel G (see **Figure 3-1**). For Phase 1 TUs, the durable cover (including asphalt, asphalt base course, concrete, gravel, debris, or obstacles) will be removed to expose the target soils. Soil will be excavated to the original TU boundaries, as practicable. Following excavation to the original TU boundaries, additional excavation of approximately 6 inches of the trench sidewalls and floors will be performed to provide ex-situ scanning and sampling of the trench sidewalls and floors. Excavated soil will be 100 percent gamma scanned by one of two methods: soil may be laid out on Radiological Screening Yard (RSY) pads for a surface scan, or soil may be processed and scanned using automated soil segregation technology. Systematic and biased samples will be collected from the excavated soil for offsite analysis.
 - Phase 2 TUs – Additional gamma scan surveys and soil sampling will be conducted on the remaining 42 TUs (from 1 to 22 feet deep) associated with former sanitary sewers and storm drains in Parcel G (see **Figure 3-1**). Each Phase 2 TU will undergo a 100 percent radiological surface gamma scan of accessible areas, along with soil sample collection via borings from soil within the former trench boundaries and from soil representing the former trench walls and floors, as practicable. Prior to the survey, the durable cover (including asphalt, asphalt base course, concrete, gravel, debris, or obstacles) will be removed to expose the target soils. The borings will be advanced approximately 6 inches below the depth of previous excavation and will be gamma scanned upon retrieval. Phase 2 will only be performed if no contamination is

found during Phase 1. If contamination is found during Phase 1, then all of the Phase 2 TUs will be excavated and investigated in a manner similar to that used for the Phase 1 TUs.

- Former Building Site and Crawl Space Soil SUs – The radiological investigation will be conducted at the 28 SUs⁵ associated with surface soil at building sites in Parcel G (see **Figure 3-1**). The SUs will be investigated by conducting a 100 percent gamma scan of the surface soil, along with sample collection from systematic and biased locations. Systematic and biased samples will be collected from the excavated soil for offsite analysis.
 - At the Former Buildings 317/364/365 Site, SUs 27 (peanut spill) and 28 (liquid waste transfer system [LWTS]) will be excavated to 2 and 10 feet below ground surface (bgs), respectively, for consistency with the previous excavation boundaries. The two SUs will be excavated to the original excavation boundaries, as practicable, and gamma scans of the excavated material will be conducted, similar to that used for the Phase 1 TUs. Excavated soil will be gamma-scanned by one of two methods. Soil may be laid out on RSY pads for a surface scan, or soil may be processed and scanned using soil segregation technology. Following excavation to the original SU boundaries, additional excavation of approximately 6 inches of the trench sidewalls and floors will be performed to provide ex situ scanning and sampling of the trench sidewalls and floor.
- The soil samples collected will be analyzed for the applicable ROCs by accredited offsite laboratories, and the results will be evaluated as described in Step 6. The excavated soil from within each trench and the over-excavation will be tracked separately, and global positioning system (GPS) location-correlated results will be collected or surveying conducted.

3.2 Radionuclides of Concern

The ROCs for Parcel G soil are based on the HRA (NAVSEA, 2004) and ROD (Navy, 2009) as presented in **Table 3-4**.

Table 3-4. Soil Radionuclides of Concern

Soil Area	Radionuclide of Concern
Former Sanitary Sewer and Storm Drain Lines	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr (²³² Th for TU 115)
Former Buildings 317/364/365 Site	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr, ²³⁹ Pu ⁶ , ²³⁵ U
Building 351A Crawl Space	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr, ²³⁹ Pu, ²³² Th

3.3 Remediation Goals

The soil data from the radiological investigation will be evaluated to determine whether site conditions are compliant with the RAO in the Parcel G ROD (Navy, 2009). The RAO is to prevent exposure to ROCs in concentrations that exceed RGs for all potentially complete exposure pathways. The RG for each ROC is

⁵ Previously, 32 SUs were investigated at the Former Buildings 317/364/365 Site and Building 351A Crawl Space; however, some SU areas overlapped. For the Former Buildings 317/364/365 Site, former SU 22 overlaps TU 153 and will be investigated as part of TU 153. For the Building 351A Crawl Space, former SU R, SU S, and SU U overlap SU M, SU N, and SU O and will be investigated as SU M, SU N, and SU O.

⁶ ²³⁹Pu is only an ROC for former Buildings 364 and 365 (NAVSEA, 2004); however, it is included as an ROC for soil at the Former Buildings 317/364/365 Site, that includes former Building 317 based on the location and proximity.

presented in **Table 3-5**. The soil data will be compared to the applicable RGs using a single sample comparison and evaluated as described in **Section 5**.

Table 3-5. Soil Remediation Goals from Parcel G ROD

Radionuclide	Residential Soil Remediation Goal ^a (pCi/g)
¹³⁷ Cs	0.113
²³⁹ Pu	2.59 ^b
²²⁶ Ra	1.0
⁹⁰ Sr	0.331
²³² Th	1.69 ^c
²³⁵ U	0.195 ^d

^aAll RGs will be applied as concentrations above background.

^b²³⁹Pu is an ROC only for the Former Buildings 317/364/365 Site.

^c²³²Th is an ROC only for TU 115 and the Building 351A Crawl Space.

^d²³⁵U is an ROC only for the Former Buildings 317/364/365 Site.

3.3.1 Investigation Levels

ILs are media-specific or instrument-specific measurements that trigger a follow-up response, such as further investigation, if exceeded.

ILs are expressed in units of the instrument’s response (such as counts per minute [cpm]) that are used to indicate when additional investigations (**Section 5**) are required. ILs are established for each instrument and vary with measurement type (e.g., scan, static). Scan survey measurements will be flagged when they exceed ILs.

For gamma scan survey measurements collected, individual measurement results above the IL will prompt investigations that may result in the collection of biased samples or additional field measurements to determine the areal extent of the elevated activity. Potential causes of elevated gamma scanning measurements may include discrete radioactive objects (e.g., deck markers), localized soil contamination, measurement geometry effects, and NORM. Ex situ gamma scan surveys will be performed using detector systems equipped with gamma spectroscopy to provide real-time radionuclide-specific measurements. The spectra will be evaluated using region of interest (ROI)-peak identification tools for the ROCs that correspond to gamma rays at 186 kiloelectron volts (keV) for ²²⁶Ra, 609 keV for ²²⁶Ra daughter bismuth-214 (²¹⁴Bi), 662 keV for ¹³⁷Cs, and other gamma emissions associated with the uranium and thorium decay series. The gamma scanning system will detect ¹³⁷Cs photons; however, individual measurements are not intended to characterize ¹³⁷Cs at or below the RG. In addition, gross gamma energy windows may be used to identify radiological anomalies that are not readily identified with a single gamma energy, such as the bremsstrahlung radiation from a deck marker containing ⁹⁰Sr.

The gamma spectroscopy detector system also may be used to assess gamma scan investigation locations using a 1-minute or greater static count and spectral analysis to compare the activity at a specific point to background. For gamma scan investigations, the net spectrum will be plotted and the critical levels assessed for ROC-specific energy ranges to find out if there is any activity present above background. Critical levels, as defined in the MARSSIM Section 6.7.1, represent thresholds above which

net counts are statistically greater than background (USEPA et al., 2000). If the gamma spectroscopy detector system static measurements identify elevated locations, biased samples will be collected; otherwise, the static count spectra will be provided in the data reports. The analysis of scanning data collected by the RS-700 system and triggers for further investigation are described in **Section 3.5.1.1**. ILs for other field instrumentation are typically equal to an upper estimate of the instrument- and material-specific background, such as the mean plus three standard deviations. Appropriate instrument and site-specific gamma scan ILs for site ROC and gross gamma (i.e., full-energy spectrum) measurements will be determined following mobilization and provided to regulatory agencies. **Section 3.5** describes the minimum gamma scan survey instrument requirements and the methodology to determine instrument soil scan minimum detectable concentrations (MDCs) in soil.

3.4 Radiological Investigation Design

This section describes the design of the radiological investigation, including gamma scan surveys and soil sampling. The radiological investigation design is primarily based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012) with the ultimate requirement to demonstrate compliance with the Parcel G ROD RAO (Navy, 2009). The SAP (**Appendix B**) provides additional guidance on soil sampling, chain-of-custody, laboratory analysis, and quality assurance (QA)/quality control (QC) requirements.

There are two types of Parcel G soil investigations discussed in this section to include surveys of:

- Surface and subsurface soil associated with former sanitary sewer and storm drain lines (TUs)
- Surface soil areas associated with soil from building sites (SUs)

A phased investigation approach is planned for surface and subsurface TU soil associated with former sanitary sewer and storm drain lines. Phase 1 includes the radiological investigation of 21 previously established TUs and Phase 2 includes the remaining 42 TUs in Parcel G. The approach is based on a proposal by the regulatory agencies to achieve a high level of confidence that the Parcel G ROD RAO has been met for soil (Attachment 2.1 in **Appendix A**). For Phase 1, 100 percent of soil will be re-excavated and characterized at 33 percent of TUs in Parcel G. Soil sampling and scanning at the remaining 67 percent of TUs will be performed as part of Phase 2 to increase confidence that current site conditions comply with the Parcel G ROD RAO. The Navy will re-excavate 100 percent of Phase 2 TUs if contamination is identified in Phase 1 TUs. For both Phase 1 TUs and Phase 2 TUs, the durable cover (including asphalt, asphalt base course, concrete, gravel, debris, or obstacles) will be removed to expose the target soils.

For surface soil areas associated with soil from building sites, radiological investigation will be conducted at the 28 SUs⁷ in Parcel G.

The principal features of the investigation protocol to be applied to the Parcel G soil TUs and SUs are discussed herein and include the following:

- Number of samples
- Locating samples
- Establishing radiological background
- TU design
- SU design

⁷ Previously, 32 SUs were investigated at the Former Buildings 317/364/365 Site and Building 351A Crawl Space; however, some SU areas overlapped. For the Former Buildings 317/364/365 Site, former SU 22 overlaps TU 153 and will be investigated as part of TU 153. For the Building 351A Crawl Space, former SU R, SU S, and SU U overlap SU M, SU N, and SU O and will be investigated as SU M, SU N, and SU O.

To the extent possible, manual data entries will be reduced or eliminated through use of electronic data collection and transfer processes.

3.4.1 Number of Samples

Soil samples will be collected on a systematic sampling grid and/or from biased locations identified by the gamma scanning surveys. The number of systematic soil samples collected will be based on the guidance described in MARSSIM Section 5.5.2.2 (USEPA et al., 2000) using ^{226}Ra as the example basis for calculating the minimum sample frequency. Even if the MARSSIM-recommended or other statistical tests are not used to evaluate site data, these calculations serve as a basis for determining the number of samples per SU to be collected. The number of biased samples will be determined based on results of scan surveys, and a minimum of one biased sample will be collected in every TU and SU.

MARSSIM Section 5.5.2.2 defines the method for calculating the number of soil samples when residual radioactivity is uniformly present throughout an SU. Therefore, determining the number of samples will be based on the following factors:

- RG for radioactivity in soil (upper boundary of the gray region [UBGR])
- Lower boundary of the gray region (LBGR)
- Estimate of variability (standard deviation [σ]) in the reference area and the SUs
- Shift ($\Delta = \text{UBGR} - \text{LBGR}$)
- Relative shift ($(\text{UBGR} - \text{LBGR}) / \sigma$) (see **Equation 3-1**)
- Decision error rates for making a Type I or Type II decision error that the mean or median concentration exceeds the RG (determined via MARSSIM Table 5.2)

Each of the preceding factors is addressed in the following paragraphs. Example data are provided to assist in explaining the process for calculating the minimum sample frequency. Actual numbers of samples for SUs will be based on reference area data once they become available. The data quality assessment (DQA) of SU data will include a retrospective power curve (based on the MARSSIM Appendix I guidance) to demonstrate that a sufficient number of samples was collected to meet the project objectives.

The ^{226}Ra RG is defined as 1 pCi/g plus background. As a basis for the calculations, the background ^{226}Ra soil concentration is assumed to be 1 pCi/g.

MARSSIM defines a gray region as the range of values in which the consequences of decision error on whether the ^{226}Ra concentration is less than or exceeds the RG are relatively minor. The RG of 1 pCi/g of ^{226}Ra above background (1 pCi/g) was selected to represent the UBGR (2 pCi/g). The LBGR is the median concentration in the SU, and the retrospective power will be determined after the survey is completed. Given the absence of data prior to performing the investigation activities, MARSSIM Section 2.5.4 suggests arbitrarily selecting the LBGR as half the RG. Therefore, for this example, the LBGR = $0.5 \text{ pCi/g} + 1 \text{ pCi/g} = 1.5 \text{ pCi/g}$. Assuming the UBGR equals the RG, then $\Delta = 0.5 \text{ pCi/g}$ for this example.

MARSSIM defines σ as an estimate of the standard deviation of the measured values in the SU. Because SU data will not be available until the investigation activities are completed, MARSSIM recommends using the standard deviation of the RBA as an estimate of σ . Given the absence of data prior to performing the investigation activities, an arbitrary value of 0.25 pCi/g has been selected as an estimate of σ for this example.

The relative shift is calculated based on MARSSIM guidance (Section 5.5.2.2) as shown in the following equation:

Equation 3-1

$$\frac{\Delta}{\sigma} = \frac{(UBGR - LBGR)}{\sigma} = \frac{(RG - LBGR)}{\sigma} = \frac{(2.0 - 1.5)}{0.25} = 2.0$$

The minimum number of samples assumes the ^{226}Ra concentration in the SU exceeds the RG. Type I decision error is deciding that the ^{226}Ra concentration in the SU is less than the RG when it actually exceeds the RG. To minimize the potential for releasing soil with concentrations above the RG, the Type I decision error rate is set at 0.01. Type II decision error is deciding that the ^{226}Ra concentration exceeds the RG when it is actually less than the RG. To protect against remediating soil with concentrations below the RG, the Type II decision error rate is set at 0.05.

MARSSIM Table 5.3 lists the minimum number of samples to be collected in each SU and RBA based on the relative shift and decision error rates. For a relative shift of 2, with a Type I decision error rate of 0.01 and Type II decision error rate of 0.05, MARSSIM Table 5.3 recommends a minimum of 18 samples in each SU and RBA. For example, for Phase 1, a minimum of 18 samples would be collected for every 152 cubic meters (m^3) of soil (calculation provided in **Section 3.4.4.2**).

The USEPA has requested that initially⁸, a minimum of 25 samples be collected in each survey unit. Therefore, 25 samples will be a placeholder until data from the RBA study become available. The minimum number of samples per SU will be developed based on the variability observed in the RBA data. A retrospective power curve will be prepared to demonstrate that the number of samples from each SU was sufficient to meet the project objectives. If necessary, additional samples may be collected to comply with the project objectives.

3.4.2 Locating Samples

Systematic soil samples will be located using Visual Sample Plan (VSP) software (or equivalent). Each TU or SU will be mapped in VSP, such that at a minimum, 18 systematic soil samples will be collected in each TU or SU. The systematic soil samples will be plotted using a random start triangular grid using the VSP software with GPS coordinates for each systematic sample.

3.4.3 Radiological Background

The RGs presented in **Table 3-5** are incremental concentrations above background; therefore, RBA samples and measurements will be collected and evaluated to provide generally representative data sets estimating natural background and fallout levels of man-made radionuclides for the majority of soils at HPNS. The RBA characterization will incorporate three survey techniques: gamma scans, surface soil sampling, and subsurface soil sampling to support data evaluations. The details on soil locations, surveying, sampling, and data evaluation are presented in the Soil RBA Work Plan (**Appendix C**).

3.4.4 Phase 1 Trench Unit Design

Radiological investigations will be conducted on a targeted group of 21 of the 63 TUs associated with former sanitary sewer and storm drain lines (**Figure 3-1**). The former TUs selected for Phase 1 investigation were based on their location adjacent to (downstream/upstream) impacted buildings and considered the recommendations from the Radiological Data Evaluation Findings Report (Navy, 2017). The name, size, and boundary of the TUs will be based on the previous plans and reports (**Table 3-1**).

The Phase 1 TUs will be re-excavated to the previous excavation limits by making reasonable attempts to ensure accuracy in relocating the former TU boundaries (see **Section 3.6.3**). The excavated soil material will be investigated by gamma scan surveys and systematic and biased soil sample collection

⁸ The initial sampling will be conducted in the TU and SU locations USEPA, Department of Toxic Substances Control (DTSC), and California Department of Public Health (CDPH) identified with the likelihood of finding contamination, highest potential variability, representativeness, etc. For the TUs, TU 153, TU 98, and TU 103 were identified. For the Former Building Site and Crawl Space SUs, Former Buildings 317/364/365 Site SUs 23 and 28, and Building 351A Crawlspace SU B.

following either the automated soil sorting system process (**Section 3.6.3.1**) or the RSY process (**Section 3.6.3.2**). If the investigation results from the gamma scan surveys and results from the analysis of systematic and biased soil samples demonstrate potential exceedances of the RGs and background, the material will be segregated for further evaluation as described in **Section 5.3**.

To address the Phase 1 radiological investigations of the former trench sidewalls and floors, a strategy to not only excavate the former trenches to the previous excavation limits, but to over-excavate at least an additional 6 inches outside the estimated previous boundaries of the sidewalls and bottom will be employed. The exhumed over-excavated material will represent the trench sidewalls and bottom and will be gamma scan-surveyed and sampled ex situ, to provide the following benefits:

- Significant improvement of the measurement quality for gamma scan surveys by controlling the measurement geometry.
 - Material thickness will not exceed 6 inches
 - Use of large-volume sodium iodide (NaI) detectors with shielding
 - Use of large-volume NaI detectors with spectroscopy
- Reducing the potential safety risks associated with in situ trench sidewall and bottom scanning and sampling.
- Reducing the water management required to de-water trenches to provide unsaturated material to investigate.
- Increasing assurance that all potentially impacted materials are investigated because of the inherent limitations of finding exact boundaries.

The over-excavated material (representing sidewalls and floors) will be investigated in the same fashion as the excavated soil by gamma scan surveys and soil sample collection by soil sorting system process (**Section 3.6.3.1**) or RSY process (**Section 3.6.3.2**). The over-excavated material representing trench sidewalls and floors will be maintained as separate volumes (e.g., piles) of soil from the original excavated soil. If the investigation results from the gamma scan surveys and results from the analysis of systematic and biased soil samples of the over-excavated material demonstrate exceedances of the RGs and background, the material will be segregated for further evaluation. An in situ investigation of the trench sidewalls and floor will be performed as described in **Section 5.3**. An example Phase 1 TU location is presented on **Figure 3-3**.

3.4.4.1 Nomenclature of Phase 1 Trench Units

The former TUs will be excavated and characterized in “batches” that will be given new unique identifiers at the time of excavation by the geologist or radiation technician. Excavated material representing the backfill material from former TUs will use the following nomenclature format:

AABB-ESU-NNNA

- Where:
- AA = facility (HP for Hunters Point will be used in this work plan)
 - BB = site location (PG for Parcel G will be used in this work plan)
 - ESU = excavation soil unit
 - NNN = former trench unit number
 - A = alpha-numeric digit of each “batch” (beginning with A, in sequential order)

For example, the third “batch” of backfill TU material excavated from the former TU 69 will be identified as follows:

HPPG-ESU-069C

In this example, “HPPG” identifies Hunters Point Parcel G, “ESU” identifies excavation soil unit, “NNN” identifies the unit as being excavated from the former Trench Unit 69, and “C” represents the third unit created from excavating this former TU.

Excavated material representing the sidewalls and bottoms of former TUs will use the following nomenclature format:

AABB-SFU-NNNA

Where: AA = facility (HP for Hunters Point will be used in this work plan)
 BB = site location (PG for Parcel G will be used in this work plan)
 SFU = sidewall floor unit
 NNN = former trench unit number
 A = alpha-numeric digit of each “batch” (beginning with A, in sequential order)

For example, the first “batch” of sidewall and floor material excavated from the former TU 153 will be identified as follows:

HPPG-SFU-153A

In this example, “SFU” identifies sidewall floor unit, “NNN” identifies the unit as being excavated from the former Trench Unit 153, and “A” represents the first unit created from excavating this former trench unit.

3.4.4.2 Size of Phase 1 Trench Units

RSY pads are designed to be approximately 1,000 square meters (m²) (TtEC, 2009d, 2012). Using the assumption that material will be assayed in geometries yielding soil column thickness of 6 inches, the volume of a “batch” of excavated material (either ESU or SFU) is calculated as:

$$1000m^2 \times 0.1524m \text{ (6 inches)} = 152m^3$$

Therefore, an individual ESU or SFU volume will not exceed 152 m³. Converting from m³ to tons of soil (a more commonly used unit), the maximum “batch” size of excavated material will not exceed:

$$152m^3 \times \frac{1.3yd^3}{m^3} \times \frac{2,200lbs \text{ soil}}{yd^3} \times \frac{1ton}{2,000lbs} \approx 217 \text{ tons soil}$$

This calculation assumes 2,200 pounds of loose soil per cubic yard, actual field conditions may vary from this assumption. Each former TU will be excavated and managed in no larger than approximately 152 m³ “batches” (i.e., ESUs or SFU) and individually stockpiled prior to radiological screening. Using a maximum size of 152 m³, the estimated number of expected ESUs created during the excavation of backfill from former TUs are listed in **Table 3-1**. Similarly, using a maximum size of 152 m³, the estimated number of expected SFUs created during the over-excavation of former TUs (representing sidewalls and floors) are listed in **Table 3-1**.

The actual sizes of individual ESUs and SFUs will be determined in the field, based on the actual final excavation limits and volumes of soil material excised from the former trenches.

3.4.5 Phase 2 Trench Unit Design

The Phase 2 TUs are listed in **Table 3-2** and depicted on **Figure 3-1**. Investigations of the Phase 2 TUs will consist of a combination of gamma scan surveys and soil samples.

Each Phase 2 TU will undergo a 100 percent radiological surface gamma scan of accessible areas using an appropriate instrument listed in **Section 3.5**. The instrument will be composed of a gamma scintillation detector equipped with a spectroscopy system that measures gross gamma counts along

with radionuclide-specific measurements and is coupled to a data logger that logs the count rate data in conjunction with location. Gross gamma and gamma spectra obtained during the surface gamma scan surveys will be analyzed using region-of-interest peak identification tools for the ROCs. Elevated areas will be noted on a survey map and flagged in the field for verification. Manual scans using a handheld instrument may be performed to further delineate suspect areas in the TU. Biased samples will be collected from potential areas of elevated activity displaying gamma scan survey results greater than the ILs (**Section 5.3.1**).

Within the backfill of each previous TU boundary, VSP software (or equivalent) will be used to determine the systematic soil boring locations (as determined in **Section 3.4.1**). A stylized graphic of an example Phase 2 TU with 18 systematic boring locations placed using a triangular grid is shown on **Figure 3-4**. Each location will be cored down to approximately 6 inches below the depth of previous excavation. Each retrieved core will be scan-surveyed along the entire length of the core. Scan measurement results of the retrieved core will be evaluated to investigate the potential for small areas of elevated activity in the fill material. A sample will be collected from the top 6 inches of material, and a second sample will be collected from the 6 inches of material just below the previous excavation depth. Additionally, a third sample will be collected from the core segment with the highest scan reading that was not already sampled. At least three samples will be collected from each of the 18 borings, for a total of 54 samples per previous TU boundary. The anticipated number of subsurface soil samples is shown in **Table 3-2**; however, additional locations or samples may be required based on the evaluation following analysis of RBA data.

In addition, systematic cores will be placed every 50 linear feet on each trench sidewall in order to collect samples from locations representative of the trench sidewalls. The systematic boring locations will be located approximately 6 inches outside of the previous sidewall excavation limits and will extend 6 inches past the maximum previous excavation depth on both sidewalls in every trench. In the same fashion described in the previous paragraph, core sections will be retrieved, scanned, and sampled such that at least three samples will be collected from each of the boring locations. The projected number of borings and soil samples obtained from sidewall material is presented in **Table 3-2**. The typical sample locations representing the TU sidewalls are shown on **Figure 3-4**. The subsurface soil sampling process is detailed in **Section 3.6.4.1**. The soil samples will be submitted to the offsite analytical laboratory for analysis according to the SAP (**Appendix B**).

3.4.6 Former Building Site and Crawl Space Survey Unit Design

Radiological investigations will be conducted at the 28 SUs associated with soil from building sites where only surface soil scanning and sampling was previously conducted (**Figure 3-1**). The name, size, and boundary of the SUs will be based on the previous plans and reports (**Table 3-3**).

Each surface SU will undergo a 100 percent radiological surface gamma scan of accessible areas using an appropriate instrument listed in **Section 3.5**. The instrument will be composed of a gamma scintillation detector equipped with spectroscopy coupled to a data logger that logs the resultant data in conjunction with location. Gross gamma and gamma spectra obtained during the surface gamma scan surveys will be analyzed using ROI-peak identification tools for the ROCs. Elevated areas will be noted on a survey map and flagged in the field for verification. Manual scans using a handheld instrument may be performed to further delineate suspect areas in the SU. Biased samples will be collected from potential areas of elevated activity displaying gamma scan survey results greater than the IL (**Section 5.3.1**).

Following the completion of the gamma scan surveys, the SU area will be plotted using VSP software (or equivalent) to determine the location of systematic samples. A stylized graphic of an example SU with 18 systematic samples placed using a triangular grid is shown on **Figure 3-4**. The surface soil sample collection process is detailed in **Section 3.6.5.1**. The soil samples collected from each SU will be submitted to the offsite analytical laboratory for analysis according to the SAP (**Appendix B**).

At the Former Buildings 317/364/365 Site, SUs 27 (peanut spill) and 28 (LWTS) will be excavated to 2 and 10 feet bgs, respectively, for consistency with the previous excavation boundaries (**Figure 3-1**). The two SUs will be excavated to the original excavation boundaries, as practicable, and gamma scans of the excavated material will be conducted similar to that used for Phase 1 TUs, discussed in **Section 3.4.4**.

3.5 Instrumentation

Radiation instruments, consistent with Basewide Radiological Management Plan (TtEC, 2012), have been selected to perform measurements in the field. Specifics related to radiological investigation implementation are provided in **Section 3.6**. The laboratory instruments used to analyze the soil samples and the associated standard operating procedures (SOPs) for calibration, maintenance, testing, inspection, and QA/QC are discussed in the SAP (**Appendix B**).

The following instrumentation information is included in this section:

- Soil gamma scanning instruments
- Instrument detection calculations
- Calibration
- Daily performance checks

Instruments that are expected to be used during fieldwork for activities other than soil gamma scan surveys are described in **Section 6.5**.

3.5.1 Soil Gamma Scanning Instruments

The gamma scanning survey instruments should be selected to provide a high degree of defensibility and based on their capability to measure and quantify gamma radiation and position using the best available technology. The primary gamma scanning instrument that will be used during Phase 2 TU surface scan surveys, soil scan surveys of excavated trench soil (either following the RSY or soil sorting processes), and soil area SUs will consist of NaI or plastic scintillation detectors equipped with automated data logging. The gamma scan survey system will be equipped with gamma spectroscopy capabilities, providing the benefit of collecting spectral measurements in addition to the gross gamma measurements. The spectra will be evaluated using ROI-peak identification tools for the ROCs that correspond to gamma rays at 186 keV for ^{226}Ra , 609 keV for ^{226}Ra daughter ^{214}Bi , 662 keV for ^{137}Cs , and a gross gamma window (i.e., full energy spectrum). Details on the evaluation of ROIs and gross gamma windows for the RS-700 system are provided in **Section 3.5.1.1**.

For gamma scan surveys conducted on the Phase 2 TU surfaces, in the RSY pads, and in the surface soil area SUs, the gamma scanning instrument will also be equipped with a GPS positioning sensor and software that is able to simultaneously log continuous radiation and position data. The gamma radiation measurement will be coupled to the position measurement to allow for precise visualization of the data set. For gamma scan surveys of retrieved cores, a gamma instrument consisting of a NaI detector equipped with gamma spectroscopy. The instruments that are expected to be used during fieldwork are listed in **Table 3-6**.

Table 3-6. Gamma Survey Instruments

Meter Manufacturer and Model	Detector Manufacturer and Model	Detector Type	Use
Radiation Solutions, Inc RS-700	RSI RSX-1	4 inches x 4 inches x 16 inches (4-liter) NaI(Tl) detectors (2)	Ex situ RSY and soil area gamma scan surveys

Table 3-6. Gamma Survey Instruments

Meter Manufacturer and Model	Detector Manufacturer and Model	Detector Type	Use
Ludlum 2221, Multi-channel Analyzer	Ludlum Model 44-20	3 inches x 3 inches NaI(Tl) detector	Soil area gamma scans, sample screening, soil core surveys
Automated Soil Sorting System	To Be Determined	Large-volume NaI(Tl) detector	Gamma soil surveys in soil sorting system

Notes:

Equivalent alternative instrumentation may be used following approval by the PRSO and Field Team Lead.

NaI(Tl) = sodium iodide activated with thallium

PRSO = Project Radiation Safety Officer

3.5.1.1 RS-700 Gamma Scan Data Analysis

The data collected during the gamma scan using the RS-700 system are evaluated as follows. A tiered approach is used during data review for the RS-700 system data to identify areas requiring additional surveys and biased samples as described in the second stage of the gamma count rate surveys. Ten ROIs have been established for radium and progeny as well as other naturally occurring or anthropogenic gamma-emitting radionuclides that may be of interest. Three virtual detectors (VDs) are set up in the analysis software (RadAssist). VD1 denotes both detectors summed, VD3 refers to the left detector, and VD4 refers to the right detector.

First, the data file is replayed in RadAssist and reviewed for elevated count rates in several relevant ROIs. Next, the count rates for several relevant ROIs are plotted in a time series and reviewed for additional peaks. The Z-scores are calculated for each location in all ROIs for VDs 1, 3, and 4. Local Z-scores are also calculated using a moving average to identify elevated count rates where the background is variable, for SUs that meet this criterion. Semi-local Z-scores are calculated using the global average but with a moving average for the standard deviation to identify smaller areas of elevated count rates that may not be otherwise identified by the initial Z-score review, for SUs that meet this criterion. Any location with four or more ROIs having a Z-Score, local Z-score, or semi-local Z-score, respectively, greater than 3 ($Z > 3$) is marked for follow-up. These three types of Z-scores are also plotted in a time series and reviewed for additional peaks in Z-score. Finally, count rate ratios are calculated for key ROIs and reviewed for obvious peaks or outliers.

3.5.2 Instrument Detection Calculations

The equations to calculate efficiencies, MDCs, and minimum detectable count rates (MDCRs) at HPNS are based on the methodology and approach used in MARSSIM (Chapter 6) and Nuclear Regulatory Commission (NRC) Regulation (NUREG)-1507 (Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions [NRC, 1998]) (Chapter 6). The instrument equations in this section may be used to calculate adjustments if the changes are approved in writing by a Certified Health Physicist before initial use. The following calculations are examples intended to illustrate the calculation approach.

3.5.2.1 Gamma Surface Activity

Estimating the amount of radioactivity that can be confidently detected using field instruments is performed by adapting the methodology and approach used in MARSSIM (Section 6.7.2.1) and NUREG-1507 (NRC, 1998) (Section 6.8.2) for determining the gamma scan MDC for photon-emitting radionuclides.

The scan MDC (in pCi/g) for areas is based on the area of elevated activity, depth of contamination, and the radionuclide (energy and yield of gamma emissions). The computer code Microshield can be used to model expected exposure rates from the radioactive source at the detector probe NaI crystal and includes source-to-detector geometry. The geometry is used to calculate the total flow of photons incident upon the detector crystal, called the gamma fluence rate, ultimately corresponding to an exposure rate that is associated with a count rate in the instrument.

The amount of radiation the detector crystal is exposed to from the modeled source is used to determine the relationship between the detector's net count rate and the net exposure rate (counts per minute per microrentgen per hour [cpm/ μ R/hr]).

3.5.2.2 Gamma Scan Minimum Detectable Concentration

The minimum detectable number of net source counts in the scan interval is given by s_i , which can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in d'), as shown in **Equation 3-2** (Equation 6-8 of MARSSIM):

Equation 3-2

$$s_i = d' \sqrt{b_i}$$

Where:

- d' = index of sensitivity (α and β errors [performance criteria])
- b_i = number of background counts in scan time interval (count)
- i = scan or observation interval (seconds)

For scanning at HPNS, the required rate of true positives will be 95 percent, and the false positives will be 5 percent. From Table 6.5 of MARSSIM, the value of d' , representing this performance goal, is 3.28. The MDCR, in cpm, is calculated by **Equation 3-3** (Equation 6-9 of MARSSIM):

Equation 3-3

$$MDCR = s_i \times (60/i)$$

Where:

- s_i = minimum detectable number of net source counts in the scan interval
- i = scan or observation interval (seconds)

Next, the MDCR is used to calculate the *Surveyor* MDCR by applying a surveyor efficiency factor shown in **Equation 3-4** (Page 6-45 of MARSSIM):

Equation 3-4

$$MDCR_{Surveyor} = \frac{MDCR}{\sqrt{p}}$$

Where:

- $MDCR$ = minimum detectable count rate
- p = surveyor efficiency

After a surveyor efficiency is selected, the relationship between the $MDCR_{Surveyor}$ and the radionuclide concentration in soil (in becquerels per kilogram or pCi/g) is determined. This correlation requires two steps: 1) establish the relationship between the detector's net count rate and net exposure rate (cpm/ μ R/hr), and 2) determine the relationship between the radionuclide contamination and exposure rate. The relationship between the detector's net count rate and the net exposure rate may be determined analytically, using reference guidance documents, or obtained from the detector

manufacturer. Modeling (using Microshield) of the source area is used to determine the net exposure rate produced by a given concentration of radionuclides at a specific distance above the source. The scan MDC is calculated by **Equation 3-5** (Page 6-45 of MARSSIM):

Equation 3-5

$$Scan\ MDC = \left(\frac{MDCR_{surveyor}}{\epsilon_{inst}} \right) \times \left(\frac{Radionuclide\ Concentration[pCi/g]}{Exposure\ rate[\mu R/h]} \right)$$

Where:

$MDCR_{surveyor}$ = minimum detectable count rate surveyor

ϵ_{inst} = instrument efficiency (cpm/ μ R/hr)

Radionuclide Concentration = modeled source term concentration (pCi/g)

Exposure Rate = result of model (μ R/hr)

3.5.2.3 Example Gamma Scan Minimum Detectable Concentrations

An example a priori scan MDC calculation is provided herein for ²²⁶Ra using a Ludlum 2221 with a Model 44-20 (3-inch by 3-inch NaI) detector. This example assumes a background level of 18,000 cpm and 95 percent correct detections and 5 percent false positive rates resulting in a *d'* of 3.28. A scan rate of 0.5 meter per second (m/s) (19.7 inches per second) provides an observation interval of 2 seconds (based on a diameter of approximately 1 m for the modeled area of elevated activity). The $MDCR_{surveyor}$ was then calculated assuming a surveyor efficiency (ρ) of 1 (assumes automated data logging). The scan MDC is calculated as follows:

$$s_i = 3.28 * \sqrt{\frac{18,000 * 2sec}{60sec}} = 80\ counts$$

$$MDCR = 80 * \left(\frac{60\ sec}{2\ sec} \right) = 2,410\ cpm$$

$$MDCR_{surveyor} = \frac{2,410\ cpm}{\sqrt{1}} = 2,410\ cpm$$

The relationship between the detector's net count rate and the net exposure rate has been obtained from the detector manufacturer and is 2,300 cpm/ μ R/hr. The relationship between the radionuclide contamination and exposure rate has been determined by modeling (using Microshield) the source area to determine the net exposure rate produced by a given concentration of radionuclides at a specific distance above the source. The Microshield Version 11.20 model has a source activity of 1 pCi/g of ²²⁶Ra, a circular area of elevated activity of 1 m², a contaminated zone depth of 15 centimeters (cm) (6 inches), and a soil density of 1.6 grams per cubic centimeter. The modeling code determined an exposure rate at the detector height (dose point) of 10 cm (4 inches) above the source to be 1.130 μ R/hr. The scan MDC for this source geometry is calculated as follows:

$$Scan\ MDC = \left(\frac{2,410cpm}{2,300cpm/\mu R/h} \right) \times \left(\frac{1.0[pCi/g]}{1.130[\mu R/h]} \right) = 0.93\ pCi/g$$

Additional a priori determinations are provided in **Table 3-7**. The MicroShield model parameters are identical to those described in the previous example, using either ²²⁶Ra with a concentration of 1 pCi/g, or ¹³⁷Cs with a concentration of 0.113 pCi/g. Note that the measurement geometry and parameters modeled are meant to illustrate an assumption for the calculation. Contamination, if present, may not exist in the same modeled configuration, and the modeled scan MDCs may not apply. As shown in **Table 3-7**, the calculated gamma scan sensitivity for ¹³⁷Cs is not expected to be sufficient to detect ¹³⁷Cs at or below the RG. Therefore, compliance with the Parcel G ROD RAO for ¹³⁷Cs will be based on the analytical data from soils sampling.

Table 3-7. A Priori Scan MDCs

Nal Detector	RG	Scan MDC
Ludlum 44-20, 3x3	²²⁶ Ra, 1.0 pCi/g	0.93 pCi/g
	¹³⁷ Cs, 0.113 pCi/g	2.30 pCi/g
RS-700	²²⁶ Ra, 1.0 pCi/g	0.036 pCi/g
	¹³⁷ Cs, 0.113 pCi/g	1.18 pCi/g
Soil sorting system	²²⁶ Ra, 1.0 pCi/g	To be determined
	¹³⁷ Cs, 0.113 pCi/g	To be determined

After field mobilization, MDC calculations will be revised using actual site-and instrument-specific data. Observed MDCs will be provided to regulatory agencies and will be documented in the RACR.

3.5.3 Calibration

Portable survey instruments will be calibrated annually at a minimum, in accordance with American National Standards Institute (ANSI) N323a-1997 Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments (ANSI N323) (ANSI, 1997), or an applicable later version. Instruments will be removed from service on or before calibration due dates for recalibration. If ANSI N323 does not provide a standard method, the calibration facility should comply with the manufacturer’s recommended method.

3.5.4 Daily Performance Checks

Before use of the portable survey instruments, calibration verification, physical inspection, battery check, and source-response check will be performed in accordance with SOP RP-108, *Count Rate Instruments*, and SOP RP-109, *Dose Rate Instruments (Appendix D)*, or equivalent. Portable survey instruments will have a current calibration label that will be verified daily prior to use of the instrument.

Physical inspection of the portable survey instrument will include the following:

- General physical condition of the instrument and detector before each use
- Knobs, buttons, cables, connectors
- Meter movements and displays
- Instrument cases
- Probe and probe windows
- Other physical properties that may affect the proper operation of the instrument or detector

Any portable survey instrument or detector having a questionable physical condition will not be used until problems have been corrected. A battery check will be performed to ensure that sufficient voltage is being supplied to the detector and instrument circuitry for proper operation. This check will be performed in accordance with the instrument’s operations manual. The instrument will be exposed to the appropriate (alpha, beta, gamma) check source to verify that the instrument response is within the plus or minus 20 percent range determined during the initial response check. The calibration certificates and daily QA/QC records for each instrument used and the instrument setup test records will be provided in the project report.

If any portable survey instrument, or instrument and detector combination, having a questionable physical condition that cannot be corrected fails any of the operation checks stated in SOP RP-108, *Count Rate Instruments*, or SOP RP-109, *Dose Rate Instruments (Appendix D)*, or has exceeded its annual

calibration date without PRSO approval, the instrument will be put in an “out of service” condition. This is done by placing an “out of service” tag or equivalent on the instrument and securing the instrument or the instrument and detector combination in a separate area such that the instrument and instrument and detector combination cannot be issued for use. The PRSO and Radiological Control Technician (RCT) and their respective supervisors will be notified immediately when any survey instrumentation has been placed “out of service.” Instruments tagged as “out of service” will not be returned to service until all deficiencies have been corrected. The results of the daily operation checks, previously discussed, will be documented.

3.6 Radiological Investigation Implementation

This section provides guidance on the implementation of radiological investigations for soil.

3.6.1 Premobilization Activities

Before initiating field investigations, several premobilization steps will be completed to ensure that the work can be conducted in a safe and efficient manner. The primary premobilization tasks include training of field personnel and procurement of support services.

A list of the various support services that are anticipated to be required are as follows:

- Radiological analytical laboratory services
- Drilling subcontractor
- Civil surveying subcontractor
- Utility location subcontractor
- Vegetation clearance subcontractor
- Transport (trucking) subcontractor
- Concrete coring subcontractor

3.6.1.1 Training Requirements

Any non-site-specific training required for field personnel will be performed before mobilization to the extent practical. Training requirements are outlined in **Section 6**.

Medical examinations, medical monitoring, and training will be conducted in accordance with the APP/SSHP and **Section 6** requirements.

In addition to health and safety-related training, other training may be required as necessary including but not limited to the following:

- Aerial Lift (for personnel working from aerial lifts)
- Fall Protection (for personnel working at heights greater than 5 feet)
- Equipment as required (e.g., fork lift, skid steer, loader, back hoe, excavator)

3.6.1.2 Permitting and Notification

Before initiation of field activities for the radiological investigation, the contractor will notify the Navy Remedial Project Manager (RPM), Resident Officer in Charge of Construction (ROICC), Radiological Affairs Support Office (RASO), and HPNS security as to the nature of the anticipated work. Any required permits to conduct the fieldwork will be obtained before mobilization.

The contractor will notify the California Department of Public Health at least 14 days before initiation of activities involving the Radioactive Material License.

3.6.1.3 Pre-construction Meeting

A pre-construction meeting will be held before mobilization of equipment and personnel. The purpose of the meeting will be to discuss project-specific topics, roles and responsibilities of project personnel, project schedule, health and safety concerns, and other topics that require discussions before field mobilization. Representatives of the following will attend the pre-construction meeting:

- Navy (RPM, RASO, ROICC, and others as applicable)
- Contractor (Project Manager, Site Construction Manager, Project QC Manager, PRSO, and Site Safety and Health Officer [SSHO])
- Subcontractors as appropriate

3.6.2 Mobilization Activities

Mobilization activities will include site preparation, movement of equipment and materials to the site, and orientation and training of field personnel.

At least 2 weeks before mobilization, the appropriate Navy personnel, including the Navy RPM and ROICC and Caretaker Site Office, will be notified regarding the planned schedule for mobilization and site remediation activities. Upon receipt of the appropriate records and authorizations, field personnel, temporary facilities, and required construction materials will be mobilized to the site.

The temporary facilities will include restrooms, hand-washing stations, and one or more secure storage (Conex) boxes for short- and long-term storage of materials, if needed.

The applicable activity hazard analysis (AHAs) forms will be reviewed prior to starting work.

All equipment mobilized to the site will undergo baseline radioactivity surveys in accordance with **Section 6**. Surveys will include direct scans, static measurements, and swipe samples. Equipment that fails baseline surveying will be removed from the site immediately.

3.6.2.1 Locating and Confirming Boundaries

The first step to begin the radiological investigations is locating and marking the boundaries of the former TUs and SUs. This will be accomplished by using best management practices (BMPs) to identify boundaries and depths of the former TUs and SUs based on the previous TtEC reports (e.g., survey reports, drawings, and sketches), field observations (such as GPS locations from geo-referencing, borings, and visual inspection), and durable cover as-built records. Once the boundaries are located, the areas will be marked with paint or pin flags.

3.6.2.2 Site Preparation

After boundary location and mark-outs are completed, the following steps will be implemented to prepare the site for investigation and facilitating access.

- A radiologically controlled area (RCA) will be established around work areas and delineated with temporary fencing or caution tape, or equivalent, and have the appropriate warning signage posted. Access control points will be established and maintained. Radiological screening of personnel, equipment, and materials will be required when exiting the RCA. The RCA will be posted consistent with the requirements of the Radiation Protection Plan and SOP RP-102, *Radiological Postings (Appendix D)*. Routine surveys and inspections will be performed along the fence line, consisting of dose rate measurements and visual inspections. Surveys will be performed to ensure that there is no change in dose readings in accessible areas that could negatively affect the public or environment. Any breaches in the fence during site activities will be repaired.

- Stormwater, sediment, and erosion control measures will be implemented to prevent soil from entering and leaving the site as detailed in **Section 8**.
- Dust control methods and air monitoring will be implemented during intrusive activities as detailed in **Section 8**.
- An independent field survey to identify, locate, and mark potential underground utilities or subsurface obstructions will be performed by a third-party utility locator subcontractor following a review of existing utility drawings of the affected areas. The survey will be conducted over the known or suspect areas where underground utilities may exist using ground-penetrating radar or electromagnetic instrumentation. Underground Service Alert will be contacted at least 72 hours before initiating intrusive activities. The results of the geophysical survey will be compared to the available historical drawings and combined with Underground Service Alert markings (if any) to identify locations of underground utilities. Additionally, a visual survey of the area to validate the chosen location will also be conducted. Colored marking paint (or stakes or equivalent) will be used to mark identified utilities, if any, within the proposed work area. A minimum of 2 feet from the closest observed utility will be maintained to prevent accidental exposure to the utility, based on the utility hazard or importance. Utility lines encountered will be assumed active, unless specifically determined to be inactive through consultation with the subject utility company and with the Navy Caretaker Site Office representative, ROICC, and RPM.
- For both Phase 1 TUs and Phase 2 TUs, the asphalt cover will be removed to expose the target soils. Because of the inherent difficulty expected to determine the exact horizontal boundaries of the previous excavation, to provide access to the TU, and to account for regrading, an additional 1 foot of asphalt material on both sides of the historical trench excavation boundary will be removed to allow for a sufficient buffer for excavation of trench materials (Phase 1 TUs) and access for the surface gamma scan (Phase 2 TUs). After the asphalt cover is removed, attempts will be made to confirm the delineation between fill materials and native soils by reviewing cut-and-fill drawings and visual inspections.
- Durable cover materials, listed above, will require release surveys prior to offsite disposal. Release surveys of the materials will be performed according to SOP RP-105, *Unrestricted Release Requirements (Appendix D)*.

3.6.3 Phase 1 Trench Unit Investigation

Once all site preparation activities previously described are completed, TU investigation activities will commence.

Each former TU will be excavated to the original excavation limits and evaluated in approximately 152 m³ ESUs. The excavated material will then undergo radiological assay following either the automated soil sorting process or RSY pad process as described in the following sections. One hundred percent of the Phase 1 ESU soils will undergo scan surveys using real-time gamma spectroscopy equipment in the soil sorting process or the RSY pad process. Details on the scanning instrumentation can be found in **Section 3.5**.

Once the excavation to the original excavation limits has been complete, over-excavation of at least an additional 6 inches outside the estimated previous boundaries of the sidewalls and bottom will be initiated. This exhumed over-excavated material (SFU) will be maintained separate from the backfill volumes (ESU) and will represent the trench sidewalls and bottom. The over-excavated material (SFUs) will be investigated in the same fashion as the excavated soil (ESU) methodology by gamma scan surveys and soil sample collection (soil sorting system process or RSY process). Following completion of scanning activities, the ESU and SFU material will either be returned to the same trench that the material originated from or will be segregated for further investigation.

3.6.3.1 Automated Soil Sorting System Process

Excavated TU materials will be transported to a soil sorting area for processing. Processing activities using automated soil sorting technology include gamma surveys using large-volume gamma spectroscopy detectors to monitor multiple isotopes simultaneously (including ^{226}Ra and ^{137}Cs) and to provide real-time NORM background subtraction, systematic and biased sampling and analyses, performing investigation activities (as necessary), radiologically –clearing the materials for either reuse or disposal and transport of the materials out of the soil sorting area.

Because soil sorting systems are designed to be deployed on a flexible and scalable platform, the system will be tailored to achieve the project-specific requirements and objectives. The configuration details, including detectors, MDCs, and specific operating set points, will be provided under separate cover in a Soil Sorting Operations Plan. The Soil Sorting Operations Plan will be submitted to the regulatory agencies for review and concurrence. The remainder of this section generally describes the soil sorting process and the minimum requirements of the soil sorting technology.

Transfer of Excavated Soil for Processing

Excavated TU materials will be transported to the soil sorting area by dump truck or other conventional means. Excavated soil entering the soil sorting area must be accompanied by a truck ticket (paper or digital) to facilitate transfer of the material for radiological processing. This ticket will provide the soil sorting staff with the following information:

- Location of excavation, including former TU name
- From which TU sidewall or floor surface material was excavated (if applicable)
- Load number
- Estimated volume of soil
- Date and time of excavation

The material will be collected into individual 152 m³ batches as described herein. The soil sorting personnel will tell the driver where to place the material for subsequent processing through the soil sorting system.

General Process

Soil sorting systems are radiological monitoring and processing systems designed to perform real-time segregation of soil into two distinct bins based upon its radiological properties. The system is capable of processing and segregating large volumes of soil with relatively high throughput rates. Commercially available material conveyors are used to physically manage the soil. These conveyors prepare and condition material, they transport the material past the monitoring devices (various radiation sensors), and they provide the physical means to sort material.

The material is sorted into two distinct bins (piles), commonly referred to as the “Below Criteria” and “Diverted Pile” bins. The basis upon which the soil material is sorted and segregated into distinct volumes is controlled by the establishment of “diversion control setpoints” that automatically trigger the diverting mechanism, sorting the material into the appropriate bin. The selection of the system’s diversion control setpoints depends on a number of factors and will ultimately be chosen and described in the Soil Sorting Operations Plan. At a minimum, diversion control setpoints will sort soil at the ILs listed in **Section 3.3.1** and will and divert radiological commodities such as deck markers if encountered. Soil diverted to the “Diverted Pile” bin will be investigated as a potential area of elevated activity (**Section 5.3.2**).

Soil stockpiles (ESUs or SFUs) consisting of either former TU fill material or trench sidewalls and bottom materials with a maximum size of 152 m³ will be staged near the soil sorting system. Using typical earth moving equipment such as a front-end loader or excavator, soil will be fed to the soil sorting system. If necessary, the material may be processed through a trommel to condition the soil to flow through the

conveyor-based system. Once the soil reaches the primary assay conveyor, the material will pass under a fixed strike-off plate (or equivalent) to ensure that the thickness of the material does not exceed 6 inches. The material will move past the active area of the detectors, and the system's software will interpret the spectroscopy data to determine whether the volume of soil exceeds the specified alarm points. As the material continues to travel up the conveyor, it is automatically sorted in one of two bins. The typical soil sorting layout is shown on **Figure 3-5**.

Although the specific configuration details will be detailed separately in the Soil Sorting Operations Plan, the soil sorting system will maintain compliance with the following established soil gamma scanning requirements:

- Survey belt will not exceed 0.5 m/s
- System will be equipped with at least 1 large-volume gamma detector (e.g., 4-inch x 4-inch x 16-inch NaI)
- Soil thickness on the belt will be a maximum of 6 inches

Following completion of an ESU or SFU batch, the radiological results will be generated using soil sorting reporting software. Reports will include the basic statistical metrics for each of the two bins of soil that were created including the mean, median, min, max, and standard deviation of the gamma-emitting ROCs.

Soil Sampling and Follow-up Activities

The ultimate compliance with the Parcel G ROD RAO is demonstrated by collecting and analyzing soil samples for the applicable ROCs. Eighteen systematic soil samples (as determined in **Section 3.4.1**) will be collected from each ESU and SFU during assay with the soil sorting system. In the case of soil sorting, systematic samples will be collected at a given time period, the frequency of which is determined to provide a systematic distribution of sample collection throughout each ESU or SFU. For example, if the soil sorting system is configured to process a 152 m³ batch in 3 hours, a systematic sample will be collected every 10 minutes (180 minutes/18 samples = 10 minutes). Systematic samples will be collected by compositing material within each 10-minute interval. Samples will be collected from material moving through the soil sorter before discharge.

If soil material has been discharged to the "Diverted Pile," an investigation of the potential area of elevated activity (i.e., the Diverted Pile material) will be conducted. At a minimum, the soil sorting reporting software results will be reviewed to identify the causes for diverting material, and biased soil samples will be collected. The biased soil samples will be collected from the soil material that has been discharged to the Diverted Pile bin at a frequency equal to the volumetric frequency of sampling for ESU or SFU material. Using the current minimum number of systematic samples in a given unit (18), with a maximum unit size of 152 m³, a sample will be collected roughly every 8.5 m³, with a minimum of at least one sample being collected if the volume is less than 8.5 m³. Additionally, if the soil material discharged to the Diverted Pile originates from an SFU and is confirmed to contain contamination, an in situ investigation of the open trench will be performed at the excavation location of the soil. Material discharged to the Diverted Pile will remain segregated until completion of the investigation activities. The trench under investigation will remain open until investigation and remediation activities are completed. If necessary, additional samples may be collected from diverted material to support characterization for waste disposal.

The SFU in situ investigation will include the performance of a gamma scan over the trench surface requiring investigation and additional biased and systematic sampling. The trench investigation gamma count rate survey will be performed in two stages. The first stage is a gamma count rate scan conducted over 100 percent of the accessible area using the Ludlum Model 44-20 and Ludlum Model 2221 (or equivalent) handheld instrument, consistent with the requirements for a MARSSIM survey (USEPA et al.,

2000). The data collected during the gamma scan are evaluated, and if all readings are below the instrument-specific gamma scan IL or otherwise do not indicate the presence of an anomaly (e.g., via Z-score analysis, spatial plots, or other statistical analysis), the second stage is not required, and systematic samples will be collected as described in **Section 3.4.2**.

If the count rate exceeds the instrument-specific gamma scan IL or indicates that further investigation is warranted, the second stage commences (additional survey and possible soil sampling at the location and adjacent area where the count rate exceeded the scan instrument-specific scan IL and nearby areas). The second stage will consist of reacquiring the location of the elevated gamma count rate and conducting a 1-minute gamma static count using a Ludlum Model 44-20 and Ludlum Model 2221, or equivalent, handheld instrument. The nearby area will be resurveyed to assess whether the elevated gamma scan reading is the result of a point source or distributed radioactive material. If the gamma static (1-minute) count is less than the instrument-specific static IL, and there is no evidence of a point source, further survey investigation is not required, and systematic samples will be collected.

Surface soil samples will be collected on a systematic sampling grid and/or from biased locations identified by the gamma static survey. A minimum of 18 systematic soil samples (as determined in **Section 3.4.1**) will be collected from each SU as described in **Section 3.4.2**.

Each 1,000 m² trench SFU will be plotted using VSP software (or equivalent) to determine the location of the 18 systematic soil samples. The systematic soil samples will be plotted using a random start triangular or square grid with VSP software. Soil samples will be collected from the trench surface at a depth of 0 to 6 inches. The technique for locating systematic samples is provided in **Section 3.4.2**. Soil samples will be containerized and submitted to an offsite laboratory with appropriate chain-of-custody documentation as established in the SAP (**Appendix B**).

Soil processed by the soil sorter system and subsequently staged for offsite disposition or onsite reuse will be staged pending evaluation of offsite analytical results and Navy approval for disposition or reuse.

Soil pending offsite analytical results may be staged in stockpiles smaller than 152 m³, which would permit the re-evaluation of smaller soil volumes should elevated soil sample results be received from the offsite laboratory.

If elevated sample results are identified by offsite analysis, the contractor will notify the Navy and determine a suitable soil rescreening process, either by RSY pad or by the soil sorter. SFU sampling locations with results that exceed RGs and background will be remediated by additional soil excavation.

Mobilization, Setup, and Calibration

Mobilization and setup of the system typically requires up to 2 weeks. The system will be setup and configured at a suitable location with respect to accessibility, while not impacting load paths for heavy excavation equipment. Depending on the configuration of the material handling components, conveyors typically arrive on flatbed tractor trailers and require offloading into their designated position.

Assembling the conveyors and other physical structures typically takes 1 to 2 days. Assembling and testing of all the measurement equipment and sensors, data cables, computers and mobile command center typically takes an additional 2 days. Additionally, it usually takes 3 days for configuring and calibrating the system. Before setup, the area where the system will be operated will be radiologically scan-surveyed to document the existing conditions.

Several dust management practices can be used during soil sorting operations to minimize potential dust. Practices include adding wind panels to shield against winds that may create dust from the initial loading process, equipping discharge chutes with shrouds, in-line misting systems, dust mist oscillation cannons, and sorting under an enclosure. The usage of an enclosure, if deemed appropriate, would require a tent approximately 25 feet by 50 feet. The final dust management practices will be finalized before mobilization of the system and may be modified during operations as necessary.

Quality Assurance and Quality Control

The automated soil sorting system will adhere to strict QA/QC measures, to ensure accurate assay of the soil. The specific performance and documentation of the QA/QC measures will be included in the Soil Sorting Operations Plan; however, at a minimum, the following QA/QC tests will be interwoven with routine material processing operations:

- Spectral alignments
- Belt speed test
- Mass (weight) scale test
- Ambient background response
- Independent testing and confirmation

3.6.3.2 Radiological Screening Yard Pad Process

If a conveyor-based automatic soil sorting system process is not selected, excavated TU material will be assayed using the previously applied RSY process. Excavated TU materials will be transported to an RSY pad and spread approximately 6 to 9 inches thick for processing. Processing activities in the RSY pads include gamma scan surveys, using a large-volume gamma scintillator equipped with spectroscopy, systematic and biased sampling and analyses, performing investigation activities (as necessary), radiologically clearing the materials for either reuse or disposal, and transport of the materials off the RSY pads. The objective of the processing activities on the RSY pads is to characterize the material. Material that meets the RGs identified in **Table 3-5** will be used as backfill material or shipped offsite as non-LLRW. Before initiating excavation activities at each TU, existing RSY pads will be identified for use or new pads will be constructed. Transport routes between the TU and the selected RSY pads will be established and approved by the Navy before initiating excavation activities at each TU.

Construction of Radiological Screening Yard Pads

If no existing RSY pads are available for use, pads will be constructed to meet the requirements specified in the Basewide Radiological Management Plan (TtEC, 2012) and the RSY Construction Details (TtEC, 2009b). RSY pads will be constructed with a size limit of 1,000 m². Before construction, the area where the RSY pads will be constructed will be radiological scan-surveyed to document the existing conditions.

Transfer of Excavated Soil for Processing

Excavated TU materials will be transported to the RSY pad by dump truck or other conventional means. Excavated soil entering an RSY must be accompanied by a truck ticket (paper or digital), to facilitate transfer of the material for radiological processing along a designated truck route. This ticket will provide the RSY staff with the following information:

- Location of excavation, including former TU name
- From which TU sidewall or floor surface material was excavated (if applicable)
- Load number
- Estimated volume of soil
- Date and time of excavation

The RSY personnel will direct the driver to the appropriate RSY pad for soil placement. The truck ticket will be amended with the assigned unique RSY pad number for tracking purposes. Placement of soil on a RSY pad in the RSYs will continue until the soil placed on the RSY pad reaches capacity as identified by the RSY Manager (or designee) and is ready for processing.

Each individual 152 m³ TU stockpile will be loaded into the RSY pad, spread out, and leveled to a maximum depth of 6 inches for investigation.

General Process

The RSY process will include gamma scans over 100 percent of the surface area, systematic, and biased soil sampling. A minimum of 18 systematic soil samples (as determined in **Section 3.4.1**) will be collected from each pad along with any biased samples based on the results of the gamma scan surveys.

Gamma scans of the spread soil will be performed using a GPS coupled to an appropriate gamma scintillation scanning system, examples of which are provided in **Section 3.5**. The RS-700 gamma detection system will be used as the primary gamma scanning instrument.

Using the RS-700 system (or equivalent), the scans will be performed by scanning straight lines at a not-to-exceed rate of 0.25 m/s with a consistent detector distance from the soil surface (approximately 4 inches above the surface). Generally, RSY pad lift will be gamma scanned as follows (the following description assumes the RSY area is positioned such that the sides align with north, south, east, west directions):

- Begin with the detector positioned in the southwest corner of the RSY pad at a height of approximately 4 inches above the surface. Orient the system to face north and initiate data collection (detector is automatically logging radiation readings and GPS is automatically logging position readings) so that the system is recording at a rate of one reading per second (or other, as determined by the project Health Physicist).
- Move the detector in the north direction at a not-to-exceed speed of 0.25 m/s.
- Once the detector has reached the edge of the pad, turn the system around (now facing south) and offset the next detector path by the appropriate offset based on the instrument's detector size (e.g., field of view), to allow for a small overlap in the detector field of view.
- Move the detector in the southern direction at a not-to-exceed speed of 0.25 m/s.
- Repeat these steps until the soil on the RSY pad area has been scan-surveyed.

The data collected during the gamma scan using the RS-700 are evaluated as described in **Section 3.5.1.1**. If gamma scan surveys indicate areas of potentially elevated activity in soil above the ILS (**Section 3.3.1**), an investigation of the potential area of elevated activity will be initiated. At a minimum, the contractor will further evaluate the gamma scan data and collect biased soil samples. A biased soil sample will be collected from the approximate location of the highest elevated gamma scan survey measurement. If areas displaying elevated activity are collocated, an attempt will be made to locate the area with the highest gamma scan results and designate it as the biased sample location to represent the collocated elevated areas. Material with potentially elevated concentrations will remain segregated until completion of the investigation activities. Additionally, if soil sampling indicates areas of potentially elevated soil above the RGs and it is confirmed that the soil contains contamination, and if the soil material originates from an SFU, an in situ investigation of the open trench will be performed at the excavation location of the soil, as described in **Section 3.6.3.1**.

Each 1,000 m² RSY pad area will be plotted using VSP software (or equivalent) to determine the location of the 18 systematic soil samples. The systematic soil samples will be plotted using a random start triangular or square grid using the VSP software. Soil samples will be collected from the surface at a depth of 0 to 6 inches. The technique for locating systematic samples is provided in **Section 3.4.2**. Soil samples will be containerized and submitted to offsite laboratory with appropriate chain-of-custody documentation as established in the SAP (**Appendix B**).

Soil processed by the RSY process and subsequently staged for offsite disposition or onsite reuse will be staged pending evaluation of offsite analytical results and Navy approval for disposition or reuse. If elevated sample results are identified by offsite analysis, the contractor will notify the Navy and

determine a suitable soil rescreening process, either by RSY pad or by the soil sorter. SFU sampling locations with results that exceed RGs and background will be remediated by additional soil excavation.

Following completion of scan surveys, sampling, and any potential investigation activities, the excavated material will be returned to the same trench that the material originated from.

3.6.4 Phase 2 Trench Unit Investigation

Investigations of the Phase 2 TUs will consist of a combination of gamma scan surveys and soil samples.

Gamma scan surveys of the surface soil will be performed using one or a combination of the gamma detectors listed in **Table 3-6** (or equivalent). The scan surveys will generally be performed using the same protocols and methods as those in the RSY pads. Of the accessible surface of the Phase 2 TUs, 100 percent will be gamma scan-surveyed using a GPS coupled to a large-volume gamma scintillator, equipped with real-time gamma spectroscopy and data logging.

Data sets will be transferred from the data logger onto a personal computer to create spreadsheets and to map the gamma scan survey results. Data obtained during the surface gamma scan surveys, including gross gamma and individual radionuclide spectral measurements, will be analyzed to identify areas where surface radiation levels appear to be greater than the radionuclide-specific ILs using ROI-peak identification tools.

If gamma scan surveys indicate areas of potentially elevated activity in soil above the ILs (**Section 3.3.1**), an investigation of the potential area of elevated activity will be initiated. At a minimum, the contractor will further evaluate the gamma scan data and collect biased soil samples. The biased soil sample will be collected from the approximate location of the highest elevated gamma scan survey measurement. If areas displaying elevated activity are collocated, an attempt will be made to locate the area with the highest gamma scan results and designate it as the biased sample location to represent the collocated elevated areas.

The systematic boring locations will be cored down to approximately 6 inches below the depth of previous excavation within each TU boundary. Soil samples will be collected as described in **Section 3.6.4.1**. Sanitary sewer and storm drain lines were sometimes installed on bedrock. In these situations, sampling of bedrock will not be performed. If refusal is encountered within 6 inches of the expected depth of the trench, the soil sample will be collected from the deepest section of the core. If refusal is encountered more than 6 inches above the expected depth of the trench, the sample location will be moved to avoid the subsurface obstruction.

To acquire three samples from each boring, one surface and one floor sample will be collected from each sample core. The sample cores will be scanned for gamma radiation along the entire length of each core using a Ludlum Model 44-20 3-inch by 3-inch NaI (or equivalent) equipped with gamma spectroscopy. Scan measurement results will be evaluated against the IL to identify core section with elevated gamma radiation. Core sections that exceed the IL will have biased soil samples collected to investigate the potential for small areas of elevated activity in fill. If no core section exceeds the IL, a biased sample will be collected from the core segment with the highest gamma scan reading that was not already sampled, for a total of at least three samples from each core.

Additionally, systematic samples will be collected from sidewall locations every 50 linear feet, representative of each of the trench sidewalls. The boring locations will be located within 1 meter of the previous sidewall excavation limits and will extend to the maximum previous excavation depth. In the same action described in the previous paragraph, core sections will be retrieved, scanned, and sampled such that at least three samples will be collected from each of the six boring locations. An example graphic showing the sample locations representing the TU sidewalls is provided on **Figure 3-4**.

If GPS reception is available, soil sample locations will be position-correlated with GPS data and recorded. If GPS reception is not available, a reference coordinate system will be established to document gamma scan measurement results and soil sample locations. The reference coordinate system will consist of a grid of intersecting lines referenced to a fixed site location or benchmark. If practical, the GPS coordinates of the fixed location or benchmark will be recorded.

Remediation of soil with analytical results above the RGs and background will be performed by excavation of the identified location of the elevated activity or by excavation of the complete TU (for Phase 2 TUs) for further processing using the RSY pad or soil sorting processes. Following excavation, a minimum of five bounding confirmation samples will be collected at the lateral and vertical extents to confirm the removal of contaminated soil. If a Phase 2 TU is excavated in its entirety, it will be investigated following the process described for a Phase 1 TU in **Section 3.6.3**. Material with potentially elevated activity will remain segregated until completion of the investigation activities.

3.6.4.1 Subsurface Soil Sample Collection

Subsurface soil samples will be collected by following the *Soil Sampling* SOP, included in **Appendix D**. Subsurface soil samples will be collected using drilling-rig-mounted equipment to collect samples with thin-walled tube sampling or split-spoon sampling. When needed, other methods may be considered and applied. Specific sampling methods used will be documented in the field, and deviations from the work plan will be described in the final report. Disposable sampling equipment will be used whenever practical and will be disposed of immediately after use. If reusable sampling equipment is used, decontamination between sampling locations will be performed following the *Decontamination of Personnel and Equipment* SOP, included in **Appendix D**. Generally, drilling and retrieving the boring using the thin-walled tube method will be as follows:

- Using a drilling rig, a hole is advanced to the desired depth. The samples are then collected following the ASTM International (ASTM) D 1587 standard.
- The sampler is lowered into the hole so that the sample tube's bottom rests on the bottom of the hole. The sampler is advanced by a continuous, relatively rapid downward motion. The sampler is withdrawn from the soil formation as carefully as possible to minimize disturbance of the sample. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch-internal-diameter sampler may be required.
- Upon removal of the tube from the ground, drill cuttings in the upper end of the tube are removed, and the upper and lower ends of the tube are sealed. The soil tube will be turned over to the project geologist and radiation technician for sample preparation, radiological surveys, and containerization. Once retrieved from the hole, the tube is carefully cut open to maintain the material in the tube.

Generally, drilling and retrieving the boring using the split-spoon sampling method will be performed as follows:

- Using a drilling rig, a hole is advanced to the desired depth. The samples are then collected following the ASTM D 1586 standard.
- The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven down using a weight ("hammer"). To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch-internal-diameter sampler may be required.
- Upon removal of the soil core from the ground, the soil core will be turned over to the project geologist and radiation technician for sample preparation, radiological surveys, and containerization. Once retrieved from the hole, the sampler is carefully split open to maintain the material in the tube.

Once the soil tube has been cut open or the core has been split open, soil examination and sample collection will occur as follows:

- The geologist log will log the soil boring to provide accurate and consistent descriptions of soil characteristics. Soil boring logs will be maintained according to the *Logging of Soil Borings* SOP, included in **Appendix D**.
- The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces and removing gravel. The depth, recovery position, and scan measurement information should be correlated to each sample extracted from the core.
- A minimum of 200 grams of soil (approximately 1 cup) are required to complete all required analyses, or 400 grams if the sample is selected as a field duplicate. If sample size requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the original sample location within the core and compositing the sample.
- The entire mixed sample will be placed in the designated laboratory sample container and the range of soil depths included in the sample recorded in the field logbook.
- Samples will be identified, labeled, and cataloged according to the SAP (**Appendix B**) and **Section 3.6.6**, and then placed into the appropriate sample cooler (if required) for transport to the laboratory. Custody of the sample will be maintained according to the *Chain-of-Custody* SOP, included in **Appendix D**.
- When a field duplicate sample is required (1 for every 10 field samples collected), the sample will be evenly split following mixing of the material and removal of extraneous material, and each aliquot placed into an appropriately labeled sample container.
- If insufficient soil for sampling is obtained from the original borehole, an adjacent location will be considered.

3.6.5 Former Building Site and Crawl Space Soil Survey Unit Investigation

Surface soil SUs will be characterized in a similar fashion as the RSY process described in **Section 3.6.3**, using a combination of surface soil gamma scan surveys and systematic and biased soil sampling.

Gamma scan surveys will be performed using one or a combination of the gamma detectors listed in **Table 3-6**. The scan surveys will be performed using the same protocols and methods as those in the RSY pads. One hundred percent of the accessible surface of the Phase 1 SUs will be gamma scan-surveyed using a large volume gamma scintillator, equipped with real-time gamma spectroscopy and data logging.

If GPS reception is available, gamma scan surveys will be position-correlated with GPS data. If GPS reception is not available, which is likely for SUs located within the Building 351A Crawl Space, a reference coordinate system will be established to document gamma scan measurement locations. The reference coordinate system will consist of a grid of intersecting lines referenced to a fixed site location or benchmark. If practical, the GPS coordinates of the fixed location or benchmark will be recorded.

Data sets will be transferred from the data logger onto a personal computer to create spreadsheets and, if feasible, gamma scan survey results will be mapped. Data obtained during the surface gamma scan surveys, including gross gamma, and individual radionuclide spectral measurements, will be analyzed to identify areas where surface radiation levels appear to be greater than the radionuclide-specific ILs using ROI-peak identification tools.

The data collected during the gamma scan using the RS-700 are evaluated as described in **Section 3.5.1.1**.

If gamma scan surveys indicate areas of potentially elevated activity in soil above the ILs (**Section 3.3.1**), an investigation of the potential area of elevated activity will be initiated. At a minimum, the gamma scan data and collection of biased soil samples will be conducted. The biased soil sample will be collected from the approximate location of the highest elevated gamma scan survey measurement. If areas displaying elevated activity are collocated, an attempt will be made to locate the area with the highest gamma scan results and designate it as the biased sample location to represent the collocated elevated areas. Potentially elevated material will remain segregated until completion of the investigation activities.

Areas known or suspected of containing radioactive materials will be isolated pending removal of the material. Discrete radioactive objects (or highly concentrated and localized soil contamination) will be identified during gamma count rate scan surveys. Measurements exceeding instrument-specific ILs will be delineated to the extent possible based on gamma surveys prior to removal.

If the anomaly is confirmed to be radioactive material, it will be removed. Removal actions will involve evaluating the area around the coordinates of the suspected radioactive material. A minimum of 1 foot in each direction of the surrounding soil will be removed and designated as LLRW.

After the radioactive material and surrounding soil are excavated, the resulting excavation will be resurveyed by gamma scan. If elevated gamma emitters persist, further gamma surveys of the soil will be performed until the source of the elevated gamma activity is found and removed. Four or more post-excavation bounding samples will be collected from the soil at the edge of the bounding excavation and beneath the discrete source (e.g., radium object), if present, to verify that the contamination was removed.

If the source of elevated radioactivity above the RGs and background cannot be readily identified as a point source, the limits of the anomaly will be identified, and the excavated material will be segregated for disposal. Sampling locations with results that exceed RGs and background will be remediated by soil excavation of the SU.

The location of the 18 systematic soil samples will be determined using VSP software, or equivalent, and located using GPS if available, or the established reference coordinate system used during the gamma scan survey. The systematic and biased soil samples collected from each SU will be collected based on the process described in **Section 3.6.5.1** and submitted to the offsite analytical laboratory for analysis according to the SAP (**Appendix B**).

3.6.5.1 Surface Soil Sample Collection

Prior to surface soil sampling, the necessary gamma scan measurements will be collected as described above. Surface soil samples will be collected in accordance with the *Soil Sampling* SOP, included in **Appendix D**. Disposable sampling equipment will be used whenever practical and will be disposed of immediately after use. If reusable sampling equipment is used, decontamination between sampling locations will be performed following the *Decontamination of Personnel and Equipment* SOP, included in **Appendix D**. Generally, the surface soil sample will be collected as follows:

- A clean shovel, hand auger, or other tool will be used to remove a small area (about 3 inches in diameter) of soil to a depth of 6 inches.
- The removed soil will be transferred directly into a clean stainless-steel bowl for mixing.
- The soils removed from the sample location will be visually described in the field logbook in accordance with the *Preparing Field Log Books* SOP, included in **Appendix D**. Color, moisture, texture, and clast composition (i.e., serpentine, shale, sandstone, chert, gabbro) will be identified.

- The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces, removing overburden gravel and biological material. The entire mixed sample, or aliquot thereof, will be placed in the designated laboratory sample container.
- When a field duplicate sample is required (1 for every 10 field samples collected), the duplicate sample will be collected following mixing of the material and splitting the aliquot into an additional sample container.
- Samples will be identified, labeled, and cataloged according to the SAP (**Appendix B**) and **Section 3.6.6**, and then placed into the appropriate sample cooler (if required) for transport to the contract laboratory. Custody of the sample will be maintained according to *Chain-of-Custody* SOP, included in **Appendix D**.
- A minimum of 200 grams of soil (approximately 1 cup) are required to complete all required analyses, or 400 grams if the sample is selected as a field duplicate.

3.6.6 Sample Identification

Each soil sample will be uniquely identified at the time of collection as described herein.

3.6.6.1 Phase 1 Trench Unit Samples

Sample identifications (IDs) from the Phase 1 soil trench unit investigation will be identified using the following format:

AABB-CCC-NNNA-DDD

Where:

- AA = facility (HP for Hunters Point will be used in this work plan)
- BB = site location (PG for Parcel G will be used in this work plan)
- CCC = excavation soil unit or sidewall floor unit
- NNN = former trench unit number
- A = alpha-numeric digit of each “batch” (beginning with A, in sequential order)
- DDD = numeric sample digit (beginning with 001, in sequential order)

For example, the first soil sample collected from the third “batch” of backfill TU material excavated from the former TU 69 will be identified as follows:

HPPG-ESU-069C-001

In this example, “HPPG” identifies Hunters Point Parcel G, “ESU” identifies excavation soil unit, “069” identifies the unit as being excavated from the former Trench Unit 69, “C” represents the third unit or “batch” created from excavating this former TU, and “001” identifies the first sample.

3.6.6.2 Phase 2 Trench Unit Samples

Sample IDs from the Phase 2 soil trench unit investigation will be identified using the following format:

AABB-CCC-NNN-EEFF-GG-DDD

Where:

- AA = facility (HP for Hunters Point will be used in this work plan)
- BB = site location (PG for Parcel G will be used in this work plan)
- CCC = excavation soil unit (ESU) or sidewall floor unit (SFU)
- NNN = former trench unit number
- EEFF = two-digit sample interval in feet bgs (EE feet = top of sample interval and FF feet = bottom of sample interval). EE and FF are whole numbers such that a value of “01” represents “1 foot bgs.” Surface samples (samples collected from the 0.0- to 0.5-foot

depth interval) will be designated as 000H; H is for half foot. If the surface sample is collected from a depth other than a half foot, the H designation will still be used; however, a note will be included in the field book to indicate the actual depth sampled.

GG = soil boring number within the TU

DDD = numeric sample digit (beginning with 001, in sequential order)

For example, the first soil sample collected from the surface of sidewall TU material from the former TU 66 will be identified as follows:

HPPG-SFU-066-000H-01-001

In this example, “HPPG” identifies Hunters Point Parcel G, “SFU” identifies sidewall floor unit, “066” identifies the unit as being excavated from the former Trench Unit 66, “000H” represents the depth interval for a surface sample (000H is the agreed-upon code established for surface samples as explained above), “01” identifies soil boring number 01, and “001” identifies the first sample.

3.6.6.3 Former Building Site and Crawl Space Soil Survey Unit Samples

Sample IDs from the soil SU investigation will be identified using the following format:

AABB-CCCC-SUNN-DDD

Where: AA = facility (HP for Hunters Point will be used in this work plan)

BB = site location (PG for Parcel G will be used in this work plan)

CCCC = building site name

SUNN = survey unit number

DDD = numeric sample digit (beginning with 001, in sequential order)

For example, the second soil sample collected from the Building 351A Crawl Space in Survey Unit D will be identified as follows:

HPPG-351A-SUD-002

In this example, “HPPG” identifies Hunters Point Parcel G, “351A” identifies the Building 351A Crawl Space, “SUD” identifies the unit as being Survey Unit D, and “002” identifies the second sample.

3.6.7 Site Restoration and Demobilization

The open excavations will be backfilled with the excavated soil upon concurrence from RASO. The excavated material will be returned to the same trench that the material originated from. If additional backfill is required, a clean import source will be identified and used. Imported fill will be sampled and analyzed in accordance with the Basewide Radiological Management Plan (TtEC, 2012) and will be approved by the RASO before use. If the trench excavations are water logged, crushed rock or gravel will be placed as bridging material. With Navy concurrence, radiologically cleared recycled fill materials (e.g., crushed asphalt) may be used for backfill. The backfill will be compacted to 90 percent relative density by test method ASTM D1557. Once the excavated areas have been backfilled, the durable cover will be repaired “in kind” to match pre-excavation action conditions.

3.6.7.1 Deconstruction of Radiological Screening Yard Pads

Following completion of radiological screening and with Navy approval, the RSY pads will be deconstructed. Before deconstruction, the RSY pads will be radiologically screened and released in accordance with **Section 6**. The area will be down-posted for the deconstruction activities. The RSY pad material will be consolidated onsite for offsite disposal at an approved disposal facility. If the RSY pad

buffer material cannot be reused onsite, it will be disposed of offsite at an approved disposal facility (**Section 7**). Following deconstruction, the area will be restored to pre-removal action conditions.

3.6.7.2 Decontamination and Release of Equipment and Tools

Decontamination of materials and equipment will be conducted at the completion of fieldwork. Numerous decontamination methods are available for use. If practical, manual decontamination methods should be used. Abrasive methods may be necessary if areas of fixed contamination are identified. Chemical decontamination can also be accomplished by using detergents for nonporous surfaces with contamination present. Chemicals should be selected for decontamination that will minimize the creation of mixed waste. Decontamination activities will be conducted using SOP RP-132, *Radiological Protective Clothing Selection, Monitoring, and Decontamination* (**Appendix D**).

3.6.8 Demobilization

Demobilization will consist of surveying, decontaminating, and removing equipment and materials, cleaning the project site, inspecting the site, and removing temporary facilities. Survey of equipment and materials will be performed in accordance with **Section 6.6**, and decontamination will be performed in accordance with **Section 3.6.7.2**. Demobilization activities will also involve collection and disposal of contaminated materials, including decontamination water and disposable equipment for which decontamination is inappropriate (**Section 7**).

3.7 Radiological Laboratory Analysis

Samples will be containerized and submitted to offsite laboratory with appropriate chain-of-custody documentation as established in the SAP (**Appendix B**). All laboratory analyses will be performed by a Department of Defense Environmental Laboratory Accreditation Program or National Voluntary Laboratory Accreditation Program-accredited laboratory certified by the State of California to perform analyses. All soil samples will be retained for possible California Department of Public Health confirmatory analysis until the final RACR for Parcel G is issued.

Analysis will be based on the site-specific ROCs listed in **Table 3-4**, and in accordance with the SAP (**Appendix B**) and as follows:

- Soil samples will be assayed using gamma spectroscopy analysis for ^{137}Cs and ^{226}Ra . Gamma spectroscopy data will be reported for all gamma-emitting ROCs by the laboratory after a full 21-day ingrowth period.
 - If the gamma spectroscopy laboratory results indicate a concentration of ^{226}Ra above the RG in a sample, the sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , and ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra to evaluate equilibrium conditions. Additional details regarding the equilibrium evaluation are provided in **Section 5.6**. All detected isotopes will be reported.
 - If laboratory results indicate a concentration of ^{137}Cs above the RG in a sample, the sample will be analyzed by gas flow proportional counting for ^{90}Sr and by alpha spectroscopy for ^{239}Pu .
- At least 10 percent of randomly selected samples will be analyzed by gas flow proportional counting for ^{90}Sr .
 - If laboratory results indicate a concentration of ^{90}Sr above the RG in a sample, the sample will be analyzed via alpha spectroscopy for ^{239}Pu .
- At the Former Buildings 317/364/365 Site and adjacent TUs 95, 117, 118, and 153 (**Figure 3-1**), where ^{239}Pu and ^{235}U are ROCs, at least 10 percent of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for ^{239}Pu and ^{235}U .

- At the Building 351A Crawl Space and adjacent TUs 115 and 97 (**Figure 3-1**), where ^{239}Pu and ^{232}Th are ROCs, at least 10 percent of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for ^{239}Pu and ^{232}Th .
- At TU 107 (**Figure 3-1**), adjacent to Building 408 where ^{232}Th was an ROC, at least 10 percent of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for ^{232}Th .

If the results following the full ingrowth are below the RGs shown in **Table 3-5**, additional analyses are not required.

All laboratory data packages will have independent data verification and data validation performed to demonstrate that the data meet the project objectives. Following independent data verification and validation, the sample data will be evaluated as described in **Section 5**.

Table 3-1
Phase 1 Soil Trench Units
Parcel G Removal Site Evaluation Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Former Trench Unit Name	Excavation of Original Trench Unit		Sidewalls + Bottom		Total		
	Estimated Volume of Original Excavation ^a [yd ³]	Number of Excavation Soil Units ^b	Estimated Volume of 6-Inch Over-Excavation of Sidewalls + Bottom [yd ³]	Number of Sidewall Floor Units ^b	Volume [yd ³]	Number of Units	Number of Systematic Samples ^c
TU-69	895	5	409	3	1,304	8	144
TU-70	1,282	7	431	3	1,713	10	180
TU-76	1,732	9	338	2	2,070	11	198
TU-77	2,109	11	448	3	2,557	14	252
TU-78	875	5	368	2	1,243	7	126
TU-79	1,308	7	349	2	1,657	9	162
TU-95	809	5	287	2	1,096	7	126
TU-97	556	3	253	2	809	5	90
TU-98	596	3	215	2	811	5	90
TU-99	720	4	210	2	930	6	108
TU-100	21	1	27	1	48	2	36
TU-101	94	1	87	1	181	2	36
TU-103	314	2	168	1	482	3	54
TU-104	745	4	366	2	1,111	6	108
TU-107	287	2	99	1	386	3	54
TU-108	438	3	164	1	602	4	72
TU-109	1,517	8	334	2	1,851	10	180
TU-115	250	2	111	1	361	3	54
TU-121	442	3	367	2	809	5	90
TU-124	493	3	245	2	738	5	90
TU-153	493	3	234	2	727	5	90
					Total Excavation Volume [yd³]		21,485
					Total Number of Units		130
					Total Number of Systematic Samples		2,340

Notes:

^a The estimated volume of the original excavation was determined by assuming the greater of the volumes calculated using Estimate Import Fill and Backfill information provided in the survey unit SUPRs or Table 3-1 and Table 3-2 from the Parcel G RACR.

^b The number of Excavation Soil Units and Sidewall Floor Units are calculated from dividing the estimated volume of the excavation by 198 yd³, which is based on a volume of 1,000 m² x 6-inches = 198 yd³ (~300 tons of soil).

^c Assumes 18 systematic samples in each survey unit.

Table 3-2
Phase 2 Soil Trench Units
Parcel G Removal Site Evaluation Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Trench Unit	Surface Area [m ²] ^a	Number of Systematic Borings in Original TU Material	Number of Samples in Original TU Material	Number of Borings from Sidewalls and Bottom ^b	Number of Samples from Sidewalls and Bottom
TU-66	651	18	54	16	48
TU-67	467	18	54	12	36
TU-68	825	18	54	18	54
TU-71	872	18	54	36	108
TU-72	935	18	54	23	69
TU-73	928	18	54	22	66
TU-74	384	18	54	8	24
TU-75	410	18	54	14	42
TU-80	502	18	54	11	33
TU-81	812	18	54	22	66
TU-82	913	18	54	21	63
TU-83	367	18	54	11	33
TU-84	651	18	54	10	30
TU-85	907	18	54	17	51
TU-86	670	18	54	16	48
TU-87	669	18	54	15	45
TU-88	690	18	54	17	51
TU-89	926	18	54	19	57
TU-90	328	18	54	7	21
TU-91	718	18	54	13	39
TU-92	275	18	54	5	15
TU-93	722	18	54	10	30
TU-94	716	18	54	16	48
TU-96	825	18	54	17	51
TU-102	67	18	54	4	12
TU-105	650	18	54	11	33
TU-106	687	18	54	15	45
TU-110	871	18	54	15	45
TU-111	664	18	54	13	39
TU-112	668	18	54	15	45
TU-113	874	18	54	15	45
TU-114	173	18	54	3	9
TU-116	342	18	54	10	30
TU-117	335	18	54	5	15
TU-118	712	18	54	16	48
TU-119	579	18	54	15	45
TU-120	762	18	54	18	54
TU-122	636	18	54	24	72
TU-123	777	18	54	24	72
TU-129	326	18	54	10	30
TU-151	185	18	54	5	15
TU-204	974	18	54	19	57
<i>sample subtotals</i>			2268		1839

Total Number of Systematic Samples (Original TU Material + Sidewalls and Bottom) 4107

Notes

^aFrom Parcel G RACR, Table 3-1

^bAssumes a boring every 50 linear feet of trench on each sidewall

Table 3-3
Former Building Site and Crawl Space Soil Survey Units
Parcel G Removal Site Evaluation Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Building Site	Former Survey Unit Name	Area [m²]	Number of Systematic Samples
Building 351A Crawlspace	SU-A	100	18
Building 351A Crawlspace	SU-B	100	18
Building 351A Crawlspace	SU-C	100	18
Building 351A Crawlspace	SU-D	100	18
Building 351A Crawlspace	SU-E	100	18
Building 351A Crawlspace	SU-F	100	18
Building 351A Crawlspace	SU-G	100	18
Building 351A Crawlspace	SU-H	100	18
Building 351A Crawlspace	SU-I	100	18
Building 351A Crawlspace	SU-J	100	18
Building 351A Crawlspace	SU-K	100	18
Building 351A Crawlspace	SU-L	100	18
Building 351A Crawlspace	SU-M	100	18
Building 351A Crawlspace	SU-N	100	18
Building 351A Crawlspace	SU-O	100	18
Building 351A Crawlspace	SU-P	100	18
Building 351A Crawlspace	SU-T	53	18
Building 317/364/365 Site	SU-20	354	18
Building 317/364/365 Site	SU-21	408	18
Building 317/364/365 Site	SU-23	155	18
Building 317/364/365 Site	SU-24	343	18
Building 317/364/365 Site	SU-25	504	18
Building 317/364/365 Site	SU-26	436	18
Building 317/364/365 Site	SU-27	28	18
Building 317/364/365 Site	SU-28	104	18
Building 317/364/365 Site	SU-29	848	18
Building 317/364/365 Site	SU-30	539	18
Building 317/364/365 Site	SU-31	367	18
Total Number of Systematic Samples			504

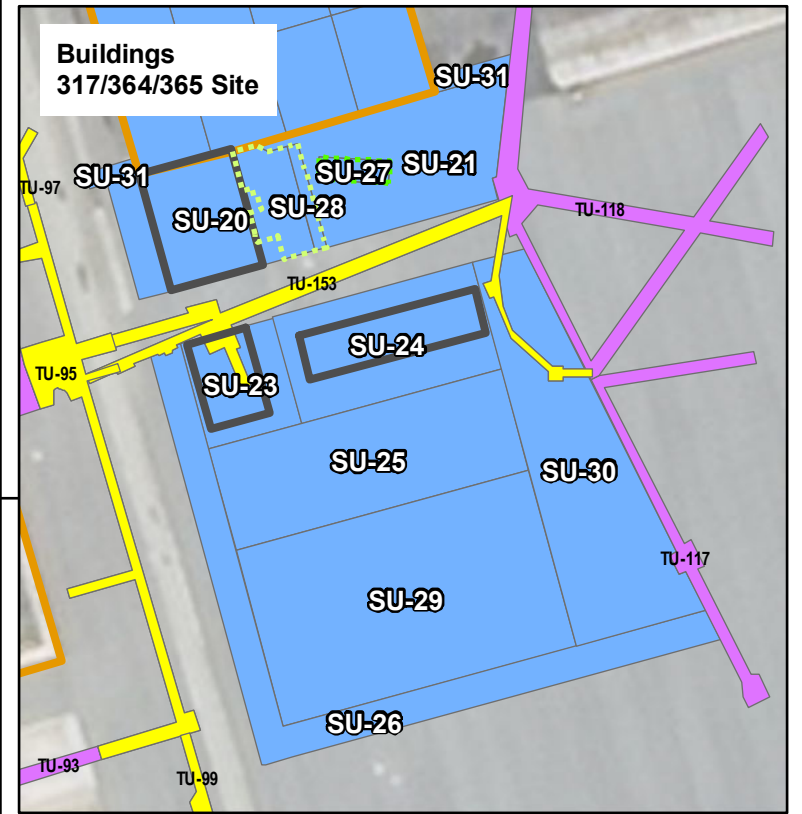
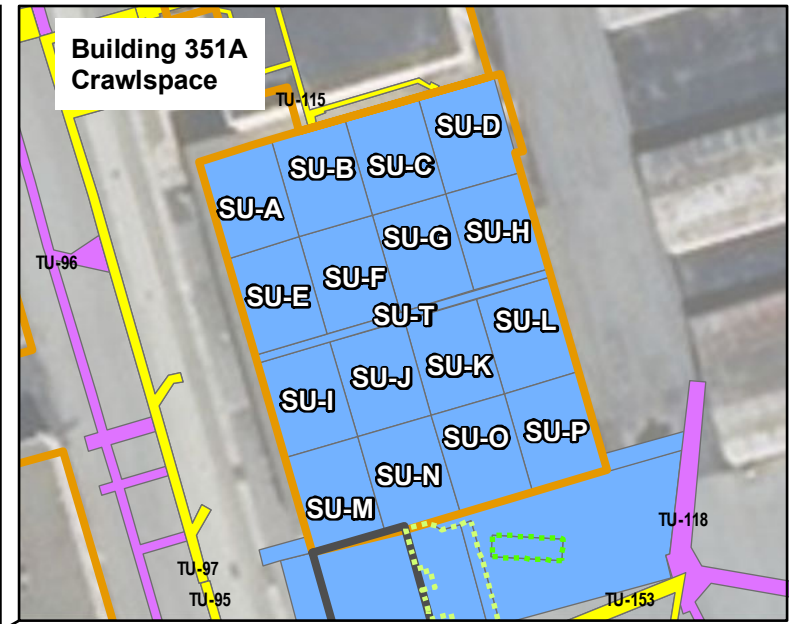
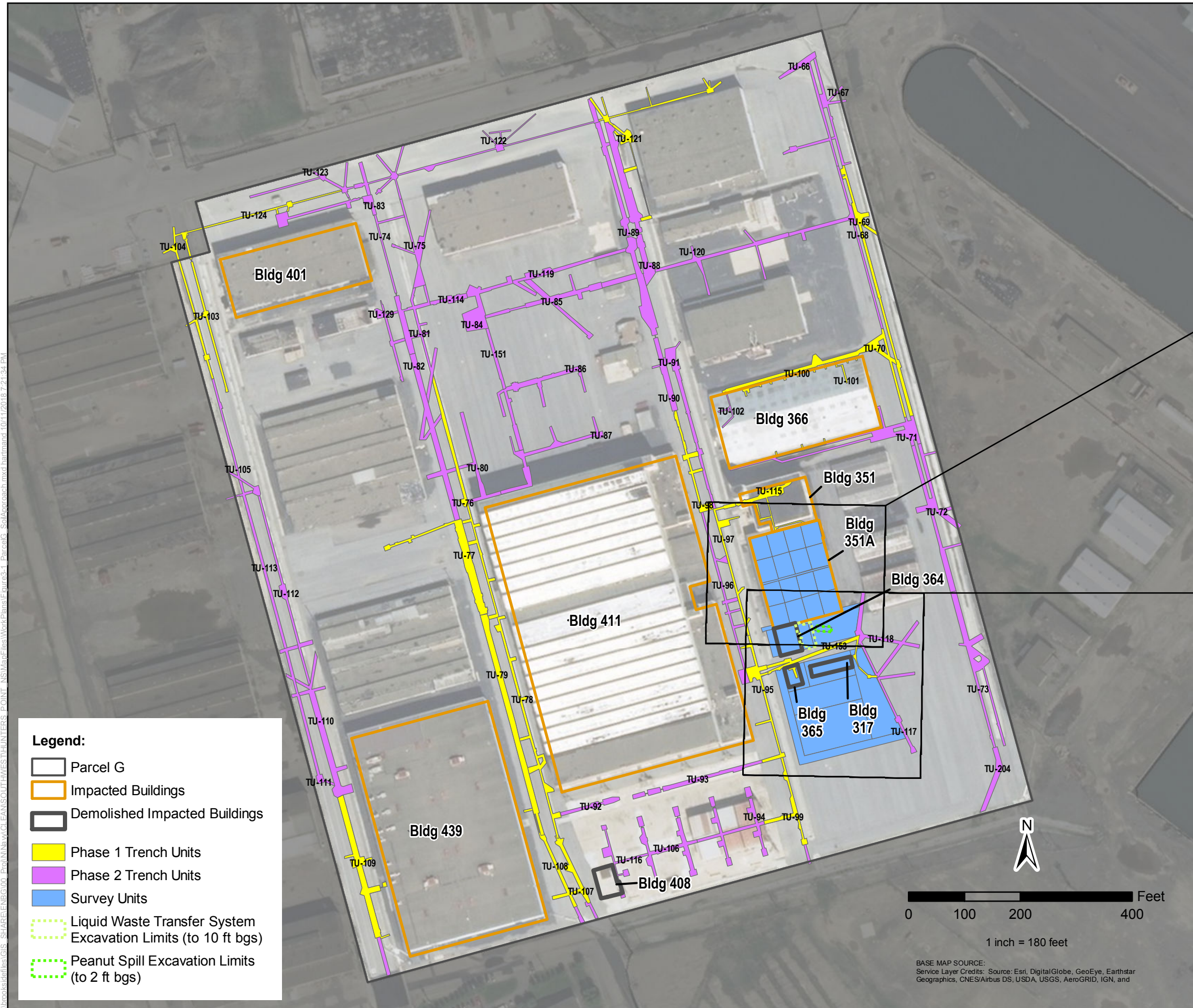
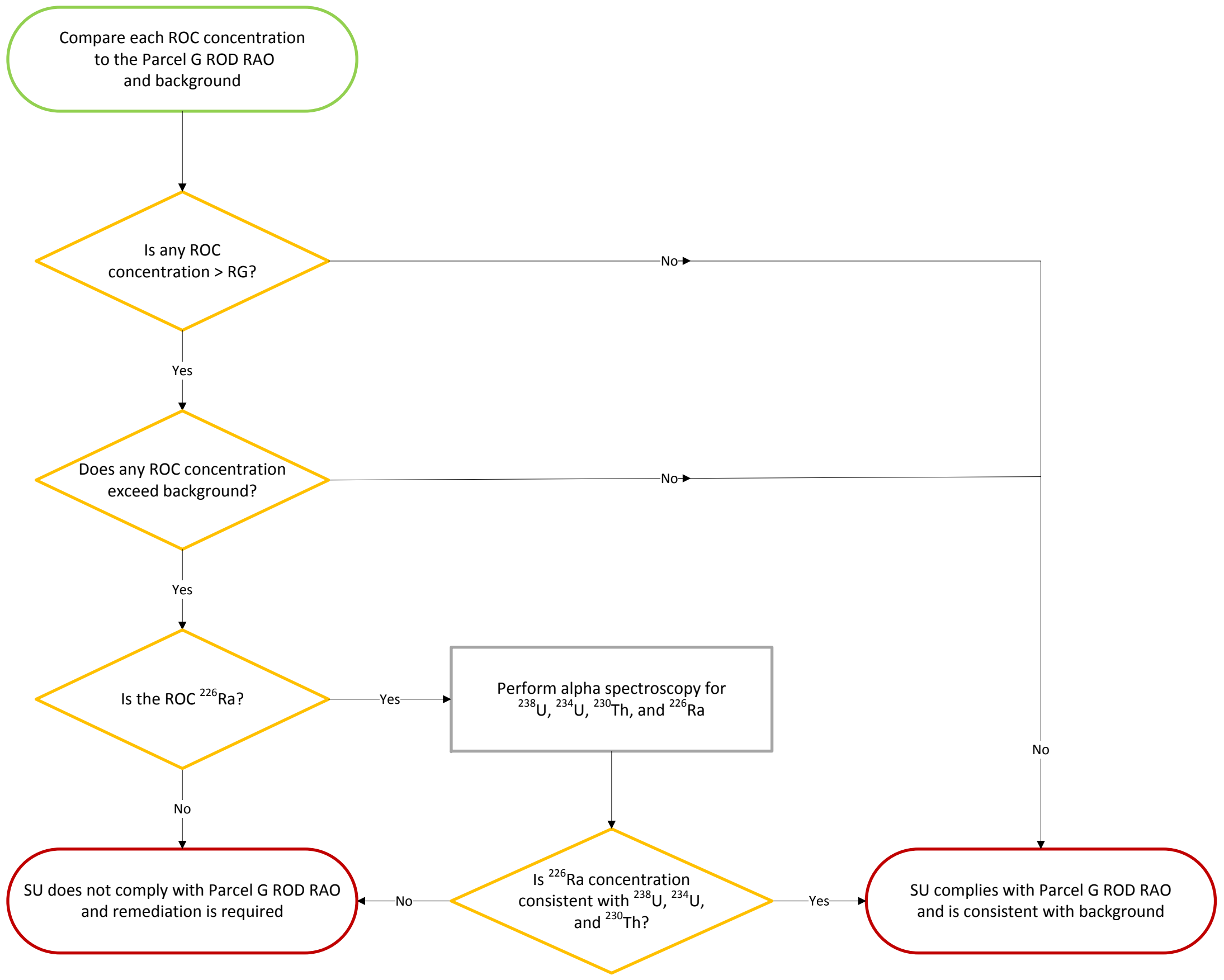
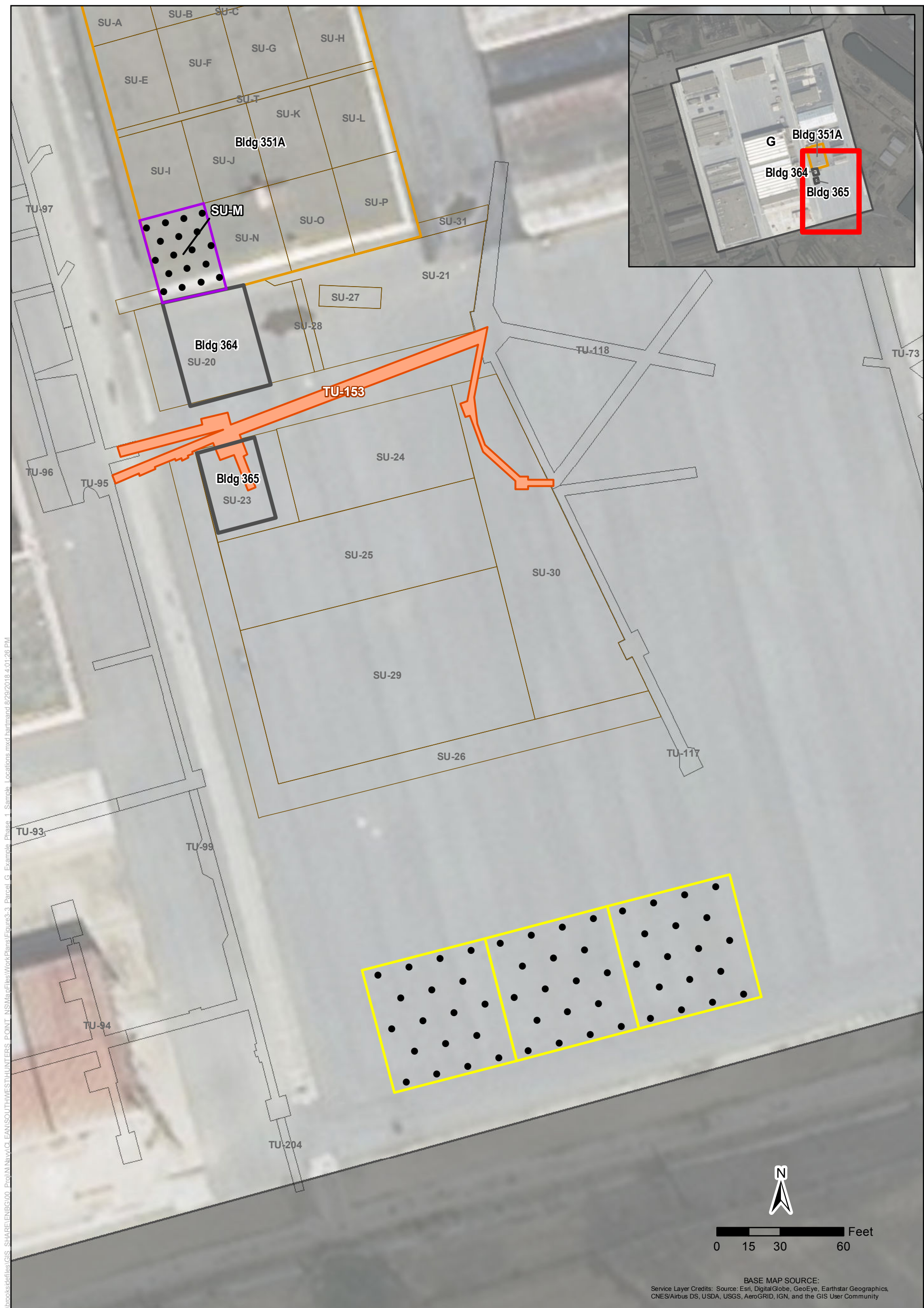


Figure 3-1
Soil Investigation Approach
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



- Acronyms:**
- Ra** = radium
 - RAO** = remedial action objective
 - RG** = remediation goal
 - ROC** = radionuclide of concern
 - ROD** = record of decision
 - SU** = survey unit
 - Th** = thorium
 - U** = uranium

Figure 3-2
Performance Criteria for Demonstrating Compliance with the Parcel G ROD – Soil
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



I:\projects\GIS\SHARE\ENR\G000\Prof\Map\G000\ENR\SOUTHWEST\HUNTERS POINT\NSI\MapFiles\Work\Plans\Figure3-3 Parcel G Example Phase 1 Sample Locations.mxd lastmod 9/29/2018 4:01:26 PM

Legend:

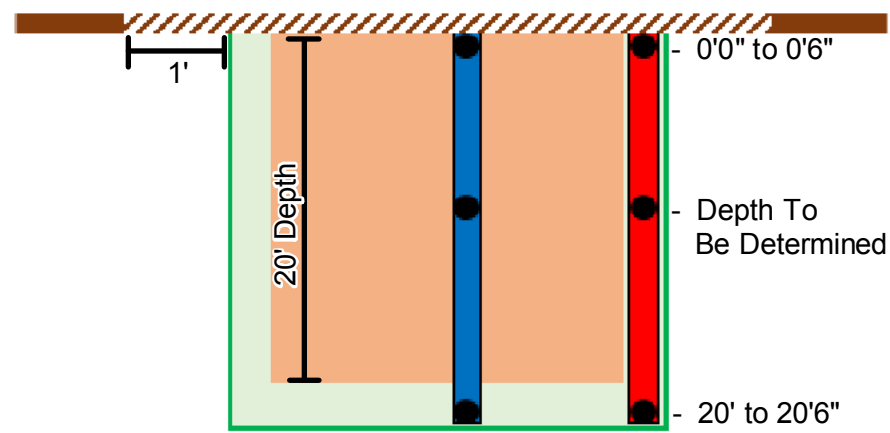
- Systematic Sample Location
- Demolished Impacted Buildings
- SU-M
- Impacted Buildings
- TU-153
- Survey Units
- RSY Pad
- Trench Units

BASE MAP SOURCE:
 Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics,
 CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

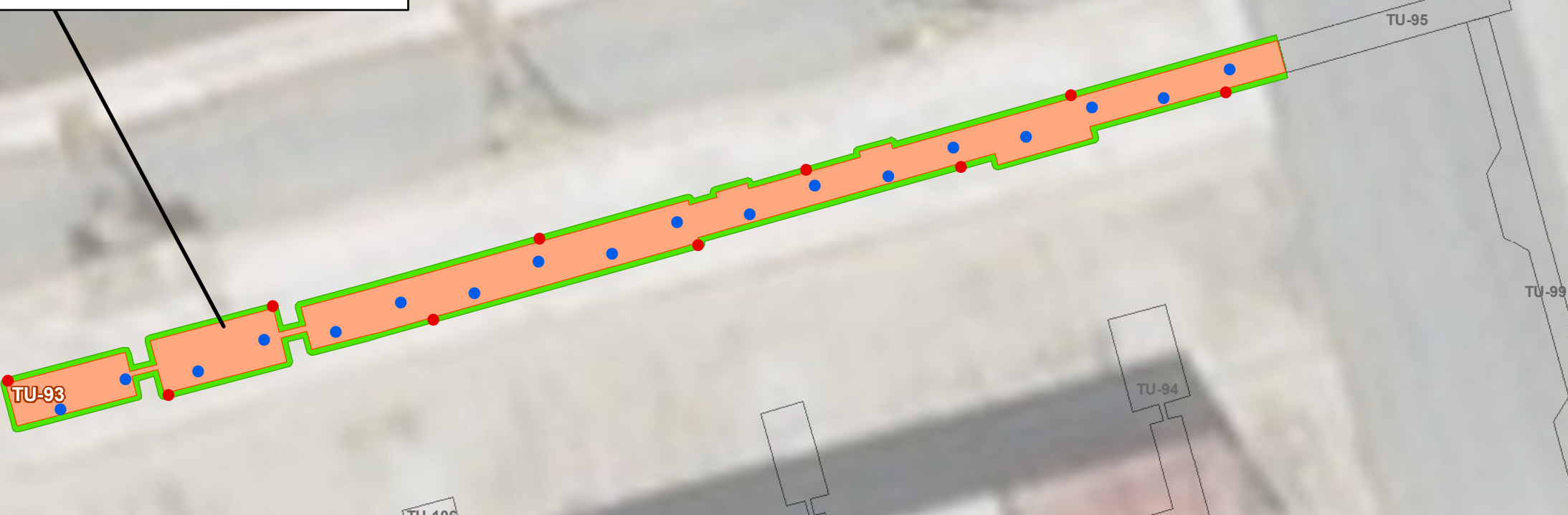
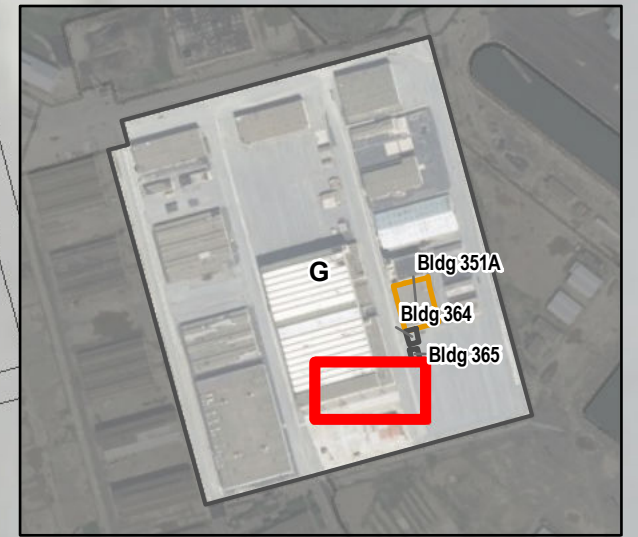
Figure 3-3
Example Soil Sample Locations
for Phase 1 Trench Unit and a
Survey Unit
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

\\brockserver\GIS_SHARE\ENR\00_Proj\MapFiles\WorkPlans\Figure3-4_Parcel G_Example Phase 2_Sample Locations.mxd hartmand 9/29/2018 6:20:04 PM

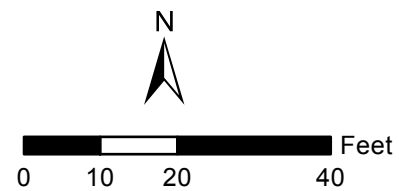
Example Trench Unit Cross-Section



- Core Samples
- ▨ Asphalt to be removed
- Asphalt to remain
- Core Locations Inside TU Buffer
- Core Locations Inside TU
- Trench Unit
- Trench Unit Buffer (6 Inches)



- Legend:**
- Core Locations Inside TU
 - Core Locations Inside TU Buffer
 - TU-93
 - TU-93 Buffer (6 Inches)
 - Trench Units



BASE MAP SOURCE:
 Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-4
Example Phase 2 Trench Unit
Soil Sample Locations
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

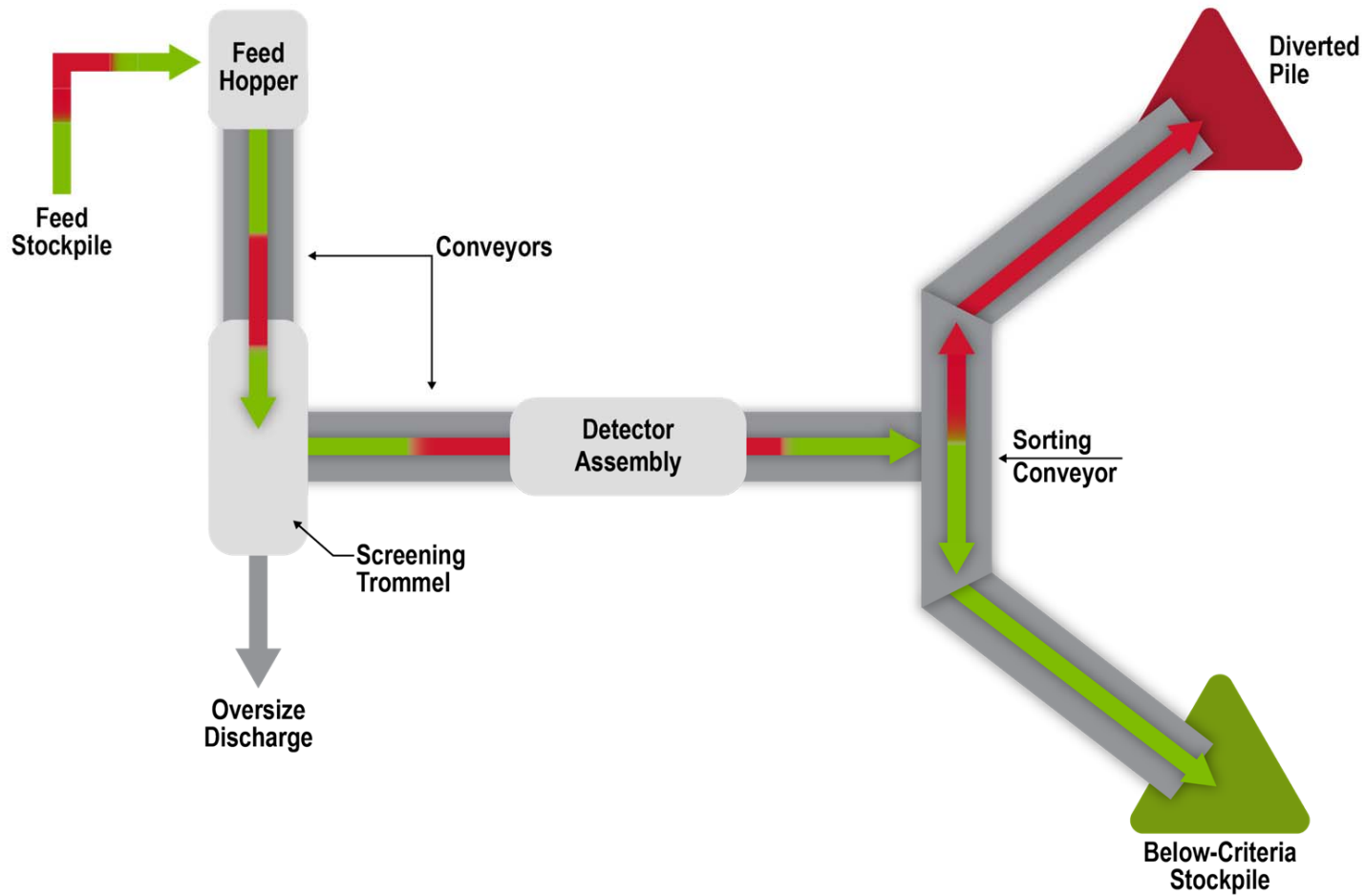


Figure 3-5
Typical Soil Segregation System
Layout
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

Building Investigation Design and Implementation

This section describes the DQOs, ROCs, RGs, ILs, and radiological investigation design and implementation for Parcel G buildings.

4.1 Data Quality Objectives

The DQOs for the building investigation are as follows:

- **Step 1-State the Problem:** Data manipulation and falsification were committed by a contractor during past building surveys. The Technical Team evaluated building data and found evidence of potential manipulation and falsification. The findings call into question the reliability of the data and there is uncertainty whether radiological contamination was present or remains in place. Therefore, the property is unable to be transferred as planned. Based on the uncertainty and the description of radiological activities in the HRA, there is a potential for residual radioactivity to be present on building interior surfaces.
- **Step 2-Identify the Objective:** The primary objective is to determine whether site conditions are compliant with the Parcel G ROD RAO (Navy, 2009).
- **Step 3-Identify Inputs to the Objective:** The inputs include alpha-beta static, alpha and beta scan, and alpha-beta swipe data on building and reference area surfaces.
- **Step 4-Define the Study Boundaries:** The study boundaries are accessible interior surfaces of Buildings 351, 351A, 366, 401, 411, and 439, and the concrete pad at former Building 408 (**Figure 4-1**). The building floor (i.e., Class 1 SUs) are depicted on **Figures 4-2** through **4-8**.
- **Step 5-Develop Decision Rules:**
 - If the investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically-based RGs⁹ at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a RACR will be developed.
 - If the investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically-based RGs⁹ at agreed upon statistical confidence levels and are not shown to be NORM or anthropogenic background, then remediation will be conducted, followed by a RACR.
 - The RACR will describe the results of the investigation, explain remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel G ROD RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.

⁹ The RGs are statistically based because they are increments above a statistical background.

- **Step 6-Specify the Performance Criteria:** The data evaluation process for demonstrating compliance with the Parcel G ROD is presented as follows, depicted on **Figure 4-9**, and described in detail in **Section 5**:
 - Compare each net alpha and net beta result to the corresponding RG presented in **Section 4.3**. If all results are less than or equal to the RGs, then compliance with the ROD RAO is achieved.
 - Compare survey data to appropriate RBA data from HPNS as described in **Section 5**. Multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include, but is not limited to, population-to-population comparisons, use of an MLE or BTV, and graphical comparisons. If survey data are consistent with NORM or anthropogenic background, site conditions comply with the Parcel G ROD RAO.
 - If any result is greater than the RG and cannot be attributed to NORM or anthropogenic background, remediation will be conducted.
- **Step 7-Develop the Plan for Obtaining Data:** Radiological investigations will be conducted on floors, wall surfaces, and ceiling surfaces, and will consist of alpha and beta scan surveys, alpha-beta static measurements, and alpha-beta swipe samples as described herein.

4.2 Radionuclides of Concern

The ROCs for Parcel G buildings, as identified in the HRA and in subsequent investigations, include ^{137}Cs , ^{60}Co , ^{239}Pu , ^{226}Ra , ^{90}Sr , and ^{232}Th and are presented in **Table 4-1**.

Table 4-1. Building Radionuclides of Concern

Building	ROCs	Reference
Building 351	^{137}Cs , ^{226}Ra , ^{90}Sr , ^{232}Th	NAVSEA, 2004
Building 351A	^{137}Cs , ^{239}Pu , ^{226}Ra , ^{90}Sr , ^{232}Th	NAVSEA, 2004
Building 366	^{137}Cs , ^{226}Ra , ^{90}Sr	NAVSEA, 2004
Building 401	^{137}Cs , ^{226}Ra , ^{90}Sr	TtEC, 2009c
Building 408	^{137}Cs , ^{226}Ra , ^{90}Sr , ^{232}Th	NAVSEA, 2004
Building 411	^{137}Cs , ^{60}Co , ^{226}Ra	NAVSEA, 2004
Building 439	^{137}Cs , ^{226}Ra	TtEC, 2009a

4.3 Remediation Goals

The building data from the radiological investigations will be evaluated to determine whether site conditions are compliant with the RAO in the Parcel G ROD (Navy, 2009). The RAO is to prevent exposure to ROCs in concentrations that exceed RGs for all potentially complete exposure pathways. These RGs for structures, equipment, and waste are presented in **Table 4-2** for each of the ROCs identified for the applicable buildings. Also identified for each ROC is the primary particle type emitted during the ROC's decay or during the ROC's radioactive progeny's decay.

Table 4-2. Building Remediation Goals from Parcel G ROD

ROC	Particle Emissions	RGs for Structures (dpm/100 cm ²)	RGs for Equipment, Waste (dpm/100 cm ²)
¹³⁷ Cs	β	5,000	5,000
⁶⁰ Co	β	5,000	5,000
²³⁹ Pu	α	100	100
²²⁶ Ra	α, β	100	100
⁹⁰ Sr	β	1,000	1,000
²³² Th	α, β	36.5	1,000

dpm/100 cm² = disintegration(s) per minute per 100 square centimeters

Data collected from building surfaces during this investigation represent the total (fixed and removable) gross activity on the surface, which may result from radiations from multiple radionuclides. Because these survey data are radiation-specific (α and β) but not radionuclide-specific, they cannot be attributed to a particular ROC. Instead, the survey data will be compared to the most restrictive building-specific RG_α and RG_β as presented in **Table 4-3**. For each building, the RG_α is chosen as the structure's lowest RG for an alpha-emitting ROC, and the RG_β is chosen as the structure's lowest RG for a beta-emitting ROC.

Table 4-3. Building-specific Remediation Goals for Parcel G Work Plan

Building	RG _α (dpm/100 cm ²) and ROC	RG _β (dpm/100 cm ²) and ROC
Building 351	36.5 (²³² Th)	1,000 (⁹⁰ Sr)
Building 351A	36.5 (²³² Th)	1,000 (⁹⁰ Sr)
Building 366	100 (²²⁶ Ra)	1,000 (⁹⁰ Sr)
Building 401	100 (²²⁶ Ra)	1,000 (⁹⁰ Sr)
Building 408 slab	36.5 (²³² Th)	1,000 (⁹⁰ Sr)
Building 411	100 (²²⁶ Ra)	5,000 (¹³⁷ Cs)
Building 439	100 (²²⁶ Ra)	5,000 (¹³⁷ Cs)

4.4 Radiological Investigation Design

This section describes the design of radiological investigations, including scan and static measurements on building surfaces. The radiological investigation design is based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012), with the ultimate requirement to demonstrate compliance with the Parcel G ROD RAO.

The principal features of the investigation protocol to be applied to the Parcel G building SUs are discussed herein and include the following:

- Determine the SUs.
- Select survey instruments.
- Determine instrument ILs and MDCs.

To the extent possible, manual data entries will be eliminated through use of electronic data collection and transfer processes.

4.4.1 Building Survey Overview

The radiological surveys of the impacted Parcel G buildings have two primary components (scanning measurements and static measurements), which are discussed in subsections 4.4.1.1 and 4.4.1.2. In addition, swipe samples will be collected to assess potential gross alpha and beta removable contamination. If needed, swipe samples will be analyzed offsite to speciate the radionuclides present. Building material samples may be collected and analyzed offsite to characterize areas of interest identified by the surveys.

4.4.1.1 Scanning Measurements

Scanning measurements are performed on building surfaces to locate radiation anomalies indicating residual radioactivity that may require further investigation or remediation. As noted in **Section 4.3**, the scanning design is dictated by the most restrictive RG_{α} and RG_{β} values for the building. Where appropriate, scanning measurements will be performed using the assumptions of equilibrium described in **Section 4.5.5**.

4.4.1.2 Static Measurements

Static measurements will be the primary means of demonstrating compliance with the Parcel G ROD RAO. Gross alpha and beta static measurements will be performed so that the measurement MDC is below the most restrictive RG_{α} and RG_{β} values for the building.

Static measurements will be performed in each SU and in the RBAs. They will consist of measurements in scaler mode for simultaneous alpha-beta counting using a Ludlum Model 43-68 gas proportional detector, Ludlum Model 43-93 plastic scintillation detector, or other appropriate instrument. While 1-minute count times were used in the following example calculations, static count times will be updated during investigations to meet DQOs using instrument-specific information. Static measurements will be performed on a systematic sampling grid or biased to locations identified by the alpha-beta scanning surveys.

The number of systematic static measurements performed will be based on the guidance described in MARSSIM Section 5.5.2.2 (USEPA et al., 2000) using the unity rule as the example basis for calculating the minimum static measurement frequency. Even if the MARSSIM-recommended or other statistical tests are not used to evaluate site data, these calculations serve as a basis for determining the number of static measurements per SU to be performed. The number of biased static measurements will be determined based on results of scan surveys.

MARSSIM Section 5.5.2.2 defines the method for calculating the number of static measurements when residual radioactivity is uniformly present throughout an SU. Therefore, determining the number of static measurements will be based on the following factors:

- RG for radioactivity on structural surfaces (UBGR)
- LBGR
- Estimate of variability (standard deviation $[\sigma]$) in the reference area and the SUs
- Shift ($\Delta = \text{UBGR} - \text{LBGR}$)
- Relative shift ($[(\text{UBGR} - \text{LBGR})/\sigma]$; see **Equation 4-1**)
- Decision error rates for making a Type I or Type II decision error that the mean or median concentration exceeds the RG (determined via MARSSIM Table 5.2)

Each of the preceding factors is addressed in the following paragraphs. Example data are provided to assist in explaining the process for calculating the minimum static measurement frequency. Actual numbers of static measurements for SUs will be based on reference area data once they become available. When using the unity rule, the RG is defined as 1 (unitless) plus background. As a basis for the calculations, the background surface activity concentration is assumed to be 0.5.

MARSSIM defines a gray region as the range of values in which the consequences of decision error on whether the residual surface activity is less than or exceeds the RG are relatively minor. The RG of 1 above background (0.5) was selected to represent the UBGR (1.5). The LBGR is the median concentration in the SU, and the retrospective power will be determined after the survey is completed. Given the absence of usable data prior to performing the investigation activities, MARSSIM Section 2.5.4 suggests arbitrarily selecting the LBGR as half the RG. Therefore, for this example, the LBGR = 0.5 + 0.5 = 1. Assuming the UBGR equals the RG, then $\Delta = 1.5 - 1.0 = 0.5$ for this example.

MARSSIM defines σ as an estimate of the standard deviation of the measured values in the SU. Because SU data will not be available until the investigation activities are completed, MARSSIM recommends using the standard deviation of the RBA as an estimate of σ . Given the absence of data prior to performing the investigation activities, an arbitrary value of 0.25 has been selected as an estimate of σ for this example.

The relative shift is calculated based on MARSSIM guidance (Section 5.5.2.2) as shown in **Equation 4-1**.

Equation 4-1

$$\frac{\Delta}{\sigma} = \frac{(UBGR - LBGR)}{\sigma} = \frac{(RG - LBGR)}{\sigma} = \frac{(1.5 - 1.0)}{0.25} = 2.0$$

The minimum number of samples assumes the ROC concentration in the SU exceeds the RG. Type I decision error is deciding that the ROC concentration in the SU is less than the RG when it actually exceeds the RG. To minimize the potential for releasing buildings with concentrations above the RG, the Type I decision error rate is set at 0.01. Type II decision error is deciding that the ROC concentration exceeds the RG when it is actually less than the RG. To protect against remediating building surfaces with concentrations below the RG, the Type II decision error rate is set at 0.05 as recommended by MARSSIM.

MARSSIM Table 5.3 lists the minimum number of static measurements to be performed in each SU and RBA based on the relative shift and decision error rates. For a relative shift of 2, a Type I decision error rate at 0.01, and Type II decision error rate of 0.05, MARSSIM Table 5.3 recommends a minimum of 18 static measurements in each SU and RBA.

The USEPA has requested that initially¹⁰, a minimum of 25 static measurements be collected. Therefore, 25 static measurements will be collected as a placeholder until background data are available. The minimum number of static measurements per SU will be developed based on the variability observed in the RBA data. The DQA of SU data will include a retrospective power curve (based on the MARSSIM Appendix I guidance) to demonstrate that enough static measurements were performed to meet the project objectives. If necessary, additional static measurements may be performed to comply with the project objectives.

¹⁰ The initial sampling will include 25 systematic samples at one SU (statics and swipes) for each building material type, e.g., concrete, wood, drywall, etc. Based on USEPA, DTSC, and CDPH review of building history, previously collected data, and other information about the building SUs, either Building 351 SU 7, Building 351 SU 46, Building 351A SU 7, Building 351A SU 26, or Building 366 SU 62 were identified.

4.4.2 Radiological Background

Building 404 will serve as the primary RBA in the investigation of Parcel G buildings (**Figure 4-1**). Building 404 is a non-impacted, unoccupied former supply storehouse constructed in 1943 (see Reference 1598 in NAVSEA, 2004). From the same construction era and with materials similar to those of the impacted Parcel G buildings, Building 404 has 43,695 square feet of concrete floors, a wooden superstructure, prepared roll or composition roof, and drywall offices.

At least 18 static measurements will be taken on each surface material in the RBA that is representative of the material in the building SUs. Alternate RBAs may be identified and used if needed based on site-specific conditions identified during the building investigations.

4.4.3 Survey Units

Parcel G buildings will be divided into identifiable SUs similar in area and nomenclature to the previous investigation of each building. **Table 4-4** lists the SUs, classification, and areas by building. Generally, impacted floor surfaces and the lower 2 meters of remaining impacted wall surfaces will form Class 1 SUs of no more than 100 m² each. The remaining impacted upper wall surfaces and ceilings will generally form Class 2 SUs of no more than 2,000 m² each. Class 3 SUs consist of floor areas in Building 411 and the exterior of Building 366, which were investigated as part of past scoping surveys.

Several buildings on HPNS were remediated for lead and asbestos. This resulted in most of the interior wall and ceiling surfaces being removed, leaving only the wall structural components (i.e., wooden or metal framing). Areas with known releases have been remediated and recovered during past investigations such that there are no areas of suspected surface or volumetric contamination remaining in Parcel G buildings. This investigation measures only the remaining, accessible and impacted surfaces through a combination of scanning, static, and swipe measurements. The SU designations and floor boundaries will remain the same as those used in the historical TtEC investigations; however, the overall survey area will be reduced by the amount of area remediated for lead-based paint and asbestos.

The floor plans and floor SUs are shown for each building on **Figures 4-2** through **4-8**. Two example figures are provided that depict SU-specific details for a Class 1 SU (**Figure 4-10**) and a Class 2 SU (**Figure 4-11**). **Figure 4-10** is a two-dimensional representation of Building 366 (SU 1) and shows the Class 1 floors, remaining lower wall surfaces, and intended static measurement and swipe sample locations. **Figure 4-11** is a two-dimensional representation of Building 366 (SU 60) and shows the Class 2 upper walls, ceiling, and intended static measurement and swipe sample locations.

Additional building-specific information regarding the Parcel G buildings is provided in the following paragraphs and in **Table 4-4**.

4.4.3.1 Building 351A

There are 40 Class 1 SUs (SUs 1 to 3, 5 to 14, 16, 18 to 27, and 29 to 44) consisting of concrete flooring and concrete (perimeter and SU 6 interior) lower walls (**Figure 4-2**). There are three Class 2 SUs (SUs 45 to 47), which divide all the concrete perimeter upper walls and the concrete ceiling in SU 6. There are no other remaining ceilings. SUs 4, 15, 17, and 28 were originally surveyed by TtEC but incorporated into other SUs during past investigations and are no longer present.

The limiting alpha-emitting ROC for the Building 351A scans is ²³⁹Pu, and for Building 351A static measurements is ²³²Th. The limiting beta-emitting ROC is ⁹⁰Sr.

4.4.3.2 Building 351

There are 11 Class 1 SUs on the first floor (SUs 1 to 11) consisting of concrete flooring, concrete support columns, concrete perimeter lower walls, and asphalt cover over remediation trenches (**Figure 4-3**). There are 20 Class 1 SUs on the second floor (SUs 17 to 36) consisting of concrete flooring, concrete

support columns, and concrete perimeter lower walls. There are no remaining interior lower wall surfaces on the first or second floors. There are 10 Class 1 SUs on the third floor (SUs 42 to 51) consisting of concrete flooring, concrete support columns, concrete perimeter lower walls, and metal interior lower walls around SU 45. There are five Class 2 SUs (SUs 39, 40, and 52 to 54). SU 39 is the Class 2 SU formed by the first floor concrete ceiling and concrete (perimeter) upper walls. SU 40 is the Class 2 SU formed by the second floor concrete ceiling and concrete (perimeter) upper walls. SU 52 is the Class 2 SU formed by the third floor concrete ceiling and concrete (perimeter) or metal (SU 45 interior) upper walls. SU 53 consists of the Class 2 areas with the stairwells, and SU 54 consists of the Class 2 floor, walls, and ceiling within the elevator. SU designations 12 to 16, 37, 38, and 41 were originally surveyed by TtEC but incorporated into other SUs during past investigations and are no longer present.

The limiting alpha-emitting ROC for Building 351 is ^{232}Th , and the limiting beta-emitting ROC is ^{90}Sr .

4.4.3.3 Building 366

There are 45 Class 1 SUs (SUs 1 to 14, 18, 24 to 28, 31 to 38, and 43 to 59) consisting of concrete flooring and sheet metal (perimeter) or sheetrock (interior) lower walls (**Figure 4-4**). SU designations 15 to 17, 19 to 23, 29 and 30, and 39 to 42 were originally surveyed by TtEC but incorporated into other SUs during past investigations and are no longer present. There are nine Class 2 SUs (SUs 60 to 68) and one Class 3 SU (SU 69). SUs 60 to 63 divide the metal roof and perimeter metal upper walls into four Class 2 SUs. SUs 64 and 65 are the Class 2 areas formed by the metal gables at the building's western and eastern ends. SUs 66 to 68 are the Class 2 faces of metal firewalls in place on three roof trusses. The building exterior (SU 69) is a Class 3 SU. The mezzanine level in the southwest corner of the building is SU 70, which will be surveyed as a Class 1 SU if it can be safely accessed.

The limiting alpha-emitting ROC for Building 366 is ^{226}Ra , and the limiting beta-emitting ROC is ^{90}Sr .

4.4.3.4 Building 401

There are 26 Class 1 SUs on the first floor (SUs 1 to 22 and 32 to 35) consisting of concrete flooring, wooden or concrete perimeter lower walls, and sheetrock interior lower walls (**Figure 4-5**). There are seven Class 1 SUs on the second floor (SUs 24-29 and 36) consisting of wooden or metal flooring and wooden perimeter lower walls. There are no remaining impacted, interior lower wall surfaces on the second floor. SUs 30 and 31 divide the first floor upper walls and ceilings into two Class 2 SUs consisting of wood paneled, sheetrock, or wooden upper walls and the undersides of the second floor's wooden or metal floors. The upper walls and ceilings of the second floor, as well as the remaining of the building, were not considered impacted by the tenant's storage of gauges and were not previously surveyed. Portions of the second floor SUs include wooden flooring that is highly deteriorated and may not be safely accessible for survey.

The limiting alpha-emitting ROC for Building 401 is ^{226}Ra , and the limiting beta-emitting ROC is ^{90}Sr .

4.4.3.5 Building 408

The remaining concrete slab of the former building (**Figure 4-6**) will be investigated as a single Class 1 SU. A Class 2 buffer area (SU 2) surrounding the Class 1 SU will also be surveyed.

The limiting alpha-emitting ROC for Building 408 is ^{232}Th , and the limiting beta-emitting ROC is ^{90}Sr .

4.4.3.6 Building 411

There are five Class 1 SUs on the first floor (SUs 5 to 7 and 9 and 10) consisting of concrete flooring (**Figure 4-7**). Class 1 SUs are surrounded by two Class 2 SUs (SUs 8 and 11) consisting of concrete flooring and lower walls. The ground level floor surfaces surrounding the Class 2 SUs form two Class 3 SUs (SUs 3 and 4) consisting of concrete flooring or steel grating. SU 3 and SU 4 contain many deep and water-filled pits/sumps that were not previously surveyed because of safety and accessibility concerns. SU 2 forms a single Class 3 SU on the second floor and consists of concrete flooring. The third floor and mezzanine are

no longer accessible because of concerns about structural stability; therefore, the Class 3 SU 1 that was previously surveyed by TtEC is not included in this investigation. Access points to that area will be included with surveys of adjacent SUs.

The limiting alpha-emitting ROC for Building 411 is ^{226}Ra , and the limiting beta-emitting ROC is ^{137}Cs .

4.4.3.7 Building 439

The radiologically impacted area within Building 439 is an enclosed area that was historically leased to Young Laboratories. The original survey area consisted of two Class 1 SUs (SU 1 and SU 2) on the floors and lower walls of the enclosure, and a Class 2 SU (SU 3) on the enclosure's upper walls and ceiling (**Figure 4-8**). After remediation was performed in a small area within SU 1, a new Class 1 SU (SU 4) was established within the remediated area. In addition, two Class 2 SUs were established as buffer areas within the enclosure and in a 2-meter perimeter on the outside of the enclosure (SUs 5 and 6, respectively). Because of the overlap of the pre- and post-remediation SUs, the investigation at Building 439 will consist of Class 1 surveys in SUs 1 and 2, and Class 2 surveys in SUs 3 and 6. The Class 1 survey in SU 1 will capture areas previously surveyed as SUs 4 and 5.

The limiting alpha-emitting ROC for Building 439 is ^{226}Ra , and the limiting beta-emitting ROC is ^{137}Cs .

4.4.4 Reference Coordinate System

Survey unit scan lanes and static measurement locations will be marked using a consistent reference coordinate system throughout the building. In the absence of other technologies, locations will reference from the southernmost and westernmost points in the SU.

4.5 Instrumentation

Investigation data will be collected using position-sensitive proportional counters (PSPCs), gas proportional counters, and swipe sample counters as described herein.

4.5.1 Position-sensitive Proportional Counters

Large area surface scanning and static measurements for alpha and beta radiations will be performed using PSPCs such as the Radiation Safety and Control Services, Inc. (RSCS) Surface Contamination Monitor (SCM) or equivalent instrument. The RSCS SCM simultaneously acquires alpha-beta data from motor-controlled dual detectors moving over a surface at a fixed rate between 1.25 and 12.5 centimeters per second (cm/s). Detector functions, movement, and response are controlled through a Survey Information Management System (SIMS). The SIMS is also used to log, display, and interpret investigation data and generate survey reports. The detectors are configured in parallel and the system can identify the location of each reading within 5 cm along a detector's length. Operated in rolling (dynamic) mode for scanning, the SCM acquires data for each 5 cm of detector width and every 5 cm of forward travel. The data for the resulting 25-square-centimeter (cm^2) area is binned, then combined as one-fourth of the overall 100 cm^2 response.

4.5.2 Gas Proportional Detectors

Gas proportional detectors, such as the large area Ludlum Model 43-37, small area Ludlum Model 43-68, or equivalent instruments, will be used for scanning measurements in areas that are not accessible to or practicable for the RSCS SCM. The Ludlum Model 43-37 detector physical size is 2.5 by 15.9 by 46.4 cm (H by W by L) with an active area of 584 cm^2 . The Ludlum Model 43-68 is 10 by 11.7 by 19.8 cm, with an active area of 126 cm^2 . Scanning speed is surveyor-controlled, and data are automatically logged when used with an appropriate data-logging scaler/ratemeter, such as the Ludlum Model 2360 or equivalent. The Ludlum Model 43-68 may also be used to perform static measurements.

4.5.3 Scintillation Detectors

Alpha-beta scintillation detectors may also be used for scanning and static measurements. The Ludlum Model 43-93 has an active detector area of 100 cm² and simultaneously counts alpha radiation using a zinc sulfide scintillator and beta radiation using a thin plastic scintillator.

4.5.4 Alpha-Beta Sample Counter

Swipe samples to assess removable activity will be performed using an alpha-beta plastic scintillation counter, such as the Ludlum Model 3030 Alpha-Beta Sample Counter or equivalent. The Ludlum Model 3030 has an active detector area of 20.3 cm² and simultaneously counts alpha-beta radiation from 5.1 cm swipe papers loaded into a single sample tray.

4.5.5 Instrument Efficiencies

Manufacturer-provided parameters are provided in **Table 4-5**, including the detector physical (active) areas, detector widths in the direction of scanning, total (4π) efficiencies, and background count rates. These parameters will be updated during the investigation for each instrument used. In accordance with NUREG-1507 (NRC, 1998), during survey activities total 4π efficiencies for alpha/beta instruments will be determined by multiplying the reported 2π instrument efficiency (ϵ_i) from the instrument calibration and a source efficiency (ϵ_s) of 0.5 for beta-emitters with maximum beta energies exceeding 0.4 MeV, and 0.25 for beta-emitters with maximum beta energies between 0.15 and 0.4 MeV and for alpha-emitters. In the following sections, manufacturer-provided 4π efficiencies are used to illustrate the example calculations.

Table 4-5. Typical Survey Instrument Efficiencies and Background Count Rates from Manufacturers

Parameter	RSCS SCM	Ludlum Model 43-37	Ludlum Model 43-68	Ludlum Model 43-93	Ludlum Model 3030
Type of Measurement	Scanning	Scanning	Scanning/Static	Scanning/Static	Smear Counting
Detector active area, A (cm ²)	100	584	126	100	20.3
Width in direction of scan, d (cm)	20	13.335	8.8	6.94	NA
Alpha total efficiency (4π) for ²³⁹ Pu		0.175	0.175	0.20	0.37
Alpha total efficiency (4π) for ²³⁵ U	NA	NA	NA	NA	0.39
Alpha total efficiency (4π) for ²³⁰ Th		NA	NA	NA	0.32
Alpha total efficiency (4π) for ²²⁶ Ra	0.188	NA	NA	NA	NA
Beta total efficiency (4π) for ⁹⁹ Tc		0.20	0.20	0.15	0.27
Beta total efficiency (4π) for ⁹⁰ Sr/ ⁹⁰ Y	0.90	0.20	0.20	0.20	0.26
Beta total efficiency (4π) for ¹³⁷ Cs		NA	NA	NA	0.29

Table 4-5. Typical Survey Instrument Efficiencies and Background Count Rates from Manufacturers

Parameter	RSCS SCM	Ludlum Model 43-37	Ludlum Model 43-68	Ludlum Model 43-93	Ludlum Model 3030
Alpha background (cpm)	1	< 10	≤ 3	≤ 3	≤ 3
Beta background (cpm)	636	800 - 1300	350	≤ 300	≤ 50

Notes:

⁹⁰Y = yttrium-90

⁹⁹Tc = technetium-99

< = less than

≤ = less than or equal to

NA = not applicable

The response of a detector to the incident radiations from building surfaces differs from the values in **Table 4-5** depending on the presence and state of equilibrium of radioactive progenies. Of the ROCs in **Table 4-1**, ²²⁶Ra, ⁹⁰Sr, and ²³²Th have radioactive progenies that emit alpha or beta particles during their decay. The concentration of each progeny relative to its parent depends on its parent’s decay fraction and the equilibrium fraction of the entire series or chain. ²²⁶Ra and ²³²Th both have radon isotopes as progeny. Because both radon (²²²Rn) and thoron (²²⁰Rn) are gases, a fraction of their concentration may escape the building area before decaying, and the relative abundance (equilibrium fraction) of the subsequent progenies is reduced. For the ²²⁶Ra decay series, the radon decay products typically have a 0.4 equilibrium fraction indoors (see Question 17 in USEPA, 2014) such that the progeny of radon (²²²Rn) is only present at 40 percent of the ²²²Rn concentration. Similarly, for the ²³²Th decay series, the radon decay products typically have a 0.02 equilibrium fraction indoors (see Question 17 in USEPA, 2014) such that the progeny of thoron (²²⁰Rn) is only present at 2 percent of the ²²⁰Rn concentration.

In **Table 4-6**, each ROC and its progeny is listed along with the associated type of particle emitted during decay, the fraction of times that particle type is emitted, the radon decay product abundance relative to ²²²Rn or ²²⁰Rn, and the 4-π efficiencies and 4-π weighted efficiencies for the three example detector types for building investigations. The 4-π weighted efficiencies for each radionuclide and detector is the product of its decay fraction, equilibrium fraction, and 4-π efficiency. The total alpha (or beta) 4-π weighted efficiencies for ²²⁶Ra, ⁹⁰Sr, and ²³²Th are the summed alpha (or beta) 4-π weighted efficiencies of themselves and their progeny. To illustrate, the alpha response (4-π efficiency) of the RSCS SCM to pure ²²⁶Ra is 0.188 (or 18.8 counts per 100 disintegrations of ²²⁶Ra). However, ²²⁶Ra exists in partial equilibrium with its radioactive progeny, and for each disintegration of ²²⁶Ra, there are 3.2 alpha particles and 1.6 beta particles formed. The resultant total alpha 4-π weighted efficiency for the RSCS SCM and the ²²⁶Ra chain is 0.188 x 3.2 = 0.602. Consistent with Section 4.3.2 of MARSSIM (USEPA et al., 2000), the weighted efficiencies provided in **Table 4-6** are used for the instrument sensitivity calculations described in the remainder of this section.

Table 4-6. Detector Efficiencies for Each ROC and Alpha- or Beta-emitting Progeny

Parent ROC and Alpha- or Beta-emitting Progenies	Particle Emission	Decay Fraction	Equilibrium Fraction	4π Efficiencies (Estimated)					4π Weighted Efficiencies (Estimated)				
				RSCS SCM	Ludlum Model 43-37	Ludlum Model 43-68	Ludlum Model 43-93	Ludlum Model 3030	RSCS SCM	Ludlum Model 43-37	Ludlum Model 43-68	Ludlum Model 43-93	Ludlum Model 3030
¹³⁷ Cs	Beta	1.00	1.00	0.900	0.200	0.200	0.200	0.290	0.900	0.200	0.200	0.200	0.290
⁶⁰ Co	Beta	1.00	1.00	0.900	0.200	0.200	0.150	0.270	0.900	0.200	0.200	0.150	0.270
²³⁹ Pu	Alpha	1.00	1.00	0.188	0.175	0.175	0.200	0.370	0.188	0.175	0.175	0.200	0.370
²²⁶ Ra	Alpha	1.00	1.00	0.188	0.175	0.175	0.200	0.320	0.188	0.175	0.175	0.200	0.320
²²² Rn	Alpha	1.00	1.00	0.188	0.175	0.175	0.200	0.370	0.188	0.175	0.175	0.200	0.370
²¹⁸ Po	Alpha	1.00	0.40	0.188	0.175	0.175	0.200	0.370	0.075	0.070	0.070	0.080	0.148
²¹⁴ Pb	Beta	1.00	0.40	0.900	0.200	0.200	0.200	0.260	0.360	0.080	0.080	0.080	0.104
²¹⁴ Bi	Beta	1.00	0.40	0.900	0.200	0.200	0.200	0.260	0.360	0.080	0.080	0.080	0.104
²¹⁴ Po	Alpha	1.00	0.40	0.188	0.175	0.175	0.200	0.370	0.075	0.070	0.070	0.080	0.148
²¹⁰ Pb	Beta	1.00	0.40	0	0	0	0	0	0	0	0	0	0
²¹⁰ Bi	Beta	1.00	0.40	0.900	0.200	0.200	0.200	0.260	0.360	0.080	0.080	0.080	0.104
²¹⁰ Po	Alpha	1.00	0.40	0.188	0.200	0.175	0.200	0.370	0.075	0.080	0.070	0.080	0.148
Total ²²⁶Ra alphas			3.20						0.602	0.570	0.560	0.640	1.134
Total ²²⁶Ra betas			1.60						1.080	0.240	0.240	0.240	0.312
⁹⁰ Sr	Beta	1.00	1.00	0.900	0.200	0.200	0.200	0.260	0.900	0.200	0.200	0.200	0.260
⁹⁰ Y	Beta	1.00	1.00	0.900	0.200	0.200	0.200	0.260	0.900	0.200	0.200	0.200	0.260
Total ⁹⁰Sr betas			2.00						1.800	0.400	0.400	0.400	0.520
²³² Th	Alpha	1.00	1.00	0.188	0.175	0.175	0.200	0.390	0.188	0.175	0.175	0.200	0.390
²²⁸ Ra	Beta	1.00	1.00	0.900	0	0	0	0	0	0	0	0	0

Table 4-6. Detector Efficiencies for Each ROC and Alpha- or Beta-emitting Progeny

Parent ROC and Alpha- or Beta-emitting Progenies	Particle Emission	Decay Fraction	Equilibrium Fraction	4 π Efficiencies (Estimated)					4 π Weighted Efficiencies (Estimated)				
				RSCS SCM	Ludlum Model 43-37	Ludlum Model 43-68	Ludlum Model 43-93	Ludlum Model 3030	RSCS SCM	Ludlum Model 43-37	Ludlum Model 43-68	Ludlum Model 43-93	Ludlum Model 3030
²²⁸ Ac	Beta	1.00	1.00	0.900	0.200	0.200	0.200	0.260	0.1088	0.200	0.200	0.200	0.260
²²⁸ Th	Alpha	1.00	1.00	0.188	0.175	0.175	0.200	0.370	0.188	0.175	0.175	0.200	0.370
²²⁴ Ra	Alpha	1.00	1.00	0.188	0.175	0.175	0.200	0.370	0.188	0.175	0.175	0.200	0.370
²²⁰ Rn	Alpha	1.00	1.00	0.188	0.175	0.175	0.200	0.370	0.188	0.175	0.175	0.200	0.370
²¹⁶ Po	Alpha	1.00	0.02	0.188	0.175	0.175	0.200	0.370	0.004	0.004	0.004	0.004	0.007
²¹² Pb	Beta	1.00	0.02	0.900	0.200	0.200	0.150	0.270	0.018	0.004	0.004	0.003	0.005
²¹² Bi	Beta	0.64	0.02	0.900	0.200	0.200	0.200	0.260	0.012	0.003	0.003	0.003	0.003
	Alpha	0.36	0.02	0.188	0.175	0.175	0.200	0.370	0.001	0.001	0.001	0.001	0.003
²¹² Po	Alpha	1.00	0.02	0.188	0.175	0.175	0.200	0.370	0.004	0.004	0.004	0.004	0.007
²⁰⁸ Tl	Beta	1.00	0.02	0.900	0.200	0.200	0.200	0.260	0.018	0.004	0.004	0.004	0.005
Total ²³²Th alphas			4.05						0.761	0.708	0.708	0.809	1.517
Total ²³²Th betas			2.05						0.948	0.211	0.211	0.210	0.274

Notes:

Total alphas or betas = sum of (decay fraction x equilibrium fraction)

²⁰⁸Tl = thallium-208²¹⁰Bi = bismuth-210²¹⁰Pb = lead-210²¹⁰Po = polonium-210²¹²Bi = bismuth-212²¹²Pb = lead-212²¹²Po = polonium-212²¹⁴Pb = lead-214²¹⁴Po = polonium-214²¹⁶Po = polonium-216²¹⁸Po = polonium-218²²⁴Ra = radium-224²²⁸Ac = actinium-228²²⁸Ra = radium-228²²⁸Th = thorium-228

4.5.6 Calibration

Portable survey instruments will be calibrated annually at a minimum, in accordance with ANSI N323 (ANSI, 1997), or an applicable later version. Instruments will be removed from service on or before calibration due dates for recalibration. If ANSI N323 does not provide a standard method, the calibration facility should comply with the manufacturer's recommended method.

4.5.7 Daily Performance Checks

Before using the portable survey instruments, calibration verification, physical inspection, battery check, and source-response check will be performed in accordance with SOP RP-108, *Count Rate Instruments*, and SOP RP-109, *Dose Rate Instruments (Appendix D)*. Portable survey instruments will have a current calibration label that will be verified daily before use.

Physical inspection of the portable survey instrument will include the following:

- General physical condition of the instrument and detector before each use
- Knobs, buttons, cables, connectors
- Meter movements and displays
- Instrument cases
- Probe and probe windows
- Other physical properties that may affect the proper operation of the instrument or detector

Any portable survey instrument or detector having a questionable physical condition will not be used until problems have been corrected. A battery check will be performed to ensure that sufficient voltage is being supplied to the detector and instrument circuitry for proper operation. This check will be performed in accordance with the instrument's operations manual. The instrument will be exposed to the appropriate (alpha or beta) check source, to verify that the instrument response is within the plus or minus 20 percent range determined during the initial response check. The calibration certificates and daily QA/QC records for each instrument used and the instrument setup test records will be provided in the project report.

If any portable survey instrument, or instrument and detector combination, having a questionable physical condition that cannot be corrected fails any of the operation checks stated in SOP RP-108, *Count Rate Instruments*, or SOP RP-109, *Dose Rate Instruments (Appendix D)*, or has exceeded its annual calibration date without PRSO approval, the instrument will be put in an "out of service" condition. This is done by placing an "out of service" tag or equivalent on the instrument and securing the instrument or the instrument and detector combination in a separate area such that the instrument and instrument and detector combination cannot be issued for use. The PRSO and RCTs and their respective supervisors will be notified immediately when any survey instrumentation has been placed "out of service." Instruments tagged as "out of service" will not be returned to service until all deficiencies have been corrected. The results of the daily operation checks, discussed above, will be documented.

4.5.8 Instrument Detection Calculations and Investigation Levels

Instrument-specific parameters used for building investigations are calculated in the following sections. These include the average scan rate, ILs, alpha detection probabilities and MDCs for scanning measurements and the ILs and MDCs for static measurements. These calculations will be updated during building investigations (**Section 4.6.3**) using information from calibration sheets and background measurements for each instrument.

4.5.8.1 Scan Rate

While scanning, the period that a moving detector spends above an area of elevated activity, or the dwell time (in seconds), depends on the rate of scanning (cm/s) and the size of the area of elevated

activity (cm²). The detector dwell time (*t*) is also called the detector residence time or observation interval (*i*) in some references. The size of any area of elevated activity cannot be known before investigation, so the conventional approach is to assume a typical size for the area (e.g., 100 cm²) and choose a scan rate that provides a reasonable value for *t*. Generally, dwell times in the 0.5- to 2-second range are considered reasonable. If the 100 cm² area of elevated activity is 10 cm x 10 cm, then these dwell times would result in average detector scan rates, *v*, between 5 and 20 cm/s.

Average scan rates for each instrument used for scanning will be determined during instrument preparations (**Section 4.6.3.1**) to meet required detection sensitivities. Movement of a PSPC, such as the RSCS SCM, is motor-controlled and has a fixed scan rate, *v*, which is typically between 1.25 and 12.5 cm/s. Movement of other large area detectors, such as the Ludlum Model 43-37, is surveyor-controlled and the average scan rate will be monitored during scanning and verified during data evaluation.

4.5.8.2 Scan Investigation Levels

Scan data are compared to scan ILS. ILS are instrument-, ROC-, and surface material-specific surface activity levels, in units of the instrument's response (cpm). Scan data that exceed an applicable scan IL will be investigated using biased measurements (**Section 4.6.3.4**). Scan ILS will be updated during instrument preparations (**Section 4.6.3.1**).

The measurements for alpha and beta surface activity occur simultaneously during scanning; however, the signal detection theory for alpha emitters differs greatly from that of beta emitters. Surface conditions and other factors result in relatively low probabilities that alpha particles emitted from sources on a surface will reach the detector, while beta scanning provides a more reliable and efficient method for the detection of beta emitters. Given that ²²⁶Ra and ²³²Th have progeny that emit beta particles, the collection of beta scanning measurements will supplement and verify alpha scans where ²²⁶Ra and ²³²Th are ROCs.

Scan ILS are calculated using **Equation 4-2** and the detector-specific information in **Table 4-5** and **Table 4-6**. To enable direct comparison to the alpha ratemeter output during scanning, the RG for each alpha-emitting ROC is converted from units of dpm/100 cm² to cpm (beta) using **Equation 4-2**, which is based on the discussion of data conversion in MARSSIM Section 6.6.1 (USEPA et al., 2000). The beta scan IL is determined in a similar manner.

Equation 4-2

$$\text{Scan IL}_{(\alpha \text{ or } \beta)} \text{ (cpm)} = RG_{(\alpha \text{ or } \beta)} \cdot \epsilon_T (\alpha \text{ or } \beta) \cdot \left(\frac{A}{100 \text{ cm}^2} \right) + R_B (\alpha \text{ or } \beta)$$

Where:

$RG_{(\alpha \text{ or } \beta)}$	= remediation goal for alpha- or beta-emitting ROC (dpm/100 cm ²)
$\epsilon_T (\alpha \text{ or } \beta)$	= detector total (4- π) efficiency (counts per disintegration), equal to 2- π instrument efficiency (ϵ_i) multiplied by surface efficiency (ϵ_s)
A	= detector probe physical (active) area (cm ²)
$R_B (\alpha \text{ or } \beta)$	= alpha or beta background count rate (cpm)

For illustration, calculated scan ILS are presented in **Table 4-7** for each ROC and for three detector models. Site-specific scan ILS will be determined during instrument preparations (**Section 4.6.3.1**).

Example: ²³²Th alpha scan IL for the RSCS SCM.

$$\text{Scan IL}^{232\text{Th},\alpha} \text{ (RSCS SCM)} = 36.5 \cdot 0.761 \cdot \left(\frac{100}{100} \right) + 1 = 28.8 \text{ cpm}$$

Where:

$$RG^{232\text{Th},\alpha} = 36.5 \text{ dpm/100 cm}^2$$

$$\begin{aligned}\varepsilon_{T,\alpha} &= 0.761 \text{ (total weighted efficiency for } ^{232}\text{Th)} \\ A &= 100 \text{ cm}^2 \text{ (combined area of four } 25 \text{ cm}^2 \text{ bins)} \\ R_{B,\alpha} &= 1 \text{ cpm}\end{aligned}$$

Table 4-7. Preliminary Instrument Scan Investigation Levels

ROC	RSCS SCM (cpm)		Ludlum 43-37 (cpm)		Ludlum 43-68 (cpm)	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
¹³⁷ Cs	NA	5,136	NA	6,890	NA	1,435
⁶⁰ Co	NA	5,136	NA	6,890	NA	1,435
²³⁹ Pu	19	NA	107	NA	23	NA
²²⁶ Ra	61	780	337	1,190	72	205
⁹⁰ Sr	NA	2,436	NA	3,386	NA	679
²³² Th	28	703	159	1,095	34	184

Notes:

NA = not applicable

4.5.8.3 Probability of Alpha Detection for High-background Detectors

The measurements for alpha and beta surface activity occur simultaneously during scanning; however, the signal detection theory for alpha emitters differs greatly from that of beta emitters. For alpha scanning, one verifies that while scanning at rate ν , there is a specified probability (typically 90 percent) that surface activity present at the RG_α will be detected.

Equation 4-3 (adapted from Equation 6-14 in MARSSIM [USEPA et al., 2000]) is used for detectors having higher background rates (i.e., 5 to 10 cpm) to determine the probability of recording at least two alpha counts, $P(n \geq 2)$, while passing over an area contaminated at the RG_α , during t . It is assumed that all the elevated activity is contained in a 100 cm² area and that the detector passes over the area in one or multiple scan passes.

To achieve the sensitivity needed to detect alpha-emitting ROCs at the release criteria, where possible the SCM will be used in the coincidence, with two detectors hard-mounted to each other at a set distance. The system will be operated at a target speed of 2.5 to 5 cm/s, with the detector approximately 0.5 inch from the surface. The probability of detecting two or more counts due to a source at the RG_α is given by Equation 4-3 (Equation 6-14 from MARSSIM [USEPA et al., 2000]), as follows:

Equation 4-3

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE + B)t}{60} \right) \left(e^{-\frac{(GE+B)t}{60}} \right)$$

Where:

$P(n \geq 2)$	=	probability of getting two or more counts during the time interval t (percent)
t	=	time interval (seconds)
G	=	contamination activity (disintegrations per minute [dpm]) = equal to the RG_α
E	=	total efficiency (4-pi), equal to 2-pi instrument efficiency (ε_i) multiplied by surface efficiency (ε_s)
B	=	background count rate (cpm)

Because the detectors associated with the SCM are manufactured to the same specifications, the efficiency of each detector is similar. Therefore, the probability of obtaining two or more counts on each detector as they traverse the same source (assumed to be 36.5 dpm for the purposes of this calculation) is the square of the probability for a single detector.

Typical alpha background values observed with the SCM are less than 5 cpm/100 cm². The total detector efficiency (4- π) of the SCM for the alpha emission from ²³²Th is assumed to be 0.761, according to **Table 4-6**. The detector width is 20 cm in the direction of travel. Survey speed for alpha emitters is 2.5 cm/s (1 inch per second), resulting in a dwell time of 8 seconds. Using these parameters, **Equation 4-3** is solved as follows:

$$P(n \geq 2) = 1 - \left(1 + \frac{(36.5 \times 0.761 + 5)8}{60} \right) \left(e^{-\frac{(36.5 \times 0.761 + 5)8}{60}} \right) = 93.2\%$$

Where:

$P(n \geq 2)$	=	probability of getting two or more counts during the time interval t
t	=	8 seconds
G	=	36.5 dpm
E	=	0.761 (total weighted efficiency for ²³² Th alphas from Table 4-6)
B	=	5 cpm

As calculated above, the probability of getting two or more counts during the SCM observation interval of 4 seconds when surveying a 36.5-dpm hotspot is equal to 93.2 percent at a scan speed of 2.5 cm/s. Alpha detection probabilities and associated scan speeds for large area detectors will be updated as needed during survey preparation (**Section 4.6.3.1**) to reflect instrument-, ROC-, and surface material-specific information.

4.5.8.4 Probability of Alpha Detection for Small Area Detectors

The alpha count rate on various surfaces will average approximately 2 cpm with a small area Ludlum Model 43-68 detector. When using a 126 cm² or smaller detector, scanning for alpha emitters differs because the expected background response of most alpha detectors is close to zero. A single count in the defined residence time will result in a second measurement of equal duration. One or more additional counts will require investigation with a static measurement as described in **Section 4.6.3.4**.

The probability of detecting given levels of alpha surface contamination for smaller detectors can be calculated by use of Poisson summation statistics. Given a known measurement interval and a surface contamination release limit, the probability of detecting a single count for the measurement interval to be used during this project and sample data from a typical Ludlum Model 43-68 setup is given by Equation 6-12 of MARSSIM (USEPA et al., 2000), shown as **Equation 4-4**:

Equation 4-4

$$P(n \geq 1) = 1 - e^{-\frac{(GE)d}{60v}}$$

Where:

$P(n \geq 1)$	=	probability of observing a single count
G	=	contamination activity = RG_{α}
E	=	total efficiency (4- π), equal to 2- π instrument efficiency (ϵ_i) multiplied by

surface efficiency (ϵ_s)
 d = width of detector in direction of scan (cm)
 v = scan speed (cm/s)
 B = background count rate

Equation 4-4 may be solved as follows:

$$P(n \geq 1) = 1 - e^{-\frac{(36.5 \times 0.708)8.8}{60 \times 2.5}} = 78.1\%$$

Where:

$P(n \geq 1)$ = probability of observing a single count
 G = 36.5 dpm
 E = 0.708 (**Table 4-6**)
 d = 8.8 cm
 v = 5 cm/s

As calculated above, the probability of getting one or more counts during a Ludlum Model 43-68 scan moving at 2.5 cm/s when surveying a 36.5-dpm hotspot is equal to 78.1 percent. Alpha detection probabilities and associated scan speeds for small area detectors will be updated as needed during survey preparation (**Section 4.6.3.1**) to reflect instrument-, ROC-, and surface material-specific information.

4.5.8.5 Beta Scan Minimum Detectable Concentration

The rate at which each detection instrument traverses across the surface being surveyed is necessarily detector- and radionuclide-specific and varies with accepted error rates, surveyor efficiency, and surface beta background. We assume that 95 percent true positive ($\alpha = 0.95$) and 5 percent false positive ($\beta = 0.95$) rates are required, such that $d' = 3.28$ from MARSSIM Table 6.5. A value of 0.5 for p , the surveyor efficiency, is typical for surveyor-controlled detectors and 1.0 for motor-controlled detectors. The β scan MDC is calculated using **Equation 4-5** (adapted from MARSSIM, Equation 6-10 [USEPA et al., 2000]). Instruments will be selected for scanning to ensure that their beta scan MDC is less than or equal to the RG_β for the building from **Table 4-3**. **Equations 4-5** through **4-7** are derived as follows:

Equation 4-5

$$\beta \text{ scan MDC (dpm/100 cm}^2\text{)} = \frac{MDCR}{\sqrt{p} \cdot \epsilon_{i,\beta} \cdot \epsilon_{s,\beta} \cdot \frac{A}{100 \text{ cm}^2}}$$

Where:

$MDCR$ = minimum detectable count rate
 p = surveyor efficiency
 $\epsilon_{i,\beta}$ = detector ($2-\pi$) beta efficiency (counts per disintegration)
 $\epsilon_{s,\beta}$ = surface ($2-\pi$) beta efficiency (counts per disintegration)
 A = detector physical (active) area (cm^2)

Substituting $MDCR = 60 \cdot s_i / t$ (MARSSIM Equation 6-9), $t = i$, $s_i = d' \cdot (b_i)^{1/2}$ (MARSSIM Equation 6-8) and $\epsilon_{T,\beta} = \epsilon_{i,\beta} \cdot \epsilon_{s,\beta}$ yields **Equation 4-6**:

Equation 4-6

$$\beta \text{ scan MDC (dpm/100 cm}^2\text{)} = \frac{60 \cdot s_i / t}{\sqrt{p} \cdot \epsilon_{T,\beta} \cdot \frac{A}{100 \text{ cm}^2}} = \frac{60 \cdot d' \cdot \sqrt{b_i} / t}{\sqrt{p} \cdot \epsilon_{T,\beta} \cdot \frac{A}{100 \text{ cm}^2}}$$

Where:

s_i = minimum detectable net source counts in t

- d' = index of sensitivity (for error rates α and β)
- b_i = background counts in t
- t = d/v = detector dwell time (seconds)
- d = width of detector in direction of scan (cm)
- v = average scan rate (cm/s)
- $\epsilon_{T,\beta}$ = detector total (4- π) beta efficiency (counts per disintegration)

Substituting $b_i = R_{B,\beta}$ (cpm)· t (seconds)/60 yields **Equation 4-7**:

Equation 4-7

$$\beta \text{ scan MDC (dpm/100 cm}^2\text{)} = \frac{d' \cdot \sqrt{R_{B,\beta} \cdot \frac{t}{60} \cdot \frac{60}{t}}}{\sqrt{p} \cdot \epsilon_{T,\beta} \cdot \frac{A}{100}}$$

Where:

- $R_{B,\beta}$ = background beta count rate (cpm)

The beta scan MDCs for each scan survey instrument and ROC are presented in **Table 4-8** for various detector average scan rates.

Example: Beta Scan MDC Calculation for the RSCS SCM.

The β scan MDC is calculated for the RSCS SCM scanning for beta emitters at 5 cm/s and using the parameters presented in **Table 4-5** and **Table 4-6**. Because the scan rate is motor-controlled and there are no scanning pauses, the surveyor efficiency, p , is 100 percent.

$$\beta \text{ scan MDC (RSCS SCM, } ^{137}\text{Cs)} = \frac{3.28 \cdot \sqrt{636 \cdot \frac{4.0}{60} \cdot \frac{60}{4.0}}}{\sqrt{1.0} \cdot 0.900 \cdot \frac{100}{100}} = 356.0 \text{ dpm/100 cm}^2$$

Where:

- d' = 3.28 (for 95% true positive and 5% false positive)
- $R_{B,\beta}$ = 636 cpm
- t = d/v = 20 cm/(5 cm/s) = 4 seconds
- p = 1
- $\epsilon_{T,\beta}$ = 0.900 for beta emitters
- A = 100 cm²

Table 4-8. Beta Scan Minimum Detectable Concentrations (dpm/100 cm²) at 5 cm/s

Scan Rate (5 cm/s)		
ROC	RSCS SCM	Ludlum Model 43-37
¹³⁷ Cs	356	610
⁶⁰ Co	356	610
²²⁶ Ra	297	509
⁹⁰ Sr	178	305
²³² Th	338	580

Table 4-8 demonstrates that at a scan rate for the RCSC SCM of 5 cm/s, the beta scan MDCs for all ROCs are below the most restrictive RG_{β} (1,000 dpm/100 cm² for ⁹⁰Sr) for both large area survey instruments. Beta scan MDCs and associated scan speeds will be updated as needed during survey preparation (**Section 4.6.3.1**) to reflect instrument-, ROC-, and surface material-specific information.

4.5.8.6 Static Investigation Levels

Static measurement data are compared to static ILs. Static measurement data that exceed an applicable static IL will be investigated using biased measurements (**Section 4.6.3.4**).

The alpha and beta static ILs are determined using the static measurement count time in **Equation 4-8**, which is based on the discussion of data conversion in MARSSIM Section 6.6.1 (USEPA et al., 2000). Static ILs will be updated as needed during survey preparation (**Section 4.6.3.1**) using instrument-, ROC- and surface material-specific information.

Equation 4-8

$$\text{Static IL}_{(\alpha \text{ or } \beta)} \text{ (counts)} = [RG_{(\alpha \text{ or } \beta)} \cdot \varepsilon_{T(\alpha \text{ or } \beta)} \cdot \left(\frac{A}{100 \text{ cm}^2}\right) + R_{B(\alpha \text{ or } \beta)}] \cdot T_{S+B}$$

Where:

$RG_{(\alpha \text{ or } \beta)}$	= remediation goal for alpha- or beta-emitting ROC (dpm/100 cm ²)
$\varepsilon_{T(\alpha \text{ or } \beta)}$	= detector total (4- π) efficiency (counts per disintegration), equal to 2- π instrument efficiency (ε_i) multiplied by surface efficiency (ε_s)
A	= detector probe physical (active) area (cm ²)
$R_{B(\alpha \text{ or } \beta)}$	= alpha or beta background count rate (cpm)
T_{S+B}	= SU static counting time (minutes)

For illustration, the following example calculates the alpha static IL equivalent to the ²³²Th RG for the Ludlum Model 43-93, on concrete, using a 1-minute static count time.

Example: Alpha static IL for the Ludlum Model 43-93

$$\text{Static IL}_{\alpha} \text{ (Ludlum Model 43-93, } ^{232}\text{Th)} = [36.5 \cdot 0.200 \cdot \left(\frac{100}{100}\right) + 1] \cdot 1 = 8.3 \text{ counts}$$

Where:

$RG^{232}\text{Th}_{,\alpha}$	= 36.5 dpm/100 cm ²
$\varepsilon_{T,\alpha}$	= 0.200 (total efficiency for ²³² Th, Table 4-6)
A	= 100 cm ²
$R_{B,\alpha}$	= 1 cpm
T_{S+B}	= 1 minute

4.5.8.7 Alpha Static Minimum Detectable Concentration

Simultaneous static alpha-beta (paired) measurements are typically taken with alpha-beta detectors coupled to scaler and ratemeter data loggers, and operated in scaler mode for the counting time, T . The division of counting times between background counting time, T_B , and SU counting time, T_{S+B} , is optimized such that the static MDCs will be less than or equal to the RG_{α} for the building from **Table 4-3**. The static MDC is the a priori net activity concentration above the critical level that is expected to be detected 95 percent of the time. When the count times for the background and SU measurements are different, the static MDC, for either alpha or beta activity, is calculated using **Equation 4-9** (adapted from Strom and Stansbury, 1992). Any areas of elevated activity are assumed to be 100 cm² in size. MDC calculations for static measurements will be updated during survey preparations (**Section 4.6.3.1**) using instrument-, ROC-, and surface material-specific information.

Equation 4-9

$$\text{Static MDC (dpm/100 cm}^2\text{)} = \frac{[3 + 3.29\sqrt{R_B \cdot T_{S+B} \cdot (1 + \frac{T_{S+B}}{T_B})}]}{\epsilon_T \cdot \frac{A}{100} \cdot T_{S+B}}$$

Where:

- R_B = background count rate (cpm)
- T_{S+B} = SU counting time (minutes)
- T_B = background counting time (minutes)
- ϵ_T = detector total (4- π) efficiency (counts per disintegration), equal to 2- π instrument efficiency (ϵ_i) multiplied by surface efficiency (ϵ_s)
- A = detector probe physical (active) area (cm²)

Instruments will be selected for static measurements to ensure that their alpha static MDC is less than or equal to the RG_α for the building from **Table 4-3**.

Example: Alpha Static MDC Calculation for the Ludlum Model 43-93.

The α static MDC is calculated for the Ludlum Model 43-93 using the parameters presented in **Table 4-5** and **Table 4-6**. Using **Equation 4-9**, the calculated α static MDC for ²³⁹Pu is 30.8 dpm/100 cm².

$$\alpha \text{ Static MDC (43-93, } ^{239}\text{Pu)} = \frac{[3 + 3.29\sqrt{2 \cdot 2 \cdot (1 + \frac{2}{2})}]}{0.200 \cdot \frac{100}{100} \cdot 2} = 30.8 \text{ dpm/100 cm}^2$$

Where:

- $R_{B,\alpha}$ = 2 cpm
- T_{S+B} = 2 minutes
- T_B = 2 minutes
- $\epsilon_{T,\alpha}$ = 0.200
- A = 100 cm²

4.5.8.8 Beta Static Minimum Detectable Concentration

Beta static MDC calculations are also performed using **Equation 4-9** and information from **Table 4-5** and **Table 4-6**. Instruments will be selected for static measurements to ensure that their beta static MDC is less than or equal to the RG_β for the building from **Table 4-3**. MDC calculations for static measurements will be updated during survey preparations (**Section 4.6.3.1**) using instrument-, ROC-, and surface material-specific information.

The alpha and beta static MDCs for each survey instrument and ROC are presented in **Table 4-9** for 1-minute measurements in the SUs and RBAs.

Table 4-9. Instrument Static Minimum Detectable Concentrations

ROC	Ludlum Model 43-68 (dpm/100 cm ²)		Ludlum Model 43-93 (dpm/100 cm ²)		Ludlum Model 3030 (dpm/100 cm ²)	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
¹³⁷ Cs	NA	178.7	NA	225.1	NA	90.6
⁶⁰ Co	NA	178.7	NA	300.2	NA	97.3
²³⁹ Pu	27.9	NA	30.8	NA	23.5	NA
²²⁶ Ra	27.9	148.9	30.8	187.6	7.67	84.2

⁹⁰ Sr	NA	178.7	NA	225.1	NA	47.8
²³² Th	27.9	169.7	30.8	214.8	5.73	95.9

Notes:

SU background static measurement count times = 2 minutes.

NA = not applicable

4.6 Radiological Investigation Implementation

Investigations will be generally implemented in the following order of activities: premobilization/mobilization, surveys, additional investigations, and demobilization.

4.6.1 Premobilization Activities

Before the start of survey activities, a walkthrough of Parcel G buildings will be completed to accomplish the following:

- Establish building access points and assess security requirements.
- Assess survey support needs such as power, lighting, ladders, or scaffolding.
- Verify the types of materials in each SU.
- Identify safety concerns and inaccessible or difficult-to-survey areas.
- Identify radiological protection and control requirements.
- Identify materials requiring removal or disposal, and areas requiring cleaning.
- Assess methods for marking survey scan lanes and static measurement locations.

Impacted areas that are deemed unsafe for access or surveys, such as the mezzanine of Building 411, will be posted, secured, and annotated in reports.

4.6.1.1 Training Requirements

Any required non-site-specific training required for field personnel will be performed before mobilization to the extent practical. Training requirements are outlined in **Section 6**.

Medical examinations, medical monitoring, and training will be conducted in accordance with the APP/SSHP and **Section 6** requirements.

In addition to health and safety-related training, other training may be required as necessary including but not limited to the following:

- Aerial Lift (for personnel working from aerial lifts)
- Fall Protection (for personnel working at heights greater than 5 feet)
- Equipment as required (e.g., fork lift, skid steer, loader, back hoe, excavator)

4.6.1.2 Permitting and Notification

Before initiation of field activities for the radiological investigations, the contractor will notify the Navy RPM, ROICC, RASO, Caretaker Site Office, and HPNS security as to the nature of the anticipated work. Any required permits to conduct the fieldwork will be obtained before mobilization.

The contractor will notify the California Department of Public Health at least 14 days before initiation of activities involving the Radioactive Material License.

4.6.1.3 Pre-construction Meeting

A pre-construction meeting will be held before mobilization of equipment and personnel. The purpose of the meeting will be to discuss project-specific topics, roles and responsibilities of project personnel,

project schedule, health and safety concerns, and other topics that require discussions before field mobilization. Representatives of the following will attend the pre-construction meeting:

- Navy (RPM, RASO, ROICC, and others as applicable)
- Contractor (Project Manager, Site Construction Manager, Project QC Manager, PRSO, and SSO)
- Subcontractors as appropriate

4.6.2 Mobilization Activities

Mobilization activities will include site preparation, movement of equipment and materials to the site, and orientation and training of field personnel.

At least 2 weeks before mobilization, the appropriate Navy personnel, including the Navy RPM, ROICC, and Caretaker Site Office, will be notified regarding the planned schedule for mobilization and site remediation activities. Upon receipt of the appropriate records and authorizations, field personnel, temporary facilities, and required construction materials will be mobilized to the site.

The temporary facilities will include restrooms, hand-washing stations, and one or more secure storage (Conex) boxes for short- and long-term storage of materials, if needed.

The applicable AHAs will be reviewed prior to starting work.

All equipment mobilized to the site will undergo baseline radioactivity surveys in accordance with **Section 6**. Surveys will include direct scans, static measurements, and wipe samples. Equipment that fails baseline surveying will not be removed from site immediately.

Loose, residual debris from past building occupation, investigations, vandalism, or asbestos and lead abatement will be removed for disposal and to prepare the buildings for cleaning. Cleaning will be sufficient to remove loose, surface material that may not be native to the building construction and may inhibit or damage survey instruments. Cleaning activities will be conducted consistent with the radiation protection procedures in **Section 6.4**. Dust control methods and air monitoring will be implemented, if warranted, as detailed in **Section 8.5**. Floors will be cleaned using ride-on floor scrubbers and vacuums. Walls and other surfaces will be cleaned as required during surveying. Wet areas will be dried using vacuums, blowers, or squeegees and may be delineated with spill containment booms if water infiltration is recurrent. Waste from debris removal and cleaning activities will be evaluated as described in **Section 6.4** and **Section 7**.

4.6.3 Building Investigation and Remediation Activities

Once all site preparation activities previously described are completed, building investigation and remediation activities will commence in the following general sequence:

- Mark SUs.
- Prepare instruments.
- Perform alpha-beta scanning in SUs and RBA and conduct preliminary data review.
- Perform alpha-beta systematic static and swipe measurements in SUs and RBA and conduct preliminary data review.
- Perform alpha-beta biased static and swipe measurements in SUs and conduct preliminary data review.
- Delineate and remediate residual contamination, if present.
- Evaluate and report data as described in **Section 5**.

4.6.3.1 Survey Unit Preparation

SUs will be durably marked prior to measurement activities to indicate SU boundaries, number, scan lanes and directions, and systematic measurement locations. Scan lane widths will be approximately 10 percent smaller than the detector's active width, in the direction of scanning, to ensure overlapping coverage.

Upon receipt of survey instruments for the building investigations and completion of performance checks, background measurements will be obtained in the RBAs for each instrument and on each surface material type (e.g., concrete, metal, wood, and sheet rock) that is also present in the SUs. The background measurements will consist of at least 18 static measurements on each surface to match the number performed in each SU. The mean instrument- and material-specific background count rate will be used to update the instrument detection calculations and static count times in **Section 4.5.8**.

4.6.3.2 Survey Unit and Reference Background Area Alpha-Beta Scanning

Survey units will be scanned to detect alpha and beta emitters using average scan rates that ensure an alpha probability of detection of approximately 90 percent (**Sections 4.5.8.3 and 4.5.8.4**) where feasible and that the beta scan MDC (**Section 4.5.8.5**) is less than or equal to the RG_{β} for the building (**Section 4.3**). Scanning will cover a total area of each SU according to its classification. The total surface area of remaining, accessible impacted surfaces to be scanned will be 100 percent in Class 1 SUs, 50 percent in Class 2 SUs, and up to 10 percent in Class 3 SUs.

The scan rate for the RSCS SCM is entered using the SIMS and results in a fixed, motor-controlled scan rate. At least every 10 SUs of scanning, the RSCS SCM scan rate will be verified manually using the distance scanned and scan duration. The distance scanned is the linear distance, in centimeters, traveled by the detector during data acquisition. The scan duration is the total time, in seconds, of data acquisition. Dividing the distance scanned (cm) by the scan duration (seconds) gives an estimate of the average detector scan rate (cm/s) for that scanning period. Direct observation or review of the positional data from the RSCS SCM serve to verify that the detector was in constant motion during scanning. The scan rates for other planned instruments (e.g., Ludlum Model 43-37 and Ludlum Model 43-68) are manually controlled by the surveyor and will be verified manually in each SU by direct observation and measurement of the time elapsed while scanning a known distance.

While using a PSPC, scanning may traverse multiple SUs at once for efficiency, but alpha-beta scan data will be assigned to, and analyzed by, individual SUs. Areas inaccessible to a PSPC will be scanned using a gas-proportional detector with data logging functions. A DQA of the alpha-beta scan data (**Section 5.2**) will identify locations that exceed the applicable beta scan IL (**Section 4.5.8.2**) and, therefore, require further investigation (**Section 5.3**). Alpha-beta scan data will also be used to verify the assumptions for the relative shift and revise the number of static measurements for each SU, if necessary (**Section 4.4.1**).

4.6.3.3 Survey Unit Systematic Alpha-Beta Static Measurements

Static measurements will be performed at each systematic static location and will total 18 in each SU and the RBA, or the revised number determined in **Section 4.4.1**. Locations that pose safety concerns or obstructions will be relocated to the nearest accessible location and noted on the field measurement forms.

Each static measurement will be performed in scaler mode for a count duration sufficient to ensure that the alpha and beta static MDCs are equal to or less than the RG_{α} and RG_{β} for the building, respectively. A DQA of the static measurement data (**Section 5.2**) will identify locations that exceed the applicable alpha or beta static IL (**Section 4.5.8.6**) and, therefore, require further investigation (**Section 5.3**) or remediation.

4.6.3.4 Biased Alpha-Beta Static Measurements

Biased static measurements will be used to further investigate areas with potential elevated surface activity, as indicated by beta scan data exceeding the beta scan IL or systematic static data exceeding the applicable alpha or beta static IL. The survey meter will be operated in scaler mode and measurements will be made for the same count duration as that for the systematic static measurements.

4.6.3.5 Alpha-Beta Swipe Samples

Swipe samples will be taken at all locations of systematic and biased static measurements. They will be taken dry, using moderate pressure, over an area of approximately 100 cm². Swipe samples will be measured for gross alpha and beta activity using a Ludlum Model 3030 or equivalent. The surface activity on the sample will be compared to the total surface activity measured by the static measurement to assess the removable fraction of surface activity. This information will be used in any dose or risk assessment performed.

4.6.3.6 Assessment of Residual Materials and Equipment

Several buildings contain residual materials and equipment from past operations, such as piping, ventilation, shelving, or machinery, that will undergo radioactivity surveys in accordance with SOP RP-104, *Radiological Surveys*, and SOP RP-105, *Unrestricted Release Requirements (Appendix D)*. These surveys may include a combination of surface scans and static measurements, swipe samples, and material samples. Where possible, sampling or survey points accessed during previous surveys will be used as a starting point. Surveys of impacted building material and equipment will be incorporated into the building SU. After data evaluation, disposition decisions, and subsequent investigation of the surfaces below the materials and equipment, will be coordinated with the Navy.

4.6.3.7 Decontamination and Release of Equipment and Tools

Decontamination of mobilized materials and equipment may be necessary at completion of fieldwork if radioactive materials above RGs are encountered. Numerous decontamination methods are available for use. If practical, manual decontamination methods should be used. Abrasive methods may be necessary if areas of fixed contamination are identified. Chemical decontamination can also be accomplished by using detergents for nonporous surfaces with contamination present. Chemicals should be selected for decontamination that will minimize the creation of mixed waste. Decontamination activities will be conducted using SOP RP-132, *Radiological Protective Clothing Selection, Monitoring, and Decontamination (Appendix D)*.

4.6.3.8 Remediation of Contaminated Building Surfaces

Following the identification and characterization of contaminated building surfaces, remediation may be required so that residual radioactivity meets the Parcel G ROD RAO. Specific remediation or decontamination techniques selected will depend on contaminant, type of surface, and other site-specific factors. Types of decontamination that may be performed include concrete scarifying or scabbling, application of strippable surface coatings, and bulk removal of building components. Remediation will be conducted in building areas that exceed RGs and background. Confirmation measurements will be collected where remediation is performed to verify that contamination has been removed.

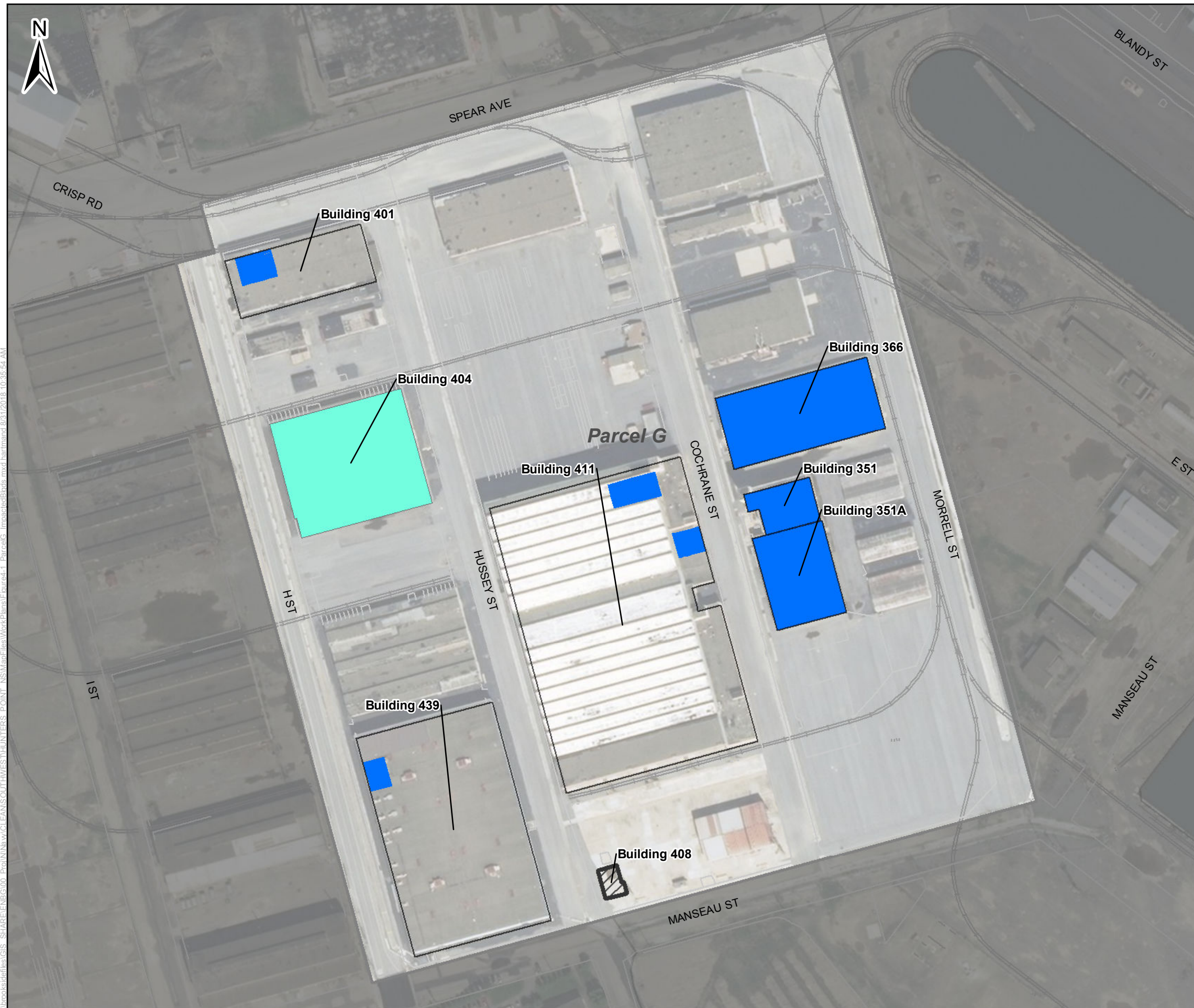
4.6.4 Demobilization

Demobilization will consist of surveying, decontaminating, and removing equipment and materials used during the investigations; cleaning and inspecting the project site; and removing temporary facilities. Survey of equipment and materials will be performed in accordance with **Section 6.6**, and decontamination will be performed in accordance with **Section 3.6.7.2**. Demobilization activities will

also involve collection and disposal of contaminated materials, including decontamination water and disposable equipment for which decontamination is inappropriate (**Section 7**).

Table 4-4
Building Summary Table
Parcel G Removal Site Evaluation Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Building	Former Uses	ROCs	Class 1 Survey Units	Class 2 Survey Units	Class 3 Survey Units	Corresponding Figure
351A	Building 351A was used as a radiation detection, indication and computation repair facility and electronics shop for radiation detection equipment and a facility for the calibration, repair, and reconditioning of other instruments. The NRDL also used the building as a chemistry laboratory, applied research branch, administrative offices, nuclear and physical chemistry laboratory, and chemical technology division.	^{137}Cs , ^{239}Pu , ^{226}Ra , ^{90}Sr , ^{232}Th	SU-1, SU-2, SU-3, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-12, SU-13, SU-14, SU-16, SU-18, SU-19, SU-20, SU-21, SU-22, SU-23, SU-24, SU-25, SU-26, SU-27, SU-29, SU-30, SU-31, SU-32, SU-33, SU-34, SU-35, SU-36, SU-37, SU-38, SU-39, SU-40, SU-41, SU-42, SU-43, SU-44	SU-45, SU-46, SU-47		4-1; 4-2
351	Building 351 was previously used as an electronics work area/shop, optical laboratories, Navy Bureau of Medicine and Surgery storeroom, machine shop (first floor), sampling laboratory, general research laboratories, and biological research laboratories. The NRDL also used the building as materials and accounts division, technical information division, office services branch, thermal branch, engineering division, and library.	^{137}Cs , ^{226}Ra , ^{90}Sr , ^{232}Th	SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-17, SU-18, SU-19, SU-20, SU-21, SU-22, SU-23, SU-24, SU-25, SU-26, SU-27, SU-28, SU-29, SU-30, SU-31, SU-32, SU-33, SU-34, SU-35, SU-36, SU-42, SU-43, SU-44, SU-45, SU-46, SU-47, SU-48, SU-49, SU-50, SU-51	SU-39, SU-40, SU-52, SU-53, SU-54		4-1; 4-3
366	Building 366 was used as administrative offices, applied research and technical development branches, radiological safety branch, management planning division, nucleonics division, instruments evaluation section, general laboratories, chemical research laboratory, shipyard radiography shop, boat/plastic shop, and other military/navy branch project officers station. NRDL also used the building for instrument calibration and management engineering and comptroller department.	^{137}Cs , ^{226}Ra , ^{90}Sr	SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-12, SU-13, SU-14, SU-18, SU-24, SU-25, SU-26, SU-27, SU-28, SU-31, SU-32, SU-33, SU-34, SU-35, SU-36, SU-37, SU-38, SU-43, SU-44, SU-45, SU-46, SU-47, SU-48, SU-49, SU-50, SU-51, SU-52, SU-53, SU-54, SU-55, SU-56, SU-57, SU-58, SU-59	SU-60, SU-61, SU-62, SU-63, SU-64, SU-65, SU-66, SU-67, SU-68	SU-69	4-1; 4-4; 4-10; 4-11
401	Building 401 was previously utilized as a supply storehouse, trades shop, and general stores, and by public works as a maintenance shop and offices. In 2005, the civilian tenant had been made aware of the presence of gauges and dials containing ^{226}Ra and provided the gauges and dials to the Navy.	^{137}Cs , ^{226}Ra , ^{90}Sr	SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-12, SU-13, SU-14, SU-15, SU-16, SU-17, SU-18, SU-19, SU-20, SU-21, SU-22, SU-24, SU-25, SU-26, SU-27, SU-28, SU-29, SU-33, SU-34, SU-35, SU-36	SU-30, SU-31		4-1; 4-5
Former Building 408 Concrete Pad	Previously a steel-framed structure enclosing two free-standing furnaces, used for smelting, that were constructed in 1947. The building was the equivalent of three stories at its northern end, dropping to one story at its southern end, and open-sided on the north. A firebrick-lined hearth occupied most of the open area at the north. Natural gas burners were present on the east and west sides of the hearth and a pair of smokestacks extended from the lower rear segment of the building. The building has been demolished, and the concrete building pad is all that remains.	^{137}Cs , ^{226}Ra , ^{90}Sr , ^{232}Th	SU-1	SU-2		4-1; 4-6
Building 411	Building 411 was used for source storage, as a civilian cafeteria, shipfitters and boilermakers shop, and ship repair shop. A leading enclosure measuring approximately 25 feet by 15 feet was in the building and housed an x-ray machine used for radiography.	^{137}Cs , ^{60}Co , ^{226}Ra	SU-5, SU-6, SU-7, SU-9, SU-10	SU-8, SU-11	SU-2, SU-3, SU-4	4-1; 4-7
Building 439	Building 439 was previously used by the Navy as an equipment storage facility. Following closure of HPNS, the building was leased by a skateboard company for use as a manufacturing and assembly plant. In 2002, Young Laboratories, a civilian tenant, was relocated to a 40-foot by 50-foot enclosed area in the northwest corner of the building with a separate outside entrance. Young Laboratories processed and analyzed metals and other materials containing metals as part of its assay operations. Previous investigations in Building 364 identified an old kiln that was assumed to have been used by Young Laboratories and a subsequent survey identified slag material inside containing ^{226}Ra . Additional surveys within Building 364 identified areas of elevated ^{137}Cs activity. The Navy identified Building 439 as potentially impacted based on potential cross-contamination from Building 364 during relocation.	^{137}Cs , ^{226}Ra	SU-1, SU-2, SU-4	SU-3, SU-5, SU-6		4-1; 4-8



Legend

- Impacted Building Areas
- Background Reference Areas
- Impacted Building Extent
- Demolished Impacted Buildings
- Parcel G Boundary

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

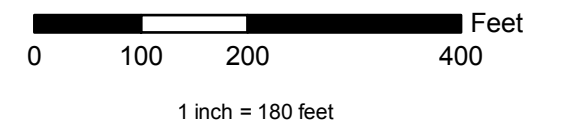
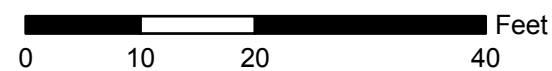
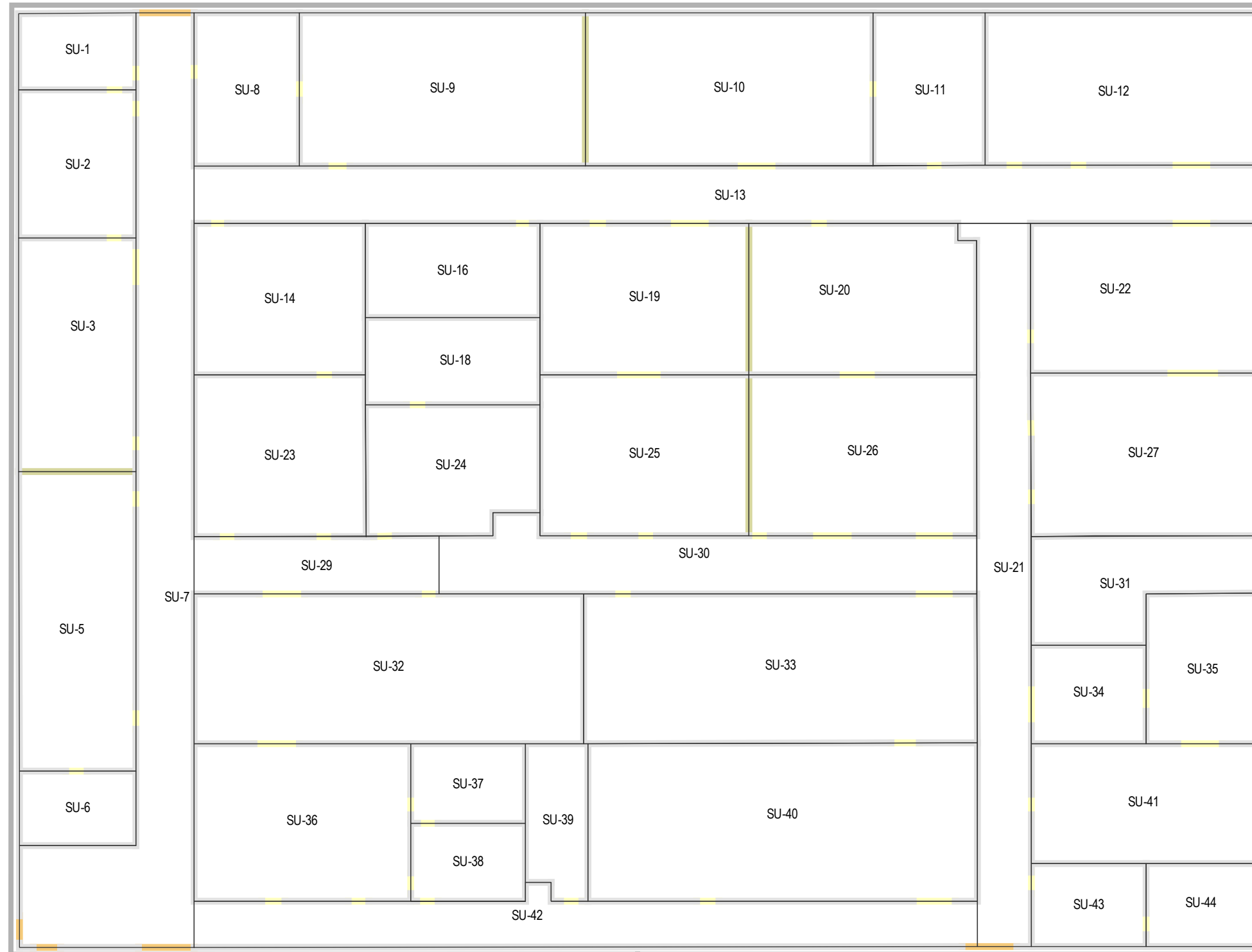


Figure 4-1
Impacted Buildings and
Background Locations
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

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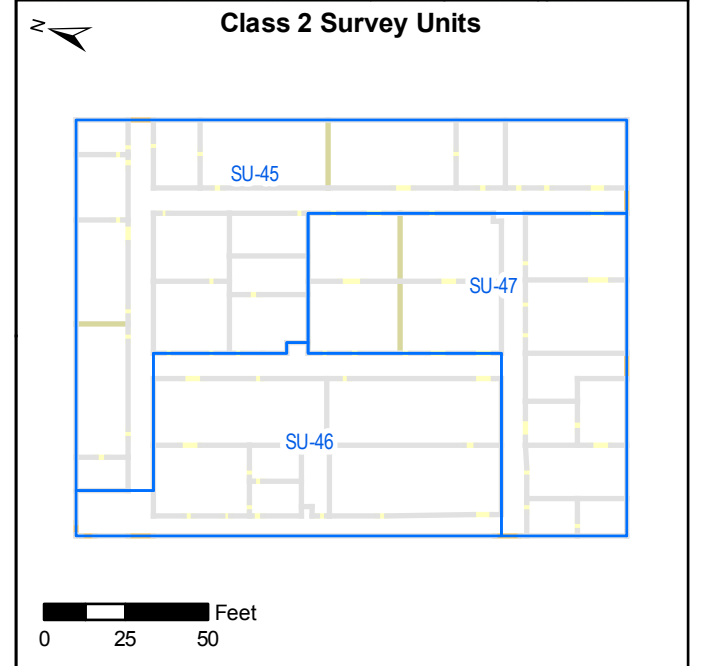
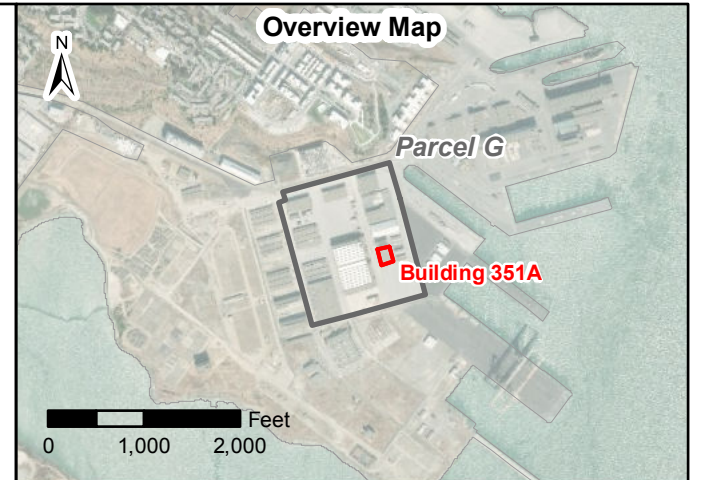
Class 1 Survey Units



Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, July 26, 2010, DCN: ECSD-5713-0072-0015.RI" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit and Floor Plan data are based on Figure 4-1 (2010).



Legend

- Class 1 Survey Unit (Floor and Lower Wall)
- Class 2 Survey Unit (Ceiling and Upper Wall)

Floor Plan

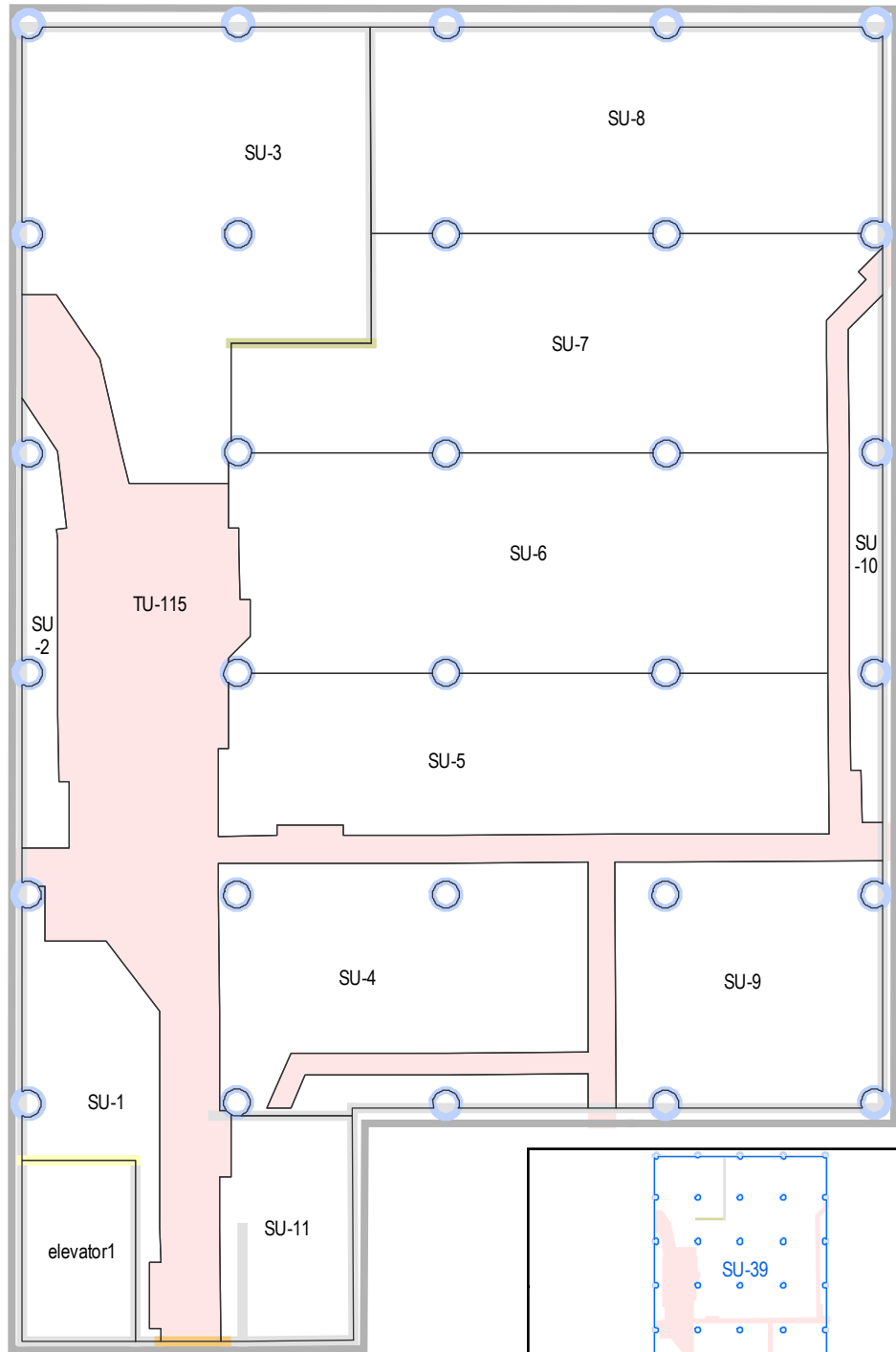
- Interior Door
- Exterior Door
- Divider
- Wall
- Exterior Wall

Figure 4-2
Building 351A Floor Plan
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

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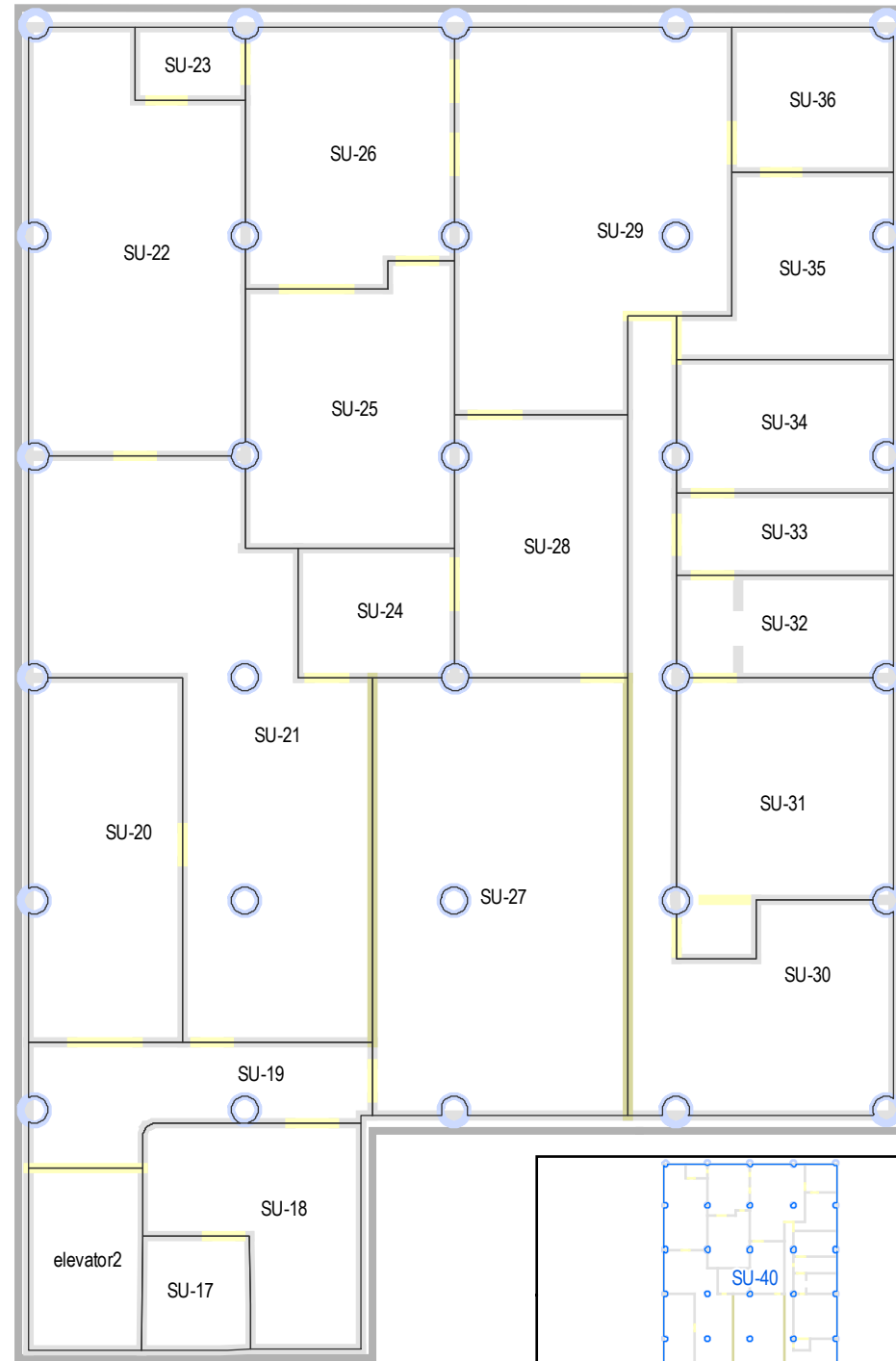
Floor 1



Class 1 Survey Units

Class 2 Survey Units

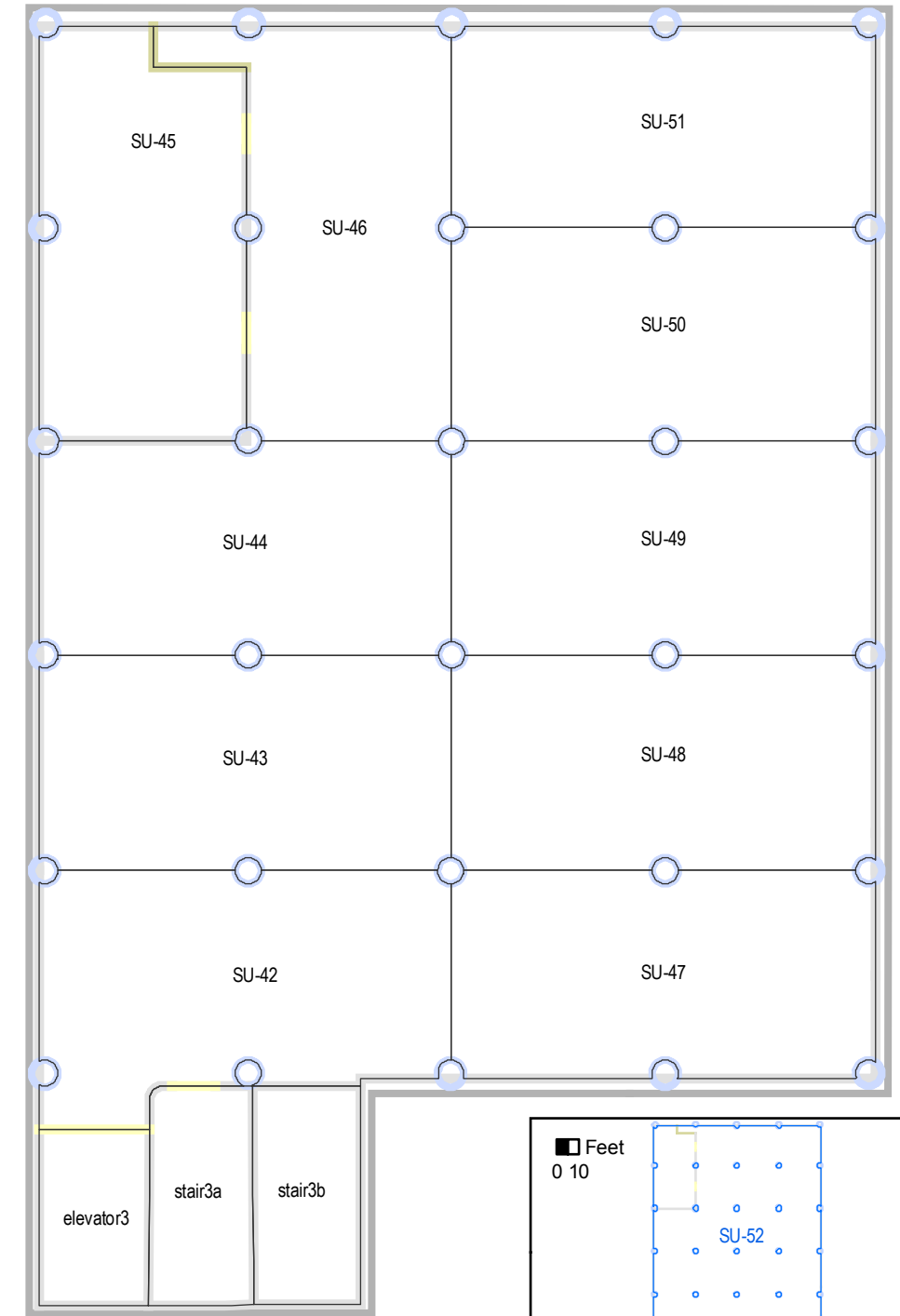
Floor 2



Class 1 Survey Units

Class 2 Survey Units

Floor 3

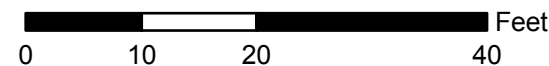


Class 1 Survey Units

Class 2 Survey Units

Legend

- Class 1 Survey Unit (Floor and Lower Wall)
- Class 2 Survey Unit (Ceiling and Upper Wall)
- Trench Unit
- Interior Door
- Exterior Door
- Divider
- Wall
- Column
- Exterior Wall



Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, March 5, 2010, DCN: ECSD-5713-0072-0045.R1" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit and Floor Plan data are based on section 4 figures (2010). Trench Units from CH2M Phase 1 report. Dimensions are approximate.

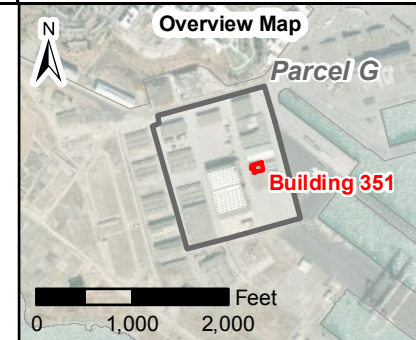
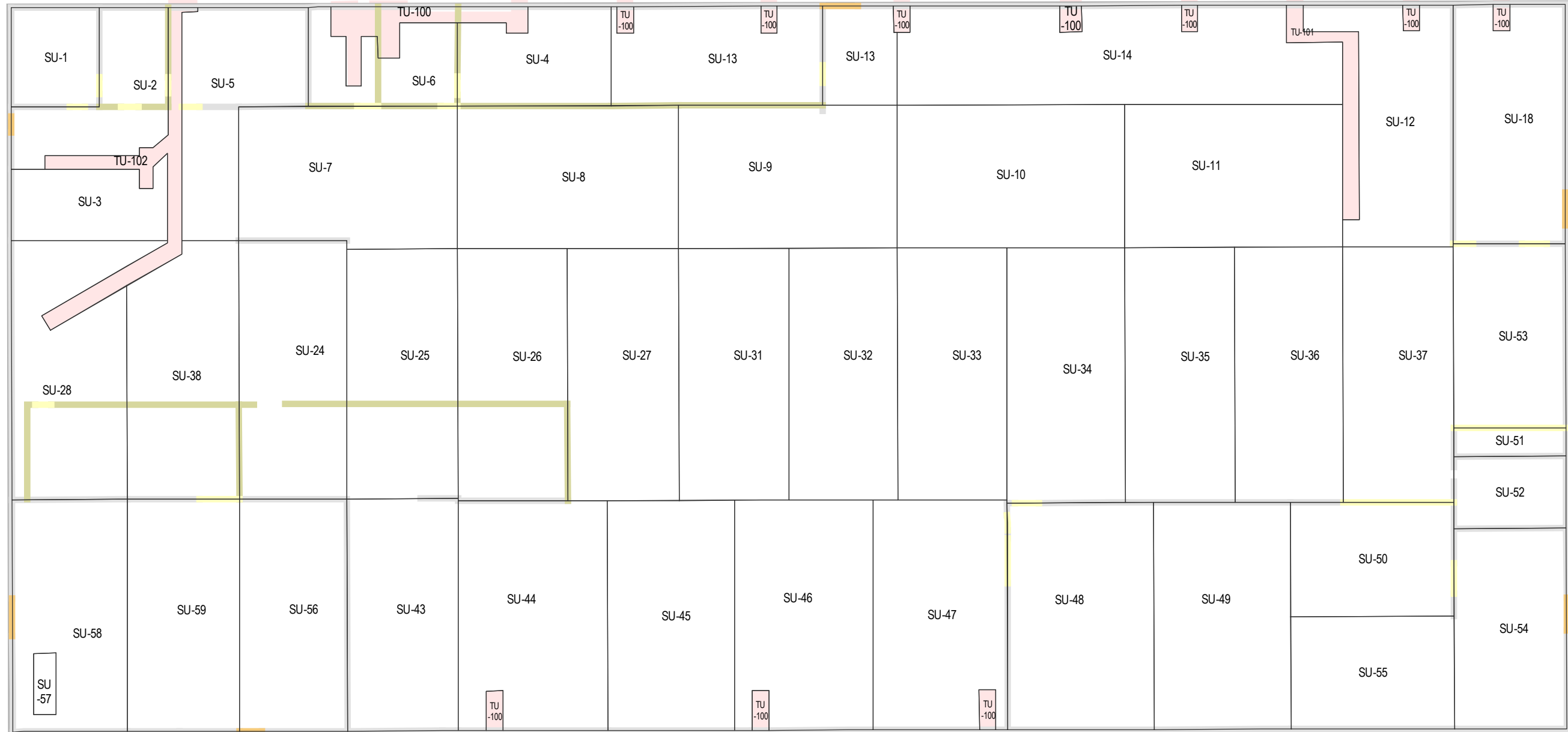


Figure 4-3
Building 351 Floor Plan
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

Class 1 Survey Units



Additional Survey Units (not drawn):

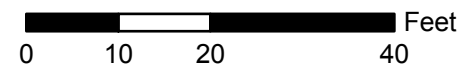
SU 69 consists of the building exterior surfaces, designated as Class 3.

SU 70 is a mezzanine level in the southwest corner of the building. If it can be safely accessed, it will be surveyed as a Class 1 SU.

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, December 30, 2009, DCN: ECSD-5713-0072-0043" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on figures 1-2 (2007), 2-7 (2008), and 4-2 (2008). Trench Units from CH2M Phase 1 report. Dimensions are approximate.



Legend

- Class 1 Survey Unit (Floor and Lower Wall)
- Class 2 Survey Unit (Ceiling and Upper Wall)
- Trench Unit
- Pitched Roof
- Truss
- Upper Wall
- Interior Door
- Exterior Door
- Wall
- Exterior Wall
- Divider
- Wall
- Exterior Wall

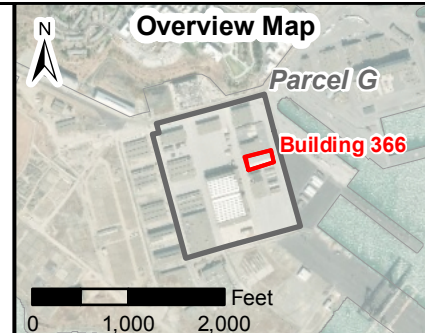
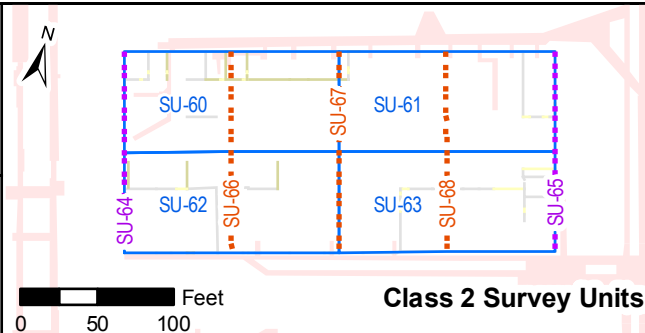
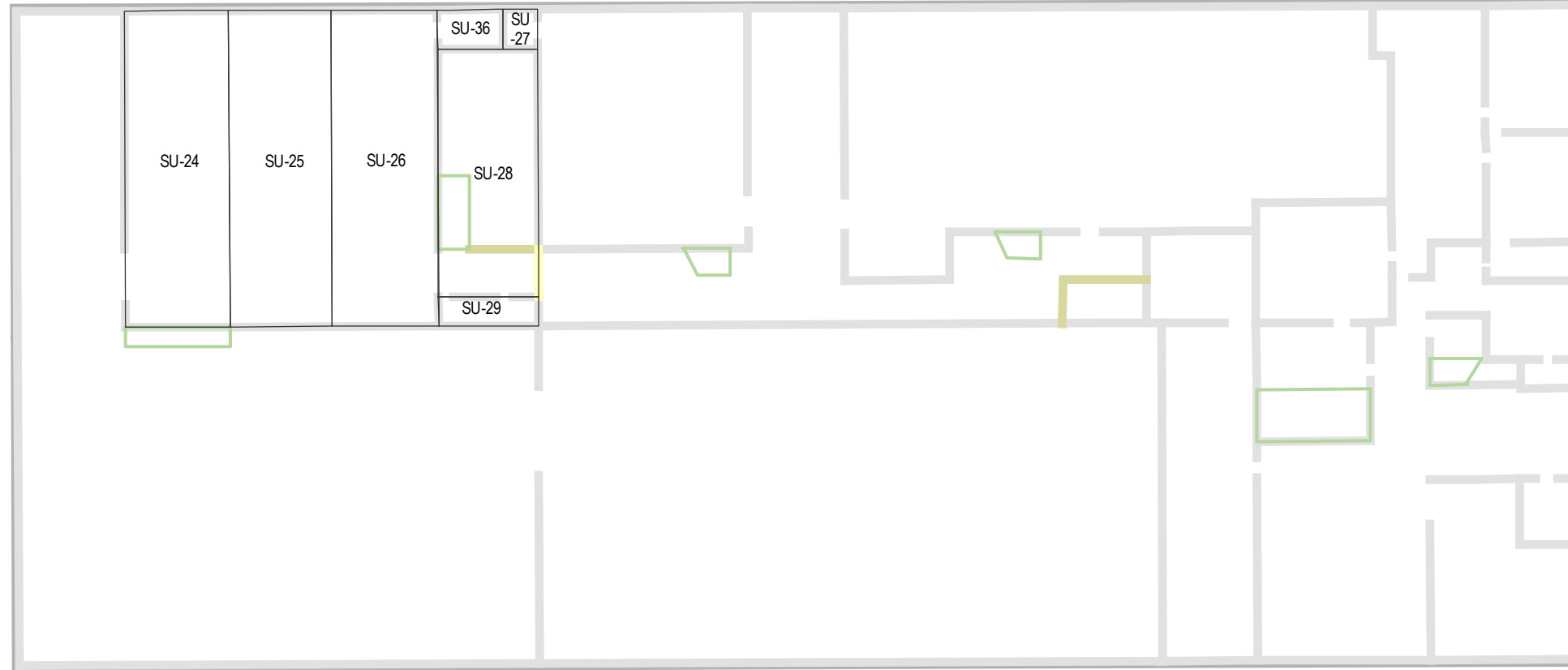
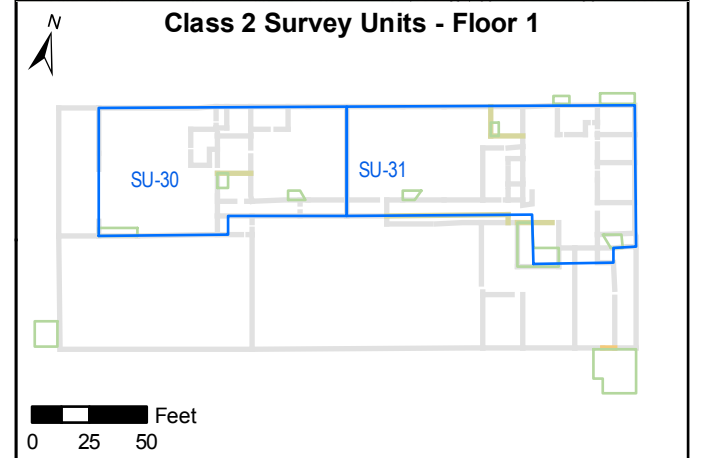
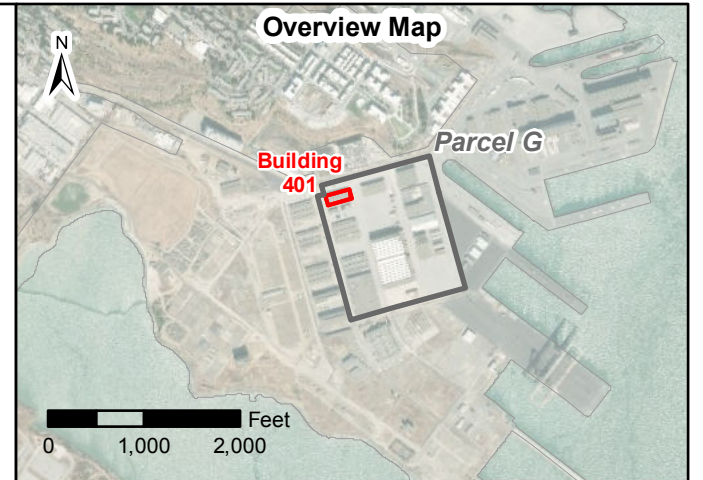


Figure 4-4
Building 366 Floor Plan
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

Class 1 Survey Units



Floor 2



0 5 10 20 Feet



Floor 1

Legend

- Class 1 Survey Unit (Floor and Lower Wall)
- Class 2 Survey Unit (Ceiling)
- Floorplans**
- Interior Door
- Exterior Door
- Divider
- Stairs
- Wall
- Exterior Wall

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

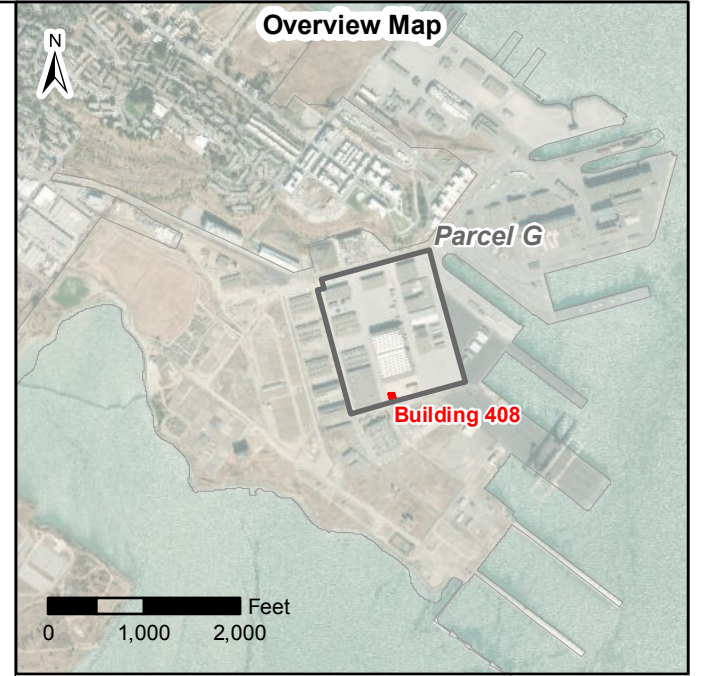
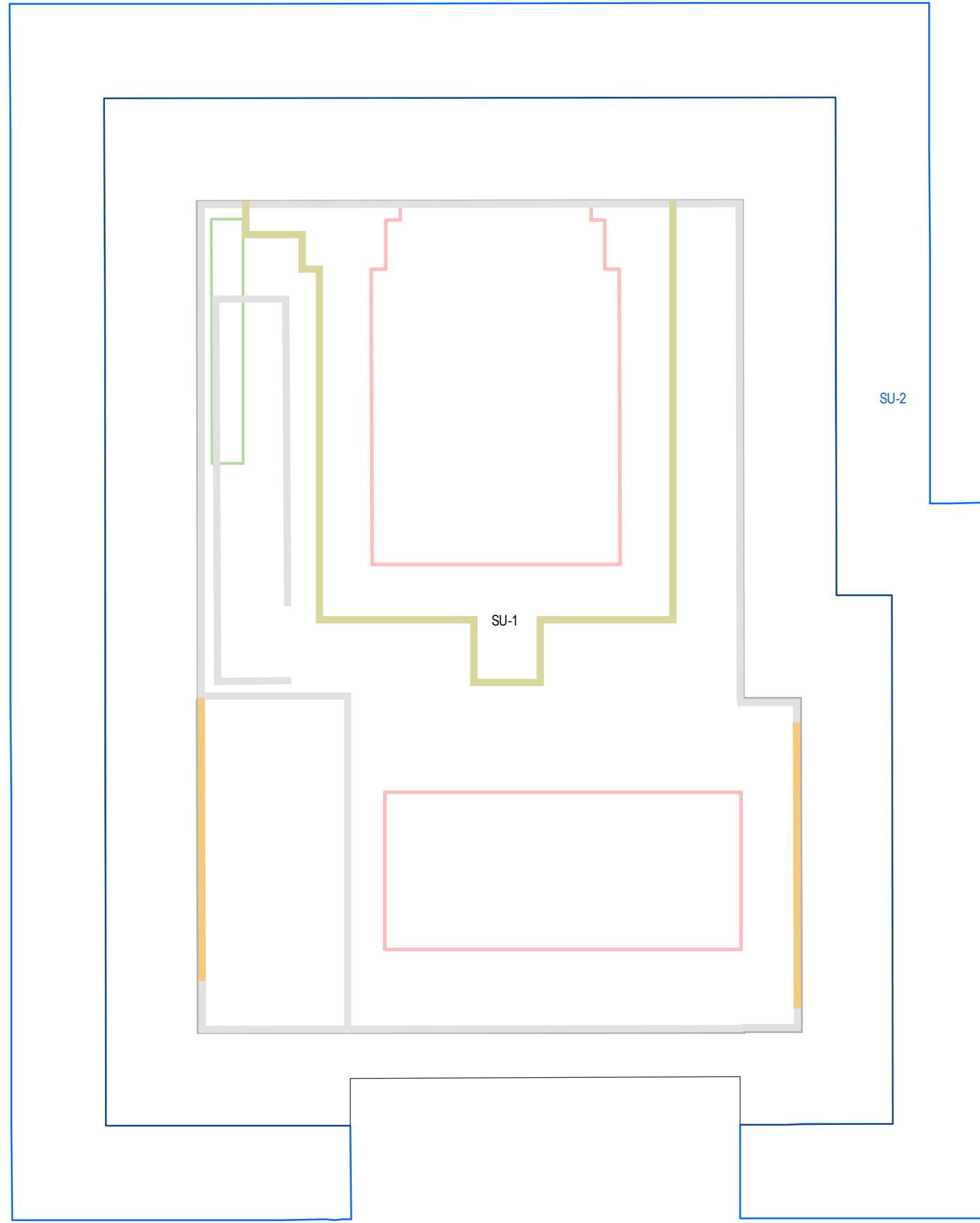
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, September 21, 2009, DCN: ECSD-5713-0072-0015.R1" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on section 4 figures (2009) and Floor Plans (2008). Dimensions are approximate.









Figure 4-5
Building 401 Floor Plan
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

I:\projects\GIS\SHARE\ENR\G00_Proj\Navy\CLIFANS\Southwest\Hunters_Point_NavalShipyard\WorkPlans\Figures\4-5_ParcelG_Building401.mxd harrimand 9/27/2018 5:38:45 PM

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Legend

-  Class 1 Survey Unit
-  Class 2 Survey Unit
- Floorplans**
-  Demolished Exterior Door Location
-  Demolished Divider Location
-  Demolished Wall Location
-  Demolished Stairs Location
-  Demolished Furnace Location
-  Existing Concrete Floor

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, July 8, 2009, DCN: ECSD-S713-0072-0019.R1" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Floorplan data are based on Figure 1-1. Survey Unit data based on Figure 4-1 (2008). Dimensions are approximate.

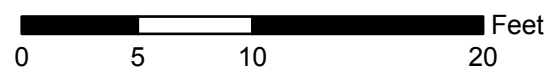
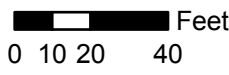


Figure 4-6
Building 408 Floor Plan
Parcel G Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

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Additional Survey Units (not drawn):

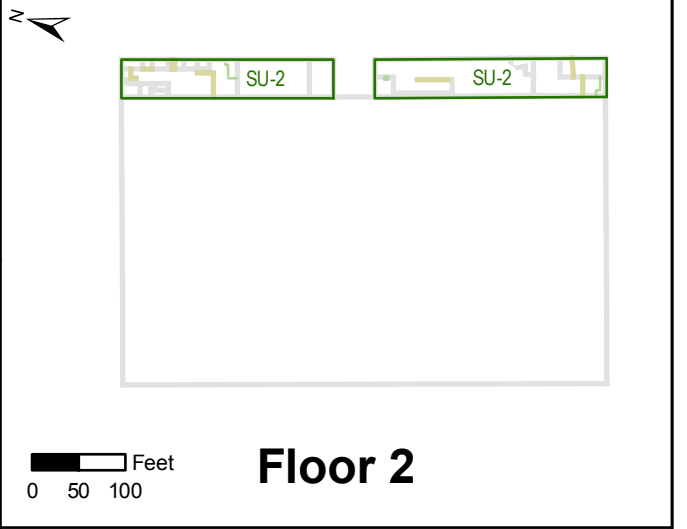
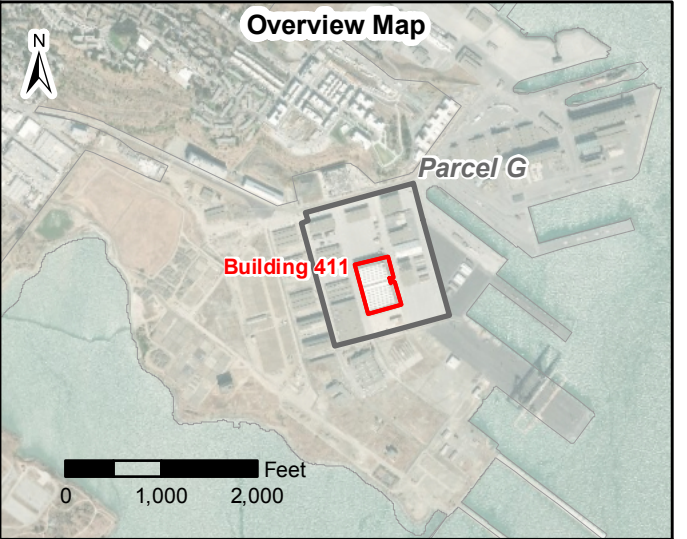
The third floor and mezzanine are no longer accessible because of concerns about structural stability; therefore, the Class 3 SU 1 that was previously surveyed is not included in this investigation. Access points to that area will be included with surveys of adjacent SUs.

Floor 1

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

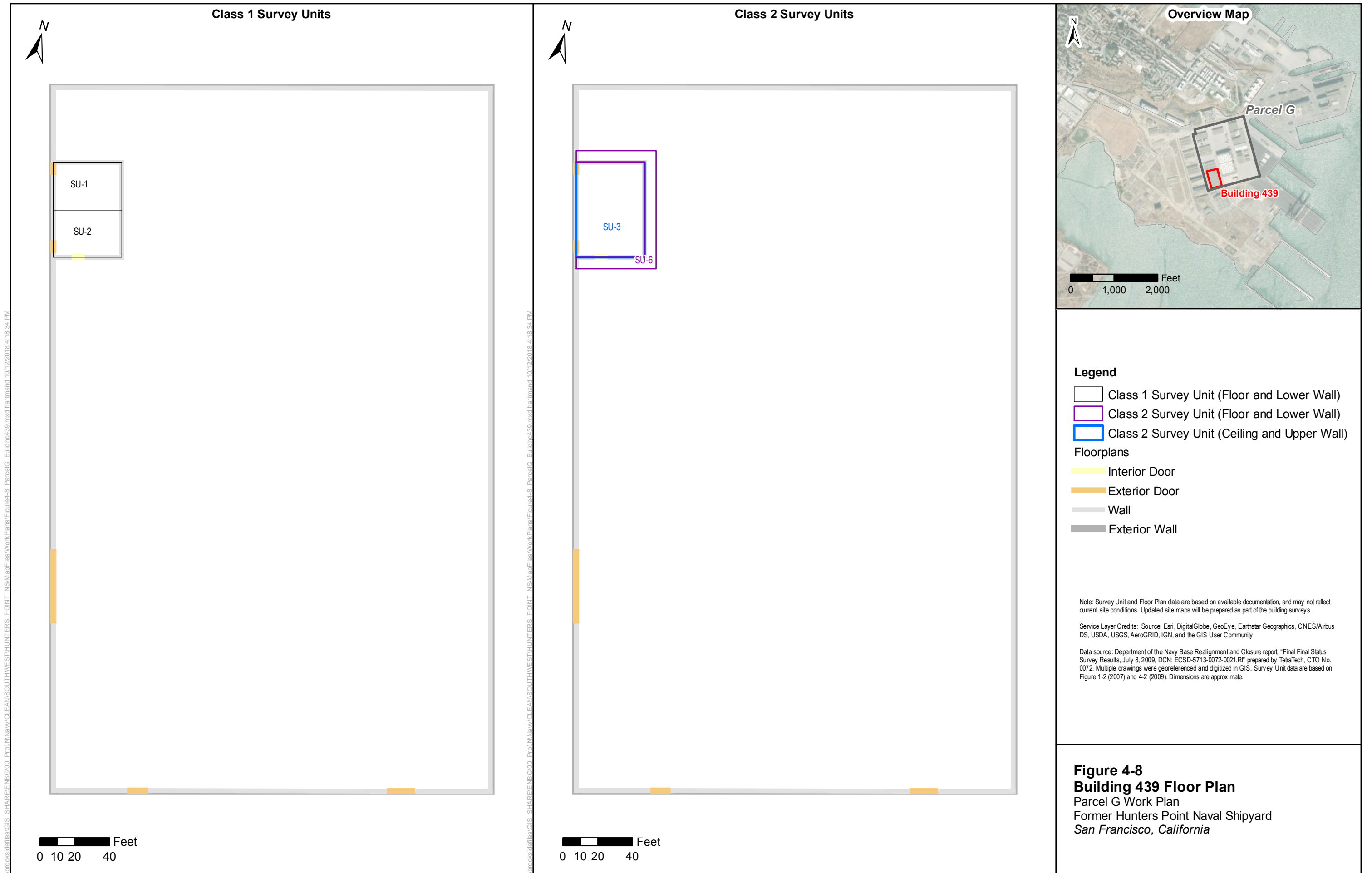
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, July 6, 2010, DCN: ECSD-S713-0072-0081" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Floor 1 data are based on Figure 4-5 (2010). Dimensions are approximate.



- Legend**
- Class 1 Survey Unit (Floor)
 - Class 2 Survey Unit (Floor)
 - Class 3 Survey Unit (Floor)
- Floorplans
- Interior Door
 - Exterior Door
 - Divider
 - Wall
 - Stairs
 - Exterior Wall

Figure 4-7
Building 411 Floor Plan
Parcel G Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California



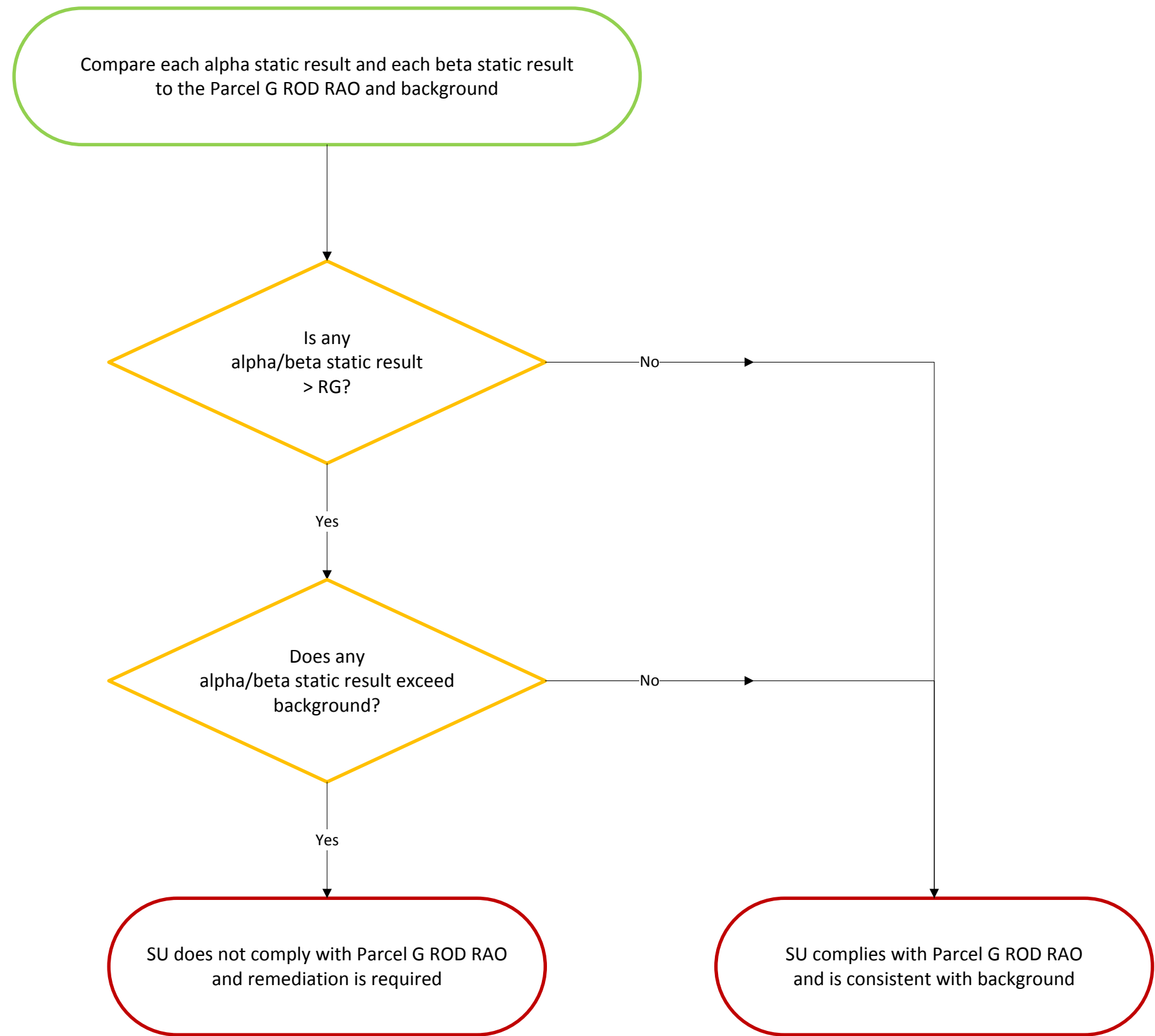
- Legend**
- Class 1 Survey Unit (Floor and Lower Wall)
 - Class 2 Survey Unit (Floor and Lower Wall)
 - Class 2 Survey Unit (Ceiling and Upper Wall)
- Floorplans**
- Interior Door
 - Exterior Door
 - Wall
 - Exterior Wall

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, July 8, 2009, DCN: ECSD-5713-0072-0021.RI" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on Figure 1-2 (2007) and 4-2 (2009). Dimensions are approximate.

Figure 4-8
Building 439 Floor Plan
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



Acronyms:

RAO = remedial action objective

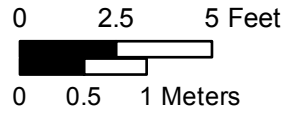
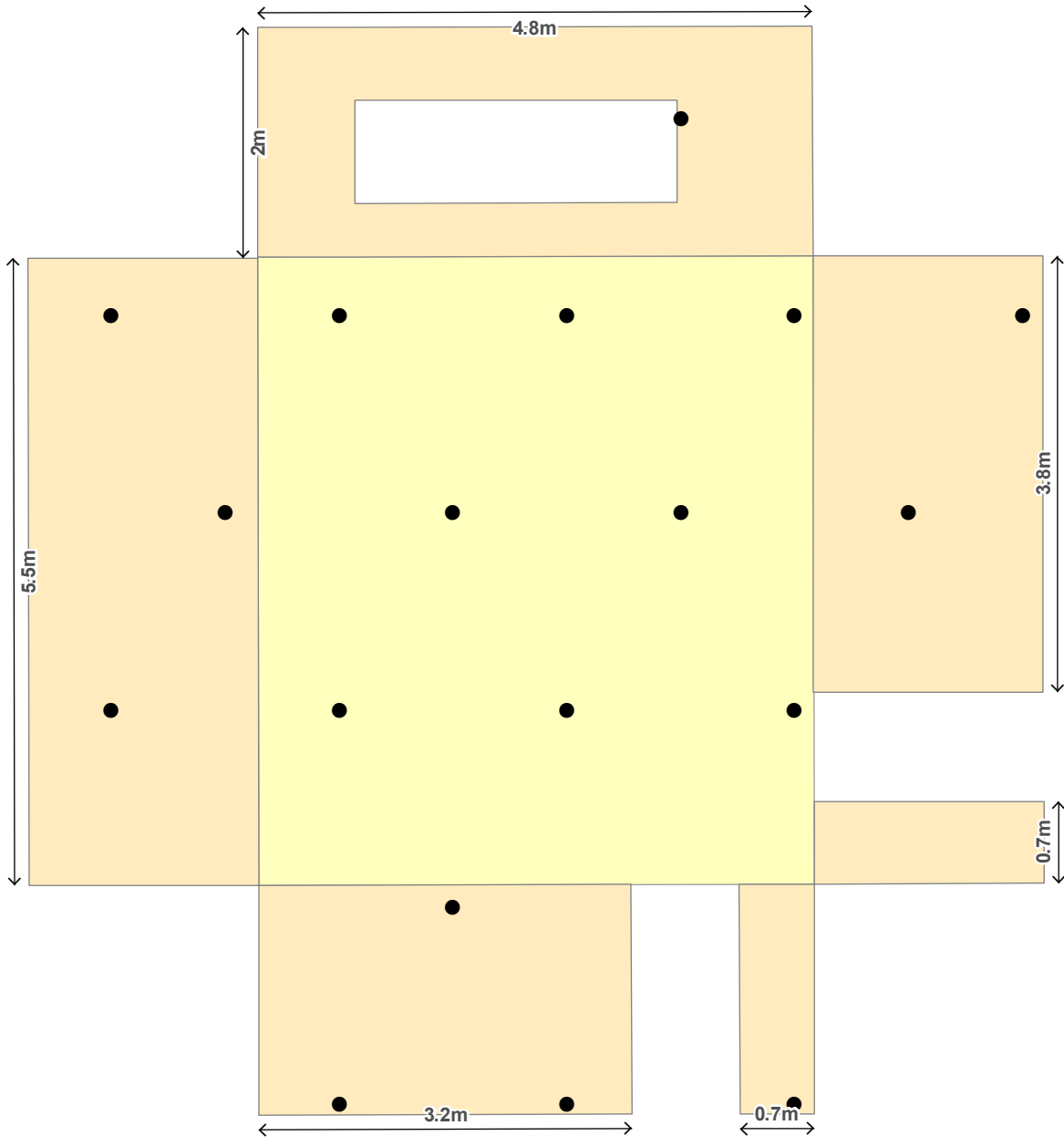
RG = remediation goal

ROD = record of decision

SU = survey unit

Figure 4-9
Performance Criteria for Demonstrating Compliance with the Parcel G ROD – Buildings

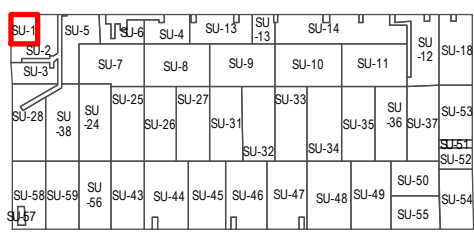
Parcel G Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Legend

- Systematic Static and Swipe Location
- Estimated Wall Area* = 35 m²
- Floor Area* = 26 m²

Total Area* = 61 m²
 *Areas are estimates, may not sum to total due to rounding

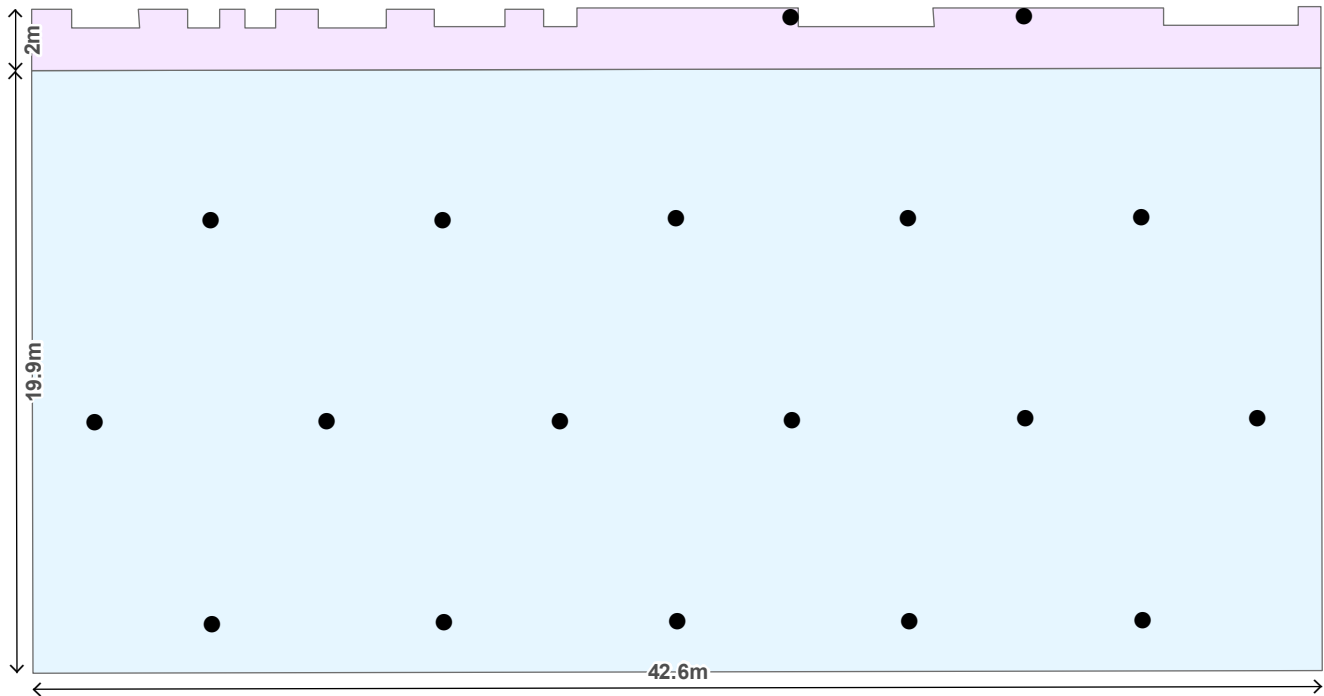


Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, December 30, 2009, DCN: ECSD-5713-0072-0043" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on figures 1-2 (2007) and 4-2 (2008). Trench Units from CH2M Phase 1 report. Dimensions are approximate.

Figure 4-10
Example Building Class 1
Survey Unit and Sample Locations
(Building 366 Survey Unit 1)
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

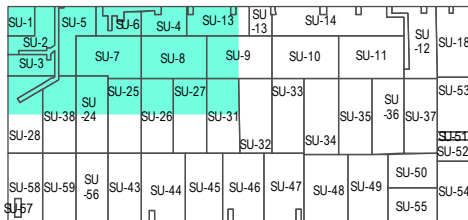
\\brooksides\files\GIS - SHARE\ENB\300 - Protin\Nav\CL EANSOUTH\HUNTERS POINT - NS\MapFiles\WorkPlans\Figure4-11 - ParcelG - Building366 - EXCIZ.mxd hartmand 9/28/2018 11:12:15 AM



Legend

- Systematic Static and Swipe Location
- Estimated Ceiling Area* = 850 m²
- Estimated Upper Wall Area* = 74 m²

Total Estimated Area* = 923 m²
 *Areas are estimates, may not sum to total due to rounding.



- Class 1 Survey Units (Floors and Lower Walls)
- Class 2 Survey Unit (Ceiling and Upper Walls): SU-60

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, December 30, 2009, DCN: ECSD-5713-0072-0043" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on figures 1-2 (2007), 2-7 (2008), and 4-2 (2008). Trench Units from CH2M Phase 1 report. Dimensions are approximate.

Figure 4-11
Example Building Class 2
Survey Unit and Sample Locations
(Building 366 Survey Unit 60)
 Parcel G Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

Data Evaluation and Reporting

Data from the radiological investigation will be evaluated to determine whether the site conditions are compliant with the Parcel G ROD RAO. If the residual ROC concentrations are below the RGs in the Parcel G ROD or are shown to be NORM or anthropogenic background, then the site conditions are compliant with the Parcel G ROD RAO.

Radiological surveys will include scan measurements of accessible surfaces combined with collection and analysis of samples and static measurements on building interior surfaces. Scan measurements are used to identify potential areas of elevated radioactivity for investigation using biased samples and static measurements and are not used to directly demonstrate compliance with the Parcel G ROD RAO. Sample and static measurement results at systematic, random, and biased locations are used to evaluate compliance with the Parcel G ROD RAO. A separate compliance decision will be made for each ROC for each sample and static measurement.

In general, the following actions will occur during data evaluation and reporting:

- Scan data will be evaluated to identify potential areas of elevated activity for additional investigation, as follows:
 - Confirm that required scan surveys have been performed on accessible surfaces as described in **Section 3** for soil and **Section 4** for buildings.
 - Scan data will be verified as described in the SAP (**Appendix B**).
 - DQA will be performed on scan data as described in **Section 5.2**.
 - Potential areas of elevated activity will be identified as described in **Section 5.3.1**.
 - Potential areas of elevated activity will be investigated as described in **Section 5.3.2**.
- Soil sample and static measurement data will be evaluated to determine whether site conditions comply with the Parcel G ROD RAO, as follows:
 - Confirm that required soil samples have been collected from systematic and biased locations as described in **Section 3** and required building measurements have been performed as described in **Section 4**.
 - Confirm that samples have been submitted to the laboratory and backup samples have been archived in a secure area under chain-of-custody protocols.
 - Confirm that laboratory analyses have been performed as described in the SAP (**Appendix B**).
 - All analytical data will be validated by an independent third party.
 - DQA will be performed as described in **Section 5.2**.
 - Sample and direct measurement results will be compared to the corresponding RGs as described in **Section 5.4**.
 - Sample and direct measurement results will be compared to the appropriate RBA data from HPNS as described in **Section 5.5**.
 - Samples with gamma spectroscopy results that exceed the RG and the expected range of background for ^{226}Ra will be analyzed by alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra to evaluate the equilibrium status of

the uranium natural decay series to determine whether ^{226}Ra is NORM as described in **Section 5.6**.

- Results of the investigation will be documented as described in **Section 5.7**.

5.1 Data Quality Validation

Analytical data validation will be performed by an independent third party as described in the SAP (**Appendix B**). Data validation will be performed on all TU/SU data and all RBA data.

5.2 Data Quality Assessment

The DQA is a scientific and statistical evaluation that determines whether the survey data are the right type, quantity, and quality to support the survey objectives (USEPA, 2006). There are five steps in the DQA process:

1. Review the DQOs and survey design.
2. Conduct a preliminary data review.
3. Select the statistical test.
4. Verify the assumptions of the statistical test.
5. Draw conclusions from the data.

The effort expended during the DQA should be consistent with the graded approach used to develop the survey design. The DQA process will be applied to all SU data and all RBA data.

5.2.1 Review the Data Quality Objectives and Survey Design

The sampling design and data collection documentation will be reviewed for consistency with the DQOs. At a minimum, this review will include:

- Number of soil samples or measurements in each SU
- Location of soil samples and measurements
- Measurement technique (i.e., scan, static, sample, or swipe) and instrumentation
 - Measurement uncertainty
 - Detectability (critical level and MDC)
 - Quantifiability
- Statistical power

The purpose of the review should focus on identifying the information required to complete the evaluation of the data, the determination of whether the survey objectives were achieved will be completed during Step 5 of the DQA Process (see **Section 5.2.3**).

5.2.2 Conduct a Preliminary Data Review

A preliminary data review will be conducted to learn about the structure of the data by identifying patterns, relationships, or potential anomalies. The preliminary data review will include calculating statistical quantities, preparing posting plots of scan and sample data, preparing histograms of scan and sample data, preparing quantile-quantile (Q-Q) plots (sometimes referred to as normal probability plots) of scan and sample data, preparing box plots of scan and sample data, preparing retrospective power curves, and analysis of data distributions.

If additional data evaluation tools are used to support conclusions concerning compliance with the Parcel G ROD RAO, the report will provide a complete description of the evaluation performed and any assumptions used. For example, if a contour plot is provided to describe site conditions, the report would contain a description of the contouring technique used, a list of parameter values and

assumptions used to prepare the contour plots, a copy of the contour plot, and an interpretation of the contour plot relative to compliance with the Parcel G ROD RAO.

5.2.2.1 Convert Survey Results

The RGs for soil (**Table 3-5**) are stated in units of pCi/g, and soil sample results from analytical laboratories will be reported in units of pCi/g, so no conversion will be necessary for soil sample data.

The RGs for buildings surfaces (**Tables 4-2 and 4-3**) are stated in units of dpm/100 cm²; however, alpha and beta static measurement results will be reported in units of counts during a specified counting interval, while scan measurement results will be reported in units of cpm. Example ILs for alpha and beta scan measurements are provided in **Table 4-7** where the RGs have been converted into cpm using **Equation 4-2** and example total efficiencies from **Table 4-6**. Example ILs for alpha and beta static measurements are provided in **Table 4-9** where the RGs have been converted into counts using **Equation 4-8** and example total efficiencies from **Table 4-6**. Instrument-specific total efficiencies and material-specific backgrounds will be determined in the field, along with instrument-specific ILs corresponding with the RGs for alpha and beta static and scan measurements on building surfaces.

Once all the survey results and RGs are available in the same or comparable units, the evaluation of the data can continue.

5.2.2.2 Calculate Statistical Quantities

The mean, median, standard deviation, minimum, and maximum for each data set will be reported. Other statistical quantities that may be reported to describe individual data sets include percentiles (25th and 75th for interquartile range, 95th and 99th for upper bound estimates), skewness (a measure of deviation from normal), coefficient of variation, and total number of data points in the data set.

5.2.2.3 Prepare Posting Plots

Posting plots are maps on which measurement results are shown at the location where the measurement was performed. Posting plots will be prepared for scan survey data, and static and swipe data from biased, systematic, and random locations on building surfaces. Posting plots of soil sample locations may also be prepared for Phase 1 TUs, Phase 2 TUs, and surface soil SUs. Posting plots will be prepared for each SU but are not required for each RBA.

Posting plots are inspected to identify patterns or inconsistencies in the data, especially potential areas of elevated activity requiring additional investigation or spatial trends identifying survey data that are not independent, violating the assumptions of the statistical tests. Posting plots may be prepared using counts, count rates, concentrations, or normalized data (standard deviations or z-scores) allowing comparison of results from multiple detectors or different measurement methods. Posting plots are most useful when presented in the same units as the RGs or ILs being evaluated.

5.2.2.4 Prepare Histograms

Histograms, or frequency plots, are used to examine the general shape of a data distribution. Histograms will be prepared for scan survey data, static and smear survey data from systematic and random locations, and soil sample data from systematic locations for each SU and RBA. Biased survey data do not need to be included when preparing histograms; however, care should be taken when interpreting histograms that include data collected from biased locations. Histograms reveal obvious departures from symmetry, including skewness, bimodality, or significant outliers.

5.2.2.5 Prepare Q-Q Plots

Q-Q plots compare a data distribution to an assumed normal distribution. Q-Q plots will be prepared for scan survey data, static and smear survey data from systematic and random locations, and soil sample data from systematic locations for each SU and RBA. Biased survey data do not need to be included

when preparing Q-Q plots; however, care should be taken when interpreting Q-Q plots that include data collected from biased locations.

Background data usually approximate a normal distribution, so comparing SU data to a normal distribution is one technique in comparing survey data to background. Data from a normal distribution appear as a straight line on a Q-Q plot, so deviations from a straight line indicate potential deviations from a normal distribution, or potential deviations from background. Normal probability plots from different data sets, such as a SU and an RBA or adjacent SUs, can be shown on the same graph to allow for direct comparisons between multiple data sets.

5.2.2.6 Prepare Box Plots

Box plots are a non-parametric graphical depiction of numerical data based primarily on quartiles (25th, 50th, and 75th percentiles). Box plots may include whiskers showing extreme values, usually the minimum and maximum. Box plots may also show outliers as individual points. The ends of the whiskers and selection criteria for outliers are not standardized and may represent different values depending on the underlying assumptions.

Box plots provide visual estimates of dispersion and skewness for a data set including the range, interquartile range, and median. Box plots from different data sets, such as an SU and a RBA or adjacent SUs, can be shown on the same graph to allow for direct comparisons between multiple data sets.

5.2.2.7 Prepare Retrospective Power Curves

A retrospective power curve provides an evaluation of the survey design and is used to demonstrate enough data were collected to support decisions regarding the radiological status of the SU. Retrospective power curves will be prepared for static and smear survey data from systematic and random locations, and soil sample data from systematic locations for each SU. Biased survey data will not be included when preparing retrospective power curves. The retrospective power curve is compared with the DQOs (**Section 3.1** and **Section 4.1**) and the Type II decision error rates from Section 4.4.6 of the Basewide Radiological Management Plan (TtEC, 2012), to evaluate whether a sufficient number of samples was collected.

No statistical tests are required for individual data sets because compliance with the Parcel G ROD RAO is based on point-by-point comparisons. Because the number of measurements per SU was determined assuming that a statistical test would be performed, the retrospective power curve assists in determining whether the survey design was adequate and is not directly related to compliance decisions.

5.2.2.8 Analysis of Data Distributions

The distribution of data within a data set can provide important information during data evaluation. Determining the type of distribution may be important for selecting additional evaluation tools to answer specific questions about individual data sets. The analysis of data distributions for this investigation may be used primarily for establishing MLE values for RBA data sets (**Appendix C**).

Environmental data are most often associated with three distributions: normal, lognormal, or gamma. Statistical tests to identify a distribution have a null hypothesis that the data set comes from the distribution being tested. This means there must be sufficient evidence showing that the data do not follow a specific distribution before the initial assumption is rejected. For this reason, it is not unusual for a data set to be associated with more than one type of distribution. Moreover, negative values in a data set cannot provide results for analyzing lognormal or gamma distributions.

Individual data sets will be analyzed to determine whether the data appear to follow a normal, lognormal, or gamma distribution at a 5 percent significance level using software such as ProUCL. Data

sets that do not follow at least one of these distributions will be identified as not following any known distribution and will be evaluated using nonparametric tools and tests.

5.2.3 Draw Conclusions from the Data

Figures 3-2 and **4-9** present an overview of how decisions for soil and building data, respectively, are combined to draw a conclusion on compliance with the Parcel G ROD RAO. Each sample and static measurement result will be compared to the corresponding RG. If all residual ROC concentrations are less than or equal to the corresponding RG, then site conditions comply with the Parcel G ROD RAO.

Sample and measurement data will be compared to appropriate RBA data from HPNS, and multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include population-to-population comparisons, use of a MLE or BTV, graphical comparisons, and comparison with regional background levels. If all residual ROC concentrations are determined to be consistent with NORM or anthropogenic background, site conditions comply with the Parcel G ROD RAO.

Each ^{226}Ra gamma spectroscopy result exceeding the ^{226}Ra RG and outside the expected range of background will be compared to concentrations of other radionuclides in the uranium natural decay series from the same sample. If the concentrations of radionuclides in the uranium natural decay series are consistent with the assumption of secular equilibrium, then the ^{226}Ra concentration is NORM, and site conditions comply with the Parcel G ROD RAO.

If the investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically-based RGs¹¹ at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a RACR will be developed.

If the investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically-based¹¹ RGs at agreed upon statistical confidence levels and are not shown to be NORM or anthropogenic background, remediation will be conducted, followed by a RACR. The RACR will describe the results of the investigation, explain remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel G ROD RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.

5.3 Investigation of Potential Areas of Elevated Activity

The investigation of potential areas of elevated activity consists of comparing each measurement result from every SU with the ILs discussed in **Section 3.3.1** for soil, **Section 4.5.8.2** for building scans, and **Section 4.5.8.6** for building static measurements. In general, the ILs are consistent with the RG values. This investigation is performed for all measurement results; scans, static measurements, and samples, at systematic, random, and biased locations. The investigation of potential areas of elevated activity ensures that unusually high measurement and sample results will receive proper attention, and any area having the potential for significant contributions to total dose will be identified.

5.3.1 Identify Potential Areas of Elevated Activity

Scan data, measurement data, and sample data will be evaluated to identify statistical and spatial anomalies indicating potential areas of elevated activity. All scan data will be compared directly to RGs or ILs. Posting plots will be used to identify trends and patterns in the scan data to help in identifying potential areas of elevated activity and support defining the areal extent of potential areas of elevated

¹¹ The RGs are statistically based because they are increments above a statistical background.

activity. Histograms and Q-Q plots will be used to identify significant outliers and evidence of multiple distributions to identify potential areas of elevated activity. Any sample or measurement exceeding a ROC-specific RG will be investigated as a potential area of elevated activity. In addition, SU areas with multiple lines of evidence indicating a potential increase in localized activity based on posting plots, histograms, and Q-Q plots of scan, static measurement, or sample data will be investigated as a potential area of elevated activity.

If direct measurement or sample results exceed the RG or IL for a specific ROC for locations not identified by scan survey, the scan survey technique will be reviewed and investigated to determine whether the scan survey was implemented correctly and whether the scan methodology met the survey objectives.

5.3.2 Investigate Potential Areas of Elevated Activity

The objective of investigating potential areas of elevated activity is to characterize the ROCs present and the size, or extent, of all areas of elevated activity. To accomplish this objective, a minimum of one potential area of elevated activity will be investigated in every SU. If no potential areas of elevated activity are identified in a TU/SU based on **Section 5.3.1**, the location of the maximum scan result will be identified as a potential area of elevated activity.

The first step in investigating potential areas of elevated activity is to confirm the measurement or sample results that indicated the potential area of elevated activity. For alpha and beta scans, this may be accomplished by pausing during scanning to collect additional information, or it may require returning to a location to perform a biased static measurement. For gamma scans this may involve rescanning the area surrounding the potential elevated reading, sifting through near surface soil for a discrete source of activity (e.g., deck marker), or collecting a biased soil sample for analysis. The selection of the confirmatory action will depend on the initial results and the decision on whether the original results are confirmed. In general, minimal information is acceptable when deciding to continue with the investigation of a potential area of elevated activity. In most cases, at least one measurement or sample result documenting the lack of elevated activity will be required to support a decision to terminate the investigation of a potential area of elevated activity.

Once the presence of an area of elevated activity has been confirmed, the ROCs present will be identified. In most cases the identification of ROCs can be accomplished using existing data. For building surfaces, it is sufficient to identify the elevated activity as alpha, beta, or a combination of alpha and beta radiation. For soil samples, it is generally necessary to identify the radionuclide based on laboratory analysis.

The final step in investigating areas of confirmed elevated activity is determining the area, or extent, of the elevated results. The identification of the ROCs present will assist in determining whether additional data are required to determine the extent of elevated activity, and the number and type of measurements or samples that will be used for that determination. For building surfaces, the posting plot of the scan data is generally all that is needed to determine the extent of elevated readings. The determination may be accomplished similarly for soil areas when the ROC is ^{226}Ra and the elevated activity is readily detected by scan surveys. Determining the extent of elevated activity for ROCs without a significant gamma emission, such as ^{90}Sr and ^{239}Pu , will require collecting additional soil samples or establishing a correlation between the difficult-to-detect ROC and ^{226}Ra . Even when a correlation can be determined, the scan survey objectives will need to be reviewed and adjusted to account for detecting ^{226}Ra at lower activity levels. If the elevated activity is associated with ^{90}Sr or ^{239}Pu results significantly above background, a Field Change Request will be initiated to document the characterization of any potential areas of elevated activity. The results of the investigation should identify an area of elevated activity bounded by measurements or sample results below the RGs or ILs.

If all alpha or beta static measurement or ROC-specific soil sample analysis result are less than the RGs or ILs, compliance with the Parcel G ROD RAO is achieved.

5.4 Comparison to RG Values

The Parcel G ROD establishes RGs for soil and building surfaces. These RG values are provided in **Table 3-5** for soils and **Tables 4-2** and **4-3** for building surfaces.

Analytical data from systematic and biased surface and subsurface soil sample results will be compared directly with the RGs listed in **Table 3-5**. Each soil sample will have gamma spectroscopy data for ^{137}Cs (reported from its 661-keV peak) and ^{226}Ra (reported using the 609-keV gamma emission from ^{214}Bi following a 21-day ingrowth period). For all soil TUs and SUs, 10 percent of samples will have analysis for ^{90}Sr performed. In addition, a minimum of 10 percent of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for ^{239}Pu at the Former Building 317/364/365 Site. These analytical results will be compared directly with the RGs listed in **Table 3-5** to determine compliance with the Parcel G ROD RAO.

^{137}Cs is considered to be the indicator for all fission product radionuclides associated with NRD activities. The limited number of systematic samples analyzed for ^{90}Sr and ^{239}Pu will serve to supplement the investigation. Sample results above the ^{137}Cs RG will trigger additional analyses in the same sample for ^{90}Sr or ^{239}Pu . The results of these additional analyses will be compared directly with the corresponding RG value for ^{137}Cs , ^{90}Sr , and ^{239}Pu . Based on the inability to perform gamma scanning for these radionuclides at the RG, demonstrating compliance with the Parcel G ROD RAO will be based on soil sample analytical results.

The RGs for building surveys are listed in **Table 4-2**. Static measurement results will be provided for total alpha and total beta activity and are not radionuclide-specific. Therefore, the lowest RG values for alpha and beta emitting ROCs will be selected and are listed in **Table 4-3**. Total alpha and total beta results will be corrected for material-specific background and reported as net activity above the mean activity for that material from the RBA representing background for a specific building, on a specific material, using a specific detector. The net total activity will be compared directly with the corresponding RG.

If all sample and direct measurement results are less than or equal to the corresponding RG, then the site conditions are compliant with the Parcel G ROD RAO, and a RACR can be prepared as described in **Section 5.7**.

5.5 Comparison to Background

Sample and static measurement data shown to be NORM or anthropogenic background comply with the Parcel G ROD RAO, even if the results exceed the corresponding RG value. In addition, to address California Department of Public Health requirements for radiological release specified in California Code of Regulations Title 17, Section 30256, a comparison of site data with background will be performed.

RBA data sets for soil will be developed as described in the Soil RBA Work Plan (**Appendix C**) or selected from existing RBA data sets determined to be representative of soil at HPNS. RBA data sets for building surfaces will be developed as described in **Section 4.4.2** to provide building-specific, material-specific, and instrument-specific RBA data. Final selection of RBA data sets will be reviewed by the Navy, USEPA, and the State of California.

The comparison of site data with background may include, but is not limited to, the following:

- **Population-to-population comparisons.** Site data sets may be compared with RBA data using parametric or nonparametric tests, depending on the distributions of the data. Following the performance of any population test, the underlying assumptions of the test will be verified.
- **Use of an MLE or BTV.** A point-by-point comparison of site data with the MLE or BTV may be performed if RBA data allow for calculation of those values. MLE values will be calculated using USEPA's ProUCL software.

- **Graphical comparisons.** Graphical representations of site and RBA data may be useful in visually comparing two or more data sets. Typical graphical tools include histograms, box-and-whisker plots, and probability plots.
- **Comparison with regional background levels.** As noted in **Section 5.5**, much of HPNS was constructed using fill materials from offsite sources. As such, soil conditions at the site are heterogeneous, and the onsite RBAs may not accurately capture background levels of ROCs for all soil types that may be present at HPNS. Where appropriate, available RBA data from other sources may be used for comparison with site data.

If all residual ROC concentrations are consistent with NORM or anthropogenic background, site conditions comply with the Parcel G ROD RAO. If any ^{226}Ra gamma spectroscopy results for soil exceed the RG and the expected range of NORM concentrations, the equilibrium status of the uranium natural decay series will be evaluated for the sample as described in **Section 5.6**.

5.6 Determine Equilibrium Status

The RBA data set for ^{226}Ra and other naturally occurring ROCs will be selected to represent as much of the soil at HPNS as practical. However, the history of HPNS shows that a wide variety of fill materials have been used as part of construction and maintenance activities over the life of the site. These fill materials may have a range of naturally occurring radioactivity, so an incorrect identification of fill material could result, with higher levels of NORM being identified as contamination. To avoid this situation, additional evaluation may be performed for samples in which the ^{226}Ra gamma spectroscopy result exceeds the RG and the expected range of background, but the sample could still indicate association with NORM instead of contamination.

The uranium natural decay series is one of the primordial natural decay series that are collectively referred to as NORM. The members of the uranium natural decay series are present in background at concentrations that are approximately equal, a situation referred to as secular equilibrium. Secular equilibrium for the uranium natural decay series is established over hundreds of thousands of years. Concentrations of ^{226}Ra higher than the concentrations of other members of the uranium natural decay series may indicate contamination, while ^{226}Ra concentrations consistent with other members of the series indicate natural background.

Determining the equilibrium status of the uranium natural decay series requires analyzing a sample for multiple radionuclides from the series using the same or comparable analytical techniques. Observed differences in concentrations result primarily from differences in concentrations, and the uncertainty is primarily associated with the analysis.

Radionuclides from the uranium natural decay series with ^{226}Ra as a decay product (i.e., ^{238}U , ^{234}U , and ^{230}Th) will be analyzed by alpha spectroscopy, along with ^{226}Ra . It is not necessary to analyze for the decay products of ^{226}Ra because these radionuclides re-establish secular equilibrium with ^{226}Ra over a period of several weeks. In addition, most of the ^{226}Ra decay products are not readily analyzed by alpha spectroscopy. If practical, the analyses will be performed using the same sample aliquot to reduce sampling uncertainty. The results of the four analyses will be compared. If the ^{226}Ra result is similar to the results for the other radionuclides, the ^{226}Ra activity is NORM and complies with the Parcel G ROD RAO, and the equilibrium determination will be documented in the RACR. If the ^{226}Ra result is significantly greater than the results for the other radionuclides and exceeds the RG, the elevated ^{226}Ra level may be attributed to site contamination, and remediation may be required.

5.7 Reporting

Results of radiological investigations for buildings and TUs/SUs complying with the Parcel G ROD RAO will be documented in a RACR, and the buildings and TUs/SUs will be recommended for unrestricted radiological release. The RACR will describe the results of the investigation, provide visualizations of spatially correlated data, explain remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel G ROD RAO. The final status survey results, including a comparison to background and discussion of remedial activities performed as part of the investigation, will be included as an attachment to the RACR.

Radioactive Materials Management and Control

Project requirements, including personnel roles and responsibilities, required training, and health and safety protocols are presented in this section. This section was prepared based on CH2M and their subcontractor, Perma-Fix, leading and conducting the field activities presented in this work plan and should be amended for contractor-specific information, as needed. **Appendix D** contains contractor-specific information, including the Radioactive Material License, SOPs, Organizational Chart, and Radiation Protection Plan. A separate APP/SSHP will be prepared to outline the health and safety requirements and procedures for the work included in this work plan.

6.1 Project Roles and Responsibilities

The personnel responsible for the execution of site activities and program oversight is presented in the Organization Chart in **Appendix D**. The Field Team Leader is responsible for overseeing all field activities for this project. The Field Team Leader will serve as the primary point of contact for scheduling and field-related issues. The Radiation Safety Officer (RSO) has overall responsibility for ensuring that fieldwork is conducted by trained staff in accordance with the Radioactive Material License and applicable plans and procedures.

The RSO will be supported by radiation protection staff to implement the requirements of the licensed SOPs and for conducting radiological data collection in accordance with **Sections 3** and **4** of this work plan.

6.2 Licensing and Jurisdiction

The Radioactive Material License is State of California Radioactive Material License 8188-01 (dated November 15, 2017). The license is attached to this work plan in **Appendix D**. Under 10 *Code of Federal Regulations* (CFR) 150.20, Perma-Fix holds a general license to conduct these licensed activities in areas of exclusive federal jurisdiction within the State of California. Authorization will be required from California to work in certain parcels at HPNS. Authorization will be requested and approved before the start of field operations. **Figure 6-1** details the location of the specific parcels that are under exclusive federal jurisdiction and will require authorization. Perma-Fix will request reciprocity from the NRC, using NRC Form 241, to utilize Perma-Fix's State of California Radioactive Material License in areas under NRC jurisdiction. The NRC requires notification a minimum of 3 days prior to beginning licensed activities.

The following are State requirements:

- Under the Radioactive Material License (8188-01) Section 16, Perma-Fix will submit an appropriate notification to the State of California a minimum of 14 days before the start of work.
- Under the Radioactive Material License (8188-01) Section 17, Perma-Fix will obtain an appropriate agreement between Perma-Fix and the Navy. This agreement will be included in the Section 16 submittal.

A Memorandum of Understanding (MOU) for the site has been established and was updated on December 2, 2016 (**Appendix E**). This MOU supersedes all previous MOUs.

6.3 Radiological Health and Safety

Fieldwork will be conducted in accordance with Perma-Fix's State of California Radioactive Material License and associated SOPs. A list the field radiological SOPs that provide the instructions for conducting field activities involving exposure to radiation and radioactive materials and copies of the SOPs are provided in **Appendix D**.

Prerequisites for the initiation of survey activities include review of this work plan, radiological evaluation of the designated work areas, and identification of potential safety concerns. Dose rate, contamination, and air monitoring, including initial baseline sampling to determine radiological background conditions, will be performed as necessary and in accordance with this work plan and the supporting procedural documents, including the SOPs in **Appendix D**. Radiation Work Permits (RWPs) will be prepared in accordance with SOP RP-103, *Radiation Work Permits Preparation and Use*. RWPs will be used to govern radiological health and safety. Personal protective equipment (PPE) levels will be assigned or modified, according to this work plan and APP/SSHP, and included in SOP RP-132, *Radiological Protective Clothing Selection, Monitoring, and Decontamination*, such that they are protective of health and safety based on radiological considerations and physical and chemical safety issues. Radiological personnel will prepare, approve, and record monitoring records in accordance with SOP RP-114, *Control of Radiation Protection Records*.

Key radiological personnel are expected to have the requisite skills necessary to perform these functions. The key radiological personnel include the following:

- License RSO
- PRSO
- Project Manager for Perma-Fix
- Radiation Protection Supervisor
- RCTs

Roles may be combined as described in this work plan. Key personnel will be approved in advance by the project manager or field lead.

6.4 Radiation Protection

Appendix D contains the Radiation Protection Plan, which includes key Perma-Fix Radiation Protection Program procedures. The Radiation Protection Plan details requirements for activities conducted under the California Radioactive Material License and describes radiation safety practices to be applied in the field and referenced in the APP/SSHP. The Radiation Protection Plan covers project activities that involve the use or handling of licensed by-product, source, or special nuclear material (hereinafter referred to as radioactive material); tasks with the potential for radioactive material to be present based on available data and historical records; and work in posted RCAs.

6.4.1 Radiological Postings

Radiological postings are used to delineate the RCAs necessary to conduct investigation activities. Radiological posting requirements are found in SOP RP-102, *Radiological Postings* (**Appendix D**).

6.4.2 Internal and External Exposure Control and Monitoring

Based on review of historical data, radiation doses are not expected to exceed 100 millirems per year (annual public dose allotment) for any project personnel. Although worker doses are expected to be a small fraction of the annual limits, external dose rates and cumulative doses and internal doses, via airborne concentration measurements will be monitored to ensure that worker doses are maintained as low as reasonably achievable (ALARA). The dosimetry requirements are contained in SOP RP-112,

Dosimetry Issue. The expectation is that all personnel entering the controlled area except untrained, escorted individuals as described in **Section 6.4.3** will be assigned an external monitoring device such as a thermoluminescent dosimeter. Untrained, escorted personnel entries will be logged such that the escort thermoluminescent dosimeter badge results can be used as the monitoring results for that individual if a question arises as to the possible external dose that individual received. Periodic external dose rate measurements will be taken before and during intrusive activities in accordance with SOP RP-104, *Radiological Surveys (Appendix D)*, to ensure that worker exposures are maintained ALARA.

6.4.3 Radiological Access Control

Access control is necessary to provide a consistent methodology for controlling the access of personnel, equipment, and vehicles into radiological areas. Access control points further control the release of the materials, tools, and equipment from radiological areas. Access control requirements are found in SOP RP-101, *Access Control (Appendix D)*. It is anticipated that areas targeted for investigation as part of this plan, including the soil sorting area or RSYs will be established as RCAs.

Personnel and equipment exiting the boundary of an RCA will be surveyed to ensure that their clothing, equipment, and vehicles do not leave the site with contamination.

A RWP is an administrative mechanism used to establish radiological controls for intended work activities. The RWP will provide information to workers on area radiological conditions and entry requirements including PPE. The following summarizes the RWP process for this project:

- RWP creation will be done by the License RSO or designee.
- RWPs will be approved by the License RSO or designee.
- Expected levels of contamination and external exposure rates will be listed in the RWP.
- Current and expected radiological conditions will be listed in the RWP.
- PPE and monitoring requirements will be specified in the RWP.
- Special monitoring instructions, hold points, or action levels may be listed as a part of the RWP requirements.
- RWP approval duration will be for the expected length of the project or until radiological conditions change and a revision is needed.
- Where radiological conditions change such that PPE or monitoring requirements must change, the work will be suspended until a new or revised RWP containing the new RWP requirements is issued.
- Personnel working in the area covered by the RWP will be briefed on the RWP requirements and sign an acknowledgment that they have received and understand the briefing.

RWP requirements are found in SOP RP-103, *Radiation Work Permits Preparation and Use (Appendix D)*.

6.4.4 Personal Protective Equipment

PPE will be selected based on the specific hazard and will comply with the APP/SSHP, the RWP, and the AHA specific to the task being performed. Based on historical information, the planned investigation activities are not expected to encounter or generate removable or airborne radioactivity. Therefore, it is expected that fieldwork PPE will consist of wearing Level D PPE and will include the following:

- Long pants
- High visibility outer layer
- Safety-toed boots
- Hard hat
- Work gloves

- Eye protection

If the field conditions exceed action levels for additional response (detailed in Perma-Fix procedures SOP RP-101, *Access Control*; SOP RP-102, *Radiological Postings*; and SOP RP-103, *Radiation Work Permits Preparation and Use*) (**Appendix D**), PPE may be upgraded as necessary.

6.4.5 Instrumentation

Instruments to be used for worker protection and monitoring will include dose and exposure rate instruments, alpha-beta dual phosphor surface contamination detectors, handheld 2-inch by 2-inch NaI detectors for gross gamma investigations, and a dual phosphor alpha-beta bench top counter for analysis of surface swipe samples and air samples. Instruments will be operated in accordance with applicable instrument-specific SOPs.

All counting systems and instruments will be calibrated with a National Institute of Standards and Technology-traceable source at intervals not exceeding 12 months, or as recommended by the manufacturer. The source used will be appropriate for the type and the energy of the radiation to be detected. All calibrations will be documented and include the source data.

The minimum training requirements for personnel working in the field at HPNS are provided in the following sections.

6.4.6 Radiological Training

Radiological training includes the following modules in accordance with SOP RP-115, *Radiation Worker Training* (**Appendix D**):

- General Employee Radiological Training
- Radiological Worker Training and Certification
- RCT Training and Certification

Visitors and escorted persons must receive a site briefing and will be assigned to a qualified radiation worker or RCT when in a posted RCA.

6.4.7 Health and Safety Training

Health and safety training may include, but is not limited to, the following:

- Occupational Safety and Health Administration (OSHA) 40-hour Hazardous Waste Operations and Emergency Response (Hazardous Waste Operations and Emergency Response [HAZWOPER]) training
- OSHA 8-hour HAZWOPER refresher training
- OSHA 8-hour HAZWOPER supervisor training
- OSHA-required On the Job training
- Site- or task-specific AHA training
- Basic first aid training
- Cardiopulmonary resuscitation training

6.5 Radiological Support Surveys

Personnel, equipment, material, and area surveys will be performed in accordance with this work plan and appendixes. If survey results indicate levels of surface contamination, appropriate decontamination methods will be performed in accordance with applicable SOPs (**Appendix D**).

6.5.1 Personnel Surveys

Personnel surveys will be conducted in accordance with SOP RP-104, *Radiological Surveys* (**Appendix D**). Personnel surveys are used to ensure that individuals leaving a radiological area are free of contamination. Hands and feet “frisks” or scans with dual alpha-beta scintillators will be required when individuals exit RCAs.

Scanning will be performed in the alpha plus beta mode of the instrument because of the potential presence of ^{90}Sr , a pure beta emitter, and the fact that there are beta emissions from progeny in the radium decay chain that can be used as a surrogate for potential radium contamination. Where contamination is found or suspected, the PRSO will be contacted and will provide further technical direction for any personnel/clothing decontamination that may be needed.

6.6 Equipment Surveys

6.6.1 Swipe Samples

Swipe sampling will be performed to assess the presence of radioactive contamination that is readily removed from a surface. Swipe samples will be taken to evaluate the presence of removable alpha and beta activity. The procedures for collecting swipe samples are discussed in SOP RP-104, *Radiological Surveys* (**Appendix D**).

6.6.2 Exposure Rate Surveys (Dose Rates)

Exposure rate surveys are performed to measure ambient gamma radiation levels. Exposure rate surveys will be performed prior to and periodically during intrusive activities to confirm exposure levels relative to RWP requirements.

6.6.3 Equipment Baseline and Unconditional Release Surveys

Equipment mobilized and demobilized from the site will undergo radioactivity surveys in accordance with RP-104 *Radiological Surveys* and RP-105 *Unconditional Release Requirements* (**Appendix D**). Baseline and Release surveys may include a combination of surface scans and static measurements using dual alpha-beta scintillators and swipe samples.

6.7 Documentation and Records Management

The purpose of this section is to define standards for the maintenance and retention of radiological records. Radiological records provide historical data, document radiological conditions, and record personnel exposure. Field documentation requirements are outlined in the SAP (**Appendix B**) and SOP RP-114, *Control of Radiation Protection Records* (**Appendix D**).

Radiological surveys will be performed and documented in accordance with SOP RP-106, *Survey Documentation and Review* (**Appendix D**). Sample collection, field measurements, and laboratory data will be recorded electronically to the extent practicable. Electronically recorded data and information will be backed up to a SharePoint site or equivalent on a nightly basis, or as reasonably practical. Data and information recorded on paper will be recorded using indelible ink. Both electronic and paper records of field-generated data will be reviewed by the PRSO or a designee knowledgeable in the measurement method for completeness, consistency, and accuracy. Data manually transposed to paper from electronic data collection devices will be compared to the original data sets to ensure consistency and to resolve noted discrepancies. Electronic copies of original electronic data sets will be preserved on a nonmagnetic retrievable data storage device. No data reduction, filtering, or modification will be performed on the original electronic versions of data sets.

6.7.1 Documentation Quality Standards

Records will be legible and completed with an indelible ink that provides reproducible and legible copies. Records will be dated and contain a verifiable signature of the originator. Errors that may be identified will be corrected by marking a single line through the error and by initialing and dating the correction.

Radiological records will not be corrected using an opaque substance. Shorthand or nonstandardized terms may not be used.

To ensure traceability, each record will clearly indicate the following:

- Name of the project
- Specific location
- Function and process
- Date
- Document number (if applicable)

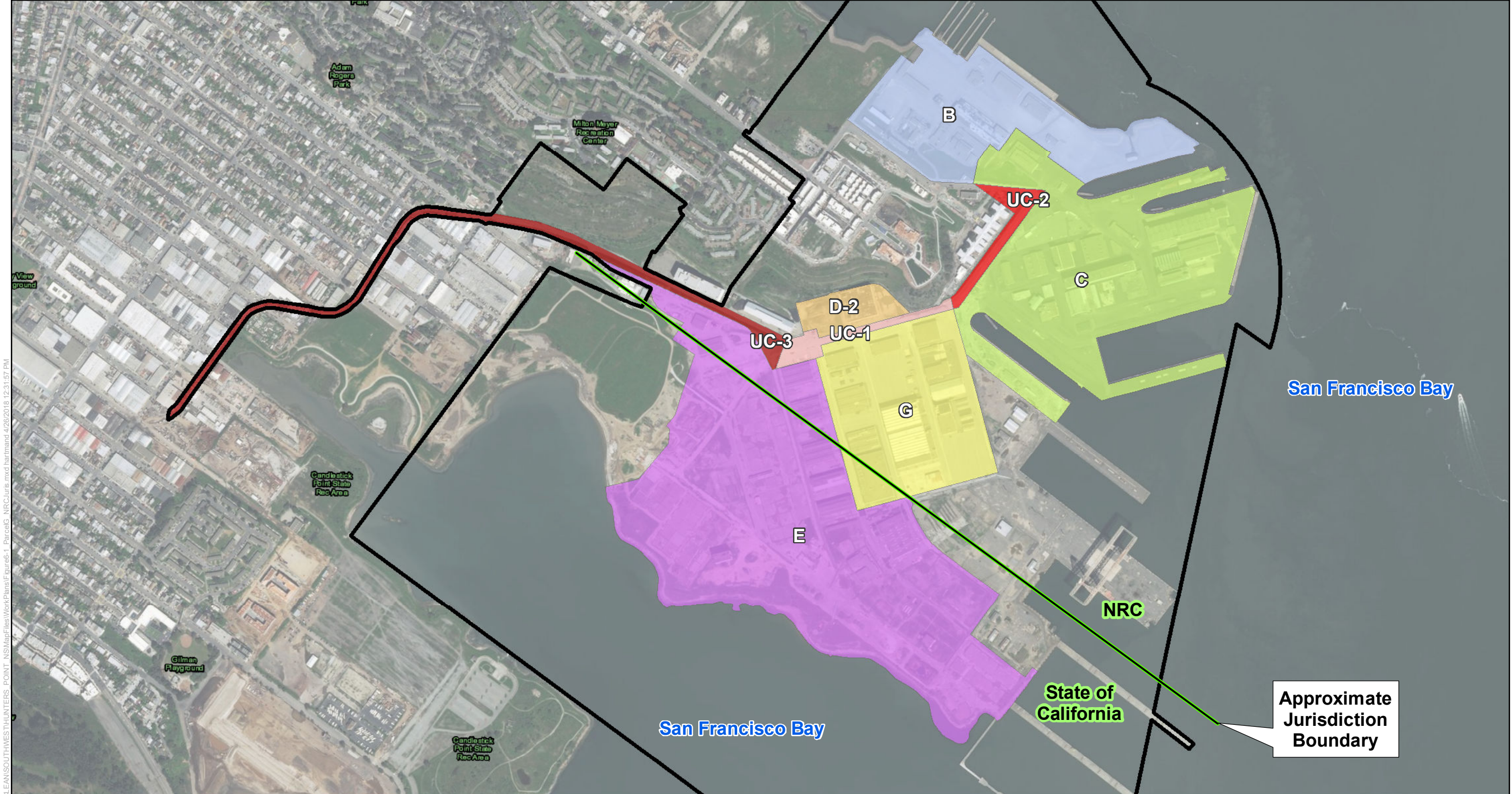
The quantities used in records will be clearly indicated in standard units (e.g., curie, radiation absorbed dose [rad], roentgen equivalent man [rem], dpm, becquerel), including multiples and subdivisions of these units.

6.7.2 Laboratory Records

Survey and laboratory data assessment records will be prepared as indicated in the contractor's QA/QC Plan.

6.7.3 Record Retention

Records resulting from implementation of this work plan will be retained as outlined in the SAP (**Appendix B**).



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Legend:

- Installation Boundary
 - Approximate Jurisdiction Boundary
- | | |
|---|---|
| <p>PARCEL</p> <ul style="list-style-type: none"> B C D-2 E | <ul style="list-style-type: none"> G UC-1 UC-2 UC-3 |
|---|---|

BASE MAP SOURCE:
Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,

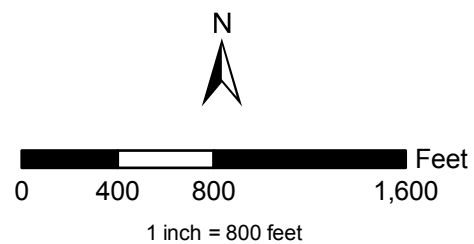


Figure 6-1
HPNS NRC Jurisdictional Boundaries
Parcel G Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Waste Management Plan

This section describes the type of waste expected to be generated and the management, transport, and disposal of the material.

7.1 Project Waste Descriptions

Waste generated during this investigation may be radiological in nature. It is anticipated that the following waste streams will be generated and managed as indicated in **Table 7-1**. Consult the project Environmental Manager for waste streams that are not specifically identified.

Table 7-1. Waste Management

Waste Stream	Source/Process	Staged in	Staged at	Final Disposition
<i>Radiological Wastes (LLRW)</i>				
Soil or sediment	Soil sampling/building cleaning activities	In accordance with 40 CFR 173, Subpart I	Navy approved location	Offsite disposal
Concrete and asphalt	Excavation/sampling	In accordance with 40 CFR 173, Subpart I	Navy approved location	Offsite disposal
Potential radiological commodities (e.g., deck markers)	Excavation/sampling	In accordance with 40 CFR 173, Subpart I	Navy approved location	Offsite disposal
Debris including PPE, plastic sheeting, disposable sampling equipment	Investigation activities involving disposable equipment	Include with soil/concrete	Navy approved location	Offsite disposal
Water from decontamination or dewatering	Excavation/sampling/equipment decontamination/building cleaning activities	In accordance with 40 CFR 173, Subpart I	Navy approved location	Offsite disposal
<i>Nonradiological Wastes (Non-LLRW)</i>				
Soil, sediment, concrete, or asphalt	Soil sampling/building cleaning activities	DOT specification drums or containers, IBC, or roll-off type bins	Navy approved location	Offsite disposal
Debris including PPE, plastic sheeting, disposable sampling equipment	Investigation activities involving disposable equipment	Include with soil	Navy approved location	Offsite disposal
Water from decontamination or dewatering	Excavation/sampling/equipment decontamination/building cleaning activities	DOT specification drums or containers	Navy approved location	Offsite disposal

Table 7-1. Waste Management

Waste Stream	Source/Process	Staged in	Staged at	Final Disposition
Miscellaneous trash that has not contacted contaminated media	Investigation activities	Black nontranslucent trash bags	Removed daily	Dumpsters at the Base

Notes:

DOT = Department of Transportation

The following sections address specific control and management practices for radiological waste (LLRW) and nonradiological waste (non-LLRW). Waste determined to be non-LLRW will be transported and disposed of by the contractor. LLRW will be transferred to the Navy’s radiological waste contractor, and disposed of offsite, in accordance with the MOU (**Appendix E**).

7.2 Radiological Waste Management

Waste materials deemed to be radioactive waste will be managed in accordance with the *Radiation Protection Workplan* and applicable license procedures, including SOP RP-111, *Radioactive Materials Control and Waste Management Program* (**Appendix D**).

7.2.1 Waste Classification

Accumulated waste deemed to be radioactive waste will be classified as LLRW based on 49 CFR, basewide requirements, or disposal facility requirements. Waste characteristics, including the radionuclides present and their associated specific activities, will be measured by an available standardized test method in accordance with the SAP (**Appendix B**), such as gamma spectroscopy, strontium analysis, or alpha spectrometry.

7.2.2 Waste Accumulation and Storage

Soil, debris, water, and materials classified as LLRW may be generated during sampling. When classified as LLRW, these wastes may be placed in containers provided by Navy (55-gallon drums, super sacks, or equivalent). When filled, LLRW containers will be transferred to the custody and control of the Navy’s radiological waste contractor, who will provide brokerage services including waste characterization sampling, transportation, and disposal in accordance with federal regulations and disposal facility requirements. Containers will be properly lined and an absorbent will be used if it is considered necessary. Containers will be radiologically surveyed when filled with material. Each container will be properly inventoried and labeled. Inventories will include material description and isotopic identification, and hazardous components, if appropriate. The contents of each container will be recorded in the field logbook, and each container will be assigned a unique identification number.

Containers will be stored in a designated and posted radioactive material storage area under the authority of the Navy’s radiological waste contractor’s California Radioactive Material License. Storage areas may be at the site where the waste originated or another location as directed by the Navy. Containers will be secured to prevent unauthorized access to their contents. Once filled, containers will be surveyed, and surface radiation dose rate measurements will be collected.

7.2.3 Labeling and Posting of Containers Containing Radioactive Waste

Each waste container containing LLRW will be labeled. The activity contained in each waste container will be reported in pCi/g, and maximum contact radiation levels will be measured in milliroentgens per hour. Following the surveying and labeling, the waste container will be placed in a designated and

posted radioactive area. The container area will be posted with a “Caution – Radioactive Materials Area” posting. An inventory of contents with radionuclide and specific activity (if available) will be maintained by the contractor until the custody of the material is transferred to the Navy’s radiological waste contractor.

7.2.4 Waste Accumulation Areas

The contractor working on this project will implement, at a minimum, the following requirements for radioactive waste stored onsite within a designated radioactive materials area:

- Industry standard posting and barrier materials will be displayed with wording that includes the following, “Caution – Radioactive Materials Area,” at each radioactive waste storage area sufficient to be seen from any approach. The signs will be legible and clearly conspicuous for outdoor and indoor locations.
- Aisle space will be maintained to allow for the unobstructed movement of personnel, fire-control equipment, spill-control equipment, and decontamination equipment to any facility operation area, in the event of an emergency, unless aisle space is not needed for any of these purposes.
- The areas will be secured to prevent unauthorized access to the material.
- The following emergency equipment will be located or available to personnel during radioactive waste management activities at each accumulation area:
 - A device, such as a telephone or a handheld two-way radio, capable of summoning emergency assistance (adjacent areas with personnel who have communication devices or areas with fixed devices that personnel can access quickly are sufficient)
 - Portable fire extinguishers, fire-control equipment, spill-control equipment, and decontamination equipment

Filled containers generated during performance of work will be stored in a material storage location until the contained material can be characterized and appropriately classified. Depending on the characterization results, the material may be moved to another storage location, transported and disposed of offsite, or reused as backfill.

7.2.5 Inspection of Waste Accumulation Areas

While all waste accumulation areas will be informally inspected daily during waste generation activities, formal inspections of all container accumulation areas will be conducted and recorded at least weekly in accordance with the appropriate Radioactive Material License requirements. The PRSO or designee will conduct inspections that will be recorded in a dedicated field logbook, and a weekly inspection checklist will be completed. The container storage areas will be inspected and the containers checked to ensure the following:

- The containers will be checked for condition. If a container is not in good condition, the certified waste broker will be informed.
- The containers will be checked to ensure that they remain closed and secured at all times, except when adding or removing waste.
- The container label will be checked to ensure that it is visible and filled out properly.

7.2.6 Waste Transportation

In accordance with the MOU, the Navy’s radiological waste contractor will be responsible for transportation of the LLRW in accordance with the DOT Radioactive Material Transportation regulations

of 49 CFR for offsite disposal. The contractor may supply DOT contamination surveys and radiation measurements on the outside of the container prior to shipment. The Navy's radiological waste contractor will ensure that empty containers being returned to vendors meet the release limits for equipment and materials.

LLRW transported from the site will be accompanied by a radioactive waste manifest or a Uniform Hazardous Waste Manifest, as appropriate. Preparation of the LLRW manifests are the responsibility of the Navy's radiological waste contractor.

BRAC will receive a copy of the manifest. The remaining copies will be given to the transporter. The manifest will be returned to the Navy signatory official in accordance with the Base's recordkeeping requirements.

7.2.7 Waste Disposal

The Navy's radiological waste contractor is responsible for the disposal of LLRW. The Navy's radiological waste contractor will coordinate closely with RASO and contractor to ensure proper transfer of custody of the waste and coordinate the shipment offsite. LLRW inventories will be managed under the appropriate Radioactive Material License.

7.3 Nonradiological Waste Management

7.3.1 Waste Classification

In general, wastes generated during the project will be assessed to determine proper handling and final disposition through chemical analysis, field testing, and possible generator knowledge. The exceptions are uncontaminated wastes (i.e., no contact with contaminated media or remediation chemicals) and trash.

Samples of these wastes will be collected and analyzed to determine whether the waste is a Hazardous Waste or a Nonhazardous Waste. Analysis will be based on the requirements of the offsite disposal facility and may include total petroleum hydrocarbons (typically C₄ to C₄₀), volatile organic compounds (VOCs), semivolatile organic compounds, corrosivity (pH), or California Assessment Manual 17 total metals. Based on the results, additional waste characterization may be needed or necessary to have the waste managed at an offsite waste management facility.

The project Environmental Manager should review the analytical data and characterize and classify the waste.

Samples will be collected in accordance with the general procedures in the following section and sent to a properly licensed laboratory for analyses. If the waste is placed in containers, one composite sample (and one grab for VOC analysis, if needed) will be collected for every 10 drums of each waste stream. If soil is staged in stockpiles or bins, a 4-to-1 composite will be collected and a grab sample for VOCs. If the waste (liquid) is placed in a tank or container, grab samples are appropriate. Offsite waste management facilities may require specific sampling per volume of waste accumulated under their waste acceptance policy.

7.3.2 Waste Sampling Procedures

7.3.2.1 Liquids

Analytical samples for liquid wastes will be collected from the 55-gallon drums before disposal; one composite sample will be collected for every 10 drums. Water samples will be collected by the following procedure:

1. Collect a water sample from a drum using a bailer or dipper if the water is homogenous or use a colliwasa if the water has more than one phase.
2. Fill the sample containers for volatile analyses first. Fill the 40-milliliter vials so there is no headspace in each vial.
3. Fill the sample containers for the remaining analyses.
4. Label and package the sample containers for shipment to the laboratory.

7.3.2.2 Solids

For soil, one grab sample and one composite sample will be collected for every 10 drums.

Soil samples procedures for collecting VOC samples are as follows:

1. Retrieve a core from the selected sample location.
2. Fill the appropriate sample jars completely full, with the sample from the core.

Soil sample procedures for collecting nonvolatile or metal samples are as follows:

1. Collect equal spoonfuls of soil from five randomly selected points and transfer into a stainless steel bowl.
2. Use a stainless-steel spoon and quartering techniques to homogenize the five samples.
3. Fill the appropriate sample jars completely full, with the homogenized sample.
4. Close the jars, label them, complete chain-of-custody documentation, and package them for shipment to the laboratory.

7.3.3 Waste Profile

Waste characterization information will be documented on a waste profile form provided by the offsite treatment or disposal facility and reviewed by a project Environmental Manager before being submitted to the Navy. The profile will be reviewed, approved, and signed by the appropriate Navy personnel. Signed profiles will then be submitted to the designated offsite facility.

The profile typically requires the following information:

- Generator information, including name, address, contact, and phone number
- Site name, including street/ mailing address
- Process-generating waste
- Source of contamination
- Historical use for area
- Waste composition (e.g., 95 percent soil and 5 percent debris)
- Physical state of waste (e.g., solid, liquid)
- Applicable hazardous waste codes
- DOT proper shipping name.

The contractor will coordinate with the disposal subcontractor to schedule the transportation of the waste to the offsite disposal facility after the copy of the approved waste profile is received.

7.3.4 Container Labeling

Waste containers containing contaminated media will be marked and labeled upon use concerning their contents. Each hazardous waste container will be marked in accordance with 22 California Code of Regulations 66262.32. In addition, containers will be labeled and in accordance with DOT 49 CFR

172.300 (Marking) and 172.400 (Labeling) and 40 CFR Subpart C. DOT labeling is only required before offering transportation offsite.

The marks will note the type of waste, location from which the waste was generated, and accumulation start date. One of the following labels will be used:

- **“Analysis Pending” or “Waste Material”**—Temporary label until analytical results are received, reviewed, and determined whether the waste is hazardous or not. This label will include the accumulation start date. An example of this mark is provided as follows:

- Contents: Example – **soil from drill/auger cuttings**
- Origin of Materials: **Former Hunters Point Naval Shipyard**
- Address:
- Contact Name and Phone Number:
- Accumulation Start Date: **Please add under the Contact**

- **“Non-Hazardous Waste”**— If the waste is determined to be non-hazardous, apply the mark below with the following information:

- Shipper: **Former Hunters Point Naval Shipyard**
- Address:
- Contents: **Example – soil from drill/auger cuttings**
- Contact Name and Phone Number:
- **Please add Accumulation Start Date somewhere on the mark**

- **“Hazardous Waste:** If the waste is determined to be hazardous, apply the mark below with the following information:

- Name: **Former Hunters Point Naval Shipyard**
- Address:
- Phone:
- City: **San Francisco**
- State: **CA**
- Zip:
- USEPA ID No.:
- Manifest number: **Add before transportation**
- USEPA Waste No.: **EM to provide**
- CA Waste No. **EM to provide**
- Accumulation Start Date: **The date the waste was first placed in the container**
- Physical State: **Check solid or liquid**
- Hazardous Properties: **Check the appropriate hazard**

- DOT proper shipping name: **EM to provide**

If additional assistance is needed in selecting the appropriate marks and labels, please contact the Environmental Manager or waste expert.

7.3.5 Waste Accumulation Areas

Although hazardous waste is not expected, if generated, the contractor will coordinate with the Navy to determine an appropriate site location to store the hazardous waste.

All containers will be physically handled in accordance with the APP/SSHP. Additional management requirements for the containers expected to be put into use can be found in **Table 7-2**.

Table 7-2. Non-LLRW Accumulation Requirements

Accumulating In:	Requirements
Drums/Small Containers	<ul style="list-style-type: none"> • Inspected upon arrival onsite for signs of contamination or deterioration. Any container arriving with contents or in poor condition will be rejected. • No penetrating dents are allowed that could affect the integrity of the drum. Pay special attention to dents at the drum seams. • Closed head drums: Will be inspected to verify that the bung will close properly. • Open head drums: Drum lids will be inspected to verify that the gasket is in good shape and that the lid will seat properly on the drum. • Arranged in rows of no more than 2 drums with at least 3 feet between rows. • Each container will be provided with its own mark and label, and the marks and labels must be visible. • Drums will remain completely closed with all lids, covers, bolts, and locking mechanisms engaged, as though ready for immediate transport, except when removing or adding waste to the drum. • Drums and small containers of hazardous waste will be transported using proper drum-handling methods, such as transportation by forklift on wood pallets, with drums secured together. Containers will be transported in a manner that will prevent spillage or particulate loss to the environment. • Drums will be disposed of with the contents. If the contents are removed from the drums for offsite transportation and treatment or disposal, the drums will be decontaminated prior to reuse or before leaving the site. • The outsides of the drums and containers must be free of hazardous waste residues. • Ignitable or reactive wastes will be stored at least 50 feet from the property line. • Drums and containers will not be located near a stormwater inlet or stormwater conveyance. • Drums containing waste liquids, hazardous or incompatible wastes will be provided with secondary containment capable of holding the contents of the largest tank and precipitation from a 24-hour, 25-year storm. • Liquid that accumulates in a secondary containment area will be removed and placed in containers within 24 hours. Removed liquids with a sheen will be characterized and classified. • New empty drums will be marked with the word "Empty". Drums that are being reused will be marked with "Empty, last contained [previous contents]" • All containers will be tracked on the field transportation and disposal log

7.3.6 Inspection of Waste Accumulation Areas

Waste container accumulation areas will be inspected at least weekly for conditions that could result in a release of waste to the environment. Inspections will focus on conditions such as equipment

malfunction, container or containment deterioration, signs of leakage or discharge. Specifically, containers (drums and roll offs) will be inspected for leaks, signs of corrosion, or signs of general deterioration.

Any deficiencies observed or noted during inspection will be corrected immediately. Appropriate measures may include transferring waste from a leaking container to a new container, replacing the liner or cover, or repairing the containment berm.

Inspections will be recorded in the project logbook or on an inspection form. Deficiencies and corrections will also be documented. All the following items will be noted in the logbook for each inspection:

- The location of the area
- Total number of containers present
- Date
- Verification that all containers are labeled with the accumulation start date, contents, Base point of contact, and any relevant hazards (such as flammable and oxidizer). Labels must be visible, legible, and not faded.
- The condition of containers. Good condition for containers is defined as no severe rusting, dents, structural defects, or leaks.
- The condition of secondary containment. Good condition for containment is defined as no structural defects or leaks.
- Verification that all containers are completely closed with all bolts, lids, and locking mechanisms engaged as though ready for immediate transport.
- Verification that containers are staged in rows not more than two drums wide, with labels facing outward and 3 feet of space between rows.
- Verification that all containers are being tracked on the transportation and disposal log.
- Verification that the accumulation area is clean and free of debris.

Verification that emergency response equipment is present if required for the waste being staged.

7.3.7 Waste Transportation

Each transportation vehicle and load of waste will be inspected before leaving the site, and the inspection will be documented in the logbook. The quantities of waste leaving the site should be recorded on a transportation and disposal log. A subcontractor licensed for commercial transportation will transport non-hazardous wastes. If the wastes are hazardous, the transporter will have a USEPA ID number and will comply with transportation requirements outlined in 49 CFR 171-179 (DOT) and 40 CFR 263.11 and 263.31 (Hazardous Waste Transportation).

The transporter will observe the following practices when hauling and transporting wastes offsite:

- Minimize impacts to general public traffic.
- Clean up waste spilled in transit.
- Line and cover trucks and trailers used for hauling contaminated waste to prevent releases and contamination.
- Decontaminate vehicles before reuse.

In accordance with the MOU, the Navy's radiological waste contractor will be responsible for transportation of the LLRW in accordance with the DOT Radioactive Material Transportation regulations

of 49 CFR for offsite disposal. The contractor may supply DOT contamination surveys and radiation measurements on the outside of the container prior to shipment. The Navy's radiological waste contractor will ensure that empty containers being returned to vendors meet the release limits for equipment and materials.

Offsite transportation and disposal of hazardous or solid wastes will be handled by the selected waste contractor. All hazardous waste transported from the site will be accompanied by a Uniform Hazardous Waste Manifest and solid (nonhazardous) waste will be accompanied by a non-hazardous waste manifest or bill of lading, as appropriate. Navy personnel will be responsible for reviewing and signing all waste documentation, including waste profiles, manifests, and land disposal restriction notifications (manifest packages). Before signing the manifest, the designated Navy official will ensure that pre-transport requirements of packaging, labeling, marking, and placarding are met according to 40 CFR Parts 262.30–262.33, and 49 CFR Parts 100–178.

7.3.8 Waste Disposal

Hazardous and solid wastes will be transported offsite for appropriate treatment and disposal.

Hazardous waste will be disposed of or managed only at a hazardous waste disposal facility prequalified by the contractor and permitted for the disposal of the particular type of hazardous or solid waste generated.

7.4 Waste Minimization

To minimize the volume of hazardous and radioactive waste generated during the project, the following general guidelines will be followed:

- Waste material will not be contaminated unnecessarily.
- Work will be planned.
- Material may be stored in large containers, but the smallest reasonable container will be used to transport the material to its destination.
- Cleaning and extra sampling supplies will be maintained outside any potentially contaminated area to keep them free of contamination and to minimize additional waste generation.
- Mixing of detergents or decontamination solutions will be performed outside potentially contaminated areas.
- When decontaminating radioactively contaminated material, every effort should be made to minimize the generation of mixed waste.
- Contaminated material will not be placed with clean material.
- Wooden pallets inside the exclusion zone will be covered with plastic.
- Material and equipment will be decontaminated and reused when practicable.
- Volume reduction techniques will be used when practicable.

7.5 Compliance with CERCLA Offsite Rule

Consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Offsite Rule, wastes generated from remediation activities, such as contaminated soil or hazardous waste, at a CERCLA site may be transferred only to offsite facilities that have been deemed acceptable by the USEPA Regional Offsite Contact (40 CFR 300.440). With Naval approval, the contractor will

request proof of Offsite Rule approval from the offsite disposal facility before transferring any wastes to an offsite facility.

Other disposal practices to be followed are as follows:

- Hazardous waste (State and Resource Conservation and Recovery Act [RCRA]) will be sent to an offsite, permitted, RCRA Subtitle C treatment, storage, and disposal facility or Wastewater Treatment Facility permitted under Clean Water Act.
- Nonhazardous wastes will be disposed of at an offsite RCRA Subtitle D facility permitted to receive such wastes. It is expected that the contaminated soil and debris will be classified as nonhazardous and disposed of at a Subtitle D facility.
- Decontamination water may be discharged to an onsite water treatment facility with written permission from the Base or disposed of offsite at a facility permitted to accept the waste.
- Uncontaminated debris may be sent to municipal landfills, landfills designated for construction/demolition debris or a recycling facility.
- General trash will be disposed of in dumpsters on-base.

The designated offsite facility will be responsible for providing a copy of the fully executed waste manifest and a certificate of treatment or disposal for each load of waste received to the generator.

7.6 Documentation

Documentation requirements apply to all waste managed during project activities. Field records will be kept of all waste-generating activities. All pages of the field data record log will be signed and dated by the person entering the data. In addition, the following information will be recorded in the log:

- Description of waste-generating activities
- Location of waste generation (including depth, if applicable)
- Type and volume of waste
- Date and time of generation
- Description of any waste sampling
- Name of person recording information
- Name of field manager at time of generation

7.7 Updating the Waste Management Plan

The Waste Management Plan section will be updated as changes in site activities or conditions occur, as changes in applicable regulations occur, and as replacement pages are added to this work plan. Revisions to waste management will be reviewed and approved by the Navy. All changes to the plan associated with radioactive or mixed waste will require approval from RASO.

Environmental Protection Plan

This section briefly describes the environmental protection plan that will be implemented.

8.1 Land Resources and Vegetation

Parcel G is within a developed former industrial area with limited to no vegetation. The administrative provisions of the applicable permit programs will be applied to protect wetlands and streams, if appropriate.

8.2 Fish and Wildlife, Threatened, Endangered, and Sensitive Species

Several hundred types of plants and animals are believed to live at or near HPNS. No federally listed endangered or threatened species are known to permanently reside at HPNS or in the vicinity (Levine-Fricke and PRC, 1997); however, San Francisco Bay is a seasonal home to migrating fish and birds.

8.3 Wetlands and Streams

Two freshwater streams, Yosemite and Islais Creeks, flow into San Francisco Bay adjacent to the border with HPNS. Surface water resources at the site are limited to small groundwater seeps from exposed bedrock and the surface water in adjacent San Francisco Bay. The administrative provisions of the applicable permit programs will be applied to protect wetlands and streams, if appropriate.

8.4 Stormwater, Sediment, and Erosion Control

Stormwater, sediment, and erosion control will be managed through the Stormwater Pollution Prevention Plan (SWPPP), to be prepared under separate cover for the work outlined in **Section 3**, and the use of BMPs.

8.4.1 Stormwater Pollution Prevention

Stormwater pollution prevention, otherwise known as stormwater management, includes measures that can reduce potential stormwater pollution from industrial activity pollutant sources. Stormwater management includes the following BMPs: a pollution prevention team, risk identification and assessment, preventive maintenance, good housekeeping, site security, spill prevention and response, stormwater pollution prevention, sediment and erosion prevention, inspection and monitoring, and personnel training. These BMPs help to identify and eliminate conditions and practices that could cause stormwater pollution. The SWPPP details the entire program to include the regulatory requirements and methods used to meet these requirements.

Inspections play a large role in the prevention of releases and pollution of stormwater. Qualified contractors and personnel perform inspections as described in the SWPPP. These inspections are documented and retained pursuant to the requirements of **Section 6**.

8.4.2 Stockpile Control

Stockpiles, although not expected, will be managed to ensure that any possible cross contamination with surrounding surfaces will be minimized to the extent possible. These measures will include, at a minimum, the following:

- All excavated material will be placed on plastic to prevent contact with the surface.
- All stockpiles will be covered with plastic or tarps at the end of shift or when stockpile additions or removals are complete and monitored on a weekly basis.
- BMPs (such as bio waddles, straw waddles, and erosion berms) will be used around stockpiles to prevent material migration.
- Stockpiling of known hazardous material will not be allowed. Hazardous material will be packaged as hazardous waste and stored under RCRA controls pending removal by a waste broker.

8.4.3 Nonradiological Hazardous Materials

Hazardous material will be managed in accordance with permits, plans, rules and laws. At a minimum, the following will be required:

- Hazardous material will be properly labeled and stored.
- Hazardous waste will be placed into approved containers and stored in designated Satellite Accumulation Areas or Waste Accumulation Areas.
- Hazardous material or waste containers will be kept closed when not in use.
- Before workers opening any container or package with hazardous material, the project Environmental Manager should be consulted to determine whether pre-entry monitoring is required.

8.5 Air Quality and Dust Control

All intrusive activities will comply with the substantive requirements of the Bay Area Air Quality Management District Rule 40 and Regulations 6-305 and 8 pertaining to fugitive dust emissions and maintaining covering and stockpiling materials. Fugitive emissions will be minimized to the extent possible. Subsurface soil within the HPNS is expected to be moist and not require dust suppression. These measures will include, at a minimum, the following:

- Visible dust caused by intrusive methods will require work to be paused and the source of the dust corrected by dust suppression.
- Continuous radiological air samples (general area) will be collected during any intrusive work within areas of known or potential radiological contamination or material.
- Areas with known or suspected radiological material that could become airborne from light winds (fine or powdered material) will be evaluated for a suitable stabilization method (dust control agent, fixatives, surfactants, or covering with erosion control covers).
- Area monitoring with direct reading dust monitors and photoionization detector.
- Stationary high-volume area sampling.

Additionally, a site-specific dust management plan will be developed. Any air permits (e.g., local air quality board) that are required for the performance of work under this contract will be detailed in the project environmental plan.

8.5.1 Radiological Air Sampling

Airborne activity monitoring (continuous or grab samples) and engineering controls may be required during work when deemed appropriate by the License, PRSO, contractor, or the Navy. To control occupational exposures, establish PPE, and determine respiratory protection requirements, monitoring and trending for airborne radioactive material will be performed as necessary. Engineered controls will be implemented if required to maintain airborne concentrations below the applicable derived air concentration (DAC) value for the ROCs (**Table 8-1**).

During work, if the airborne concentration exceeds the appropriate DAC, ongoing activities will cease and the affected location will be posted until the source of the airborne concentration is eliminated and levels are confirmed to be below the appropriate DAC. Air monitoring will be performed using the methods described in SOP RP-107, *Measurement of Airborne Radioactivity* (**Appendix D**). It is not anticipated that airborne contamination would occur.

Table 8-1. Derived Air Concentrations

Radionuclide	Radiation	DAC ($\mu\text{Ci/mL}$)
^{226}Ra	Alpha (α)	3.0×10^{-10}
^{239}Pu		3.0×10^{-12}
^{232}Th		5.0×10^{-13}
^{235}U		6.0×10^{-10}
^{90}Sr	Beta (β^-)	8.0×10^{-9}
^{137}Cs	Beta/gamma (β^-, γ)	6.0×10^{-8}

Notes:

The most protective DACs for alpha and beta-emitting nuclides will be used as determined by the ROCs in that work area.

$\mu\text{Ci/mL}$ = microcurie(s) per milliliter

8.5.2 Nonradiological Area and Personal Air Monitoring

Air monitoring for nonradiological contaminants is expected during fieldwork at HPNS. In keeping with the philosophy of “Zero Dust,” engineering controls will be the primary method to eliminate dust. To verify the effectiveness of the controls, the use of area direct reading dust monitors (e.g., DataRAM) may be used. Area dust monitors may be deployed at select locations around the boundary of the site (environmental locations).

In addition, stationary high-volume sampling will include upwind and downwind monitoring for the ROCs, total suspended particulates, arsenic, lead, manganese, particulate matter with particles larger than 10 microns in size, and asbestos.

Monitoring data will be compared with the threshold concentration levels developed for the project site. If an analyte concentration exceeds its threshold level, the upwind and downwind results will be compared to identify whether the exceedance was caused by onsite activities. If onsite activities are found to be the cause of an exceedance, the SSHO will immediately implement corrective actions to enhance the dust control measures being implemented. These measures include, but are not limited to, applying additional water and soil stabilizers, reducing driving speeds on unpaved roads, and modifying the equipment and approach used to perform the work activities.

Breathing zone action levels will be established for non-radiological contaminants (e.g., heavy metals and polychlorinated biphenyls), based on prior soil sampling at the site and task (e.g., drilling and excavation). Direct reading monitoring equipment (such as DataRAM and photoionization detector) will be used to verify action levels are not exceeded during work tasks.

Each project task plan will evaluate if nonradiological personal integrated air sampling is required, in addition to direct reading monitoring. The SSHP will be updated via a Field Change Request if additional monitoring is needed based on task-specific chemicals of concern. The APP and SSHP further discuss personal air monitoring requirements of the project.

8.6 Noise Prevention

Using standard OSHA occupational noise evaluation methods, the time weighted average for any 8-hour period will not exceed 90 decibels (dBA) to any worker. In addition, the contractor will endeavor to limit noise directly resulting from project work at or below 80 dBA at the task area boundary, or 70 dBA at the HPNS boundary.

8.7 Construction Area Delineation

Construction area delineation will be evaluated upon arrival of the advance project personnel. Following this evaluation, minor modifications will be made to the project plans and procedures to reflect the current conditions.

8.8 Traffic Control Plan

Not applicable.

8.9 General Operations

General operations will be governed under this work plan to ensure that any operation conforms to the requirements listed within. These requirements are specific to the type of hazard (e.g., radiological, hazardous material, and health and safety) and further require that each task have a corresponding AHA. All work will be released by the cognizant contractor before work is performed. Review of the general operations AHA will include all environmental programs and permits to ensure compliance.

8.10 Spill Prevention, Response, and Reporting

The project spill plan is provided in the APP/SSHP.

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Appendix A
Comments and Responses to
Comments

Attachment 2.1

EPA Recommendations for Task Specific Plan for Parcel G

1. Introduction

The previous soil data collected by Tetra Tech EC Inc. since 2006 at the Hunters Point Naval Shipyard should be viewed with significant uncertainty due to widespread signs of potential falsification, data quality concerns, and extensive allegations from former workers of fraudulent practices. EPA's comments on the Navy's draft *Work Plan Radiological Survey and Sampling*, Former Hunters Point Naval Shipyard, San Francisco, California, February 2018, demonstrate that far more extensive sampling and analysis needs to be done to address potential exposure to future workers and residents due to the uncertainty regarding the potential extent of contamination. The Navy is drafting Task Specific Plans (TSPs) for its work on specific parcels, and EPA expects to receive the draft TSP for Parcel G for review soon. In anticipation of this forthcoming draft, EPA is submitting recommendations in advance to inform the development of this draft.

The EPA, the State of California Department of Toxic Substances Control (DTSC), and the State of California Department of Public Health (CDPH) ("Regulators") require an approach that will protect public health and the environment. As we wrote in December 2016, "EPA recommends using a health-risk based approach to prioritize areas of concern based on factors that should include, but not be limited to, historical records of activities, current or future exposure based on land uses, sampling results already collected, and combination of highest risk radionuclides." Additional areas that should be prioritized include those with specific allegations from former workers and data evaluation findings of signs of falsification and/or data quality concerns.

Full excavation, sampling, and scans targeted at the survey units associated with the greatest potential for contamination will be a crucial first step to address uncertainty and demonstrate that the clean-up standards set in the Record of Decisions (RODs) have been met. The results will provide evidence and better understanding about the potential scope of contamination parcel-wide to inform plans for resampling and rescanning the remaining survey units in Parcel G.

Please note that these recommendations apply only to Parcel G, which we understand is the next parcel proposed for transfer to the City. Other parcels will be treated on a case-by-case basis. These recommendations only apply to soil survey units, which include trench units, fill units, and building site soil survey units. They do not apply to buildings, which will be discussed separately. These recommendations give a broad framework for an approach, and details will be refined after receiving the Navy's draft Task Specific Plan for Parcel G and as new reliable data is collected to inform future decisions.

2. Summary of Regulators' Proposed Approach

To achieve a high level of confidence that site conditions meet the remedial goals set forth in the Parcel G ROD, the Regulators propose a two-step process. For Step 1, full excavation, sampling, and scanning in survey units of highest concern should be done to best protect public health and the environment. For trench soil survey units ("trench units"), if resampling of these targeted trench units (starting with 21 out of 63 (33%) of the total units), and the fill soil survey units ("fill units") within them, demonstrates that contamination was left behind, the Navy must then fully excavate, sample, and scan 100% of trench units and associated fill units in Parcel G. If the initial 21 targeted trench and associated fill units meet standards, Step 2 focusing on the remaining trench units would require scanning of 100% of the surface of all fill in trenches as well as core samples at depth to increase confidence for the remaining Parcel G trenches.

Similarly, for building site soil survey units, if any of the targeted units (initially 16 out of total 32, or 50%) show contamination during Step 1 (full excavation, scanning, and sampling), then 100% of these units must be fully excavated, scanned and sampled. Even if all targeted units meet the remedial goals set forth in the Parcel G ROD, the Regulators would still require scanning of 100% of the surfaces as Step 2 for the remaining Parcel G Building Site Soil survey units. These survey units are not deep, so no core subsurface samples would be required.

Given that all survey units will receive some level of assessment of the presence of radionuclides of concern, this approach would achieve a 95-100% level of confidence that ROD remedial goals have been met for soil survey units. This is consistent with the level of confidence achieved nationally for Superfund sites slated for mixed use, including residential. In all the above activities, the regulatory agencies will send inspectors to monitor field work closely and take independent samples and scans.

3. Selection of priority survey units

Survey units for priority sampling will be selected based on criteria including the following:

- a. Historical documentation of specific potential upstream sources (e.g. buildings where radiological work was performed), spills, or other indicators of potential contamination
- b. Signs of potential falsification found in data evaluation, for example:
 - i. Gamma scan exceedance not investigated, as required, through collection of biased samples
 - ii. Gamma static samples have low variability, e.g. less than 1500 counts per minute (cpm) and/or are not consistent with the gamma scan data, which could indicate the scans were not completed according to requirements
 - iii. Onsite and off-site lab samples have different weights, which could indicate soil samples had been switched
 - iv. Some samples were analyzed on different dates
 - v. Gamma scan results low enough to indicate potential degraded detectors or failure to operate detectors according to requirements

- c. Signs of data quality problems found in data evaluation, for example:
 - i. Missing gamma scan data
 - ii. Numerous results that are zero or negative, especially for Cs-137
- d. Allegations from former workers, for example:
 - i. More than 3 rounds of excavation, which allegedly motivated falsification
 - ii. Specific locations where workers reported wrongdoing
- e. Independent field testing, e.g. EPA scans of cleanup sites.

Other criteria may also be used as appropriate.

4. Step 1 – Full excavation, sampling, and scanning of priority survey units

Full excavation, sampling, and scanning must be conducted as the first step in priority survey units for trenches and building site survey units using the broad approaches required in previous Basewide Radiological Support Workplans,¹ with updates that improve reliability of results, as noted in EPA’s comments on the Navy’s draft new *Draft Work Plan Radiological Survey and Sampling*, Former Hunter’s Point Naval Shipyard, San Francisco, California, February 2018 (“Work Plan”). The actions include full excavation of trench units, sampling and scanning of the side walls and bottom of the trenches, scanning of the excavated soil, and excavation of any contamination found.

Sampling results for each Radionuclide of Concern must be compared to the respective cleanup goal, i.e., Reference Background plus the Remedial Goal, as set in the Records of Decision, updated if needed as part of the Five-Year Review. If an exceedance of the cleanup goal is found, and evaluation of equilibrium does not demonstrate that the value represents Naturally Occurring Radioactive Material (NORM), then that finding represents evidence of contamination. This failure to meet the cleanup goal would trigger the requirement to perform full excavation, sampling, and scanning of 100% of trench units and associated fill units in Parcel G. A similar approach would apply to building site soil survey units.

5. Step 2 – 100% surface scans and core samples

Step 2 entails completing 100% surface scans and core samples. Step 2 can only be considered if Step 1 found no contamination exceeding the ROD clean-up goals in trench units or building site survey units. Otherwise, excavation of 100% of trench units or building site survey units would be required. For trench units, if in Step 1, the 33% of targeted trench units showed no contamination, then the remaining 67% (43) of trench units must receive 100% surface scans and core sampling. Similarly, for building site survey units, if in Step 1, the 50% of targeted building site soil survey units showed no contamination, then the remaining 50% (16)

¹ See for example, U.S. Department of the Navy, *Final Workplan, Basewide Radiological Support*, Hunters Point Naval Shipyard, San Francisco, California, August 2015.

of units must receive 100% surface scans. If contamination is found, then that survey unit must be fully excavated and treated in a manner similar to Step 1. If multiple Step 2 survey units have contamination, then additional survey units may need 100% full excavation and treatment in a manner similar to Step 1.

- a. 100% Surface scans – To address the potential exposure to future residents, 100% surface scans would be required. The Navy must first remove any asphalt cover and any imported fill that may have been used to achieve the desired grade, i.e. not part of backfill that potentially came from an area excavated by Tetra Tech EC Inc. Any locations where scan results exceed the investigation level would require collection of biased samples.
- b. Core samples – Only if no contamination is found in surface scans, then core samples would be an option to address potential exposure to future trench workers from contamination at depth. Each core will be scanned and will have a sample collected from the bottom, surface, and at any point exceeding the investigation level or, if no points exceed that level, then at the point of the highest gamma reading.
 - i. *Inside the trench walls* - The number of core samples required within the trench walls will be determined based in new reliable data and statistical analysis.
 - ii. *Outside the trench walls* – Additional core samples will be collected within a foot outside the trench wall, laterally along each side of the trench.

6. Conclusion

In a situation of considerable uncertainty, the Regulators have proposed a robust plan that addresses multiple possible scenarios using information from history, data review, and known allegations. Even if new allegations arise in the future, the thorough approach outlined above will protect public health and the environment through decisions based on evidence from new reliable data and sound statistical analysis.

Committee to Bridge the Gap Critique of the Work Plan for Retesting of Parcel G Hunters Point Naval Shipyard

15 August 2018

A Process Plagued with Scandal

The Navy’s cleanup of the contaminated Hunters Point Naval Shipyard has been plagued with scandal. Its contractor for much of the radioactive work, Tetra Tech, has been found to have fabricated a huge portion of the radiation measurements. For Parcel G, the parcel at issue here, the Navy itself concedes that there is evidence of data manipulation or fabrication at nearly half (49%) of the Tetra Tech soil survey units [99 out of 202].¹ The US Environmental Protection Agency and the California Department of Toxic Substances Control (DTSC) and California Department of Public Health (CDPH) have concluded that the data falsification is even higher, an additional 49%—so that only 3% of survey units in Parcel D had no signs of falsification of data, and that a total of 97% should be resampled.²

Summary of EPA, DTSC, CDPH review of Parcel G Radiological Data Evaluation

	Trench	Fill	Building Sites	Total	% of total
Total Survey Units in Parcel G	63	107	32	202	100%
Navy recommended resampling	20	53	25	98	49%
EPA, CDPH, DTSC recommend resampling	39	54	5	98	49%
Total recommended resampling	59	107	30	196	97%
No signs of falsification found in data	4	0	2	6	3%
% of total recommended resampling	94%	100%	94%	97%	

¹ Navy Base Realignment and Closure Program Management Office West, *Draft Radiological Data Evaluation Findings Report for Parcels B and G Soil Former Hunters Point Naval Shipyard San Francisco, California*, September 2017 (hereafter Navy 2017), p. iv-v

² EPA *Final Comments on Draft Navy Radiological Data Evaluation Parcels B & G Report*, December, 2017 (hereafter EPA 2017), p. 20

Courageous whistleblowers came forward with information about widespread fabrication of measurements to make it appear that soil that was contaminated was in fact clean and didn't need to get cleaned up, which would save the Navy a great deal of money. As the Navy review of Parcel G measurements summarized the allegations of soil data manipulation and falsification³:

- When sufficiently low levels of contamination were not obtained, soil samples were collected from a different area known to have lower radioactivity, and reported as having come from the location being investigated.
- Samples and analytical results were discarded when the results were above the release criteria.
- Instead of collecting soil samples from locations predetermined to have higher gamma scan readings, samples would be collected from nearby soil and represented as having come from the original location.
- When sufficiently low levels of contamination were not obtained, soil sample collection sites were moved 5 to 10 feet in another direction and a new sample was obtained. The new sample was represented as having been obtained from the original location.
- Chain-of-custody forms were falsified to support the false sample collection information
- During the screening of overburden soil, actual towed array speeds were greater than allowed speeds, thereby reducing the probability of radiation detection.
- Handheld detectors were used improperly, which may have led to increasing the detection limit of the scanning devices.
- Onsite soil sample results were reviewed and shipment of samples to the offsite lab was blocked if there was a high chance that the release criteria would be exceeded.

The whistleblower complaints were confirmed, and many other problems identified that resulted in contaminated soil being falsely declared clean and thus not cleaned up. As the EPA concluded, there was a “widespread pattern of ... deliberate fabrication”:⁴

The data analyzed demonstrate a widespread pattern of practices that appeared to show potential deliberate falsification, potential failure to perform the work required to ensure ROD [Record of Decision] requirements were met, or both. The data revealed not only potential purposeful falsification and fraud in terms of sample and/or data manipulation, they also reveal the potential failure to conduct adequate scans, a lack of proper chain of custody for ensuring samples were not tampered with, extensive data quality issues (including off-site laboratory data) and general mis-management of the entire characterization and cleanup project.

³ Navy 2017, pp. i-ii

⁴ EPA 2017, pp. 10-11, emphasis added

These observations in the record call into question the performance of Tetra Tech EC, Inc., across all of Parcel G. Many of the same personnel in Tetra Tech EC, Inc., worked in a similar time period at nearby locations in Parcel G. The pervasiveness and magnitude of the documented wrongdoing makes it difficult to conclude that similar falsification did not also occur at the four out of 63 trench units where evidence of wrongdoing was not as apparent. Therefore, none of the data generated while Tetra Tech EC, Inc., was involved with the cleanup activities at Parcel G, can be deemed to be definitive or defensible to demonstrate in the record that ROD requirements have been met.

A separate review of Tetra Tech’s radiation measurements in buildings found a similar pattern of widespread fabrication of data.⁵ It found, for example, duplicate data strings (i.e., measurements had been made in one part of a building and then merely pasted into reports for other parts of the building or other buildings, without actual measurements being made). The scans took only half the time they should have taken, indicating either that the scan speed was twice what it should be (and thus incapable of detecting contamination at the required levels) or half of the buildings were reported as scanned when they weren’t at all.

A Crisis in Public Confidence—A Cloud Over The Credibility of the Navy Hunters Point Cleanup Operation: Did Tetra Tech Act on Its Own, Or Based on Signals from the Navy?

As the EPA concluded, above, this widespread data falsification resulted in “*general mis-management of the entire characterization and cleanup project.*” The fundamental question is whether this mis-management of the entire Hunters Point radioactive cleanup project was a result of just astonishingly poor oversight by the Navy of its contractor, allowing the latter to engage in falsification for years, or whether something even more grave is at work. **Is what caused the scandal not that Tetra Tech was engaged in some rogue activity but was actually following directives, implicit or otherwise, from the Navy to declare contaminated areas in fact clean so as to reduce the Navy’s cleanup expenditures?**

Two Tetra Tech employees have pled guilty and were sentenced to prison.⁶ At least one indicated that his actions were due to pressure from supervisors and managers, to declare contaminated areas clean so they wouldn’t have to be remediated.⁷ Whistleblowers have identified a widespread pattern of orders to fabricate sampling and measurements so as to declare contaminated areas were in fact clean.⁸ How high up did those orders go? Did they stop at Tetra Tech management, or was Tetra Tech responding to its understanding of what the Navy

⁵ Department of the Navy Naval Facilities Engineering Command Base Realignment and Closure Program Management Office West, *Building Radiation Survey Data Initial Evaluation Report, Former Hunters Point Naval Shipyard San Francisco, California*, March 2018

⁶ See plea agreements, USA v. Justin E. Hubbard and USA v. Stephen C. Rolfe, US District Court, Northern District of California, San Francisco Division, May 18, 2017.

⁷ Rolfe plea agreement, *supra*, p. 4

⁸ See, e.g., Declaration of Anthony Smith in Support of Petition to Revoke the License of Tetra Tech, Inc., Before the US Nuclear Regulatory Commission, June 3, 2017

wanted—to save money by reducing cleanup, in turn by declaring soil or buildings that should be cleaned up not to need such remediation and expense?

The simplest way to answer that question is by examining the quality of the Navy proposal to remedy the falsification. If the scandal were truly limited to Tetra Tech and they had acted contrary to the Navy's wishes, explicit and implicit, then the retesting plan would be of high integrity, aimed at assuring that nothing that was contaminated went undetected and undeclared. If, on the other hand, Tetra Tech's actions were not an anomaly but a response to what it understand, at high levels, to be the Navy's wishes, whether communicated directly or by a wink and a nod, to reduce its cleanup expenses, then the retesting plan would have similar biases and deficiencies. Alas, the latter appears clearly the case.

The Work Plan Ignores the EPA Findings and Recommendations

As indicated earlier, the Navy found only 49% of the Parcel G survey units to be subject to data falsification and in need of retesting. EPA found twice that amount. And it had numerous criticisms of the Navy review.

However, the Navy has all but ignored the EPA findings in the retesting plan. The basic retesting will be limited to the survey units the Navy had initially found questionable. A second phase of far more cursory and limited surveying will occur for the additional survey units EPA (and DTSC and CDPH) found to have evidence of data fabrication and needing thorough retesting.

Furthermore, the detailed criticisms by EPA of the Navy's 2017 review of Tetra Tech's work on Parcel G have not even been acknowledged, let alone the problems fixed. One would think that given the fiasco of the years of Tetra Tech bogus work, and the failure of Navy oversight that allowed it to go on for so long—followed by the embarrassment that the Navy's review caught only half of the problems that EPA subsequently found—the Navy would acknowledge in detail the EPA review and follow EPA's recommendations to the letter. The refusal to even acknowledge the EPA review and criticisms in any real fashion suggests that the Navy's attitude remains, "full steam ahead, damn the torpedoes."

The (Hidden) Core of the Work Plan is the Astonishing Claim that Hunters Point is Too Clean, that 80% of Soil Declared Contaminated Wasn't in Fact Contaminated and Didn't Need to Be Cleaned Up.

The Navy in its public pronouncements has asserted that it recognizes the problem caused by Tetra Tech's falsification of data designed to claim contaminated soil was in fact clean, and that the Navy is committed to retesting to find all soil that was declared clean but wasn't. However, the actual Work Plan does precisely the opposite.

Buried in a few sentences on page iv and a footnote on page 2-1 the true intent is set forth, although in language that would not put any in the public on notice. Because of the importance of this breach of faith, we quote the passage from page iv verbatim:

The previous work relied on a quicker, less accurate method for analyzing radium-226 (226Ra). This method was *known by stakeholders at the time to be biased high. A large amount of soil (estimated 80 percent) was likely mischaracterized as contaminated* (Argonne National Laboratory, 2011).

(emphasis added)

As will be discussed shortly, this is completely wrong. But first let us discuss briefly the astonishing implications of these few lines.

The Navy claims that “stakeholders” have known since 2011 that the measurement technique for radium-226 gave erroneously high readings, resulting in large amounts of soil being cleaned up when they didn’t have to be, and did nothing about it. Who these stakeholders are is unclear, as they are noticeably not named, but surely the Navy is one.

Secondly, the Navy now astonishingly asserts that about 80% of soil (“a large amount”) was erroneously determined to be contaminated and shipped off as radioactive waste when it was in fact clean. Again, it says it has known this for seven years yet allowed this to continue.

If the Navy’s statement were true, it would mean a confession of misuse of tens or even hundreds of millions of taxpayer dollars. Congressperson Pelosi has called for an Inspector General investigation of the Navy’s conduct. This would seem to be a worthy aspects of such an investigation.

But the operative phrase is “if true.” The Navy’s inappropriate conduct with regards the retesting is its attempt to convert a promise to deal with Tetra Tech having declared contaminated soil clean into a plan by the Navy to now do the same at even larger scale. The irony is that if the Navy’s remarkable new claim were true—that it has known since 2011 that vast amounts of soil being cleaned up didn’t have to be—then it engaged in huge fraud against the public purse.

But it isn’t true. The heart of the claim rests on the assertion that Tetra Tech’s onsite laboratory overstated radium-226 concentrations because it couldn’t discriminate between the 186 keV gamma peak for radium-226 and the nearby peak for uranium-235. In other words, the contamination might not have been pure radium but might have included some uranium as well.

But, of course, that is completely irrelevant. One’s child should not be exposed unnecessarily to radium, uranium, or both together. Furthermore, the cleanup level of uranium-235 is about an order of magnitude lower than for radium-226, so if some of the contamination is uranium-235 rather than all being radium-226, it is worse from a cleanup standpoint than if all were radium.

The Navy may try to claim that uranium-235 isn’t a “radionuclide of concern” at Parcel G of

Hunters Point, that all uranium-235 there is from background.⁹ But that clearly isn't true. The nuclear materials licenses for the site included large amounts of U-235, and the contamination on the ships from the Pacific nuclear tests brought back to Hunters Point for decontamination, and the nuclear weapons debris from a range of nuclear tests also brought there, would have had U-235 as well.¹⁰

So, whereas the public may think the retesting plan is to deal with the fact that Tetra Tech manipulated data to claim radioactive soil was clean, the real purpose of the plan, as set forth by the Navy, is to assert that soil declared radioactive was in fact not. The site is too clean, the Navy now extraordinarily asserts.

Inflated Radiation Background

Immediately after asserting that 80% of the soil cleaned up at Hunters Point shouldn't have been, the Navy claims additionally that radiation background is much higher than previously assumed and should be pushed up to a larger value, further reducing the amount of soil that would be deemed contaminated and need cleanup. And indeed, much of the Work Plan is devoted to artificially inflating background.

“Background” refers to the amount of radioactivity that would have been at Hunters Point had the Navy done nothing to add to it. There is a bit of radium, thorium, and similar radionuclides in all soil naturally. When we mine them from the earth and concentrate them and use them and spill them, those concentrated amounts are above background. Similarly, because of the nuclear weapons tests such as those supported in the Pacific by Hunters Point naval operations in the forties and fifties, there are small amounts of artificial radionuclides spread everywhere on earth. It isn't natural radioactivity, but is now considered part of background.

The Navy is not obligated to clean up natural or fallout radionuclides at background levels, only the radioactivity it and other Hunters Point entities added to background. So it has an incentive to make background seem as large as possible. An honest retesting plan would take honest measurements for background, which would entail by definition only samples from locations that couldn't be affected by Hunters Point activities. The fundamental rule is that you don't take background measurements anywhere near the place that could be contaminated. All of Hunters Point and the area nearby are potentially contaminated from decades of radioactive activity; background measurements must be taken offsite, and at a significant distance from the site.

However, the Work Plan proposes just the opposite. Four of the five proposed locations for soil background measurements are right within Hunters Point itself; the fifth is nearby. All could be contaminated by the decades of releases, spills, and airborne deposition of contamination. Only

⁹ The Work Plan concedes that U-235 is a Radionuclide of Concern for at least parts of Parcel G, and as indicated above, there is no reason to assume it isn't a potential contaminant throughout the parcel.

¹⁰ Whereas the Operations Crossroads tests involved plutonium weapons, subsequent tests involved bombs that included uranium-235.

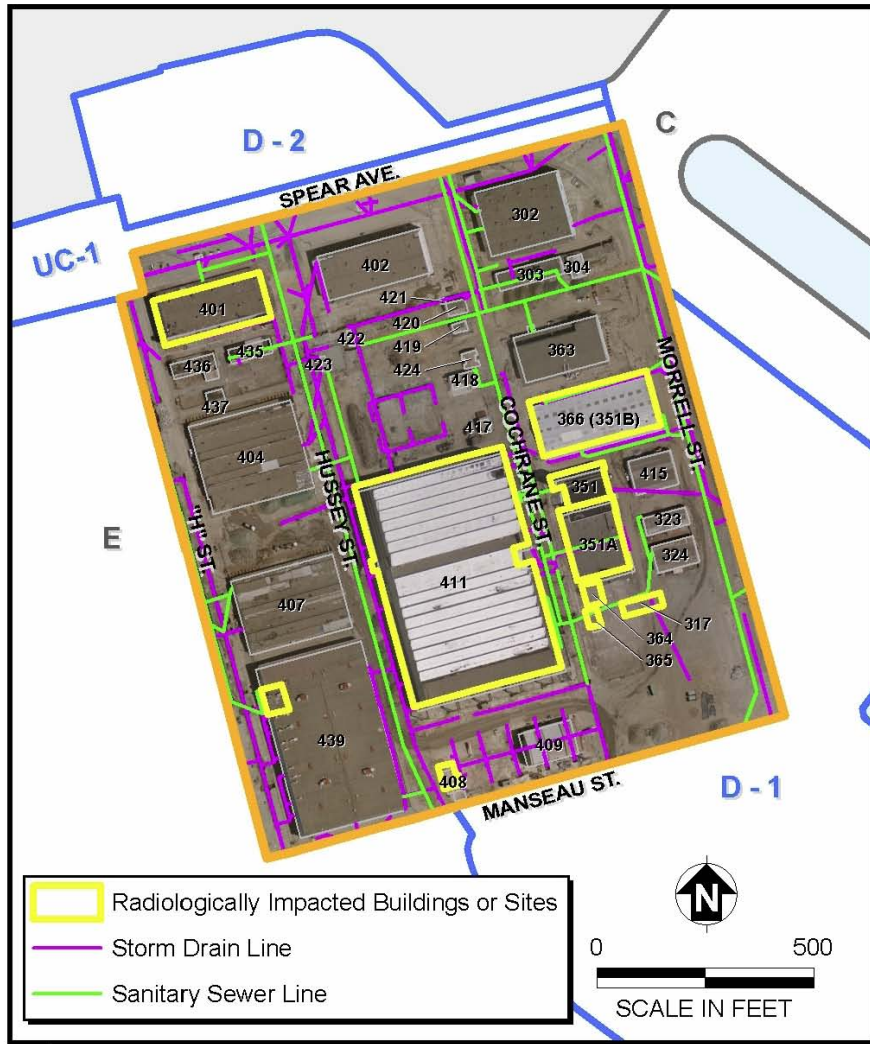


Figure 8. Radiologically Impacted Areas

To compound the problem, the Navy, in a footnote in the Work Plan, weakens its standards even further. The Record of Decision (ROD) for Parcel G sets remediation goals for all radionuclides except radium-226 as the full measured value of the radionuclide. Only radium -226 is set as the remediation goal plus background. However, the Work Plan, in a footnote, tries to change that so that all of the cleanup values are higher than those in the ROD, by making them just the incremental amount above background. One cannot change a ROD through a footnote in a testing plan. The Navy should be tightening the cleanup standards for Hunters Point to reflect current EPA guidance; instead it is further weakening those standards.

The Proposed Measurements Cannot Detect Most Radionuclides At All; and Those That Can Be Seen, Can Generally Not Be Detected at Even the Weak Cleanup Standards

The Work Plan relies heavily on gamma scans. Gamma scans, as indicated by their name, cannot see beta or alpha emitting radionuclides, only gamma ones. And the Work Plan reveals that the gamma scan can only see radium-226 at its grossly inflated cleanup level, not other gamma radionuclides such as cesium-137. Much of the measurements proposed in the Work Plan are blind to that which they are supposed to detect.

If you can't detect contaminants at the levels requiring cleanup, you can't determine that cleanup isn't required. You can declare "nothing detected," but that is only because nothing can be detected.

Conclusion

The Navy had a heavy burden in preparing this Work Plan for retesting Parcel G in the wake of the Tetra Tech data fabrication scandal. It had been demonstrated that past measurements had been falsified to declare contaminated soil and buildings clean when they weren't. The retesting plan was to regain public confidence by an honest and thorough set of new measurements that would not pretend things were clean when they weren't.

Instead, the Navy has proposed a plan that at best can't detect that which would require cleanup and at worst inflates background, further weakens already weak cleanup standards, and is intended by its own terms to declare the great majority of that which was cleaned up not having needed it. Instead of regaining public confidence, the Navy through the Work Plan has reinforced concerns that Tetra Tech's scandalous misdeeds may not have been solely at their own direction but instead part and parcel of the Navy's overall sweeping of safety under the rug and trying to minimize its cleanup costs at the expense of public safety.

Attachment – CBG Detailed Comments on Parcel G Retesting Work Plan

p. iii only references Navy reviews of Tetra Tech falsification, not EPA's. EPA found twice as many unreliable measurements as the Navy, and made numerous criticisms of the Navy reviews. The additional survey units identified by USEPA/DTSC/CDPH as needing retesting are excluded from the main retesting plan, and only a very superficial review of those survey units will be conducted, as Phase 2. This is quite inappropriate. And many of the other EPA criticisms of the Navy review are ignored. It is remarkable that the EPA/DTSC/CDPH review is essentially ignored.

“Additional reference background areas will also be identified to confirm, or update as necessary, estimates of naturally occurring and man-made background levels for ROCs not attributed to Naval operations at HPNS.” Note definition of background. “Not attributed” and focused on Naval operations at HPNS. Navy bringing in contaminated fill doesn't count, for example. This seems clearly an attempt to further inflate background.

p. iv cites ANL 2011 for claim radium measurements were biased high. The document can't be found—not on Navy website, ENVIROSTOR, or through a Google Search. It is inappropriate to not affirmatively make available a document as critical to this fundamental—and absurd--claim that the site is too clean. Note the first bullet is based on what are called accusations that “may” result in some contamination not cleaned up; next bullets are assertions that in fact too much was cleaned up. Astonishing—it asserts 80% of soil declared contaminated wasn't. No basis given. key -- says an estimated 80% of what was cleaned up didn't need to be, and says this was known since 2011 by “stakeholders”—who are unnamed. What stakeholders?

Conceptual Site Model is supposedly based on the HRA; but no, it isn't (nothing about radium measurements, falsification, or background in HRA), and HRA exempts 90% of the property from consideration.

It is very strange that the plan says they will monitor trench units but are silent on fill units. It refers to 63 trench units, but there are also 107 fill units.

phase I involves 21 of 63 former trench units, and 14 of 28 surface soil units from a former building site. Navy report had recommended retesting only 20 of trench units so it seems their Phase I is basically doing what they wanted to any way, and Phase II may touch the other units (except fill units) but not really retesting them.

Troubling that the plan targeted TUs and SUs for main retesting, based on Navy's estimate of which were fabricated; but EPA, DTSC, and CDPH said virtually all were. Plan essentially thumbs its nose at the Navy's regulators.

Excavated soil will be laid out in rad yards and gamma scanned in Phase I, which cannot see any beta or alpha radionuclides and they admit cannot see any gamma radionuclides of concern at cleanup levels except radium (admitting that it can't see cesium-137 at the cleanup levels).

p v Walk over or drive over gamma scans of surface soil units Phase I, which as indicated above, are blind to virtually all radionuclides of concern at the cleanup levels.

Phase II is deeply troubling--for 2/3 of trench units they will just do borings and do a gamma scan of the core.

Strange that they are only doing alpha-beta scans of buildings; no gamma.

p vi key comparing to the old, wrong release criteria; if meet those, everything OK. Yet the building release criteria are based on the 1974 Reg. Guide 1.86 from the now-defunct AEC, which violates EPA guidance saying one is supposed to use instead EPA's current Building PRG calculator for release criteria for buildings, and the soil release criteria are from 1991 EPA PRGs instead of the current EPA PRGs. In both cases, using the required EPA PRG calculators are far more more protective. There is no excuse to use vastly outdated and nonprotective release criteria.

(Note, there is no reference to using the sum of the fractions, no adding in other radionuclides or chemicals as is required under CERCLA.)

“Individual samples reporting 226Ra gamma spectroscopy concentrations greater than the RG for 226Ra will be analyzed for uranium-238 (238U) and 226Ra using comparable analytical methods. For that specific sample, the 238U result will be used as a more representative estimate of the background value for 226Ra, and the alpha spectrometry 226Ra concentration will be compared to the RG for 226Ra using the revised background value.” This is very erroneous and biased to reduce cleanup inappropriately. 238U can only be used to estimate 226Ra background if there is no possible added source of 238U beyond what occurred at the site in nature. Since More than a ton of 238U was licensed at Hunters Point, and additional uranium was associated with decontaminating ships and in fallout samples brought back from the nuclear test zones, no such assumption can be made. Using 238U as the 226Ra background is fundamentally flawed and designed once again to inflate background and improperly reduce cleanup. It shows a deep bias and lack of honesty in the Work Plan, a falsification not unlike that of Tetra Tech that this plan was supposed to correct.

Main Body of Work Plan

p. 1-1 only testing “radiologically impacted” soil and buildings, and only those tested by Tetra Tech. Much of HP will thus never be sampled. All of Parcel G is potentially impacted, from the decades of activities that could have resulted in widespread migration of contamination (e.g., sandblasting and steam-cleaning contaminated ships).

claims a phased approach was adopted pursuant to a suggestion by unnamed regulatory agencies. They should be identified—the silence is suspicious. It is not clear they wanted Phase II to be far less rigorous than Phase I, which is what the Navy is now proposing. If EPA etc didn't sign on to Phase II being less thorough than Phase I, claiming the phased approach comes from unnamed regulatory agencies is misleading at best.

They are not using all of MARRSIM, just parts they feel are “applicable” in light of the Basewide Rad Memo. Unclear what they are using and what not, and why.

Most of the actual plan will be in a Sampling and Analysis Plan, which is not included and is not subject to public review or input. This “hide the ball” approach is quite inappropriate, given the scandal that occurred in part because of failure of transparency and opportunity for full review.

key p 2-1 says purpose is to deal with allegations Tetra Tech misrepresented data—doesn’t say falsified, fabricated, etc. “and in addition” overestimated radium. The navy is changing the nature of the retesting entirely, which was to be to deal with Tetra Tech falsification. Instead it is now skewed toward asserting that there was too much cleanup, rather than too little.

fn is key claims used wrong measurement technique, and comparison with offsite lab was consistently higher for the onsite lab, but don’t show us those data, or why there isn’t a bias for the onsite lab. [note: if the radium measurements are biased high, so presumably should be the background, which would nullify it]

2-2 dredge spoils were used as fill. If true, than using measurements of fill that contained dredge spoils as background would be completely inappropriate, because Hunters Point activities (e.g., decontaminating ships in dry docks or slips) would have contaminated that material.

2-3 lists only a few Radionuclides Of Concern, ROCs, even fewer for most sites. There are on the order of 100 genuine ROCs, and artificially restricted them to a handful means that no measurements will be made for the great majority and even if there were, they would not be cleaned up because there are no remediation goals identified for them. So the Navy is declaring the great majority of Parcel G will never be tested, and for the parts that are, the great majority of radionuclides won’t be tested for or required to be cleaned up even if found.

2-4 outrageous; no pathway except for construction worker from ingestion or inhalation; only external exposure from ROCs for everyone else; and of course no garden KEY KEY KEY; will use for their risk assessment – only external exposure (through covers) are pathways considered.

astonishing under the uncertainties section: The assertion that there is a LOWER potential for contamination than previously assumed. Not a single item is identified about higher potential.

“LLRW bins were tested by the Navy’s independent waste broker at an offsite laboratory using 5-point composites, and only 3 out of 1,411 bins had results with 226 Ra above the RGs.” Where is the documentation for this, and what is a 5-point composite---averaging, which is inappropriate? How were they tested? This claim seems very flimsy, and the lack of information provided suggests that the Navy recognizes this.

Buried the data falsification as an issue.

3-1 the objective shouldn't be the 2009 ROD, but today's standards. If one is going to retest in 2018, one should do so against 2018 standards. But in fact, Navy isn't even using the 2009 ROD standards, but has changed them in the Work Plan – illegally – to make them all standards incremental above background, which isn't allowed in the ROD for anything except radium.

3-2 deeply troubling and wrong: “If any 226Ra gamma spectroscopy concentration is greater than the RG for 226Ra, then the soil sample will be analyzed for 238U and 226Ra using comparable analytical methods (e.g., alpha spectrometry for 238U and radon emanation for 226Ra). For that specific sample, the 238U alpha spectrometry result will be used as a more representative estimate of the background value for 226Ra, and the alpha spectrometry comparable result for 226Ra will be compared to the RG for 226Ra using the revised background value.” “Comparable” methods not delineated. But key—even with all the games they are playing, if a measurement exceeds the cleanup standard of 1 pCi/g above the established background, which should be the end of the matter and the area cleaned up, rather than using the established background, they will use the U-238 level in the radium sample. This makes no sense, for the reasons set forth above, that you can only use U-238 for Ra-226 background if there is no U-238 possible besides natural levels; but huge amounts of U-238 were used at Hunters Point, so the U-238 measurements won't reflect background but rather background plus contamination.

“The radiological investigation will be conducted on a targeted group of 21 of the 63 TUs associated with former sanitary sewers and storm drains and 14 of the 28 SUs3 associated with surface soil at building sites in Parcel G.” The rad investigation thus will be on only part of the suspect sites. thus violating EPA/DTSC/CDPH recommendation for retesting virtually everything. [The cursory scanning in Phase II of other survey units does not meet the requirement for full retesting of suspect sites.]

Here they will not disclose how many soil samples will be taken, systematic or biased.

3-3 Indefensible -- only 3 ROCs for TUs (trench units) and 4 for building soil Even the documents they cite (RODs and HRA) show more ROCs than these; but there could be a hundred ROCs. Nuclear weapons test debris would contain a full range of fission products, unfissioned plutonium and uranium, and activation products (including from activated corral and sand). There is simply no scientific basis for asserting there are only 3 or 4 possible radionuclides, even taking into account decay life.

They only have an investigation level for radium (1 pCi/g), not for anything else! They concede they can't see the other ROCs at the cleanup levels, or at all.

critical: footnote a-- “All RGs will be applied as concentrations above background.” Massive change to ROD, 2006 standards; violates EPA. KEY The ROD applies release criteria, with the exception of radium-226, as the full concentration measured; only radium RG is the concentration above background. You can't change the ROD through a footnote in a retesting Work Plan. They are weakening the standards through the retesting plan, which should be designed to increase public protection, not reduce it.

They will not do biased samples or do more measurements unless gamma scan goes over investigation level; but only have an investigation level for radium---NOTHING ELSE—and it is 1000 times the EPA PRG. So they will virtually never do biased soil samples, even though there could be contaminants above the release criteria.

3-4 can't see cesium at cleanup level with the gamma scan; and of course the Pu and Sr aren't given investigation levels either, because can't be seen, as they are alpha and beta emitters that the gamma scan can't see at all. Only scanning for radium and Cs, but no investigation for the latter because they can't see it at the level of concern.

They are limiting the scans to just those two, with no investigation limit even for Cs; whereas there are other gamma emitters worth watching out for.

All the stuff you are interested in from the NRDL work and the decon of ships—fission products, unburned Pu and U—they can't detect and aren't measuring for and don't have investigation levels for in terms of the scans.

Refers to investigation “levels”—but in fact only one investigation level for one radionuclide, radium, and that one they are cheating on.

“The radiological investigation design is primarily based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012) with the ultimate requirement to demonstrate compliance with the Parcel G ROD RAO (Navy, 2009).” In other words, the design is based on the work of Tetra Tech, which they are supposed to be throwing out because of falsification.

‘The RGs presented in Table 3-5 are incremental concentrations above background’ -- key, very dishonest, the remediation goals in the ROD are, with the exception of radium, not incremental concentrations above background; you can't change the ROD through a footnote in a subsequent retesting plan; and this in any case violates EPA guidance, which requires cleanup standards to be the full measured value (contamination plus background) and not the incremental amount above background.

following Tetra Tech, only 18 samples per unit. Pretty hard to find contamination with those few samples.

3-5 chose places to resample based largely on Navy 2017; silent about EPA's review that found twice as many suspect places.

6” over-excavation; unclear if it will be sampled, or only scanned once removed

Table 3-1 makes no sense, sidewall unit seems to have far larger volume than excavation volumes but footnote says equal. claims to take 2600 systematic samples from trench units. Really not that large given the area involved and the scope of the problem.

For Phase II, they are only taking 36 systematic samples per trench, compared to as many as 270 per trench for Phase I—stiffing EPA/DTSC/CDPH recommendations that almost everything should be fully sampled. Phase II, just a handful of cores, as opposed to excavating all the soil in the survey unit in question.

3-7 Phase I based solely on allegations of problems found in Navy 2017; silent on EPA/DTSC/CDPH analysis that found far more problems. .

former building areas; subject only to gamma scan; biased samples will only be taken where gamma scan over investigation levels (just radium); focused on peaks for the ROCs, which means only radium (and maybe cesium, but they admit they can't see it at levels of concern) what levels can they see—don't say; but since they don't have an investigation level, doesn't matter. In other words, they are relying on gamma scans that can basically see almost nothing that exceeds the cleanup levels.

3-8 instrumentation requirements will be based on Tetra Tech past report—again, relying on the work of the very contractor that has been discredited and whose work they are supposed to be independently redoing.

lab instruments will be set forth in Sampling Analysis Plan which the public can't see or comment on. Field instruments only set for radium, bismuth, and cesium (with the latter irrelevant because of poor minimum detectable activity, MDA)

3-10 don't give MDAs for field instruments, just formula how they will calculate; critical to know the actual MDA

calibrated annually! that doesn't seem sensible.

improper—3-14 “ provide real-time NORM background subtraction”
soil sorting system sounds questionable; conveyor belt, sorting into clean and dirty piles via high velocity and volume running by a detector; but you are still supposed to take actual soil samples, so not clear how you can do systematic lab samples if you have already piled all the soil into a “clean” pile

3-15 compositing the sample over a large volume; potentially problematic—averaging generally prohibited by EPA for residential use; easy to dilute

18 systematic samples but only 1 biased sample, from the diversion bin.

3-16 radiological screening yard; if not over RGs, declared clean and OK for reuse or to be sent off site; but RGs only for 3 or 4 ROCs, and the screening can only see for 1, radium, about which they are playing games (the throwing out of the lab measurements for Ra based on the spurious claim related to the nearby uranium peak). So almost all of the screening in the screening yard is useless; blind to almost any radionuclide at the levels that matter.

3-17 only 6 cores per TU; gamma scan of core, based on investigation level, which exists only for radium and which is already very elevated; 1 pCi above BKG, as they have been describing for all others, and inflated background. The gamma scanning of cores, rather than soil sampling, is designed to fail – it is blind to essentially anything that matters, can't see alpha, can't see beta, and can't see almost any gamma at the cleanup levels.

3-21 DOD certified lab; not EPA or state certified.

key—analysis will only be for the 3 or 4 ROCs!!!! and only 10% will be tested for Sr-90; and that using gas proportional counting (I don't see reference to chemical separation)

doesn't specify technique for Sr-90—important; easy to screw up

additionally, if sample is over RG for Cs (and they are using the wrong RG, not today's EPA PRG, and beyond that they are now using RG + [unspecified] BKG, rather than the RG alone), only then will they sample for Sr—very troubling, because there was a lot of separated Sr used at Hunters Point.

They only will analyze for Pu if Cs or Sr is above RG—again, deeply troubling. You can readily have Plutonium over release levels without Cs or Sr also being above their levels; in part because they have different Kd values affecting migration rates.

If Radium is over RG, they insist on additional analyses for NORM to try to throw out the reading. Everything is biased to throw out readings that would require cleanup; no parallel bias to double-check readings that are below RG, when that may be wrong. They are to alpha spec for U-238; “Analyses using alpha spectrometry for 238U along with an analytical method for 226Ra comparable with alpha spectrometry for 238U will be performed in accordance with the SAP.” Potential for some mischief here, not detailed.

Table 3-2 only 18 samples total per TU from fill for any Phase II analyses

pdf 49 (no page or figure #) action only taken if $226\text{Ra Concentration} > 238\text{U Concentration} + \text{RG}$ This is wrong and irresponsible, violates the ROD, outside of EPA practice. Issue isn't any longer whether Ra is greater than RG; it has to be greater than RG and U-238 concentration added together. If not, complies---dangerous. The error in assuming U-238 level is the background level for Ra-226 has been described above; that only could work if there was no U-238 besides that in background, but Hunters Point used huge amounts of U-238.

4-1 buildings to be tested against AEC Reg Guide 1.86, not EPA's Building PRG calculator, as required by EPA guidance for CERCLA sites. Reg. Guide 1.86 values are thousands of times less protective than EPA PRGs and outside even the upper limit of the EPA acceptable risk range.

Key – even with all these manipulations, if they still don't meet release criteria, they won't clean it up; they will do an analysis of risk to say it is OK not to clean it up. That violates the ROD. The remediation goals are the contamination levels that are supposed to trigger cleanup.

They claim they will follow EPA guidance, but clearly aren't—for example, they aren't using current PRGs for soil or the EPA building PRGs at all..

4-2 claim only 2-4 ROCs per building; not credible; there are a hundred potential radionuclides of concern at those buildings.

4-3, again following the Tetra Tech protocols, when all of Tetra Tech's work is suspect and they should be relying on none of it; only 18 measurements per; only one RBA—another potentially contaminated building

4-5 beta background for detectors is pretty high

Figure 4-1 amazing background reference area is in an admittedly impacted building, a few feet away from parts of the building admitted to be impacted!!

5-2, will report building measurements in cpm, instead of the units of the RGs, which are in dpm; suggests they are trying to hide things; should use the units comparable to the RGs

5-3 will compare to their claimed background, to say if “consistent with background,” then no action; but the background is feet away from the contaminated area and likely contaminated as well

5-4 extraordinary show of bias: if results exceed RGs, they will re-evaluate, see if they can question the measurement; if doesn't exceed RG, they accept it without question. All sorts of procedures to go back, not to the right portion of the soil that was elevated, and say they didn't find it again; but if results are below RGs, they accept that without re-evaluation. So the bias is heavy: question all readings above cleanup levels, because those could cost the Navy money, but do nothing to confirm readings below cleanup levels, which if wrong could place people's health at risk.

“All scan data will be compared directly to RGs or investigation levels.” But they concede scan data cannot see RGs for anything but radium and they have no investigation level except for radium because of that.

“If direct measurement or sample results exceed the RG or investigation level for a specific ROC for locations not identified by scan survey, the scan survey technique will be reviewed and investigated to determine whether the scan survey was implemented correctly and whether the scan methodology met the survey objectives.” But the Navy has admitted the gamma scan can't see almost any ROCs at RGs or investigation levels.

“The objective of investigating potential areas of elevated activity is to characterize the ROCs present and the size, or extent, of all areas of elevated activity. To accomplish this objective, a minimum of one potential area of elevated activity will be investigated in every SU.” The Navy may only investigate one elevated area per SU even if there are multiple elevated areas?

Bias is made clear – “The first step in investigating potential areas of elevated activity is to

confirm the measurement or sample results that indicated the potential area of elevated activity.” In other words if elevated, don’t go forward unless confirmed; if supposedly not elevated, no need for confirmation. This is a clear indication of the bias in the whole plan, biased towards reducing the Navy’s cleanup expenses at the cost of increasing the risk of missing contamination that should be cleaned up. “In most cases, at least one measurement or sample result documenting the lack of elevated activity will be required to support a decision to terminate the investigation of a potential area of elevated activity.” If you have a measurement showing it is elevated, and you take one confirmatory measurement that comes back different, you trust the no-contamination value and throw out the contamination measurement. There is no reason to believe the second measurement rather than the first. This is pure bias. As is the only requirement for confirmatory measurements is if a reading has been high, not if it was low. If the concern were public health rather than Navy expenditures, the bias would have been in the other direction.

5-5 “Determining the extent of elevated activity for ROCs without a significant gamma emission, such as 90Sr and 239Pu, will require collecting additional soil samples or **establishing a correlation between the difficult-to-detect ROC and 226Ra**. Even when a correlation can be determined, the scan survey objectives will need to be reviewed and adjusted to account for detecting 226Ra at lower activity levels. If the elevated activity is associated with 90Sr or 239Pu results **significantly above background**, a Field Change Request will be initiated to document the characterization of any potential areas of elevated activity.” Note that the issue isn’t any longer exceeding release criteria; it has to be, not just above (already inflated background values) but significantly above background, not defined.

“If all alpha or beta static measurement or ROC-specific soil sample analysis result are less than the RGs or investigation levels, compliance with the Parcel G ROD RAO is achieved.” This makes no sense; there is only 1 soil investigation level, for one radionuclide, because the gamma scanner can’t see anything else.

“A NORM background evaluation will be performed for every sample where the 226Ra concentration exceeds the average RBA 226Ra concentration by more than the RG of 1.0 pCi/g. The purpose of the NORM background evaluation is to ensure the most representative estimate of background available is used to evaluate 226Ra results for comparison with the RG, not to validate analytical methods.” Deeply troubling; the standard is to use the RBA they already set; but if it goes more than 1 pCi over that (i.e., is over the release limit), they will go back and CHANGE the background. Again, they aren’t doing this if the value is below the RG; pure bias.

“The 226Ra background at HPNS is known to vary significantly in different areas of the site. **Since 238U is not a ROC at HPNS, 238U concentrations are an acceptable representative of background** for all radionuclides included in the naturally occurring uranium decay series, which includes 226Ra. By definition, 226Ra concentrations are considered background when 226Ra is in secular equilibrium with 238U, which means the 226Ra concentration is equal to the 238U concentration. Therefore, the 238U concentration can replace the average RBA 226Ra concentration as a more representative estimate of background for a specific sample.” This is plainly wrong and biased. As indicated above, there was more than a ton of U238 at HP from HP activity; it certainly must be a ROC, which bars its use as radium background due to secular

equilibrium. Using U238 as the Radium background is irresponsible.

“Alpha spectrometry provides ²³⁸U analytical results of acceptable quality for the NORM evaluation. However, the gamma spectroscopy results for ²²⁶Ra are based on larger volumes of soil and are not always comparable with alpha spectrometry results. Therefore, an analytical method for ²²⁶Ra comparable with alpha spectrometry for ²³⁸U is required to perform the NORM evaluation. For example, radon emanation analyses for ²²⁶Ra have similar sample support in terms of sample preparation and sample volume compared to alpha spectrometry for ²³⁸U, and are considered comparable for purposes of the NORM evaluation. Alternatively, gamma spectroscopy uses minimal sample preparation and much greater volumes of soil for analysis, and may result in significantly different results based solely on the analytical method compared to alpha spectrometry and radon emanation.” Troubling; they don’t even have comparable measurement techniques for radium and uranium. They say radon emission analyses “are considered comparable for purposes of the NORM evaluation.” Considered comparable by whom? They always slide over such language. And comparable just for NORM evaluation, meaning not generally comparable and questionable for NORM. The radium background is already grossly inflated; they want to inflate it even further by declaring the amount of U-238 to be the radium background, even though there is U contamination at Hunters Point and even though the measurement techniques aren’t the same.

They had licenses for (which only accounts for a fraction of the radioactive materials there) 2520 pounds of natural or depleted uranium, essentially therefore all U-238. this doesn’t count all the U238 from ship decontamination (e.g., U238 tamper, and third stage of H bombs) and fallout debris brought back. You can’t use U-238 as a NORM at Hunters Point, or to assume secular equilibrium so you can claim it as radium background.

“The NORM background evaluation simply replaces the average RBA ²²⁶Ra gamma spectroscopy concentration with a ²³⁸U alpha spectrometry concentration as a more representative estimate of background for a specific sample. At the same time, the ²²⁶Ra gamma spectroscopy result is replaced with an analytical result using a method comparable to alpha spectrometry (such as radon emanation). If the revised ²²⁶Ra result, using an analytical method comparable to alpha spectrometry, exceeds the revised background value based on the ²³⁸U alpha spectrometry result by less than the RG of 1.0 pCi/g, the sample demonstrates compliance with the Parcel G ROD RAO. If the revised ²²⁶Ra result exceeds background by more than 1.0 pCi/g, additional evaluation may be performed. If the NORM background evaluation is inconclusive, more analysis may be conducted.” We’ve demonstrated repeatedly above why this is obviously wrong and intended to reduce cleaning up that which should be cleaned up. If over the RG, that should be the end of it; instead, they test with a different measurement, of unclear accuracy “such as radon emanation” and alpha spec for U238, subtracting U238 level from the radium level. If the second measurement is OK, the first is thrown out (bias always to throwing out); then if that is not OK, that also should be the end of it, but instead, more analysis is done. Everything is biased against public health. Also, details of what techniques they will use are not provided, so can’t review to see if credible at all; don’t even specify what technique, but just “comparable to alpha spec, such as radon emanation.” Much room for mischief; no transparency; hide the ball.

5-6 key This include numerous games to throw out readings that are above 1 pci/g above background (e.g. further inflating background, requiring measurements by several techniques before you will accept a high reading, etc.); fail to deal with the fact that 1 pCi/g above background is an immense cancer risk, far outside EPA risk range.

They plan to evaluate whether the RBA data are representative of the contaminated area being studied; by definition the contaminated should be different.

They are using median values for the entire SU – but averaging is forbidden by EPA for situations such as residential use where use is non-random. Under CERCLA they are required to use EPA’s CERCLA guidance, but are repeatedly violating it. They are setting a figure of over 3, and perhaps over 2, as non-representative; troubling.

Says using average values over wide areas, comparing to derived concentration values for wide areas – none of which they are supposed to do, as discussed above. EPA guidance requires them to use “not to exceed,” not average; release criteria, not derived concentration values for wide areas, etc.

Whole point of this discussion is to throw out reference background areas and replace them with ones with higher background. Not clear how they can claim they can look at SU/TU compared to RBA and if ratio is high, determine RBA wrong; why is it not that the SU/TU is contaminated?

Also uses “NORM evaluation”—the substitution of high U-238 values for actual background radium numbers, which we’ve shown is wrong and biased.

5-7 gives themselves a whole range of actions to take if, after all the games to declare something not contaminated, still seems to be, so they don’t have to clean it up.

6-1 says Perma-Fix will do the work. Who is Perma-Fix? Navy says no contractor selected to do the work, aside from Jacobs Engineering doing some buildings. (Navy Q&A). But p 1 of this plan says CH2MHill and its subcontractor Perma-Fix will do it. What is going on?

refers to Appendix C MOU, but that is for 2 or 3 companies that aren’t identified as part of this plan at all.

7-1 won’t disclose where it will be staged or disposed of. Doesn’t define how they will divide between LLRW and non-LLRW

7-2 very troubling: “7.2.1 Waste Classification Accumulated waste deemed to be radioactive waste will be classified as LLRW based on 49 CFR, basewide requirements, or disposal facility requirements. Waste characteristics, including the radionuclides present and their associated specific activities, will be measured by an available standardized test method per the SAP, such as gamma spectroscopy, strontium analysis, or alpha spectrometry.” 49 CFR what? why Title 49? These are Department of Transportation placarding requirements for trucks; they are not regulations defining what is low level radioactive waste and has to be disposed of in a licensed

LLRW site. Under current rules, any waste with radiation above background is LLRW and has to go to a licensed LLRW site. The passage declines to say what basewide requirements? what disposal facility requirements? It should be far more clear: anything with radioactivity above background is LLRW. At minimum, anything over proper release criteria (EPA current default PRGs for unrestricted use.) NO NO NO—49 CFR is DOT transport regs—those are not regs for determining what is LLRW for disposal purposes. Doesn't mention California law, the Keeley Act, barring LLRW in anything other than a specially licensed LLRW site with multiple barriers, retrievable, monitorable, etc. Ignores Governor Davis's moratorium, still in effect, barring disposal in municipal landfills.

Does not specify what rad concentrations, not averaged, will be considered LLRW waste. There is no Below Regulatory Concern level. NRC tried to establish a BRC level; Congress struck it down.

P. 7-9 “7.5 Compliance with CERCLA Offsite Rule

Consistent with the CERCLA Offsite Rule, wastes generated from remediation activities, such as contaminated soil or hazardous waste, at a CERCLA site may be transferred only to offsite facilities that have been deemed acceptable by the USEPA Regional Offsite Contact (40 CFR 300.440). With Naval approval, the contractor will request proof of Offsite Rule approval from the offsite disposal facility before transferring any wastes to an offsite facility.” That isn't the CERCLA offsite rule; and this doesn't say you will even get EPA approval, merely that the contractor will request info from disposal facility. Not what is required; particularly if they don't disclose to the recipient facility the fact that the waste is still radioactive (if that is what they intend to do, seemingly), even if below release criteria. REPETITION OF ORIGINAL HUNTERS POINT PROBLEM OF SENDING RADWASTE TO SITES NOT LICENSED OR DESIGNED FOR RADWASTE.

7-10 “Uncontaminated debris may be sent to municipal landfills, landfills designated for construction/demolition debris or a recycling facility.” NO. Repeating the same mistake. No definition of “uncontaminated.” If it means below release criteria for, say, restricted release (based on assumption of no groundwater use, cement cap, no residences or no gardens; or failing to consider direct contact with the recycled material), then sending it to municipal landfills or recycling is inappropriate, as there are different exposure pathways. And violates BRC prohibition, and Governor's moratorium. Note not a word about the gubernatorial moratorium.

8-3 Only monitoring for and limiting a handful of radionuclides; once again, declaring all others to not be ROCs, when scores of radionuclides are of concern at HP.

Inappropriate: set Derived Allowable Concentrations for air emissions at occupational levels, not levels for public; 100 times too high.

Appendix A

taking only 5 samples per RBA—not enough for appropriate statistics and keeping error margins small.

key again: SAP kept secret, which is where the detail and really important material are buried 2-1 surface 0-6” -- which?, matters for fallout, which tends to be in the upper part of the profile. subsurface, 1-2 foot intervals up to a depth of 10’ which? 1 or 2 foot intervals? to what depth? too much room for altering outputs.

off-base only set at surface, 0-6”? No subsurface? p3-3 says no subsurface for offsite. No good reason given. If fallout offsite is on surface and not subsurface, as would be expected, you need to know that, rather than assuming same level of fallout through the profile.

3-3 only 5 surface samples per RBA; 25 subsurface—simply at one spot, at 5 depths, from one core?

fn a p. 3-2, again says All RGs will be applied as concentrations above background. Again, violates and tries to illegally change the ROD without changing the ROD; violates EPA policy as well.

U-235 is identified as a ROC in the table and given a cleanup level; so throwing out radium readings because they may also include some U-235 is nonsensical, because it doesn’t matter to the person exposed if they are being irradiated by pure radium or radium plus uranium-235.

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FROM: Greenaction for Health and Environmental Justice
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RE: Comments to the *Draft Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard, San Francisco, California, June 2018*

DATE: August 14, 2018

I. INTRODUCTION

The Environmental Law and Justice Clinic of the Golden Gate University School of Law submits these comments to NAVFAC's *Draft Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard, San Francisco, California, June 2018* ("Draft Plan"), on behalf of Greenaction for Health and Environmental Justice and its members and constituents in Bayview Hunters Point, San Francisco and throughout California.

We are disappointed, to say the very least, with the Draft Plan, which demonstrates that the Navy has learned little during its six-year journey from denying the scope of Tetra Tech's fraud to reluctant acceptance that all Tetra Tech's work must be redone. In 2012, when the Navy learned of Tetra Tech's fraud, the Navy did nothing meaningful to discover the extent and depth of the fraud; and this Draft Plan again shows the Navy contemplates no changes to business-as-usual – that is, what got them into the Tetra Tech mess in the first place. The Navy claims it wants to repair its badly battered

relationship with the community, but in practice it continues to take actions, like this Draft Plan, that can only further erode trust.

The Parcel G Work Plan is not a good-faith effort to investigate radiological contamination. Rather, it relies on untrue assumptions, weakens cleanup standards and withholds crucial information on which it is based, apparently in a multi-pronged effort to justify minimizing the cleanup despite the massive fraud.

We urge the Navy to go back to the drawing board and come up with a realistic plan to resample all of Tetra Tech's work – to start over – as the fraudulent data requires and as the Navy promised. And we urge the regulators to reject this Draft Plan as inadequate.

II. PROCEDURAL COMMENTS

A. The Public Comment Period Cannot Close Until at Least 30 Days After the Navy Makes Available All Documents on Which the Draft Plan Relies

Documents that are essential to understanding the Draft Plan are being withheld by the Navy. As the Draft Plan concedes, “The activities presented in this work plan will be conducted in accordance with this work plan, a separate sampling and analysis plan (SAP), and a separate accident prevention plan/site safety and health plan (APP/SSHP). The SAP and APP/SSHP are currently being updated for submittal following this work plan.” (emphasis added, p. 1-1).

It is astonishing these essential documents have been withheld from the Draft Plan. How can the public or regulators comment on a work plan calling for extensive sampling without the sampling plan? According to the Draft Plan, the SAP contains crucial information on Quality Assurance and Quality Control (QA/QC), the bedrock of

data validation. If the Navy has its way, this Draft Plan's comment period will end before the SAP, including its design for data validation, is even released.

The Draft Plan itself demonstrates how the plan cannot be evaluated without the essential documents on which it relies. Although it does have a section on Radiological Investigation Design, for example, it leaves essential details to the SAP: "The SAP provides additional guidance on soil sampling, chain-of custody, laboratory analysis, and quality assurance (QA)/quality control (QC) requirements" (p. 3-4). Any "additional guidance" about such essential matters as sampling, chain-of-custody and QA/QC must be provided to fully analyze the Draft Plan.

Similarly, the Draft Plan states, "[t]he analytical methods and the radionuclides being analyzed for will be presented in the SAP and are summarized in Table 3-6." (p. 3-6) But when one looks at Table 3-6, it lists no analytical methods. Rather, the paragraph before the table says gamma surveys "will be performed using detector systems equipped with gamma spectroscopy," without identifying any such systems. The unavailable SAP will presumably specify which systems will be used, and will provide "additional guidance" on a range of important issues, specifics the public does not have access to and are precluded from commenting on.

Likewise, page 3-8 of the Draft Plan states, "[t]he laboratory instruments used to analyze the soil samples and the associated standard operating procedures (SOPs) for calibration, maintenance, testing, inspection, and QA/QC are discussed in the SAP." How can anyone comment on these topics absent filling in the blanks of how the analyses will be done and how QA/QC requirements will be met?

Among other things, the Draft Plan defers to the SAPs: soil samples which "will be submitted to the offsite analytical analysis according to the SAP" (p.3-8); "systematic and bias samples will be containerized, labeled, and analyzed, as described in the SAP"

(p. 3-15); “soil samples will be containerized and submitted to offsite laboratory with appropriate chain-of custody documentation as established in the SAP” (p 3-15); “samples will be identified, labeled, and cataloged according to the SAP” (p. 3-19); “corrective action reports, data validation reports, quality assurance management reports, and assessment reports are discussed in the SAP” (p. 4-4). (emphasis added in each case). These are but a few of the details deferred, there are more examples.

Perhaps the most important example is this: “Analytical data validation will be performed by an independent third party as described in the SAP. Data validation will be performed on all TU/SU [trench unit/survey unit] data and all RBA [reference background area] data” (p. 5-1). Data validation goes to the heart of proving the data aren’t falsified, unlike in the past. It is imperative that we be given the information necessary to comment on the adequacy of the data validation plans.

Furthermore, there is not a single separate SAP. In fact, according to email correspondence between counsel, there may be as many as seven SAPs, all being withheld, each possibly detailing a different approach to the critical subjects left to the SAPs.

Greenaction’s counsel have given repeated written notice to the Navy that the SAPs are essential to understanding and commenting on the Draft Plan and have repeatedly asked the Navy to supply them. To date, the Navy has refused not only to provide the documents, but even to indicate when they might be released.

The Draft Plan relies on numerous other documents that are not available. For example, the Navy attributes its unbelievable claim that 80% of remediated soil didn’t really need to be remediated, to a single report by the Argonne National Laboratory, *Radiological Waste Evaluation Associated with Various Base Realignment and Closure Activities* (2011). This document is not available through NAVFAC’s and the regulators’

online document repositories, nor was it readily accessible via a Google search. Hard as it is to believe, the Final Parcel G ROD is not available on NAVFAC's website either. Nor does the Navy website contain any of the five Tetra Tech documents referenced in the Draft Plan. Among them are the *Basewide Radiation Management Plan*, Feb. 3, 2012, which is heavily relied on by the Draft Work Plan and the *Final Status Survey Results, Building 401*, Sept. 21, 2009; that building is the proposed site of background sampling despite evidence of radiological impact in at least one section of the structure.

As a result of the Navy's failure to make available documents essential to understanding and commenting on the Draft Plan, the Navy has failed to fulfill its public participation obligations; it has failed to provide "sufficient information as may be necessary to provide a reasonable explanation of the proposed plan and alternative proposals considered," as required by 42 U.S.C. § 9617. The comment period must therefore be extended to at least 30 days after the Navy releases all documents on which this Draft Plan relies.

III. SUBSTANTIVE COMMENTS – General

A. The Navy Must Live up to Its Repeated Promises

The Navy has publicly and repeatedly promised it will retest all areas where Tetra Tech worked. The Draft Plan, however, contemplates no such thing. In fact, it calls for resampling only about one-third of the trench units and only half the Tetra Tech survey units: "Twenty-one of the 63 former sanitary sewer and storm drain TUs were selected for the Phase 1 investigation. Fourteen of the 28 surface soil SUs from the Buildings 317/364/365 Former Building Site and Building 351A Crawl Space were selected for the Phase 1 investigation" (p. iv).

This Draft Plan is in direct, irreconcilable contradiction to the Navy's public promises. The Draft Plan omits them despite the fact they were made at more than one public meeting, including a Board of Supervisor's Committee hearing.

The Navy must explain this dramatic about-face, and it must live up to its promises to resample all of Tetra Tech's work. Unless it does, it is quite likely that excessive levels of radioactive contamination will remain at the shipyard for generations to come.

B. There Are No Plans For Third Party Observation to Assure Fraud Is Not Repeated

The Draft Plan ignores some history and misstates the history it addresses. Resampling is only being done because Tetra Tech's fraud requires that it be redone. The Navy spent more than a year trying to avoid having to fully redo Tetra Tech's work, hoping its data review could verify the bulk of Tetra Tech's data. But it did the opposite, actually verifying the whistleblowers' testimony. And EPA's review found about double the problems the data review did. Under the circumstances, the Navy had no choice but to finally agree to discard all Tetra Tech's data.

Tetra Tech committed fraud. But the Navy is culpable too. It allowed the fraud to take place for years, right under its nose. So did the regulators. They have thus far proven incapable of the kind of supervision necessary to assure history does not repeat itself. Accordingly, the Draft Plan must contain provisions for third-parties unassociated with Tetra Tech or the re-sampling contractor(s), to observe and document the resampling activities. As detailed further below, the Draft Plan must add a "Verification Subcontractor" whose role will be to prevent fraud through direct observation and videotaping of all activities (See section IV.D.1).

C. The Navy Must Address the Production Pressure Issue

The statements of whistleblowers and the admissions of Tetra Tech supervisor Justin Hubbard, who pled guilty to federal charges, was that a primary driver of Tetra Tech's fraud was pressure from above to get the job done under budget and on time. According to these witnesses, this pressure started with the Navy, which pressured Tetra Tech to meet schedules despite changes of circumstances that, if handled properly, would have inevitably caused significant delay. In turn, Tetra Tech pressured its top onsite management and that burden was transmitted through Health Physicist Supervisors to the whistleblowers who committed the fraud.

The fixed-price nature of the contract also created compelling incentives to cheat, according to witnesses. Fixed price contracts lead bidders to reduce the price as much as possible, and maybe even more, to provide a competitive edge. Fixed price contracts punish companies that find they have to do extensive work to do it right and rewards companies with windfall profits if they cheat and get away with it.

The Draft Plan does not reduce or remove these negative incentives, it simply ignores them. The Navy should look to itself and identify any and all ways its actions could have provided incentives for fraud in order to prevent its recurrence. Like the requirement for third-party observation, the plan should acknowledge the problem, discuss the impact incentives may have on the execution of the work plan and describe appropriate steps that will be taken to minimize that impact.

D. The Navy Must Revise the HRAs, ROD and ROCs

The Parcel G ROD is out of date and inaccurate. It must be revised to reflect the actual on-the-ground post-fraud reality, particularly that improperly remediated

soil cleared for use as backfill, relying on fraudulent data, contaminated areas of the shipyard that were not previously contaminated, including in Parcel G.

The Draft Plan relies on the Conceptual Site Model (CSM), which, in turn, relies on the Historical Radiological Assessments (HRAs): “The CSM is based largely on the Historical Radiological Assessment (NAVSEA, 2004).”

But the HRAs are inconsistent with what we now know. The failure to include the most up-to-date facts renders the HRAs inaccurate and therefore misleading. For example, the HRAs claim Parcel A was not radiologically impacted except for one building that was demolished. To the contrary, we have recently brought both eyewitness and documentary proof to the Navy and regulators that it was contaminated; samples from both the former sanitary and storm water sewer systems revealed elevated levels of radiation that should have been investigated further but were not.

Another example relates to whether uranium should be a radionuclide of concern (ROC). The Navy dismisses uranium as an ROC. But long-time residents who worked at the shipyard, or who had family members who did, have alleged for years that uranium was used there just as carelessly as other radionuclides. They also say experiments with depleted uranium took place. This information is readily available to the Navy, but they never sought it. Since the Navy’s plan relies heavily on the assertion uranium is not an ROC, this potential flaw could be significant. There may be other ROCs that have been omitted from testing based on the inaccurate HRAs; the ROC issue must be revisited.

Neither the HRAs nor the Parcel G ROD could possibly have included any information supplied by the whistleblowers since both documents predated them

coming forward. Their information must inform the radiological investigation. The whistleblowers uniformly state that fraudulent soil remediation resulted in potentially still-contaminated soil being used as backfill throughout the shipyard; this spread contamination to locations that were not previously impacted. Yet reliance on the HRAs ignores this crucial evidence as well as the rest of the untapped whistleblowers' knowledge that the Navy refuses to pursue.

Furthermore there are radically different circumstances than when the Parcel G ROD was adopted. The most significant change has been a complete transformation in the intended use of the parcel. Until just a couple years ago, only a small corner of Parcel G was to be cleared for residential use. However, in 2016, after consideration of the *Feasibility Assessment for Evaluating Areas with Residential Land Use Restrictions, Parcel G*, Nov. 30, 2016, residential use is now permitted throughout the entirety of Parcel G. The implications of this change could not have been factored into either the ROD or the HRAs since they were written years earlier. Now that the Parcel G radiological work needs to be redone, it would be foolish for the Navy and regulators to blind themselves to the current state of reality and pretend they were stuck in yesterday's world.

The HRAs and the major planning documents that rely on them, like the ROD, must be updated to accurately reflect the current state of knowledge about radiological contamination at the shipyard. Only then can cleanup planning rely on them.

E. The Navy Is Improperly Changing Remediation Goals

Remediation goals (RGs) are the standard used to determine if remediation is necessary. Generally, if a sample analysis exceeds an RG this alone is sufficient to determine that cleanup is required. An exception is for radium-226, which allows adding

background levels to the RG. We believe it is an inappropriate exception insufficiently justified by the Draft Plan. Incredibly, however, the Navy's lack of clarity seems to make the exception the rule; all ROCs will be deemed to be compliant as long as they are below the background radiation level PLUS the RG.

This is suggested in Table 3-2, which lists Residential Soil Remediation Goals. Footnote "a" states, "All RGs will be applied as concentrations above background." (emphasis added.) As we note in Section III.D., virtually all of Parcel G is now approved for residential use. The Navy must clarify whether it intends this change and if so, go through the appropriate process to do so.

F. Background Sample Locations Are Inappropriate

The Draft Plan fails to recognize the history of blunders and fraud in sampling and analyzing background reference samples. According to witnesses, for years Tetra Tech had rad techs go to the officer's club parking lot on Parcel A to obtain background samples. However, witnesses say the samples were from an area that had extensive amounts of "black" sand, some of which contained radiological contamination from use for sandblasting warships used in Operation Cross Roads. This history call into question all background samples taken from Parcel A. Based on the recollections of people who worked in at the shipyard decades ago, future public health and safety would be better served by assuming all of the shipyard is radiologically impacted unless proven otherwise than by assuming the shipyard is clean until proven otherwise.

Background levels should not be obtained from the shipyard because the historical record shows, if the Navy would only look, that there is no place on the shipyard which can reliably be said to have never been impacted. Rather, after geologic study,

backgrounds should be obtained from areas nearby that have similar stone and soil composition, with no radiological history.

Furthermore, as amplified below, the proposed location of building background sampling is in a radiologically impacted building. There must be better choices. (See Section III E.)

IV. SUBSTANTIVE COMMENTS - Specific

A. The Description of the Factual Background Is False

The Navy continues its willful blindness to the best resources available to pinpoint the fraud's impact on the cleanup, the whistleblowers. We have been urging the Navy for more than a year to interview them to help target the resampling. The Navy has refused, essentially saying, "It's not our job." It is the Navy's job.

No resampling plan for Parcel G or any of the other parcels should proceed without prior investigation by the Navy of what former HPNS rad workers know about the fraud committed in that parcel.

Furthermore, the Background section of the Executive Summary states: "An independent third-party evaluation of previous data found evidence of manipulation and falsification at Parcel G (Navy, 2017, 2018). As a result, the Navy developed this work plan to investigate radiological sites in Parcel G."

This statement omits significant history. The third party evaluation did not arise out of nowhere; it was the Navy's response to sworn statements adduced by Greenaction and its counsel by former radiation workers at HPNS. They detailed their participation in massive radiological fraud including soil-sample tampering, fraudulent building scanning, data falsification and fraudulent soil remediation, among other

things. Furthermore, the Draft Plan ignores the fact that while the third-party evaluation identified “only” 49% of survey units (SU) with suspect data, EPA’s review found nearly double that, an astonishing 97%! By failing to acknowledge how the fraud came to light, the Navy omits significant facts that should inform the plan to resample Tetra Tech’s work.

B. Section 1 – Introduction The Project Purpose Is Too Narrow

In addressing background samples, the Project Purpose states, “Additional reference background areas will also be identified to confirm, or update as necessary, estimates of naturally occurring and man-made background levels for ROCs not attributed to Naval operations at HPNS” (p. 1-1).

It purports to exclude “man-made background levels for ROCs not attributed” to the Navy. But it fails to define the internally contradictory term, “man-made background levels;” by definition, man-made background levels are not background levels. Nor does it provide any evidence that “man-made background levels” of radiation not attributable to the Navy actually exist at the shipyard.

If what the Navy means is that it will not remediate in a manner that would protect public health by claiming certain existing radiation is “man-made background,” it should admit it. If the Navy has evidence that “man-made background” contamination exists, it must provide it. In any case, remediation of all man-made radiation above cleanup levels is required. Accordingly, the Project Purpose should be expanded to provide a full explanation of how background levels will be measured, where they will come from and what impact those measurements will have on the cleanup.

C. Section 2 - The Conceptual Site Model Is Inaccurate and Out of Date

a. Failure to Acknowledge the Extent of the Fraud

Like the rest of the Draft Plan, the Conceptual Site Model consistently minimizes the fraud. If the Navy took the proof of fraud seriously, it could not propose leaving two-thirds of the trench units and one-half of the survey units completely untested.

Both the Executive Summary and the body of the Draft Plan exhibit how the Navy consistently downplays the fraud. The Executive summary states, “[a] conceptual site model (CSM) was developed with current knowledge of the site.” (p. i) This is simply untrue. As stated above, the Navy is willfully ignoring eyewitness testimony that has been available for over a year. The body of the Draft Plan does no better: “Following the investigation and removal actions, there were allegations that TtEC potentially manipulated and falsely represented data.” (p.2-1).

Two years ago there were “allegations.” Now, taking the affidavits of the whistleblowers and the results of the Navy’s data review (which was intended to validate Tetra Tech’s data but did the opposite) and EPA’s review, as well as the criminal sentencing of two Tetra Tech supervisors, there can be no doubt that massive fraud took place throughout the shipyard.

It may be understandable that the Navy wants to soft-peddle the fraud, as they could have and should have prevented it and once suspicions arose they could have and should have conducted a competent investigation. The Navy’s approach has been characterized by a long-running failure to acknowledge the seriousness of the fraud and its impact on the cleanup.

The Draft Plan continues this failure. For example, the Draft Plan claims that there is uncertainty about the sampling and data fraud, stating, “Allegations of previous sample collection fraud, improper sample and document custody/controls, and data manipulation could indicate that contamination was potentially left at the site” (p. iii). But, as stated above, the whistleblowers have sworn they participated in massive fraud under oath. “Could indicate” is inaccurate. Their testimony proves without doubt that significant contamination was left at the site un-remediated and that improperly remediated soil may have contaminated sites that had not previously been tainted. This needs to be investigated in Parcel G and the other places Tetra Tech worked.

b. The Navy’s Suggestion of Over-Remediation Is Sheer Speculation

While characterizing proven facts as uncertainties, the Navy indulges in pure speculation, making the astonishing assertion that, “[t]he previous work relied on a quicker, less accurate method for analyzing radium-226 (226Ra). This method was known by stakeholders at the time to be biased high. A large amount of soil (estimated 80 percent) was likely mischaracterized as contaminated (Argonne National Laboratory, 2011).”

In other words, the Navy now claims that notwithstanding the fraud, things aren’t as bad as they seem. 80% of the soil characterized as contaminated wasn’t!

Never mind that the alleged stakeholders are not identified and the Navy offers no evidence of agreement among them. Never mind that the Argonne National Laboratory report cited has not been made available to the public by the Navy so we cannot test this dubious assertion.

Similarly, the body of the Draft Plan claims the onsite lab was biased high: “In addition, the onsite laboratory used a screening method² to analyze radium-226 (226Ra) that may have reported at levels higher than actual radioactivity. TtEC presented CSMs in removal action completion reports that were based on potentially falsified data and screening results for 226Ra reported by the onsite laboratory (results were often biased high).”

Footnote 2 states:

“Analytical results for 226Ra were reported by the onsite laboratory using a screening method based on the 186 kiloelectron volt (keV) energy peak. The offsite laboratory analyzed 226Ra using a definitive method (EPA 901.1 comparable method), allowing the soil samples to equilibrate (21-day in-growth) and reported concentrations using the 609 keV energy peak for bismuth-214 (214Bi) because 214Bi is in secular equilibrium with 226Ra. Comparisons between the onsite laboratory screening results and the offsite laboratory definitive results for 226Ra demonstrate the onsite laboratory results were consistently biased high. The 226Ra analytical results from the onsite laboratory resulted in false exceedances of the RGs, which resulted in the initiation of remediation. Remediation may have been avoided had soil samples been allowed to equilibrate (21-day in-growth) and decisions had been based on the more reliable 214Bi analysis using the 609 keV energy peak.”

In other words, the Navy claims it over-remediated for radium-226 in 80% of the remediated soil. This assertion inadvertently illustrates the Navy’s conundrum. Either it wasted millions upon millions of dollars to clean up contaminated soil that wasn't really contaminated or the Conceptual Site Model on which the Draft Plan rests is demonstrably wrong. Either serves as an acknowledgement of the Navy’s technical incompetence and the waste of time and money that resulted from it.

The Navy’s claim the onsite laboratory method was improperly biased is hardly reassuring. The Navy itself approved the laboratory methods. If the Navy finds

fault with the methods now, it only has itself to blame. How many years did it rely on methods whose results it wants to explain away?

Additionally, the Navy acknowledges the method was “quicker.” The Navy must address whether the method it now disowns was wholly or partially selected because it was faster than others to speed production. This would substantiate the whistleblowers testimony.

Although the Navy disparages the onsite laboratory method, the Draft Plan is so imprecise it does not actually state that this method will not be used in future. Nor does it specify what better methods will be used.

The Work Plan is also imprecise when it comes to determining the background level of radium-226. The text of the plan never suggests that any other radionuclide than bismuth could be used as a substitute for radium. Only delving into the footnotes to Table 3-6 does one discover the Navy may also use lead-214, either with bismuth-214 or standing alone. And yet, while the Navy at least attempts to demonstrate the bismuth equivalency, it does not even bother as to lead-214. It must.

Despite what the Plan implies by describing the radium-226 method it intends to use as “definitive,” the Navy admits it will not use an approved EPA method. Rather, it will use an unspecified “comparable” method. If the Navy relies on this “comparable” method, it must identify it and demonstrate that it is, indeed, comparable.

c. The Navy Should not Speculate About Sources of Radioactivity

The Navy claims that a third uncertainty is: “[t]he RGs used previously are within background ranges. Therefore, soil that was considered contaminated could

have been attributable to naturally occurring radioactivity or anthropogenic fallout (Argonne National Laboratory, 2011).” The Navy should either report data to demonstrate that naturally occurring radioactivity or fallout impact the cleanup rather than speculate that it “could have been.”

In addition, Table 2-1 needs to be corrected. For example, under “current status” it says, “All known sources removed by Navy using standards at the time. Follow-up investigations resulted in removal of small volumes of soil to meet current RGs.” However, the “follow up investigations” are left undescribed, not even saying how many “investigations” were conducted, let alone who conducted them. Nor do are the “results” that prompted additional remediation reported. Similarly, Table 2-1 states, “Trench excavations that have been backfilled now contain homogenized soil from onsite fill, offsite fill, or a mixture of both.” This statement ignores the certainty that “onsite fill” may have still contained levels of contaminants exceeding the RGs when it was used as fill, the result of fraudulent soil scanning. Table 2-1 also is consistent with the rest of the Draft Plan in the way it minimizes the fraud; the only reference to it is, “Potential for data manipulation or falsification.”

Again, the witness testimony and the Navy’s and EPA’s data reviews prove that the data falsification was real and extensive, not “potential.”

D. Section 3 – The Soil Investigation Design and Implementation Is Inadequate

1. Data Quality Objectives

Section 3.1 of the Draft Plan states, “[t]he primary objective is to determine whether site conditions are compliant with the Parcel G ROD RAO (Navy, 2009)” (p.3-1).

Step 5 of Section 3.1 indicates that if RGs are exceeded, “then the data will be evaluated to determine whether site conditions are protective of human health using USEPA’s current guidance on Radiation Risk Assessment at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sites (USEPA, 2014). A Removal Site Evaluation Report will be developed to include recommendations for further action.”

RGs are set precisely to be “protective of human health.” The Navy does not explain why it intends to conduct this additional risk assessment rather than do what is called for: remediate all soil and buildings that exceed the RGs. Given the history of the remediation and the approach of the Draft Plan, it is difficult not to conclude that this is yet another attempt to minimize the problem, and thus minimize the remediation necessary for free release.

Step 6 of Section 3.1 states: “If any 226Ra gamma spectroscopy concentration is greater than the RG for 226Ra, then the soil sample will be analyzed for 238U and 226Ra using comparable analytical methods (e.g., alpha spectrometry for 238U and radon emanation for 226Ra). For that specific sample, the 238U alpha spectrometry result will be used as a more representative estimate of the background value for 226Ra, and the alpha spectrometry comparable result for 226Ra will be compared to the RG for 226Ra using the revised background value” (p.vi). In other words, the calculation of radium background levels depends on the uranium results.

However, the Navy has offered insufficient validation data for this switch. Its explanation for why uranium background levels provide more reliable data on radium background is unconvincing. Even assuming substituting uranium for radium is

appropriate, the Navy offers no evidence that uranium-238 alpha spectroscopy provides “a more representative estimate of the background value of 226Ra” than Ra-226 gamma spectroscopy. If that is the case, the Navy should provide the evidence.

In addition, as stated, there is evidence that the shipyard was impacted by uranium. Thus, it must be included in the list of ROCs. As an ROC, it should not be the basis for calculating background levels of any other ROC.

Step 7 of Section 3.1 reiterates the Executive Summary’s admission the Navy has no intention to resample all of Tetra Tech’s work. This subject will be addressed in comments below. Section 3.1 also repeats the phrase “man-made background,” an issue already addressed above. (See Section IVB.)

Section 3.2 addresses Radionuclides of Concern. As stated above, the list of ROCs must be augmented to reflect what is now known about the radionuclides that impacted the shipyard. The Navy must add instruments that can identify alpha and beta radiation, as needed, to investigate the presence of the expanded list of ROCs.

Section 3.4 describes the design of the radiological investigation. It states, “[t]he radiological investigation design is primarily based on methods, techniques, and instrument systems in *the Basewide Radiological Management Plan* (TtEC, 2012).” Like the Argonne National Laboratory reference, this Management Plan was not provided by the Navy even though it is relied on by the Draft Plan.

Sections 3.44 through 3.7 address the proposed two-phase approach to soil sampling. As argued below, this approach is further evidence the Navy will jettison the commitments made publicly to resample all of Tetra Tech’s work. Phase I must be

applied to 100% of the sites Tetra Tech worked on rather than mere fractions of them. If that is done, Phase II must be reconsidered.

Section 3.5, on instrumentation, must be augmented to account for an expanded list of ROCs to include equipment that can investigate alpha and beta radiation as well as gamma.

In numerous places, the Draft Plan indicates scanning will be done with sodium iodide (NaI) detectors. (See, for example, Section 3.5.1.) However there is no justification for using NaI detectors when there are more sensitive instruments available. High Purity Germanium (HPGe) detectors are an alternative that are much more sensitive than other hand held instruments, for example. The Draft Plan should discuss what equipment was considered and should state the reasons for the selection.

Section 3.6 describes the radiological investigation implementation. It starts by listing the seven types of subcontractors that will provide support services. There is an eighth that must be added: a verification subcontractor to observe and videotape the other contractors, particularly those doing sampling and scanning, to assure there is no possibility of fraud in future. Greenaction strongly urges the Navy to require that any verification contractor hire and train residents of the Bayview Hunters Point communities for this purpose. This will serve three positive goals: preventing fraud; providing jobs; and building trust; approaching fraud prevention in a way that relies on local community members and can, in turn, inform and build trust among the broader public.

Furthermore, the training plan is deficient in in that it perpetuates the Navy's minimization of the fraud. Nowhere does the Draft Plan require that all contractors'

personnel be informed of the types of fraud Tetra Tech committed, that improper practices will not be tolerated and they will be observed and videotaped to assure the integrity of the investigation.

2. Phase I Soil

The Navy claims that, “[a] phased investigation approach is presented in this work plan that was designed to provide a high level of confidence that current site conditions either comply or do not comply with the Parcel G ROD RAO (Navy, 2009)” (p. iv). We hope the Navy considers public comments and significantly alters the plan to provide a basis for that confidence. To the contrary, the current plan undermines it.

If the history of the Tetra Tech fraud and the Navy’s complicity in it teaches anything, it is that the Navy has always been overconfident. It was confident Tetra Tech could investigate itself. It was confident in the accuracy of Tetra Tech’s false conclusion that the fraud was narrowly limited. It was confident the whistleblowers were mistaken or lying. It was confident the data review would validate Tetra Tech’s data. In each case, the Navy was wrong, its confidence was unwarranted.

The public cannot be confident the Draft Plan will provide adequate data to demonstrate compliance with the ROD. First, as mentioned, the Navy does not plan to even test substantial amounts of soil.

The Navy will not find contamination it refuses to look for. All trench and survey units and any other work or locations worked on by Tetra Tech must be sampled.

The Draft Plan also is significantly deficient in its lack of specificity about the handling of backfilled soil and soil excavated from side walls (and bottoms). If contaminated backfilled soil and side wall soil are mixed, previously uncontaminated soil may become contaminated. The Draft Plan must require that backfilled soil and side wall soil be segregated, scanned and cleared separately.

Other problems also bedevil Phase I. The Draft Plan states, “The targeted TUs and SUs were selected based on the highest potential for radiological contamination,” based on, “[h]istorical documentation of specific potential upstream sources, spills, or other indicators of potential contamination,” and “[s]igns of potential manipulation or falsification from the soil data evaluation” (p. iv).

Again, the historical record on which the Draft Work Plan relies is demonstrably wrong. Again, the Navy claims it will use the best data while simultaneously ignoring the best evidence available to it.

Furthermore the Navy claims it can use signs of manipulation and falsification in the “soil data evaluation” of Tetra Tech’s data to target Phase I resampling. That can only be true if the Navy ignores the EPA’s review of the Parcel G soil data evaluation, which found 97% of the data to be suspect. Precisely how the Navy will use data that is 97% unreliable to target one-third of the trench units and half the survey units is left unexplained.

The two factors the Navy claims it can use to narrow Phase I soil sampling are patently false. There is no rational basis stated in the Draft Plan on which to select samples sites with “the highest potential for radiological contamination.”

Furthermore, the Work Plan says the sanitary and storm water sewer systems “will be gamma scanned.” Gamma scanning is necessary but insufficient. As discussed above, the number of radionuclides of concern (ROCs) must be significantly expanded to account for the true historical evidence. Gamma scanning cannot identify all of the ROCs that should be included. Consequently, scanning for alpha and beta radiation will be necessary.

3. Phase II Soil

As stated, Phase II must be reconsidered in light of the changes necessary to Phase I. However, assuming Phase II as described is relevant, the plan states that, “subsurface soil samples will be collected via borings. The borings will be advanced beyond the floor boundary of the trench or to the point of refusal. Gamma scans of the core will be conducted” (p. v.).

Although the Navy agrees to excavate and scan 100% of the soil from the sewer systems in Phase I, it plans no such comprehensive effort during Phase II. It does not even attempt to explain why.

Borings alone are completely inadequate. They will not provide sufficiently comprehensive information to properly investigate the exceptional history of radiation contamination in Parcel G, including the likelihood that fraudulent practices resulted in contaminating soils and areas that were not previously contaminated.

And, as mentioned, the plan to limit scanning to gamma radiation is inappropriate to the expanded number of ROCs an updated understanding of the historical record will identify.

E. Section 4 - Building Investigations

“Buildings will be divided into SUs, and the size and boundary of the SUs will be based on the previous plans and reports” (p. v.) These “plans and reports” go unidentified. The Draft Plan must provide a factual rationale for the size and borders of the building SUs.

The Draft Plan also states that only the interior of buildings will be scanned, but gives no rational basis for excluding exteriors. The Draft Plan must either include building exteriors or justify excluding them.

In addition, according to Figure 4-1, building background reference samples will be taken from Building 401, a building that has been radiologically impacted. This location is apparently justified by the Navy’s assertion that the first floor was not impacted. It defies the imagination that there is not a more suitable location. Perhaps from a building no part of which was ever impacted? Like many other portions of the Draft Plan there is a paucity of information, this time on the building background sample selection process. It should be fully described, including justification for the site or sites selected.

Section 4.5.5 calls for portable survey instruments to be calibrated at least once a year. This is far too long a period to demonstrate to a distrustful community that data will be developed using properly calibrated instruments. The Navy should propose a shorter time period between calibrations and the rationale for its choice.

F. Section 5 – Data Evaluation and Reporting

Section 5.2 states, “The effort expended during DQA should be consistent with the graded approach used to develop the survey design.” The Navy should explain

what “graded approach” means. This section also contains an unnecessarily complex set of calculations to calculate equivalents of different units of measure. Subsection 5.2.2.1 states, “The RGs for buildings surfaces (Table 4-2) are stated in units of dpm/100 cm² [disintegration(s) per minute per 100 square centimeters]; however, alpha and beta static measurement results will be reported in units of counts during a specified counting interval, while scan measurement results will be reported in units of cpm [counts per minute].” The formula for conversion into dpm/100cm² follows. The Navy fails to explain why it does not intend to report results as dpm/100cm² in the first place.

One glaring shortcoming of the Draft Plan evident throughout is the different treatment given to samples that exceed the RGs and those that do not. Samples below the RG are simply declared compliant with the ROD. No further investigation is called for. In sharp contrast, should a sample exceed an RG, it undergoes additional confirmation. For example, Section 5.2.3 says, “If all measurement or sample results from a TU/SU are below the corresponding radionuclide-specific RG values or corresponding investigation level values, the TU/SU complies with the Parcel G ROD RAO.” But Section 5.3.2 states, “The first step in investigating potential areas of elevated activity is to confirm the measurement or sample results that indicated the potential area of elevated activity.” A similar provision applies to buildings (See Draft Plan Section 4.1).

We agree validation of sample results is essential. Why then is there no parallel requirement that any samples initially determined to be below the RGs undergo further investigation as well? It is equally likely that sample and analysis variability will result

in lower readings as higher ones. The difference in treatment is an example of how the Navy will go to some lengths to attempt to disprove an elevated reading while making no similar efforts to see if non-elevated readings could be just as wrong.

Section 5.2 goes on to state, “In most cases, at least one measurement or sample result documenting the lack of elevated activity will be required to support a decision to terminate the investigation of a potential area of elevated activity.” One of how many? If there are multiple samples that exhibit elevated activity but one that does not, is the decision to terminate the investigation justified?

G. Section 7 – Waste Management Plan

Section 7.5 relates to compliance with CERCLA’s Offsite Rule. It says “the contractor will request proof of Offsite Rule approval from the offsite disposal facility before transferring any wastes to an offsite facility.” What it doesn’t say is that the approval actually is granted and proof of it must be presented before the transfer. It must.

V. CONCLUSION

The Draft Parcel G Work Plan is woefully deficient. It must be revised to incorporate these comments and those of other interested members of the community. If not, the community can add just another occasion to the many, many before it over the years that the Navy has lied to them.

Laura Duchnak, director of the Navy’s Base Realignment and Closure Program, acknowledged in writing in a victim-impact statement for the sentencing of one of Tetra Tech’s supervisors that the community has lost all faith in the Navy’s

ability to do a proper cleanup. The distressing deficiencies in the Draft Plan and the corner-cutting evident in it, only deepen distrust.

The Draft Plan must be wholly reworked so that all of the sites Tetra Tech worked on will be fully resampled, as the Navy promised.

Respectfully submitted,



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Comments on Parcel G Removal Site Evaluation Work Plan

In 2012, it was discovered that Tetra Tech EC, a contractor who had worked on the Hunters Point Shipyard cleanup, had falsified and fabricated radioactivity measurements for many years. The Navy did not disclose this to the public, but instead trusted Tetra Tech to write a report on its own wrongdoing and retest a bit of the areas in question. The public only knows about this because of several Tetra Tech employee whistleblowers, and a 2014 NBC News investigation¹ based on the whistleblower reports and acquisition by NBC of the report Tetra Tech wrote.

Then in 2017, more Tetra Tech whistleblowers came out² saying they had been directed by “top-level on-site managers” in further improper sampling and data falsification. According to whistleblowers, this included a range of actions like:

- replacing contaminated soil samples with clean ones
- speeding up a soil conveyor belt so less radiation would be detected
- lowering the sensitivity of ‘portal monitors’ for outbound trucks to detect less radiation

In September 2017, the Navy prepared reports evaluating the Tetra Tech data, in response to the public outcry over these allegations, beginning with the Draft Radiological Data Evaluation Findings Report for Parcels B and G Soil. Again, the Navy did not publicly release these reports and the public only learned of them through Public Records Act requests and subsequent media stories. To this date, they are not on either the Navy’s or DTSC’s website for Hunters Point. In the Parcel G report, the Navy confirmed the whistleblower allegations and found even more problems. It found evidence of falsification in and recommended retesting of 49% of soil survey units in Parcel G. However, the main regulatory oversight agencies for this project — the U.S. Environmental Protection Agency (EPA), CA Department of Toxic Substances Control (DTSC), and California Department of Public Health (CDPH) — did an independent review, and in December of that year sent a letter to the Navy stating they had found much more evidence of data manipulation. According to them, only 3% of the soil survey units in Parcel G were free of

¹<https://www.nbcbayarea.com/investigations/Contractor-Submitted-False-Radiation-Data-at-Hunters-Point-279025911.html>

²<https://www.nbcbayarea.com/news/local/Hunters-Point-Whistleblowers-Expose-More-Alleged-Fraud-of-Shipyard-Cleanup--431638053.html>

evidence of data fabrication and thus 97% of the soil survey units in Parcel G are suspect and should be retested.

Again, this information was not released to the public, but was only obtained through a Freedom of Information Act request by Public Employees for Environmental Responsibility (PEER).³

So let's review: high level managers from a Navy subcontractor are alleged to have directed subordinates to falsify data in various ways to declare areas that were contaminated to be instead clean, which would save the Navy a good deal of money. (Already this casts suspicion on the Navy: if someone hired you to clean something up, why would you risk your job by not doing it right unless you thought it's what your employer wanted?) Although the Navy was aware of the problems years ago, it took no effective action to stop it, and it continued for years more. When the issue can no longer be entirely swept under the rug, the Navy performs an assessment of the problem and misses half of the red flags. Either there are some seriously incompetent people working at the Navy, or the Navy is conducting this cleanup in bad faith.

Given this whole sorry history, the Navy is under considerable scrutiny to show that they've turned things around, that they will be fixing the mistakes of the past and proceeding with integrity. The document in question here, the Parcel G Removal Site Evaluation Work Plan, is the first step in that process. To my great dismay, the Work Plan contains numerous flaws that will result in improper sampling, declaring that which is contaminated to be instead clean, and, ultimately, a continuation of the legacy of fraud and manipulation at Hunters Point.

Navy: 'Heads I'm Right, Tails You're Wrong'

The Tetra Tech data falsification had a clear intention: to make the site seem cleaner than it is. The worker allegations (sensors desensitized, dirty samples swapped for clean ones, etc.) all point in this direction. I expected the Parcel G Work Plan to contain a full reckoning with the many paths taken to falsify data, and to recommend strategies to ascertain beyond a shadow of a doubt if there was unacceptable contamination left in place. Yet the Parcel G Work Plan seems to labor largely in service of a different conclusion: that in fact, much of the work Tetra Tech did was too good, and removed more soil than was needed!

The Navy sows doubt for inconvenient truths and manufactures assent for conclusions that suit them using words. The worker allegations "could indicate that contamination was potentially" left over, yet meanwhile "a large amount of soil (estimated 80 percent) was likely mischaracterized as contaminated."

The Work Plan draws heavily from a document that has not been made available to the public: Low-Level Radiological Waste Evaluation Associated With Various Base Realignment And Closure Activities, Argonne National Laboratory, 2012. (The Work Plan incorrectly cites it as

³<https://www.nbcbayarea.com/investigations/EPA-Letter-Reveals-New-Problems-with-Hunters-Point-Radiation-Data-479214633.html>

being released in 2011.) Unable to find this document on any of the online document repositories, I requested it from the Navy on June 19. They sent me a copy but, despite my request for them to also post it online for others to see, the document is still inaccessible to the public as of this writing.

The Argonne study is explicitly written “for the purpose of reducing the cost of low-level radiological waste (LLRW) identification and disposal” (p. 2). To identify something as contaminated and take remedial action costs the Navy money. The Navy, eager to save money and avoid accountability, wants to shift the goalposts of what actually constitutes ‘contamination’ and necessitates cleanup, so they hired Argonne to come up with a study laying out exactly how they can do that. The report speaks of “minimiz[ing] the production of LLRW soil,” as if “the volume of LLRW soil being generated at HPS” were a problem to be solved. It is a problem for the Navy, who has to pay for all this soil being disposed, but the reason there’s so much low-level radioactive waste at Hunters Point is because it is one of the most contaminated sites in the country. Hunters Point housed the ‘Little Boy’ bomb that was dropped on Hiroshima, ships radiated by the nuclear tests at Bikini Atoll, and decades of foundational nuclear research, making it a good candidate for the center of American nuclear industry in the 20th century. Of course there are going to be high volumes of radioactive soil.

The Navy request to Argonne was completely one-sided and shows the heavy bias of the Navy and suggests that Tetra Tech was not acting completely as a rogue outfit but doing what the Navy wanted. Rather than asking Argonne to identify how measurements could be biased in either direction -- i.e., understating or overstating contamination -- with an emphasis on protecting public health by avoiding missing contamination, the Navy asked for a laundry list of ways to declare soil not contaminated and reduce costs. The bias is crystal clear.

One of the methods of deception outlined in the Argonne study concerns measurements of radium 226. Ra-226 is one of the radionuclides of concern (ROCs) at Parcel G, and with a half-life of 1600 years, it certainly would be concerning if it were left on site. The Argonne study suggests that, because of the way Ra-226 has historically been measured at Hunters Point (using gamma spectroscopy), the measurements have all been biased higher than the amount of Ra-226 actually present. The argument is that the 186-keV emission line produced by Ra-226 is similar to the gamma peak of uranium 234 and thus subject to interference, meaning that elevated readings of Ra-226 could actually be a mix of Ra-226 and U-235. Either way, one would think, there is clearly radioactive contamination present and remediation is needed. Not so: the Navy has conveniently excluded U-235 from this Work Plan’s list of Radionuclides of Concern (Table 3-4), despite large amounts of it being used at Hunters Point. So, if one measures elevated levels, it doesn’t matter whether it is pure radium-226 or radium-226 and uranium-235; one doesn’t want to expose the public to one, the other, or both. This is also particularly true because the cleanup level for uranium-235 is far lower than for radium-226, so if some of the material is U-235, that is in fact more of a concern than if all of it is radium.

Another Argonne strategy that sheds additional light on this business with Ra-226 concerns the setting of background. Background radiation is the level of radioactivity that was present before the polluter began polluting; it is usually attributable to naturally occurring radionuclides or global fallout from nuclear tests. In order to know how much of a radiation measurement is attributable to the polluter (the Navy) and how much existed previously and so is not their responsibility, background measurements are crucial. Background measurements, somewhat obviously, must be taken far enough from the contaminated site that these supposedly neutral measurements aren't also contaminated. The Parcel G Work Plan claims that "The RGs [Remediation Goals] used previously are within background ranges. Therefore, soil that was considered contaminated could have been attributable to naturally occurring radioactivity or anthropogenic fallout." This statement is false. The RGs are generally above background levels.

The Argonne study lists two approaches to background. The first one is to "expand the background dataset to encompass full Ra-226 variability in all soil types being remediated". The essential claim being made here is that different soil types have different levels of naturally occurring Ra-226. The problem here is that it looks like Argonne was proposing to try to inflate background by taking samples in enough different soils as to get a higher value, which may be irrelevant to the soil at Hunters Point to which it is being compared.

What's their second approach to background?

"Implement the 1-pCi/g plus background requirement using the upper end of the background data distribution rather than the mean."

This is what I mean by shifting the goalposts. The Navy, by enacting these suggestions, is first expanding the range of what background could be, then selecting the upper end of this range to use as background (Argonne suggests the 95th percentile). In other words, inflate what's considered background as much as possible so that more of the radioactive contamination present seems like it's not the Navy's responsibility. If the Navy finds a small amount of Ra-226, it will be considered below background; if they find a high amount of Ra-226, it will be considered interference from a radionuclide (U-235) they're ignoring. This also violates the Record of Decision and the agreement with EPA, which involved using the mean background value.

Oh, and about that "1-pCi/g plus background requirement"? That's some shady agreement the Navy made with the EPA, traceable as far back as the 2006 Basewide Radiological Removal Action Memorandum (Table 1), for the Remediation Goal for Ra-226 to be set at 1 pCi/g. Per CERCLA, Remediation Goals should be taken from the EPA's risk-based Preliminary Remediation Goals (PRGs), which list the allowable residential dose of Ra-226 as 0.0018 pCi/g — that's almost 1000x safer than setting the RG at 1 pCi/g.

All that to say that the Navy seems to have its priorities mixed up in commissioning and referencing such a study from Argonne, looking for manipulations and deceptions to save them money. This is a helpful in understanding the rest of the Work Plan.

Scope of Retesting Artificially Restricted

The EPA's comments on the Tetra Tech data at Parcel G included a recommendation that 97% of the soil units be retested. For instance, of the 63 Trench Units (TUs) in the parcel, the EPA recommends retesting 59 of them. However, in the Work Plan, only 21 of the TUs are designated for Phase I Investigation (the more comprehensive level), with the remaining TUs relegated to superficial Phase II Investigation (a single borehole sample with a gamma scan of the core, nevermind that many of the ROCs are alpha- and beta-emitters, nevermind again that the gamma scan can't detect all but one of the ROCs at the Investigation Level).

Additionally, there is no mention of retesting of the Fill Units, despite the EPA's recommendation that all 107 of them be retested.

Remediation Goals Inflated Way Above Safe Levels

The remediation goals used in the Work Plan (Table 3-5) supposedly are taken from the EPA's PRGs from 1991. The EPA has since updated these numbers, making some of them hundreds of times more protective. There is no reason that current PRGs should be used; there is no logical reason to, in retesting to be performed in 2018, to be using 1991 PRGs when modern ones exist.

Additionally, the Work Plan treats the Remediation Goals "as concentrations above background" (Table 3-5, footnote a). In CERCLA, Remediation Goals are set to include background, not as increments above background. The RGs are set for Parcel G in the Record of Decision (ROD), which only lists Ra-226 as being a concentration above background. This Work Plan then takes it upon itself to update all the RGs to be concentrations above background, which is not how the CERCLA process works. You cannot amend the ROD with a footnote in a retesting plan.

Background Sampling to Be Done in Contaminated Areas

In Figure 4-1 of the Work Plan, we are shown the proposed location from which to take samples to determine background for buildings. This building, Building 401, was previously designated impacted (in the Parcel G Record of Decision, as well as in the Building 401 Final Status Survey Report). Taking background measurements from a contaminated area is just asking for inflated background numbers... which the Navy would probably like very much.

Similarly, the background measurements for soil are proposed to be taken at 4 on-site locations and one off-site location. It sounds nice to take background from somewhere off-site, until you read (in the back, in Appendix A) that they will use a 95% confidence level, effectively cutting off outliers... such as background measurements collected from offsite locations. So background will be skewed towards the background measurements taken onsite. No background

measurements should be taken onsite, from buildings or soil, because of the likelihood of the entire site being contaminated.

Most of Parcel G (Still) Untested Under This Plan

The 2004 Historical Radiological Assessment (HRA) designates sites at Hunters Point as impacted or non-impacted. The great majority were deemed non-impacted (792 of the 883 sites considered in the HRA). This 'non-impacted' status is used by later Navy documents to rationalize not testing these sites. At all. Considering that the HRA was compiled from a survey of (incomplete) historical site records and interviews with former employees, it is highly concerning that there are no measurements conducted to determine if these sites are, as claimed, completely clean and safe. Considering the numerous migration pathways through which contamination could have (and likely has) spread throughout the site, there is no basis for considering untested sites uncontaminated.

Conclusion

The Navy knows the public is watching them closely right now. At the same time, they have a demonstrable desire to save money and not pay for a huge exodus of radioactive waste from the site. In that light, the Parcel G Removal Site Evaluation Work Plan in its current form seems designed more as a PR stunt than as a good faith attempt at verifying the presence of contamination at Parcel G. That the Navy would release such a shoddy, inadequate plan is testament to continued untrustworthiness. This Work Plan needs to be completely redone, incorporating revisions based on these comments, before the cleanup proceeds.

Sincerely,

Haakon Williams

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When you find out that something has been done wrong, you're supposed to fix it, whether that requires a simple tweak or starting from scratch. The magnitude of the falsification at Parcel G, estimated by EPA to be 97% of survey units, requires the entire site be thoroughly retested to ensure it is truly safe for the proposed use (which currently would allow residential development throughout almost all of it). In light of this, the Navy's Proposed Retesting Plan for Parcel G is a sham. What should be a plan to help reassure and protect the community of Bayview and Hunters Point is being used instead as a way for the Navy to disregard proper practice and lie about the current status of the Shipyard.

1. The Navy seems to completely disregard the need for retesting.

The Parcel G retesting plan should be a way of reassuring the residents of Hunters Point and Bayview that their community is truly clean, or will be clean by the time of its transfer back to the city. The EPA's reports released under FOIA showed that nearly all of the samples taken at Parcel G were subject to falsification, and recommended a retesting of essentially all of the survey units at the site to discover the true extent of contamination. They recommended 59 of the 63 trench units and all 107 fill units be retested. What the Navy has offered instead is a plan to retest only 21 of the trench units and none of the fill units (relegating other trench units to a second phase that would involve a cursory review). They also **falsely and astonishingly** claim the samples taken at Parcel G were *actually biased high* and therefore the site is vastly cleaner than believed (this is due to a false claim about the amount of radium onsite, and will be explained in further detail later in this comment). This is in stark contrast with EPA's findings and raises major red flags.

It is clear that the Navy cares less about having a clean site, and more about limiting the amount of work, time, and money they will have to put into the site going forward. It is imperative that the site gets cleaned up to the fullest extent in order to guarantee the safety of future residents.

2. The Navy is using the retesting as a way to circumvent proper Superfund practice.

Provided the results of the investigation come up clean, the Navy intends to use the results of this investigation to form their Remedial Action Completion Report. However, the investigation proposes remediation at levels higher than those approved in the Record of Decision for Parcel G. The ROD calls for all radiologically impacted soils to be remediated according to Residential Remediation Goals, as described in table 5 below. However, table 3-5 of the retesting plan says all RGs will be applied as concentration above background. This is allowed in the ROD for no radionuclide except radium-226. The remediation goals **are already substantially higher than the values of the current EPA Preliminary Remediation Goals**, and adding "background" on top of this allows for even further dangerous levels of

contamination to remain on site. According to the original ROD, with the sole exception of radium, the Navy must meet the remediation goals, not the remediation goal plus background. See ROD remediation goals, below. To attempt to change these goals and practices in a document that is neither a Proposed Plan, Feasibility Study, or Record of Decision seems unethical and highly suspicious, as though the Navy intended to ignore Superfund guidelines and practices by creating their own guidelines in a document that would likely be missed on the public eye.

Table 5. Remediation Goals for Radionuclides

Radionuclide	Surfaces (dpm/100 cm ²)		Soil (pCi/g)		Water (pCi/L)
	Equipment Waste ^a	Structures ^b	Construction Worker	Resident ^d	
Cesium-137	5,000	5,000	0.113	0.113	119
Cobalt-60	5,000	5,000	0.0602	0.0361	100
Plutonium-239	100	100	14	2.59	15
Radium-226	100	100	1 ^c	1 ^c	5
Strontium-90	1,000	1,000	10.8	0.331	8
Thorium-232	1,000	36.5	19	1.69	15
Hydrogen-3	5,000	5,000	4.23	2.28	20,000
Uranium-235 + daughters	5,000	488	0.398	0.195	30

Notes:

- a Limits for removable surface activity are 20 percent of these values.
- b Remediation goals are consistent with those issued in the Radiological TCRA Action Memo. Remediation goals meet the 25 millirem per year residual dose level consistent with 10 CFR Section 20.1402. Furthermore, for most radionuclides of concern, goals meet the 15 millirem per year residual dose level consistent with the 1997 EPA OSWER Directive (OSWER No. 9200.4-18). Of exception is the goal for Thorium-232 goal which due to detection limit technical limitations, corresponds to a dose of 25 mrem/yr.
- c Goal is 1 pCi/g above background per agreement with EPA.
- d All radiologically impacted soils in this parcel will be remediated according to Residential Remediation Goals.

3. The Navy has claimed that samples reading hot for Radium-226 were biased high, when in fact this is not the case.

The Navy now astonishingly claims that the measurements and measurements techniques it approved for years for Radium-226 were in fact biased high and that it knew this for years and nonetheless allowed tens of millions of dollars to be spent cleaning up soil that didn't need to be cleaned up. It bases this extraordinary claim on the assertion that the onsite laboratory couldn't discriminate between the Radium-226 gamma peak and the nearby Uranium-235 peak, and therefore the Radium value may have been high. It says this based on the assertion that U-235 is not a radionuclide of concern and therefore should be ignored. However, there were large amounts of U-235 used at Hunters Point, from unfissioned U-235 in weapons fallout and ship contamination to licensed uses for NRDL. Indeed, the ROD identifies U-235 as a radionuclide of concern (see table above). It matters little to public health whether the radioactivity in the soil sample is pure radium-226 or radium-226 plus uranium-235; they are dangerous alone or in combination. Furthermore, the remediation goal for U-235 is an order of

magnitude lower (i.e. more protective) than that for radium-226, so if part of the sample is uranium-235 rather than pure radium-226, that would make it more dangerous, not less. So to try to reduce the radium values by this spurious claim and declare 80% of past cleanup to have been unnecessary is a sign of the Navy behaving in precisely the fashion that got Tetra Tech into trouble.

Secondly, the Work Plan proposes to use Uranium-238 values as the Radium-226 background, if doing so can push the radium background up and reduce the the amount of cleanup. It is based on the assumption that Radium-226 and Uranium-238 are in secular equilibrium, which is not true if U-238 is another radionuclide of concern at the site, which it is. According to the Historical Radiological Assessment U-238 was in fact used at the site with a license allowing up to 2,426 lbs and therefore a potential ROC (Section 4 Tables 4-2 and 4-3 and Section 5 table 5-1). The argument by the Navy that there is no historical context for the use of U-238 at Parcel G in particular is weak. Historical interviews in the HRA demonstrate the lackadaisical attitude the workers had in regards to contamination migration throughout the site. It is highly probable that contamination from other parcels could have made it onto Parcel G, and given the plan for the site as a mixed use space, the safest cleanup standards should be employed, rather than relying on the chance of upward bias to avoid cleanup.

4. Background Reference Areas should not be located within, or close to the Shipyard Boundaries.

Four of the five background locations for soil proposed for the Parcel G retesting are astonishingly proposed from within the contaminated Hunters Point itself. (The one exception is proposed from an area less than two miles away.) This violates the fundamental rule of background measurements, that they be taken from places that cannot possibly have been affected by the contaminated site. According to Figure 3-1 in Appendix A, one of the four samples from onsite (RBA-1) is located in Parcel B, merely 500 feet away from the known-to- be radiologically contaminated IR sites 7 and 18. The other three onsite locations are in the midst of Hunters Point, near known contaminated areas. Furthermore, because of the decades of activities like sandblasting contaminated ships, contamination could have spread anywhere on site and in fact nearby as well. Using such potentially contaminated sites for background locations violates fundamental principles and suggests an effort to create false, inflated background values so as to inappropriately reduce cleanup obligations by not having to clean up soil that is in fact contaminated.



In regards to building sample locations, it is ludicrous that samples are being taken from a building that is identified as radiologically impacted. Building 401 is an impacted building, and yet somehow the Navy is proposing that this building can act as a reference area for itself, and other buildings at Parcel G. Samples should not even be taken from buildings within the site, much less from one of the very same buildings that is under question.

Conclusion

The Parcel G retesting Plan proposed by the Navy is wholly unacceptable, and is nothing more than their attempt at avoiding further responsibility and work. The retesting should have the purpose of determining whether there is contamination that needs to be cleaned up, so that it is safe for future residence. Instead, it is entirely clear that the Navy does not care if the site is contaminated or not, only that they can hand it off to the city with as little work or cost to them as possible. The plan needs to be redesigned to be truly thorough and protective, taking samples from acceptable locations and using reference levels and remediation goals that will protect the citizens of San Francisco and the rest of the Bay Area.

Sincerely,

Maria Caine
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ORAU agrees with the general approach described in the Work Plan to determine whether current sites conditions are compliant with the remedial action objective (RAO) in the Parcel G Record of Decision (ROD) (Navy 2009). A summary of general comments is provided below. Specific technical comments for consideration are provided in the attached table.

1. The Work Plan does not define how the field instrument minimum detectable concentrations will be calculated in order to ensure individual measurements/locations exceeding the remediation goals (RGs) can be detected.
 - a. The RGs of 1.0 pCi/g of Ra-226 and 0.113 pCi/g of Cs-137 are in the range of typical background concentrations in soils and, therefore, may not be detectable with typical radiation field detection instrumentation. Typically sites establish both an average and allowable hot spot release criteria.
 - b. Some cited detector efficiencies appear to either be over-estimated (0.90 for Sr/Y-90 for the SCM) or under-estimated (Ra-226 efficiency for the SCM). The approach cited in ISO-7503 is recommended to determine the total efficiency for all field detection systems.
2. The Work Plan does not provide the basis for the proposed 18 systematic sample population.
3. Because the RGs are very low (refer to item 1.a), a statistical comparison with an appropriate background population is needed. ORAU recommends that all the data from the background reference areas be combined and evaluated to determine a reasonable background threshold value (BTV) based on an appropriate UTL of the combined background data (for both surface and subsurface soils).



INDEPENDENT REVIEW OF THE
DRAFT PARCEL G REMOVAL SITE EVALUATION WORK PLAN
FORMER HUNTERS POINT NAVAL SHIPYARD
SAN FRANCISCO, CALIFORNIA

General Comment: Overall, the plan provides adequate detail, includes necessary components of the further investigations planned at the site, and appears to have incorporated or otherwise accounted for a number of technical team and/or regulator comments provided on the February 2018 draft *Work Plan, Radiological Survey and Sampling*. Comments and/or requests for further clarification are documented below. The associated comments in the following section-specific comment matrix are designated as **Significant** if ORAU identified technical deficiencies, simply as **Comment** for technical improvement or clarity, or as a **Minor Comment** when more editorial in nature.

Independent Review Comments				
Section	Page	Paragraph	<i>Applicable Text</i>	Comment/Observation and Recommendation
3.1	3-2	1 st	<i>For that specific sample, the ²³⁸U alpha spectrometry result will be used as a more representative estimate of the background value for ²²⁶Ra, and the alpha spectrometry comparable result for ²²⁶Ra will be compared to the RG for ²²⁶Ra using the revised background value.</i>	Comment: As this plan will likely be of interest to the public stakeholders, please consider providing additional clarifying information as to the basis why the U-238 analytical result may be more representative of the expected Ra-226 background concentration. The information was noted to have been provided in Section 5.4, page 5-5. Recommend the applicable discussion regarding the expected equilibrium between U-238 and other radionuclides in the decay series, including Ra-226, be moved and included with the applicable text. Alternatively, refer the reader to Section 5.4 for the information.
3.1	3-2	1 st	<i>If any ²²⁶Ra gamma spectroscopy concentration is greater than the RG for ²²⁶Ra, then the soil sample will be analyzed for ²³⁸U and ²²⁶Ra using comparable analytical methods (e.g., alpha spectrometry for ²³⁸U and radon emanation for ²²⁶Ra).</i>	Comment: Two comments are provided: 1) Recommend stating the Ra-226 by gamma spectroscopy will be evaluated using the photopeak of a daughter of Ra-226 (either Bi-214 or Pb-214) once equilibrium has been established. Note: The comparable information is provided in Appendix A, Section 3.1.7 but is lacking throughout Section 3 of the main body of the Work Plan, notably Section 3.7 Radiological Laboratory Analysis. 2) Recommend adding that another comparable analytical method for Ra-226 is using alpha spectrometry (not just emanation of Ra-226).

Independent Review Comments

Independent Review Comments						
Section	Page	Paragraph	Applicable Text	Comment/Observation and Recommendation		
				Alpha spectrometry for Ra-226 is a direct detection method and does not use a daughter product to quantify the Ra-226.		
3.3.1	3-3	3 rd	<i>For gamma scan survey measurements collected, individual measurement results above the RGs will prompt investigations that may result in the collection of bias samples or additional field measurements to determine the areal extent of the elevated activity.</i>	Significant Comment: The statement, as written, indicates that there is a gamma cpm that equates to the RGs, i.e., a cpm to pCi/g correlation. Was the intent to indicate gamma measurements that exceed a count per minute investigation level or is the statement indicating that the gamma scan data will be reported in units of pCi/g based on the planned deployment of the Osprey [®] digital MCA? Extensive independent verification experience at sites with Ra-226 as the radionuclide of concern has found that site reliance on a gamma cpm to activity concentration correlation results in extensive false negative results, such that the sites were found to not satisfy release criteria. Furthermore, consider revising this general statement to reflect Table 3-6, which indicates only the RG for Ra-226 is applicable, and discuss how the lack of sensitivity for Cs-137 at the RG will be addressed in the survey design and implementation.		
3.3.1	3-3	NA	Table 3-6	Significant Comment: Two comments are provided: 1) The plan should include the technical basis and measurement conditions under which the 1.0 pCi/g Ra-226 investigation level is achievable, as the value may be overly optimistic. As a comparison and to mimic varying observation intervals of an anomaly, laboratory gamma spectroscopy analysis MDCs for Bi-214 were generated and shown in Attachment A for various count times. These results indicate that under optimal laboratory conditions, achieving detection sensitivity of ~1 pCi/g above background requires a count time in excess of 60 seconds. To achieve this observation interval, one must assume that any contamination at or above the RG is widely distributed over the survey unit and confined to upper few centimeters of soil.		
			<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;"><i>Radionuclide</i></th> <th style="text-align: center;"><i>Flag Scan Measurement When:</i></th> <th style="text-align: center;"><i>Investigation Level (pCi/g)</i></th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">²²⁶Ra</td> <td style="text-align: center;">100% of RG</td> <td style="text-align: center;">1.0</td> </tr> </tbody> </table>		<i>Radionuclide</i>	<i>Flag Scan Measurement When:</i>
<i>Radionuclide</i>	<i>Flag Scan Measurement When:</i>	<i>Investigation Level (pCi/g)</i>				
²²⁶ Ra	100% of RG	1.0				

Independent Review Comments

Independent Review Comments				
Section	Page	Paragraph	Applicable Text	Comment/Observation and Recommendation
				<p>Is the reported level a nominal concentration based on some assumed background, observation interval (i.e., count time of the measurement system based on an assumed area of concern and scan speed)? The Work Plan should include additional information that would substantiate the stated investigation level performance.</p> <p>2) Is there a relationship between the tabulated investigation level and the MDC and MDCR discussions provided in Sections 3.5.2.1 Gamma Surface Activity and 3.5.2.2 Gamma Scan Minimum Detectable Concentration? That is, was the investigation level derived based on factors discussed in the latter sections or a different method?</p>
3.5.2.2	3-9	1 st	<i>Using the preferred strategy to over-excavate trenches may eliminate the requirement for a surveyor to make decisions in real time.</i>	<p>Significant Comment: Please clarify the relationship between over-excavation and a surveyor pausing and deciding whether to mark a location for further investigation? The intent of this statement is unclear, based on the preceding and following narrative, if the topic being discussed is somehow related to whether the surveyor efficiency should be included in the MDCR derivation illustrated in Equation 3-1 on page 3-10. (Note: in discussions of surveyor efficiency, p, in later Work Plan sections for the building investigation design, Section 4.5.7.4 sets $p = 1$ for motor controlled detectors). Section 3.5.2 as a whole is not sufficient and very non-specific as to parameters that will be used to determine scan detection sensitivity, other than the d' specified as 3.28.</p>
3.5.2.1, 3.5.2.2, and 3.6.5	3-9, 3-10	All, and Eq. 3-3	<i>All</i>	<p>Significant Comment: Please clarify within the work plan whether the equations (and methodology in general) presented are related to the Section 3.3.1 Investigation Levels and related comments above. It is not clear what the gamma radiation scan performance requirements are based upon. Section 3.6.5 indicates a combination of post-processed geo-referenced count data and individual radionuclide spectral data measurements will be used to identify areas for further investigations. How are these related to the MDCR determination discussed in this</p>

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				<p>section? What are the anticipated performance goals, relative to the RGs, of the scanning systems? This is particularly relevant for identifying potential Cs-137 contamination, which is indicated as “Not Applicable” in Table 3.6 and has not been further addressed.</p> <p>Most discussions and Equations 3-1 through 3-3 are based on methodology described in NUREG-1507 that was formulated to describe scan decision making performance via detector audio response and allowance for second-stage scanning. The work plan does not clearly indicate if p is planned to be set equal to 1 or a lesser value. Reliance on post-processed data does not necessarily equate to the ideal observer that is assumed when $p = 1$. In other words, what is the lower concentration bound that will be confidently identified from the scanning data assessment? Furthermore, is human performance a factor in the interpretation of geo-referenced data and the decision process for identifying anomalies? ORAU studies have shown there is a positive correlation between a GIS analyst’s true positive anomaly identification using post-processed electronic data in combination with surveyors listening to the audio detector response and pausing at suspect locations, shown in Attachment 2. There are several reasons for the correlation; one of which is the allowance for the detector output to reach full scale when the surveyor pauses near an anomaly, which is then reflected in the electronically captured data that are later evaluated.</p> <p>Additional details for the performance levels should be provided in the Work Plan, although the document states the following: <i>“Before deployment at HPNS, instrument-specific SOPs will be provided along with Field Instructions documenting operation and use of the selected instrumentation.”</i></p>

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3.5.3, 4.4.5	3-10	1 st	<i>Portable survey instruments will be calibrated annually at a minimum, in accordance with American National Standards Institute (ANSI) N323a-1997 Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments (ANSI N323) (ANSI, 1997), or an applicable later version.</i>	Comment: Although the text states “ <i>an applicable later version,</i> ” ANSI N323a-1997 has been revised and re-designated as ANSI N323AB-2013. Recommend updating calibration and performance requirements in Section 3.5.3, 4.4.5 and elsewhere in the Work Plan such as SOPs RP-108 and RP-109—references the 1978 version—to the current standard.
3.6.4	3-18	3 rd	<i>Cores less than 4 feet bgs will have samples collected from the top foot and bottom foot of the core. <u>No scans of the core are required.</u></i>	Minor comment: Why are scans of these shallower cores not required? Is there a basis that the 1- to 3-foot soil depth interval would be represented by the top and bottom foot samples? For consistency and to eliminate perceived or actual data gaps, recommend the plan include the requirement to scan all cores.
3.6.5	3-19	2 nd	<i>One hundred percent of the accessible surface of the Phase 1 SUs will be gamma scan surveyed...</i>	Minor comment: Are there any estimates of the percent of the SUs that are not accessible? What are the plans, if any, for addressing inaccessible surfaces, also what constitutes “inaccessible”? Recommend including additional information in the work plan to minimize potential stakeholder concerns for inaccessible areas.
3.6.5	3-19	4 th	<i>Elevated areas will be noted on a survey map (if applicable) and flagged in the field for verification.</i>	Minor comment: Related to prior comments on scanning procedures/methods: does this statement reflect that surveyors will be listening to the audio detector output and flagging suspect anomalies in real-time or is the intent that electronically captured data will be reviewed to select locations that should be “flagged” and further investigated?
3.7	3-21	3 rd	<i>Analyses using alpha spectrometry for ²³⁸U along with an analytical method for ²²⁶Ra comparable with alpha spectrometry for ²³⁸U will be performed in accordance with the SAP.</i>	Minor Comment: The text suggests that a method that is comparable to alpha spectrometry may be used for Ra-226 analysis. However, alpha spectrometry, itself, may also be used for Ra-226 analyses. Suggest editing text to indicate that either alpha spectrometry may (or must) be used for Ra-226 or a similar method to alpha spectrometry.

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3.7	3-22	3 rd	<i>All laboratory data packages will have independent data verification and data validation performed to demonstrate that the data meet the project objectives.</i>	Comment: Because data integrity has been a primary concern with the previous site investigations, recommend that a more robust discussion of the requirements for V&V be provided. Who will perform the V&V and to what standard?
4.5.4	4-4	NA	<i>Table 4-3</i>	<p>Significant Comment: Acknowledging that the tabulated parameters will be updated for the actual instrumentation used, several comments are listed below regarding the tabulated values presented in this draft plan:</p> <p>1) Some of the nominal efficiencies presented are potentially problematic—both under- and more importantly, over-estimating detection efficiency—if similar values are used during the investigation. Relative to the stated efficiencies, a suspected over-estimate is the 0.90 Sr/Y-90 efficiency presented for the SCM, which is more than 4× a more realistic total efficiency of 0.25 to 0.35 expected for common scintillation or gas proportional detectors. Is the 0.90 an accurate representation of the SCM's sensitivity?</p> <p>Conversely, the Ra-226 efficiency for the SCM is potentially conservative and may not account for the multiple alpha emissions from Ra-226 and progeny. Alternatively, was an assumption made that all progeny are lost with Rn-222 emanation and that only the Ra-226 alpha emissions will be measured?</p> <p>2) Furthermore, additional information should be provided on efficiency determination methods in order to assess the stated values. The efficiencies are stated as 4π value. It is unclear if the 4π values represent a total efficiency generated in accordance with the ISO-7503 guidance, and adopted in NUREG-1507, whereby the 2π instrument efficiency is modified for surface effects using an appropriate surface efficiency</p>

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				<p>factor. The Work Plan should provide the method used to generate efficiencies.</p> <p>3) Cs-137 efficiency is not provided, other than for the Model 3030 smear counter. Is the reader to assume that one of the other stated efficiencies, such as Tc-99, will be used to represent the efficiency for Cs-137 beta emissions or otherwise assume all beta contamination is due to Sr/Y-90 and data will be compared against the 1,000 dpm/100 cm² RG presented in Table 4-2? Please provide additional clarification as to how efficiency will be determined, under what conditions will a specific efficiency be used in the quantifying surface activity levels, and describe how the various surface RGs will be compared against survey results.</p>
4.5.7.2	4-7	NA	<i>Table 4-4 Investigation Levels</i>	<p>Significant comment: As stated above, the reviewer understands that the tabulated parameters will be updated for the actual instrumentation used. However, several comments are presented regarding the tabulated values. These are:</p> <p>1) Why are the Investigation Levels (ILs) stated as gross vs. net counts? As detector performance and area background will vary, the recommendation is that ILs be provided as the net counts above background. Additionally, will each detector have independent ILs calculated based on efficiency or other factors or will a single value be used for all similar detector types. If the latter, how will the single value be selected, i.e., an average, the lowest, etc.?</p> <p>2) The table may misrepresent values—recognizing the ILs are given as examples—however, there are multiple ILs that are likely in error that could be propagated into the final plan. The following were noted:</p> <p>a. The RSCS SCM ILs \approx RGs + BKG? All the beta ILs appear to assume approximately 100% detector count to disintegration efficiency, likely an artifact of the 0.90 Sr-90 efficiency listed in Table 4-3.</p>

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				<p>b. The Cs-137 and Co-60 ILs are identical for both the SCM and 43-37. However, detector efficiency for the lower energy Co-60 beta emissions will be lower—as much as much as 1/2—than the Cs-137 efficiency. Additionally, it appeared that the Sr/Y-90 efficiency was also assumed in the IL calculation for these radionuclides for the SCM, which is not a representative calibration source for these radionuclides and overestimates detection efficiency.</p> <p>The inaccuracies are such that the tables should be deleted or significantly revised.</p>
4.5.7.4	4-9	NA	<i>Example: Beta Scan MDC Calculation for the RSCS SCM and Table 4-6</i>	<p>Significant comment: Prior comments regarding the use of potentially over-estimated efficiencies and calibration standards that do not represent the contaminants of concern beta energies are applicable to the minimum detectable concentrations presented in the example and table. The table and example should be revised using realistic parameters.</p>
4.5.7.5	4-10	NA	<i>Table 4-7</i>	<p>Significant comment: See prior comments—the values provided for investigation levels are not realistic. Action levels are expected to be a fraction of those listed.</p>
4.5.7.7	4-12	NA	<i>Table 4-8</i>	<p>Significant comment: See prior comments—the values provided for static minimum detectable concentrations are not realistic. Actual MDCs are likely to be several times greater than those listed.</p>
5.2.2	5-2	1 st	<i>The preliminary data review will include ... and preparing retrospective power curves</i>	<p>Significant Comment: As there are no formal hypothesis tests discussed in the Work Plan with the exception of those associated with background data assessments in Appendix A, what is the objective of preparing a retrospective power curve? The benefit of the retrospective assessment is to evaluate the probability that Type II error occurred due to an inadequate sample population. For example, using the MARSSIM framework, Scenario A (H_0: decision unit exceeds the release criteria). The site would be concerned with the Type II error, e.g., not releasing a</p>

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				<p>clean unit. There is no effect to the Type I regulator error of concern. However, under Scenario B where H_0: assumes the decision satisfies the release criteria, a retrospective assessment is paramount to assess the probability of a Type II error and provide regulatory assurance that the investigation area is clean, i.e., \leqbackground.</p> <p>The sample population size for this work plan simply references a “previously established protocol (Ttec, 2012)” rather than providing a decision basis requirement for the 18 samples planned from survey units. The referenced protocol was reviewed and reflected the MARSSIM-based methods for planning for the WRS test.</p> <p>Note: Within the regulator comments on the February 2018 draft <i>Work Plan, Radiological Survey and Sampling</i>, specifically the file named <i>EPA Comments on HP Rad Work Plan 3.26.18.pdf</i>, extensive attention was given to the proposed 18-sample location population. Within those comments, various iterations were performed based on prior reference area background and site area population uncertainty with an output of 25 sample locations requested for each SU and background reference area. Additionally, within the file, multiple comments discussed applying the WRS test in combination with a sample-by-sample comparison to the ROD-specified release limits and requested that the WRS test be included in future reports.</p> <p>In the Parcel G Work Plan, the number of samples does not appear to be based on a specific study requirement. Responses to comments on the February 2018 draft <i>Work Plan, Radiological Survey and Sampling</i> that were provided in the electronic file named <i>RTC_Regulators.pdf</i> did not specifically address the basis for the 18 samples or address the regulators request and regulator acceptance that the WRS test would be appropriate, together with the sample-by-sample comparison to the RGs and ultimately the background parameters. Instead, the comment</p>

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				<p>responses refer to the purpose of the work plan being revised to evaluate compliance with the Parcel G ROD. Within the ROD, general terminology is used, such as: remediate and survey soils to ensure remediation objectives/goals are met; rather than providing specifics as to how achieving the stated goal is demonstrated.</p> <p>Therefore, without recognizing stakeholder consensus on what constitutes successfully demonstrating the stated remedial action objective: “Prevent of exposure to radionuclides of concern in concentrations that exceed remediation goals for all potentially complete exposure pathways”—i.e., applying the WRS test, rejecting the null hypothesis, and evaluating individual samples that exceed the RGs with the background parameters (analogous to the elevated measurement comparison described in MARSSIM)—an independent evaluation and conclusion cannot be provided for the proposed survey unit and reference background area sample populations. Overall, the combined number of background samples is likely adequate in combination for estimating background ranges, population and spatial variability, means/medians, and confidence intervals for comparison with survey unit data. However, if each survey unit is a decision unit, the 18 samples may not be adequate unless the data quality assessment includes the evaluation of the individual survey unit mean/median via the WRS test and again emphasizing that increasing the sample size would only impact, lessen, the probability of a Type II error.</p> <p>The stated ROD remediation objective to remediate/survey soils to ensure the RGs are satisfied could not be economically demonstrated for both 100% of the soils with 100% confidence, although perhaps an argument could be made provided that 100% of the soils could be successfully scanned and assurance that the detection sensitivity was a fraction of the RGs. The stated objective could be demonstrated that a specified percent of the decision unit is less than the RGs at a desired</p>

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				<p>confidence level. If that were the case, then the use of an upper tolerance limit (UTL) may be applicable to the decision of contaminated areas above the RGs vs. not contaminated. Eighteen samples provides 60% confidence that at least 95% of any other location that could potentially be sampled will be less than the RGs if the calculated UTL is less than the RGs. Achieving 95% confidence, would require approximately 60 to 450 samples, dependent upon the assumed underlying population distribution, variance, decision confidence, and desired proportion of the population that must be less than the RGs.</p> <p>There are two conceivable alternatives whereby the proposed 18 sample locations would be satisfactory. 1) Applying the WRS test to assess the survey unit mean/median against the adjusted reference background area data and 2) combining survey unit results and assessing the UTLs against the RGs for the various Parcel G Phase 1 and 2 strata in their decision units. Example: excavated soil from 21 TUs × 18 samples each = 378 samples provides 100% confidence that at least 95% of the values in the population are less than the RGs and the decision unit (the combined Phase 1 TUs) is uncontaminated.</p>
5.2.3	5-3	2 nd	<p><i>The TU/SU data are compared with the RBA data to demonstrate whether the SU is consistent with the background data. If the SU data are consistent with the RBA data, the TU/SU is considered consistent with background.</i></p>	<p>Comment: Comment is related to the utility of assessing retrospective power and ultimately providing guidance on sample size which may be a point of contention as to what size is adequate. The plan might consider another objective SU to Background statistical comparison based on hypothesis testing, in lieu of the WRS test, that combines appropriate methods for sample size determination and retrospective analysis, with the following null (H_0) and alternative (H_A) hypotheses:</p> <p>H_0: SU ROC concentrations are \leq background ROC concentrations</p> <p>H_A: SU ROC concentrations are $>$ background ROC concentrations</p>

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				<p>Provided H_0 is not rejected, individual sample results could then be compared to an agreed upon background threshold value (BTV). Consideration for the application of BTVs for individual measurement comparisons was also noted in regulator comments provided for the February 2018 draft <i>Work Plan, Radiological Survey and Sampling</i>.</p>
5.4	5-5	3 rd	<i>Alpha spectrometry provides ²³⁸U analytical results of acceptable quality for the NORM evaluation.</i>	<p>Comment: Alpha spectrometry does provide excellent results for U-238. However, the initial NORM evaluation would be much easier, faster, and less expensive if gamma spectroscopy was used to evaluate the U-238 concentrations using the 63 keV peak. This way, the gamma spectroscopy of both the U-238 and Ra-226 could be initially evaluated to determine if the two results are statistically different or equivalent. Additionally, this would eliminate potential sampling error resulting from having a large-sized sample for gamma spectroscopy from which a small aliquot is removed for alpha spectrometry.</p> <p>If, after comparing the U-238 and Ra-226 results from gamma spectroscopy, the results are not statistically different, then the alpha spectrometry for U-238 and Ra-226 would then be performed.</p>
5.5	5-6	Eq. 5-1	NA	<p>Comment: Equation 5-1 appears to be a version of the duplicate error ratio calculation for assessing the precision of duplicate measurements of the same sample. Is this an appropriate method for evaluating independent, uncorrelated samples?</p>
App. A, 3.1.3	3-2	1 st	<i>In order to simplify the sampling design, an approximately 20-foot by 20-foot square has been established within each of the four historical RBA footprints.</i>	<p>Comment: Will the small area of the RBAs provide adequate representation of the localized background spatial variability? Recommend enlarging the RBA areas if readily achievable.</p>

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App. A, 3.1.3	3-3	1 st and 2 nd	<i>The land area near the radio station building and transmitter has remained undisturbed since 1937 and has been selected as the location of the offsite RBA (RBA-Bayview). Both surface gamma scan surveys and surface soil samples will be collected from RBA-Bayview to provide a more accurate surface soil data set to represent undisturbed surface soil areas. <u>Based on field conditions, additional sample locations at Bayview Park or other reference areas may be added as necessary to characterize different soil types and depositional areas.</u></i>	Comment: Similar to the on-site RBAs, recommend that if a larger portion of the park is accessible for the background study, that sample locations be distributed quasi-randomly, to minimize spatial clustering, over the park. Recognizing that regulator comments on the previous draft work plan requested that background samples not be collected at locations at the bottom of slopes where runoff could have deposited sediment and led to accumulation of Cs-137, is it representative of potential site background conditions to exclude the lower terrain if similar fallout accumulation points exist in the study areas?
App. A, 3.1.7	3-6	Table 3-6	<i>²³⁸U Series (²³⁸U via protactinium-234m, ²¹⁴Pb, ²¹⁴Bi)</i>	Comment: The low abundance of the 1001 keV protactinium-234m photopeak may be problematic for achieving adequate quantification of U-238 at background levels. Consider replacing via the 63 and 93 keV Th-234 photopeaks to quantify U-238 for gamma spectroscopy as discussed in prior Section 5.4 comment above.
App. A, 4.2.2	4-3	Last	<i>Confirmed outliers will be removed from individual data sets</i>	Comment: Consider revising the applicable text statement regarding outliers. Section 4.4 of EPA 5QA/G-9 provides the following guidance: <i>Section 4.4 OUTLIERS: ... One should never discard an outlier based solely on a statistical test. Instead, the decision to discard an outlier should be based on some scientific or quality assurance basis. Discarding an outlier from a data set should be done with extreme caution, particularly for environmental data sets, which often contain legitimate extreme values. If an outlier is discarded from the data set, all statistical analysis of the data should be applied to both the full and truncated data set so that the effect of discarding observations may be assessed. If scientific reasoning does not explain the outlier, it should not be discarded from the data set...</i> Consider performing the assessment both with and without outliers to determine if the decision changes between the two scenarios.

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App. A, 4.2.3	4.4	3 rd	<i>The RBA data sets will be compared...as described in Section 4.1.3, to determine whether the reference areas have similar or significantly different background levels. If there are data sets that are similar (i.e., pass the KW test), they may be combined. If data sets are significantly different (i.e., they fail the KW test), further evaluation will be performed to determine the potential causes of the differences such as soil type or depth bgs. Data may be plotted on site maps or plotted against gamma-scan data to look for visual clues as to ROC distribution and to evaluate spatial independence.</i>	Comment: Please provide additional information on how the various backgrounds will be further assessed should the K-W test reject the null hypothesis that the backgrounds are from the same population. The K-W will not determine which population is different, only that there is a difference. Is the intent to perform the test on different combinations?
4.5.7.4 App. B RP-106	Table 4-6 Page 1 of 7		<i>Page: 1 of 6 RRP-106</i>	Minor comment: Change to Page: 1 of 7 as there are 7 pages in the procedure. Minor comment: Change footer from RRP-106 to RP-106.
App. B RP-106	Page 2 of 7	5.2	<i>5.2 Radiation Protection Technician (RPT) <input type="checkbox"/> RPTs are responsible for documenting surveys in a legible manner on approved forms.</i>	Comment: Consider briefly describing how the survey should be documented here beyond documenting legibly. May point to section 10.1.
App. B RP-106	Page 3 of 7	7.0	<i>7.0 PRECAUTIONS AND LIMITATIONS <input type="checkbox"/> Surveys for airborne radioactivity will be documented in accordance with RP-107, "Measurement of Airborne Radioactivity."</i>	Comment: Because air samples are excluded from this procedure, consider noting that in 7.0. For example, for clarity, consider adding in the Italicized text: "Surveys for airborne activity <i>are not covered in this procedure and</i> will be documented in accordance with ..."
App. B RP-106	Page 3 of 7	9.0	<i>9.0 RECORDS <input type="checkbox"/> PESI Survey Form (Attachment 1) <input type="checkbox"/> PESI Survey Log Number Form (Attachment 2) <input type="checkbox"/> Radiation Protection Technician (RPT) Logbooks</i>	Comment: Section 10.2.4 mentions count room printouts. Suggest adding a bullet to include other potential records to section 9.0.

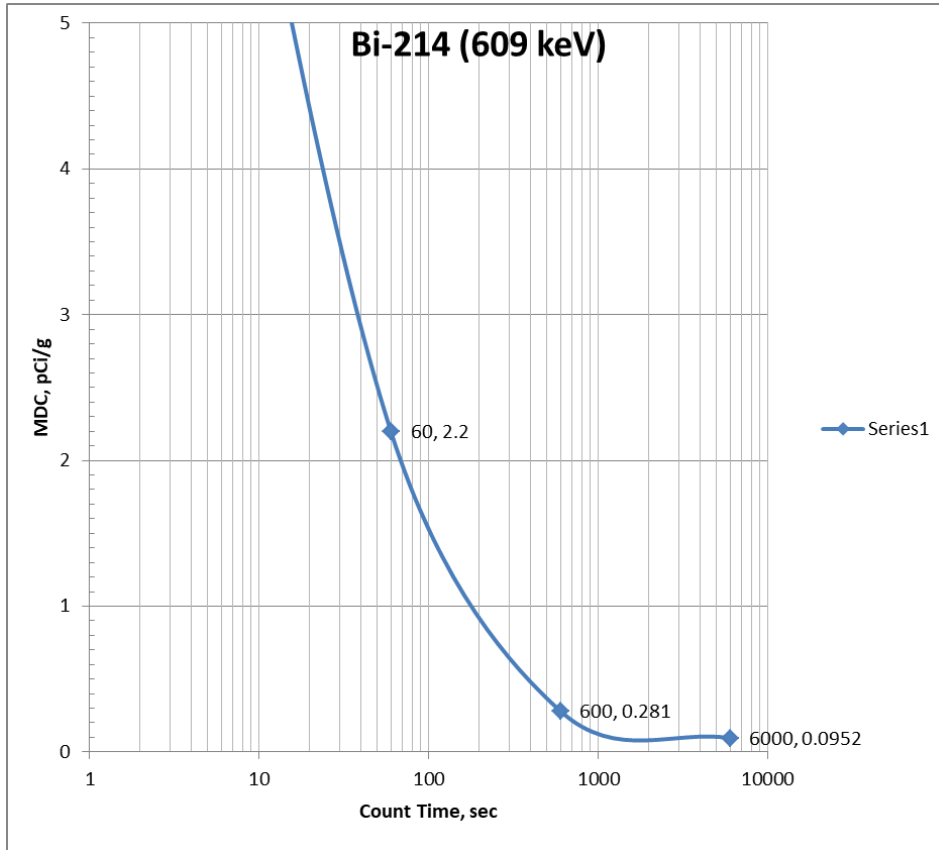
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App. B RP-106	Page 3 of 7	10.1, step 5	5. Assign the next sequential survey number to the survey from the survey number logbook.	Minor Comment: Section 10.1.2 calls the document the survey log number book. Make consistent to minimize confusion.
App. B RP-106	Page 3 of 7	10.1.1, step 6	6. Complete the following information for all surveys: <input type="checkbox"/> Date and time of survey <input type="checkbox"/> Location of survey <input type="checkbox"/> Instrument type and serial numbers and associated supporting information (i.e., detector efficiencies, calibration dates, background values, etc.) <input type="checkbox"/> HWP number, if applicable <input type="checkbox"/> Reason for survey	Comment: Consider clarifying the first bullet so that it specifies (start and stop time). Minor Comment: Spell out HWP. Comment: Suggest adding another bullet to encourage additional details, such as adding in project-related activities or conditions of significance (e.g., weather extremes); also, sufficient detail to enable independent reconstruction of the work activities and records.
App. B RP-106	Page 4 of 7	10.1.1, step 7	7. Indicate Radiological Hazard Area boundaries on the survey form using x's and -'s (-x-x or **).	Comment: Radiological Hazard Area is not defined in the definitions section.
App. B RP-106	Page 4 of 7	10.1.1, step 8	8. Note the posted Radiological Hazard using common designator such as <input type="checkbox"/> Contamination Area = CA <input type="checkbox"/> Radiation Area = RA <input type="checkbox"/> Radioactive Material Area = RMA <input type="checkbox"/> Airborne Radioactivity = ARA	Comment: Because this procedure does not cover air sampling, should the last bullet be removed? If it should stay, "Area" should be added (Airborne Radioactivity Area = ARA).

Attachment 1

Bi-214 (609 keV)

Count Time, sec	MDC, pCi/g
1	14.3
6	7.61
60	2.2
600	0.281
6000	0.0952



Attachment 2

Land Surveys Without Headphones

Surveyor No.	Survey Duration (min)	Percent ^a Coverage	Per Surveyor			Per GIS Technician		
			No. Misses	No. Found	False Positives	No. Misses	No. Found	False Positives
1	23	78	2	8	0	2	8	0
2	22	72	3	7	0	0	10	0
3	42	89	0	10	0	0	10	0
4	33	72	0	10	0	0	10	0
5	16	61	4	6	0	4	6	0
6	20	83	0	10	0	0	10	0
7	30	61	3	7	0	2	8	0
8	20	67	3	7	0	2	8	0
9	20	83	0	10	1	0	10	0
10	32	89	1	9	0	0	10	1
Sums:	NA	NA	16	84	1	10	90	1
Averages:	26	76	1.6	8.4	0.1	1.0	9.0	0.1

^aPercent coverage generally based on the number of parallel survey lanes completed divided by the ideal number of lanes (18) in the test land area; judgment used when surveyors strayed from parallel.

Land Surveys with Headphones

Surveyor No.	Survey Duration (min)	Percent ^a Coverage	Per Surveyor			Per GIS Technician		
			No. Misses	No. Found	False Positives	No. Misses	No. Found	False Positives
1	21	83	1	9	0	1	9	0
2	12	56	1	9	0	1	9	0
3	35	83	0	10	0	0	10	1
4	31	83	0	10	0	0	10	0
5	20	89	1	9	0	0	10	3
6	18	67	2	8	0	2	8	1
7	26	72	2	8	0	2	8	0
8	35	94	1	9	0	0	10	0
9	22	83	0	10	0	0	10	1
10	28	94	0	10	0	0	10	0
Sums:	NA	NA	8	92	0	6	94	6
Averages:	25	81	0.8	9.2	0	0.6	9.4	0.6

^aPercent coverage generally based on the number of parallel survey lanes completed divided by the ideal number of lanes (18) in the test land area; judgment used when surveyors strayed from parallel.

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Re: Comments on Draft Parcel G Removal Site Evaluation Work Plan (June 2018)

The retesting of Parcel G has been necessitated by the revelation that 97% of the soil measurements taken there by Navy contractor Tetra Tech during the 15+ years they worked onsite were falsified. Samples that found contamination were, for example, discarded and replaced with soil from other locations known to be clean. In the executive summary of the Parcel G Work Plan, however, it is asserted that a prime purpose of the retesting—rather than rechecking soil falsely declared clean—is to declare that ~80% of soil deemed contaminated was in fact clean and didn't need to be cleaned up, a clearly spurious claim. Strangely, the source given in the Work Plan for this dubious assertion (Argonne National Laboratory 2011), has not been made available by the Navy on its website for viewing by the public as part of the comment opportunity for this Plan.

Having a primary purpose of the retesting as attempting to advance the false assertion that 80% of soil was designated as contaminated when it wasn't and shouldn't have been remediated shatters the credibility of the entire retesting plan. For all radiological surveys conducted in Parcel G, Tetra Tech was the sole contractor. The EPA found that 97% of all of the soil measurements, including those conducted in trench units, fill units, and at buildings and former building sites, were falsified or deliberately fabricated. EPA indicates *only* 3% were free of signs of falsification. This should be the essential core of this retesting plan—to fix Tetra Tech's fabricated claims that radioactive soil was actually clean—and efforts to cloud that with a contrived argument that the site is somehow too clean is founded in the same corrupted motivations to decrease the Navy's responsibility which have guided the entire of cleanup history of the site.

According to the 2016 Explanation of Significant Differences to the Record of Decision for Parcel G, the overwhelming majority of the site, which was formerly intended to be restricted to industrial use, is now open for residential development, without any additional cleanup. It is thus of pressing importance that the future residents of this region in HPS are fully protected. Their future safety begins with a proper cleanup, which requires a truly honest and defensible testing plan. The current Draft Parcel G Work Plan appears not to have the safety of Parcel G's future inhabitants in mind, but rather to protect the Navy from additional cleanup expenditures, and mimics many of the defects observed in Tetra Tech's previous behavior. This raises the fundamental question whether the Tetra Tech scandal is merely one of failure of Navy oversight or whether it was in fact carrying out the Navy's wishes for evading expensive cleanup

obligations. The following comments address the key issues in the Work Plan which place the protection of human and environmental health second to the protection of the Navy's finances.

Scope of Retesting Disregards EPA Recommendations

The Navy's review of Tetra Tech's Parcel G work asserted that only a fraction of the Tetra Tech measurements were questionable and needed to be redone. EPA, however, found virtually none were free of signs of falsification and nearly all should be redone. For example, EPA recommended that 59 of the 63 Trench Units (TUs) receive additional testing. Yet, only 21 were selected by the Navy to receive Phase I Investigation in this Work Plan. The remaining TUs will receive Phase II Investigations, which to state candidly are grossly inadequate. A single borehole sample with a gamma scan of the core seems extremely deficient to detect possible contamination, which can involve beta or alpha emitting radionuclides, which the scan can't see at all, or gamma emitters at Remediation Goal concentrations the scan can't detect.

Furthermore, the EPA recommended retesting of all 107 of the fill units, and yet, for reasons unaddressed, fill units are completely excluded from the entire scope of the retesting plan. An explanation should be given as to why the fill units appear to exempt from retesting.

Remediation Goals Not Protective

The remediation goals (RGs) for the identified radionuclides of concern (ROCs) are not protective of human or environmental health. The soil RGs being used to guide the cleanup in Parcel G, as well as the entire HPNS site, are far less protective than the the EPA's current Preliminary Remediation Goals (PRGs).

HPNS Remediation Goals vs. EPA Guidelines

Radionuclides of Concern (ROCs)	Radionuclide Residential Soil Remediation Goals for Parcel G Work Plan (1991 PRGs) (pCi/g)	EPA Current PRG Guidelines (pCi/g)	Difference in Protectiveness, Not Including Inflated Background
Pu-239	2.59	0.006	430x less protective
Ra-226	1.0	0.0018	555x less protective
Cs-137	0.113	0.0303	3.7x less protective
Sr-90	0.331	0.0036	91x less protective

It is grossly inappropriate in 2018 to be engaged in critical retesting based on 1991 EPA PRGs rather than the ones currently in effect.

The non-protectiveness of the Remediation Goals (RGs) set forth in the Work Plan is even worse than the above table indicates, because of a grossly improper change to the RGs that the Navy attempts to slip in via a footnote. In the Work Plan, it is stated that “all RGs will be applied as concentrations above background.” (footnote a, Table 3-5). This is extremely alarming because not only do the RGs greatly exceed the preliminary remediation goals set out by the EPA, they are further relaxed by being applied not to the actual measurement of the radionuclide in soil, but only to the amount above background. Under CERCLA, remediation goals are designed to already include background levels, not the increment above background. The RGs are set forth in the Record of Decision, and there, only radium is allowed to be the incremental value above background [i.e., 1.0 pCi/g above background], (Table 5, fn. C). All other radionuclide RGs are just the actual measured value. In the Work Plan, the footnote regarding the value above background is now applied to all radionuclides, a dramatic weakening of cleanup standards that is grossly illegal. It is impermissible to alter a Record of Decision by a footnote in a subsequent retesting plan.

Furthermore, as shall be discussed later in these comments, the Work Plan entails marked inflation of background measurements, further falsifying the actual proposed sampling for contamination.

Additionally, it must be said that the radium-226 cleanup value, 1.0 pCi/g plus background, is dramatically non-protective. Whereas all other RGs for soil are said to be based on EPA residential PRGs (albeit nearly three decades old instead of the current ones), the RG for radium-226 is said to be a specially-granted exception. The RG for radium-226 is approximately one thousand times higher than the current EPA PRG, with an associated risk one thousand times higher than the CERCLA point of departure for risk and ten times even the upper limit for acceptable risk.

Investigation Levels Unclear

Page 3-3 of the work plan states that “Investigation levels are established for each instrument and vary with SU classification and measurement type.” Following that statement is a table which displays the investigation levels specifically for soil survey measurement. Please disclose in what way the investigation levels will vary between class 1, class 2, and class 3 survey units as well as amongst measurement type, and why investigation should possibly be weaker in one area than another and with one instrument or measurement type than another. It is alarming that these already high investigation levels could be further inflated depending on the classification or measurement. Investigation levels should be based on demonstrating public safety, that with all the radionuclides possibly present (scores of them), protective remediation goals are met.

Great Majority of Parcel G Never to Receive Testing

The retesting plan only includes areas in Parcel G that were asserted to be radiologically impacted by the 2004 HRA, which is an extremely small portion of the Parcel. The information used to designate sites as impacted and non-impacted was wholly qualitative and subjective, and concerningly, even the HRA itself admits that the historical database upon which they relied was incomplete (HRA 4-7). There is extreme probability that many of the sites deemed not radiologically impacted actually do in fact require testing. Because 80+ heavily contaminated ships were “decontaminated” at Hunters Point, by sandblasting and steam-cleaning, with the contaminated sandblast grit and steam being spread potentially across the whole site, and because there are numerous other pathways by which contamination would spread throughout Hunters Point by airborne deposition and surface water runoff, there is simply no credible basis to assert that any part of Hunters Point is de facto non-impacted and doesn’t need to be tested. The claim that most of Hunters Point is non-impacted and doesn’t require measurements is based on the completely spurious assertion that unless there is a record available today that radioactive materials were used in a particular building, no other part of the site can be contaminated. There are clear pathways by which all of the site could contain radioactive contamination, and no basis for excluding the great majority of Hunters Point from soil sampling or building measurements.

This argument is exemplified in Parcel G by Building 401. Originally deemed non-impacted by the HRA, it was later required to be surveyed because a civilian tenant found items from Hunters Point Naval Shipyard activities that involved radium-226 within the building. How this information was glossed over during site investigations as part of the HRA is extremely concerning and brings into question the reliability of other determinations of buildings as being non-impacted. But the key is that, whether a particular building used radioactive materials or not, radioactive contamination from elsewhere on site could readily have spread to other areas, yet the majority of the Parcel will never receive testing.

The Work Plan Still Relies on Work by Tetra Tech, Now Called into Question

Tetra Tech’s radiological design previously employed is not only faulted because of fabricated sampling and surveys, but was inadequate at the structural level. The proposed retesting in the Work Plan, however, adopts their same model, methods, and techniques, stated clearly on page 3-4, “The radiological investigation design is primarily based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012).” In addition, the actual scope of the survey—as in what areas received soil sampling, and what areas merely received gamma scans—has also been appropriated from TtEC’s model and onto the Parcel G retesting plan.

Tetra Tech’s prior survey design failed to sample areas within Parcel G that were previously neglected but should in fact receive soil sampling. For example, on page 2-3 of the Work Plan it is mentioned that releases to soil and air are recognized as potential migration pathways for

radiological contamination within Parcel G. And yet, much of the soil has never received soil sampling in Parcel G. The buildings recognized as radiologically impacted are only tested within the boundaries of the building, and the soil surrounding them—which very likely over time became exposed to the nearby radiation—has never been sampled.

The Work Plan therefore fails to address the issue that not only were previous tests unreliable, they did not test the majority of Parcel G, and therefore leave the community and environment at risk to potential exposure of contaminants.

Altered Background Radium-226 Measurement Assertions Rest on False Claims

As part of the Data Evaluation plan, it is asserted that;

“Individual samples reporting radium-226 (226Ra) gamma spectroscopy concentrations greater than the RG for 226Ra will be analyzed for uranium-238 (238U) and 226Ra using comparable analytical methods. For that specific sample, the 238U result will be used as a more representative estimate of the background value for 226Ra, and the alpha spectrometry 226Ra concentration will be compared to the RG for 226Ra using the revised background value”(ES-VI). [The “comparable” methods are not specified.]

This method of analyzing the data is not acceptable, and is essentially a way to maneuver around conducting an adequate cleanup. The assertion that one can use 238U measurements as the background value for 226Ra is based on the demonstrably false assumption there was no 238U used by the Navy at Hunters Point. However, in the HRA it is stated that 2,426 Lbs of 238U, which is 1,100,415 grams, was licensed for use at Hunters Point (HRA Sec. 5) That much 238U has the potential to contaminate *200 million tonnes of soil* at the EPA PRG concentration. Therefore, claiming that the amount of 238U which exists currently at HPS is equal to what existed prior to Naval activities, with nothing added, is clearly insupportable. The proposal to use 238U concentrations as the background level for 226 Rad thus rests on this false assertion, and should not be used if an accurate retesting of Parcel G is to be conducted.

Background Locations Selected for Buildings Intended to Inflate Background

Figure 4-1 of the Draft HPNS Parcel G Work Plan displays the selected background location for buildings, located within the northeastern corner of Building 401. However, earlier in this same document, as well as in the Parcel G ROD and the building 401 Final Status Survey Report (FSSR), it is indicated that the entirety of the building was designated as impacted. In the FSSR, carried out by Tetra Tech, it is reported that “non-licensed radioactive materials, such as check sources, electron tubes, and other radioluminescent devices” as well as “several gauges and dials containing radium-226,” were identified inside Building 401. Following that discovery, a radiological survey was conducted by Tetra Tech, the entity whose suspect work inspired this entire retesting plan. It makes no sense why one area of the building is required to be re-tested

for contamination, while the opposite corner of the same building mere feet away is being used as the background reference.

It is extremely alarming that the same Survey Units now being employed as background locations for all of the buildings receiving retesting were previously known to have been potentially contaminated. Background locations, by MARSSIM definition, should not have the potential to be contaminated by site activities. It appears, quite transparently, that selecting this location as a background reference is an attempt to inflate background levels, and thus create a bias towards lesser cleanup.

Accurate background locations are foundational to a comprehensive cleanup, and therefore, the Navy should not carry out the retesting of the buildings until a proper location is chosen. The two images below, the first showing building 401 as being wholly impacted, and the second showing a portion as being impacted and a portion being used as a background location, are both from the Parcel G Work Plan.

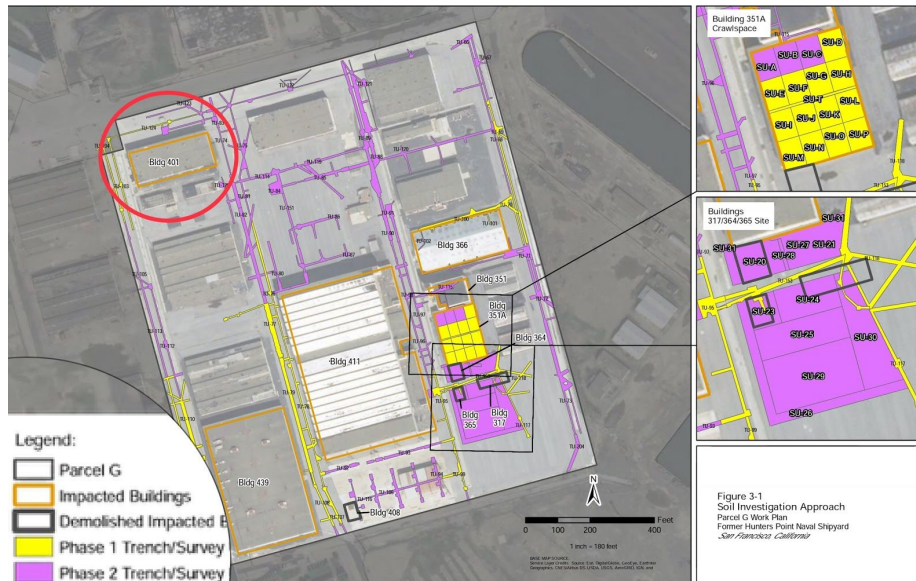


Figure 3-1
Soil Investigation Approach
Parcel G Work Plan
Former Hunters Point Naval Shipyard
JSP-3456789-101112

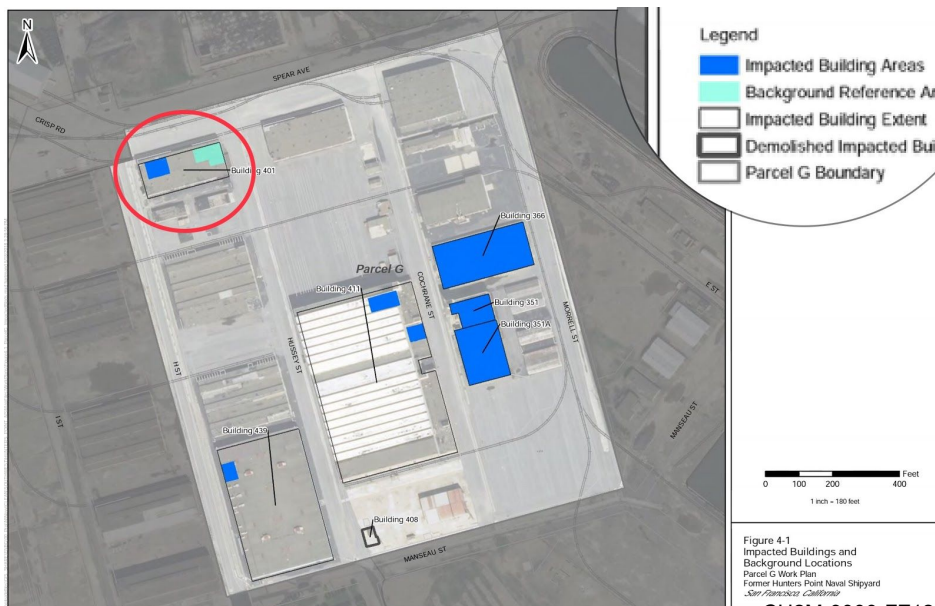


Figure 4-1
Impacted Buildings and
Background Locations
Parcel G Work Plan
Former Hunters Point Naval Shipyard
JSP-3456789-101112

Let me be clear, however: moving the background location for buildings to another building at Hunters Point would also be unsupportable. There is no basis for presuming that any building at Hunters Point is free of contamination. Decades of airborne deposition from ship decontamination, burning of contaminated fuel oil in boilers, incineration of potentially radioactive carcasses and other materials in onsite boilers, tramping into buildings with shoes that have gone through contaminated areas, to give just a few examples--there are mechanisms by which any and all buildings at Hunters Point could be contaminated. On top of that is the paucity of accurate historical records.

Because it is so easy to skew background measurements, even with offsite structures, the choice of new background locations needs to be subject to public review and scrutiny.

Survey Unit Design for Buildings Leaves Significant Portion Untested

The survey units for the buildings are stated to be all class 1—which require 100% scans and small survey unit sizes—but it turns out that that isn't really true. The Class 1 surveys appear to actually be limited to the surface area of the floor and lower 2 meters of the adjacent walls. The upper walls and ceilings, which may have just as much potential for contamination as the lower walls and floors, are not even allocated into survey units as described in the Plan. Rather, it states that “twenty-five percent of the remaining upper wall surfaces and ceilings will be scanned”(4-14). This means that that, assuming the height of the building falls somewhere around 4 meters in total, only half of the building will receive a 100% scan. The remaining 50% of the building will only receive a 25% scan, leaving a significant portion untested.

This was one of the allegations by whistleblower Anthony Smith, that even in buildings declared to be Class I, Class 1 surveys were conducted only for floors and lower parts of walls, Class 2 for upper walls, and Class 3 for ceilings. Class 2 and Class 3 surveys are far less thorough than Class 1.

Additionally, for the testing to be conducted at building sites, the scans and swipes are limited to only alpha and beta. Please provide a basis as to why collection of gamma swipe measurements are not to be collected.

Background Locations for Soil

Of the five background locations selected for reference measurements for soil, four of them are located on site at HPS, in the midst of all the contamination. Only a single background reference is located off site, nearby at Bayview Park. Unfortunately, this sole-offsite reference point will not make any significant difference to the final background measurements to be used in the testing plan. This is because according to the Work Plan, as part of the statistical analysis of the reference background measurements for soil, any outliers will be omitted (e.g., if the off site

measurement is lower than the on site ones). In addition, the 95 percent confidence level to be employed which will entail that the actual on site reference measurements used will skew the data set in favor of high background measurements. All of these components will produce background measurements that will ultimately inflate the remediation goals, and thus provide for a dangerously relaxed, if any, cleanup. No measurements for background should be taken at all on site, because all of Hunters Point is at risk of being contaminated; and off site locations should be multiple and at significant distance from the site and chosen with public review and comment.

Lack of Transparency and Failure to Communicate from Navy

In my efforts to better understand key components of the HPNS cleanup process, I repeatedly reached out to Navy representatives in hopes of receiving answers to the various questions which I was presented with during my research.

My questions were intended reach clarification of key points of the HRA, as well as the percentage of sites or survey units at HPNS that received class 1, 2, and 3 surveys, all of which were important to my review of the Parcel G retesting plan.

My first email was sent on July 9th, 2017 to Danielle Janda, an environmental engineer for the Navy. After a week without a response, I sent a second email, asking again for a response, and with additional questions.

On July 19th, when I finally received a response from Ms.Janda, it circumvented my questions. Instead of addressing my questions, I was told that “the details of the survey units can be found in the previous site reports.” As I reiterated in my July 23rd response to this email, many if not most of the documents listed on the Navy website are unavailable; when I click on the link, I am told that in order to gain access to it, a Freedom of Information Act request is required. This inhibits the productivity of my own personal research, and when Navy representatives are resistant in providing information, it is extremely challenging to receive answers on these matters. Furthermore, the Navy should be readily able to answer these questions.

My response on July 23rd reiterated (again) the previous questions that had not been answered and included additional questions necessary to my understanding of HPNS cleanup process. However, to my dismay, once again I received no response. Once again, I had to it send an additional email, on August 3rd, asking once more for a response; only thereafter did I receive a response from Ms. Janda, on August 6th. But again, the “response” was non-responsive, and I was merely told to either conduct searches myself electronically, where many documents aren’t available, or at on site locations. To reiterate, the questions I asked were ones the Navy should readily be able to answer; and if not, it was unclear how they could be doing any adequate oversight of the cleanup.

The only information I received was that “the majority” of survey units were conducted as Class I. The Navy could not, or would not, tell me what percentage were conducted as Class 2 or 3, with far weaker requirements. If what they told me was true, nearly half of the survey units had the less protective Class 2 and 3 surveys (and far more than half of the area, because of the different size survey units for different Classes). Furthermore, the information from whistleblower Anthony Smith, confirmed in information buried in some Navy documents, indicates that even for buildings categorized as Class I, the upper parts of walls and the ceilings were only given Class 2 and 3 surveys.

Transparency and thorough communication between Navy representatives and the concerned public is essential. Having not been allowed that in my research prior to this comment, I hope to see the comments and questions made here adequately addressed before the retesting in Parcel G is carried out.

Conclusion

A cloud hangs over the credibility of the Navy’s work at Hunters Point. Its contractor fabricated nearly all the measurements made in Parcel G, calling soil clean when it was contaminated. It would seem imperative that the Navy, to get the project back on the right track and restore public trust, would prepare a Parcel G Retesting Work Plan of the highest integrity.

Instead, many of the fundamental problems that were at the heart of the Tetra Tech falsifications appear in the retesting plan. Rather than trying to do an honest set of measurements aimed at ensuring that no soil or building with contamination is not identified or cleaned up, the Work Plan seems to be heavily skewed to claim that the site is somehow “too clean” and that far less cleanup should be done than is required. By such means as inflating background, illegally weakening remediation goals, proposing bogus ways of throwing out radium readings that show contamination, the Navy’s Work Plan reinforces the impression that what Tetra Tech did was not an anomaly, but in fact consistent with what the Navy wished: falsified measurements to claim there was far less contamination than truly exists, and thus reduce cleanup expenses. The Work Plan appears to, rather than fixing the Tetra Tech scandal, carry it further and even expand upon it. I urge the Navy: “Full stop. Reverse course.”

Sincerely,

Taylor Altenbern
taylor.altenbern@gmail.com

Public Comment Responsiveness Summary

Draft Parcel G Removal Site Evaluation Work Plan

Former Hunters Point Naval Shipyard, San Francisco, California

Thank you for taking the time to thoughtfully review the draft *Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard, San Francisco, California* (Plan), issued in June 2018. The Plan was prepared in response to falsification of radiological data collected by Tetra Tech EC (TtEC) at Hunters Point Naval Shipyard (HPNS or the Shipyard). The Plan has been revised and will undergo further revision as the Department of the Navy (Navy) obtains information and input.

A comprehensive evaluation of TtEC radiological data has been conducted, and it has been confirmed that data are fraudulent, ultimately resulting in a plan to gather new data in 100 percent of the areas previously tested by TtEC. Community and regulatory stakeholder input is helping the Navy to develop the path forward for HPNS. Accurate data collection and testing will be used to determine whether the site conditions at Parcel G meet original cleanup objectives and the land is suitable for transfer to the City, or if additional work (including excavation and sampling) is required.

The Navy is committed to sampling trench and survey units and scanning the building areas where TtEC conducted work at Parcel G. The Plan has been updated to reflect the retesting approach based on regulatory and stakeholder comments, including removing the durable cover and performing 100 percent surface scans of all trench and soil survey units; increasing the number of sample locations; and incorporating remediation should the results of the initial testing show that additional cleanup is needed.

Public participation is an important element of the Comprehensive Environmental Response Compensation, and Liability Act (CERCLA) of 1980 (also known as Superfund) process. The Navy considers input from the Bayview Hunters Point community essential in our environmental process. As such, all of your comments, questions, and feedback have been thoroughly reviewed and are an important part of improving the Plan.

Public comments were distilled into categories, and the Navy has provided responses to those categories.

Categories are in bold, followed by responses and general clarifications

Discrepancies between the Navy's and EPA's evaluation and retesting plan

The Navy estimates that approximately 50 percent of the radiological survey and remediation data reported by TtEC cannot be verified as accurate. The Navy and the U.S. Environmental Protection Agency (EPA) agree that the previously reported data are unreliable. The Navy will be retesting soil at 100 percent of buildings, trenches, and other areas where TtEC collected samples. Additionally, buildings identified as impacted in the Historical Radiological Assessment and cleared by TtEC will be resurveyed. The Navy is committed to conducting thorough and accurate retesting to regain public trust, ensure site safety, and meet or exceed regulatory standards.

Documents available for public review

The cleanup program at HPNS includes a vast library of documentation. Navy documents related to remedial decisions are included in the official Administrative Record, which is available to the public for review. In many cases, documents reference other reports to provide additional technical information and detail. Stakeholders are encouraged to review documents by accessing the information at the official Administrative Record, one of the local information repositories, or on the Navy's website at www.bracpmo.navy.mil/hpnsrc.

In response to the elevated interest in site activities, and as part of the Navy's efforts to rebuild confidence in its efforts to gather accurate data that confirm public safety, the Navy made the draft Plan available for a 60-day public comment period and posted the related Sampling and Analysis Plan on its website in August 2018. The Navy is expediting the development of subsequent plans to address the retesting effort and has worked closely with regulatory agencies to ensure that an agreed-upon approach is used for the upcoming retesting.

Third-party oversight and laboratory operating procedures

Verification of fieldwork integrity is a high priority for the Navy. In alignment with stakeholder requests, there are multiple layers of oversight planned, including fieldwork oversight by contractor Battelle, independent review of plans by Oak Ridge Associated Universities, and confirmation sampling and oversight by both federal and state regulators. In addition, contractors conducting fieldwork will photo-document their work. Stakeholders who expressed concern that fixed price contracting may create pressure that could cause falsification to happen again may be reassured to know that protocols have been established to ensure that fieldwork, laboratory sampling, and documentation are thorough and follow a regulatory framework with a focus on independent oversight and review. The Navy will be using only certified laboratories.

Reference Background Areas

Naturally occurring substances present in the environment in forms that have not been influenced by human activity, as well as other natural and man-made substances resulting from non-Navy activities, are known as "background." Previous background data were collected by TtEC; therefore, collection of new background data is proposed.

The Navy is committed to collecting accurate background levels for radionuclides of concern (ROCs) at HPNS. To collect new, accurate background levels at HPNS, soil samples will be collected from onsite and offsite locations in areas that have been reported as undisturbed or not impacted by site-related contamination. Additional resources will be used to establish regional background for the greater San Francisco area (e.g., United States Geological Survey).

With regard to establishing new background criteria for buildings, and in accordance with reviewer feedback, the baseline building data collection site will be revised. The site referenced in the Plan (Building 401 at Parcel G) will be changed to a building where radioactive materials were never used.

Remediation goals and protectiveness of human health and the environment

When developing the remediation goals (RGs) for HPNS, the Navy worked with the various regulatory agencies to determine what levels would be protective of human health and the environment using the EPA's preliminary remediation goal calculator and other available tools.

To ensure that final remedies remain protective of human health and the environment, the Navy conducts basewide Five-Year Reviews to ensure that remedial actions remain protective. A Five-Year Review is currently underway at HPNS. This effort is being coordinated with both state and federal regulatory agencies. As part of the Five-Year Review, remedies are being evaluated against current regulatory standards.

Basis for remediation

The draft Plan references many documents, including a 2011 Argonne National Laboratory report. References to this report have been removed as a result of public and regulator comments. The Plan is based on the regulatory proposal, not on the Argonne report. The Navy will use all historical information to inform its understanding of the site, and the Navy will be collecting data as soon as possible so that its understanding of the site can be improved.

Tests and scans

At some sites, gamma scans are needed. Gamma scanning measurements are collected in land areas to detect contamination or radioactive objects in soil. Gamma radiation can pass through soil and air, so gamma measurements detect radioactivity in subsurface as well as surface soil. Scanning data are reviewed to identify anomalies that might require further investigation by way of excavation or the collection of soil samples for laboratory analysis.

In buildings, scans for alpha and beta radiation are performed. The RGs for buildings are levels of radioactivity present on building surfaces and are based on the alpha and beta emissions of the ROCs. Gamma scanning is less effective in buildings because the influence of natural radioactivity in building materials limits the ability of gamma measurements to locate contamination. Alpha and beta radiation measurements in buildings will determine compliance with the building RGs or will identify areas that require remediation.

Methods for detecting ROCs are better explained in the Plan, which has been revised based on public and regulator comments (see also the *Regulator Response to Comments* document).

Navy public outreach

The Bayview Hunters Point community is rich in diversity and history; the former Shipyard has an important role in this history. Upon its closure as a naval facility in 1988, HPNS entered the Base Realignment and Closure program, and in 1989, the EPA evaluated HPNS and placed it on the National Priorities List in response to concerns about the effects of past hazardous wastes created by historical Shipyard activities by both the Navy and private companies. The Navy's environmental cleanup at HPNS has followed the requirements established by CERCLA, and public participation at HPNS has consistently exceeded CERCLA requirements.

Historically, the Navy has managed a robust outreach program during the cleanup of the former Shipyard, regularly exceeding outreach requirements and adjusting public participation methods to increase community input. The Navy is committed to transparency. Program documents are available for public review in the official Administrative Record, at local information repositories, and on the Navy's website. In addition, quarterly progress updates provide a list of documents available for public review.

The availability of Navy program personnel offers a chance for community members to engage with cleanup program representatives. Activities include Navy presentations and informational sessions within the community regularly throughout the year, as well as Navy participation in local events. In addition, the Navy has enhanced its efforts to reach the community by providing the Community Technical Advisor for radiological health and safety questions. To support the public's understanding of the Navy's cleanup activities at HPNS, an abundant amount of program information is prepared for the community. Informational fact sheets, frequently asked questions (FAQs), and other documents are available in a community-friendly format, both in print and electronically.

Outreach activities that have occurred during 2017 and 2018 (including planned activities through the end of the calendar year) are the following:

- Advertisements, official public notices in local periodicals, and official public comment periods: 13
- Bus tours and participation in local community events: 12
- Community liaison and Community Technical Advisor availability sessions: 35
- Community surveys, Navy website's Timely Topics postings, and distribution of program materials to community leaders, community organizations, and neighborhood associations: 24
- Electronic newsletters (approximately 1,100 distributions per issue): 34
- Fact sheets (general cleanup program): 18
- Fact sheets and FAQs (radiological retesting): 13
- Navy community meeting open houses and presentations at local group meetings: 14
- Postcard mailers (approximately 15,000 distributions per mailer): 5
- Program documents available for public review: 41 (through Third Quarter 2018)

Summary

The Navy's highest priority is public health and safety. We are committed to sampling and scanning 100 percent of areas where TtEC's radiological data indicated that remedial actions were complete. Areas involved in the retesting include trenches, buildings and former buildings, and surface soil (under and around impacted buildings). As part of the trench retesting effort, excavation, sampling, and scanning will occur in 33 percent of the areas previously excavated by TtEC. Additionally, the remaining 67 percent of trench units will be sampled and scanned. Based on the results, additional investigations or excavations may be conducted.

The Navy will continue to update members of the community about radiological retesting. These updates will occur in various formats, including the availability of subject matter experts at Navy meetings and events, individual and small group discussions on radiological health and safety with the Navy's Community Technical Advisor, and Navy presentations at local group meetings. In consideration of your comments on the Plan, and in partnership with regulatory agencies, the Plan will be updated to reflect comments on the retesting approach. Sample results and reports will determine whether further remediation is necessary. Conducting the work in phases and evaluating data with the regulatory agencies to make remedial action decisions will be imperative to ensure transparency and protection of human health and the environment. The Navy appreciates all community and regulatory input on its

documents and looks forward to finalizing the Plan to enable data gathering at Parcel G as soon as possible.

For comments that are technical and overlap concerns expressed by regulatory agencies, additional detail can be found in the *Regulator Response to Comments* document. The October 2018 *Parcel G: Radiological Retesting* Fact Sheet provides an overview of the Plan and includes visual aids for understanding the testing methods. Future work plans will address soil and buildings in the other parcels (B, C, D-2, E, UC-1, UC-2, and UC-3), including the North Pier and Ship Berths. Please visit the Navy's website at www.bracpmo.navy.mil/hpns for event announcements, Timely Topics, recent fact sheets, and other documents.

Responses to Comments

Draft Parcel G Removal Site Evaluation Work Plan

Former Hunters Point Naval Shipyard, San Francisco, California

The purpose of this document is to address comments on the Draft Parcel G Removal Site Evaluation Work Plan, dated June 2018, for Former Hunters Point Naval Shipyard, San Francisco, California. The United States Environmental Protection Agency (USEPA), Department of Toxic Substances Control (DTSC), California Department of Public Health (CDPH), and San Francisco Department of Public Health (SFDPH) comments were received August 14, 2018 and are listed below with the responses to comments provided in bold. The responses were submitted on October 11, 2018 and clarification and/or additional comments were received from DTSC and CDPH on October 19, 2018 and from USEPA on October 22, 2018. SFDPH indicated that they have no comments on the responses on October 23, 2018. The work plan will be updated to address these comments and a draft final version submitted for review.

General Response

Thank you for your comments on the draft *Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard, San Francisco, California, June 2018* and support of retesting as soon as possible. The Navy is committed to sampling every trench and survey unit where TtEC conducted work at Parcel G. The work plan has been updated to reflect the agencies' retesting approach based on the responses to comments herein, including removal of the durable cover and 100% surface scans of all trench and soil survey units; increasing the number of sample locations; and incorporating remediation based on the results of the initial testing. Updating background values will ensure cleanup of materials is based on site-related contamination rather than variations in background and naturally occurring radioactivity. The Navy is committed to performing excavation if site-related contamination is discovered.

As the regulators have noted throughout their comments, the radiological cleanup at HPNS presents a number of technical challenges. The remedial goals specified in the Parcel G ROD are very low compared with the observed ranges of naturally-occurring and anthropogenic radionuclides, making it difficult to differentiate between contamination from historical Navy operations and radioactivity that is already present in the environment.

The Navy believes a MARSSIM-based sampling approach would provide a solid basis for determining/confirming protectiveness and reducing uncertainty in the characterization of Parcel G in a more timely and effective manner.

The Navy will set aside their proposal for a MARSSIM-based sampling approach, incorporate the approach and methods proposed by the regulatory agencies, and accept the additional retest work effort that will be required.

The Navy is committed to incorporating an approach in which all agencies and stakeholders can agree. Therefore, the Navy has incorporated the regulatory agencies' retesting proposal into the work plan in the interest of gaining concurrence and collecting data as soon as possible.

USEPA Comments

General Comments

1. Executive Summary; Section 2, Conceptual Site Model; and other sections: The June 2018 draft Parcel G Removal Site Evaluation Work Plan ("Work Plan") acknowledges many aspects of the 2008 Conceptual Site Model (CSM) for storm drain/sewer lines that is cited in the Radiological Removal Action Completion Report (RACR) the Navy produced for Parcel G and other parcels. This 2008 CSM states that contamination could have come from any leaks in storm drain/sewer lines, which could have been a result of many factors that could have occurred at any locations along the lines. (See General Comment # 21 in the U.S. Environmental Protection Agency [EPA] December 2017 comments on the radiological data evaluation for Parcels B and G). The EPA, State of California Department of Toxic Substances Control (DTSC), and the California Department of Public Health (CDPH) found that the original test results from Tetra Tech EC Inc. are unreliable. Therefore, we are relying on the original 2008 CSM that states that "The potential for materials to migrate from piping/ and manholes into the surrounding soils is significant." The Executive Summary and Section 2, Table 2-1, "Uncertainties" section lists factors that could result in "Lower potential for radiological contamination than originally described in historical CSMs." While some of these factors could theoretically affect the extent of contamination potentially left behind by Tetra Tech EC Inc., until new reliable testing results are available, the 2008 CSM stands. This CSM was the basis for the EPA March 2018 comments on the Navy's February 2018 draft Work Plan for retesting any parcels.

In addition, the Executive Summary and Table 2-1 also refer to anthropogenic fallout as a potential source for Cesium 137 (Cs-137). Previous radiological work at the Hunters Point Naval Shipyard (HPNS) did not apply a reference background value for Cs-137 except in Parcel E-2. While the EPA has no objection to collecting new reference background data for Cs-137, please refer to this comment EPA previously submitted December 29, 2017, to the Navy about Cs-137 contamination due to Navy activity at Parcel G: "the Navy has found radiological contamination in portions of Parcel G, such as in the southeastern corner (associated with the buildings and the "peanut spill") and in the sewers along Cochrane Street due to previous testing during the Phase I through Phase V Radiological investigations/cleanups. The 2004 HRA [Historical Radiological Assessment] indicates that Cs-137 was found at high concentrations in sediment from a manhole along Cochrane Street." The HRA documents that the Navy used Cs-137, resulting in liquid waste that resulted in releases in Building 364 in piping, sinks, and the "peanut spill" behind the building. The HRA also documents in Table 5-1 that the Navy had 5 radioactive licenses with the Atomic Energy Commission for Cs-137, one for a quantity of 3,000 Curies and a separate quantity of 20 Curies of Cs-137. Two licenses indicate that Cs-137 was in sources. In some cases, the Navy made their own sources with Cs-137.

Please add to the Executive Summary text that Parcel G has contained Cs-137 contamination due to the Navy's activities. In Table 2-1, "Potential Source Areas" Section, please revise the text to indicate the sources related to Cs-137.

As a result of the above history, until receiving any evidence to the contrary, the underlying assumption should be that new comprehensive testing is necessary and that Cs-137 found in new testing could be due to Navy contamination. The regulators are open to evidence for an alternative CSM, such as new reliable data about the extent of contamination found after excavating the trench units (TU's) most likely to have contamination. Contamination is defined as radionuclide concentrations above the RGs in the 2009 Parcel G Record of Decision, excluding Naturally Occurring Radiological Material (NORM) or anthropogenic background. Excavation and testing of the soil survey units with the greatest likelihood of contamination is an important step toward testing the validity of the original CSM. Please ensure future versions of the Work Plan and the updated Master Sampling and Analysis Plan (SAP) address EPA's assumptions about the CSM.

The 2008 CSM is based on data collected by TtEC, which is unreliable; therefore, the Navy supports retesting the areas where TtEC conducted work as soon as possible. The results of the investigation activities presented in the Parcel G Work Plan will be used to update the CSM.

The CSM summary was removed from the Executive Summary because the level of detail needed for a comprehensive CSM is not relevant to an Executive Summary. In Table 2-1, the Site Operations and History discussion has been updated to note the Atomic Energy Commission licenses described in Table 5-1 of the HRA and that uses of Cs-137 that resulted in releases in and adjacent to Building 364. Discussion of the Phase I through Phase V investigations and cleanups has been added as a footnote to Table 2-1.

General Comment on RTCs 1: The following comments were generated based on an Evaluation of the Responses to EPA Comments on the Draft Parcel G Removal Site Evaluation Work Plan, Hunters Point Naval Shipyard, San Francisco, California (“WP”). A revised WP has not yet been submitted; therefore EPA cannot confirm if the all of the EPA concerns have been addressed and whether they were sufficiently incorporated into the WP. EPA will later fully evaluate some responses after receiving the forthcoming draft final WP, including, but not limited to, the following: General Comments 1, 2, 3, 4, 6, 10, 11, 12, 13, 15, 16, 18, 21, and Specific Comments 2, 3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 20, 21, 22, 23, 25, and 26. Similarly, the responses including, but not limited to, General Comment 7, and Specific Comment 21, cannot be fully evaluated until the revised Parcel G Removal Site Evaluation Sampling and Analysis Plan, Former Hunters Point Naval Shipyard, San Francisco, CA (SAP) is received. We expect also to review other documents will also be forthcoming that will give additional details.

Comment noted.

2. Executive Summary; Section 3, Soil Investigation Design and Implementation; and other sections: The June 2018 Work Plan does not include necessary elements of the retesting proposal presented in EPA’s prior comments in March 2018. Based on the original 2008 CSM, EPA, DTSC, and the CDPH proposed in March 2018 a scientifically driven retesting strategy that, if followed, is designed to provide confidence to the regulators and the public when the site would be suitable for redevelopment. The details appear in EPA’s attached March 2018 comments. In addition, attached is a statistical review of the June 2018 Work Plan. For example, the Work Plan does not provide information about the path forward in a scenario in which contamination is found anywhere within the Phase I TUs or Survey Units (SUs). EPA stated in its March 2018 comments that if contamination is identified in any of the initial 33 percent (%) of TUs, then all the TUs in Parcel G (100%) will require excavation and testing. Similarly, for building site SU’s, if contamination is identified in any of the initial 50% of SUs then all the similar units in Parcel G (100%) will require excavation and testing. Please revise the Work Plan to include this requirement. Similarly, Figure 3-2, Performance Criteria for Demonstrating Compliance with the Parcel G ROD – Soil, does not include a step in the logic diagram for the next steps to be taken if Ra-226 exceeds the RG (1.0 pCi/g above background). Please revise Figure 3-2 to include a complete logic diagram demonstrating actions that will occur if Ra-226 is found to exceed the RG in any sample.

The work plan has been updated as follows:

- **In the Executive Summary and Introduction sections, the following text was added: “The phased investigation approach is based on the proposal by the regulatory agencies to achieve a high level of confidence that the Parcel G ROD RAO has been met for soil. For Phase 1, 100 percent of soil will be re-excavated and characterized at 33 percent of TUs in Parcel G. Soil sampling and scanning at the remaining 67 percent of trench units will be performed as part of Phase 2 to increase confidence that current site conditions comply with the Parcel G ROD RAO. The Navy will re-excavate 100% of Phase 2 TUs if contamination is identified in Phase 1 TUs.”**
- **The Executive Summary, DQOs (in Sections 3 and 4), and Section 5 have been revised to reflect the following:**
 - **If the investigation results demonstrate there are no exceedances determined from a point-by-point comparison with the statistically-based RGs at agreed upon statistical confidence levels, or that site conditions are representative of background and naturally occurring material, then a remedial action completion report (RACR) will be developed.**
 - **If the investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically-based RGs at agreed upon statistical confidence levels and are not representative of background and naturally occurring material, remediation will be conducted and a RACR will be developed.**
 - **The RACR will describe the results of the investigation and any remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel G RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.**

For the building site SUs, 100 percent surface scans were added to the work plan. 100 percent of the building site SUs will be investigated consistently and concurrently with the TUs. There is no longer a Phase 2 reduced sampling effort for the building site SUs.

The Navy anticipates these additional actions will require the excavations to be open longer, requiring additional time for fieldwork.

General Comment on RTCs 2: In some cases, the RTCs state that “the Navy has incorporated the regulatory agencies’ retesting proposal into the work plan in the interest of gaining concurrence and collecting data as soon as possible,” while at the same time restating the Navy’s previous position, which is contrary to EPA’s. For example, the last four sentences of the “General Response,” the response to General Comments #5, 8, do not acknowledge EPA’s position stated in General Comment 16 of the August 14, 2018, comments on the draft WP that explain that a point by point comparison with a “not to exceed” remedial goal (RG) is consistent with EPA national policy and past practice at this and many other Superfund sites and that it is more conservative than the use in Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) of the Wilcoxon Rank Sum (WRS) test that may sometimes allow contaminants to remain in place above the RG. EPA’s positions on various matters have drawn from EPA national policy, the Parcel G Record of Decision, past practices at this and other sites nationwide, and other bases. If the Navy chooses to restate its position in the draft final Work Plan, then in each instance, please clearly identify that as the Navy’s position and acknowledge the regulatory agency’s position.

While the Navy believes that statistical evaluations outlined by MARSSIM offer the flexibility to manage radiological investigation and cleanup on a survey unit basis, the regulatory agencies’ position is that a point-by-point comparison of investigation results and remedial goals should be conducted. USEPA maintains that this is consistent with USEPA national policy and past practices. In this matter, the Navy and regulatory agencies have agreed to disagree. In the interest of moving the project forward, the Navy’s Parcel G Work Plan incorporates the regulatory agencies’ position and manages the investigation based on a point-by-point comparison of investigation results and remedial goals.

3. Executive Summary; Section 3, Soil Investigation Design and Implementation; and other sections: The Work Plan proposes including cleanup criteria that are not documented in the Parcel G Record of Decision (ROD). The following sections contain language regarding additional cleanup criteria at Parcel G that are not documented in the Parcel G ROD and therefore do not meet the statutory requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP) of 40 CFR §300.430 Remedial investigation/feasibility study and selection of remedy:
 - a. The Project Purpose section of the Executive Summary, states, “Portions of soil or structures at Parcel G that are not compliant with the RAO [Remedial Action Objective] specified in the Parcel G Record of Decision (ROD)] will be evaluated for protectiveness based on the United States Environmental Protection Agency’s (USEPA’s) current guidance on Radiation Risk Assessment at CERCLA Sites, Radiation Risk Assessment at CERCLA Sites (USEPA, 2014) [Radiation Risk Assessment at CERCLA Sites].” At this stage of the CERCLA process, the cleanup goals have already been legally established. A new Radiation Risk Assessment is ordinarily only performed as part of a Five-Year Review to evaluate whether or not the original RG’s are still protective. EPA has separately recommended that the Navy conduct this review, and, if any of the RGs are found to be no longer protective using the most current risk calculators, propose amendments to the Parcel G ROD to ensure protectiveness. For the current work plan, however, the current RGs still govern the cleanup and if any material is found on Parcel G that exceeds the RGs established

in the Parcel G ROD for the ROCs, excluding naturally occurring and anthropogenic background, the material should be removed and disposed of in accordance with the ROD and other applicable laws and regulations.

- b. The Executive Summary, Phase I discussion states, "To the extent practicable, soil with ROCs [radionuclides of concern] at concentrations above the RGs [remedial goals] will be evaluated further using USEPA's current guidance on Radiation Risk Assessment at CERCLA Sites." As stated above, pursuant to the ROD, the remedy at Parcel G requires that "[b]uildings, former building sites, and excavated areas will be surveyed after cleanup is completed to ensure that no residual radioactivity is present at levels above the remediation goals" and "[e]xcavated soil, building materials, and drain material from radiologically impacted sites will be screened and radioactive sources and contaminated soil will be removed and disposed of at an off-site low-level radioactive waste facility."
- c. The Data Evaluation and Reporting states, "If the investigation results demonstrate that site conditions are not compliant with the Parcel G RAO, then the data will be evaluated to determine whether site conditions are protective of human health using USEPA's current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014). A removal site evaluation report will be developed to include recommendations for further action." EPA Directive 9200.4-40 was issued as guidance only and, as such, is not a regulatory requirement or a ROD-established cleanup level for the Hunters Point Naval Shipyard (HPNS) site in accordance with the CERCLA process as promulgated in 40 CFR §300.430. At Parcel G, the ROD has already established cleanup goals that govern the remedy. Please revise these sections of the Work Plan to state that only areas that are demonstrated to comply with the Parcel G ROD requirements will be eligible for Regulatory Agency approval and release.

All references to USEPA's current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014) were removed; however, the Navy believes it is appropriate to consider USEPA's updated guidance. Changes to the cleanup levels are not proposed for this project.

4. Executive Summary and Section 3.4.4, Phase I Trench Unit Investigation: This section states that TUs will be over-excavated (i.e., excavated outside the estimated previous boundaries of the sidewalls and bottom), and will be gamma scan surveyed and sampled ex-situ (i.e., on a Radiation Screening Yard). The Work Plan Table 3-1, Phase 1 soil Trench Units indicates that the sidewalls and floor will be combined into one survey unit. The Navy's proposal to excavate all soil beyond the previous boundaries will be more protective than EPA's March 2018 proposal because more material will be excavated and tested instead of only systematic samples. In addition, scanning this material ex-situ will give more reliable results than scanning in-situ (i.e., in the trench itself). Therefore, EPA agrees with the Navy's alternative proposal to address the potential for contamination to remain in the sidewalls and bottom of the trenches. However, please revise the Work Plan to specify that in the event that an exceedance above any of the ROD ROC RGs is identified in the ex-situ scanning, the Work Plan should require in-situ investigation, i.e., the sidewalls and floor of the associated trench be scanned and systematic samples should be collected and analyzed inside the trench to identify where contamination may still be present. Furthermore, please revise the Work Plan to specify that the source trench will not be backfilled before confirming if an exceedance is found in excavated material. If an exceedance is found, then the trench will not be backfilled until the in-situ scanning and sampling is done to identify the location of the exceedance and excavation of contamination is completed.

Table 3-1 has been updated to include the Phase 1 trench units identified by the USEPA (TUs 97, 98, 115, and 121). Table 3-1 has also been corrected to show the accurate number of expected sidewall and floor units (SFU), based on a maximum soil volume per survey unit of 198 yd³.

Text in the Executive Summary and throughout the work plan has been updated to conduct an in situ investigation of the open excavation if an exceedance not attributable to background in an SFU is found, and an in situ investigation and/or remediation will be performed prior to backfill. The in situ investigations will require excavations to be open longer and will extend the fieldwork period.

5. Executive Summary and Section 3.4.5, Phase 2 Trench Unit Design: Because the surface of the trench is the location closest to potential residents, EPA recommends treating the surface over each former trench or survey unit as a new soil surface survey unit to be tested using an approach similar to that used in previous HPNS radiological investigation Work Plans and in MARSSIM. This means that after removing the asphalt and any other cover material, 100% scanning and systematic sampling should be conducted. The number of cores must be no fewer than the number of systematic locations determined from a statistical evaluation consistent with the practices described in MARSSIM. Each core location is considered to be a single systematic sample location, even though multiple depths within the core may be analyzed. In the past, 18 samples has been used as a default, but this number should be calculated based on the variability in the data actually collected, which may result in a total number higher or lower than 18. These calculations should use the variability in the sample results obtained from the new background study. Please revise the Work Plan to specify the number of locations for core sampling locations must be determined as described in EPA's General Comment # 20 in its March 2018 comments.

Surface scanning of Phase 2 trenches has been added to the Work Plan. The Executive Summary and applicable sections of the text have been revised to reflect the calculation for a minimum number of 18 systematic sample locations for soil and static measurements for buildings. Based on assumptions of a relative shift of 2.0, Type I decision error rate at 0.01 and Type II decision error rate of 0.05, MARSSIM Table 5.3 recommends a minimum of 18 systematic samples for soil and static measurements for buildings in each survey unit. Therefore, 18 systematic locations for soil and static measurements for buildings are recommended as a placeholder until data from the reference background areas becomes available. The minimum number of samples/measurements per survey unit will be developed based on the variability observed in the background data. A retrospective power curve will be prepared to demonstrate the number of samples from each survey unit was sufficient to meet the project objectives. If necessary, additional samples may be collected to comply with the project objectives.

The Navy agrees that a MARSSIM is the best guidance for designing the radiological investigation. The MARSSIM framework for calculating appropriate numbers of soil samples and survey measurements was conservatively applied to the Phase 2 TUs in the draft work plan. However, the Navy has incorporated the regulators' sampling proposal to collect three times as many samples as required in the interest of gaining concurrence of the work plan and collecting data as soon as possible.

The inputs to the MARSSIM equations are primarily valid for the statistical tests for which they were designed. The Navy therefore believes that MARSSIM should be used to both design the survey and evaluate the data. However, the Navy has incorporated the USEPA's requirement for a point-by-point comparison in the interest of gaining concurrence of the work plan.

Responses to EPA General Comments 5, 8, 12a, and 16: The responses appear to indicate that providing a point by point comparison of data with the Parcel G Record of Decision (ROD) RGs is not as valid as using the MARSSIM WRS test, which compares the medians of the data set and the background data set for assessing compliance with cleanup standards. However, the Remedial Action Objective (RAO) for radiologically impacted soil and structures in the Parcel G ROD states, "Prevent exposure to radionuclides of concern in concentrations that exceed remediation goals for all potentially complete exposure pathways." During all previous removal and remedial actions, this has been implemented as a comparison of each data point to the RGs listed in the ROD for all radionuclides of concern (ROCs) such that any exceedances are required to be excavated or removed from building surfaces. Therefore, the approach proposed by the regulators of performing a point by point comparison of all data to the RGs is consistent with the approach taken previously to demonstrate compliance with the ROD and is more conservative than performing the WRS test. Please ensure that the WP requires demonstrating that each data point meets the ROD-specified RG in order to demonstrate the cleanup goals have been achieved.

The Navy believes that statistical evaluations outlined by MARSSIM offer the flexibility to manage radiological investigation and cleanup on a survey unit basis and are consistent with the intention of the Parcel G ROD. The regulatory agencies' position is that a point-by-point comparison of investigation results and remedial goals should be conducted. USEPA maintains that this is consistent with USEPA national policy and past

practices. In this matter, the Navy and regulatory agencies have agreed to disagree. In the interest of moving the project forward, the Navy's Parcel G Work Plan incorporates the regulatory agencies' position and manages the investigation based on a point-by-point comparison of investigation results and remedial goals.

6. Executive Summary and Section 3.4.5, Phase 2 Trench Unit Design, Page 3-7: The text does not describe the percentage of land area for Phase 2 trenches that will receive gamma scanning. The Parcel G trenches should be treated as MARSSIM Class 1 trenches, as in previous HPNS radiological Work Plans, because of the CSM. The EPA stated in its March 2018 comments, "To address the potential exposure to future residents, 100% surface scans would be required. The Navy must first remove any asphalt cover and any imported fill that may have been used to achieve the desired grade, i.e. not part of backfill that potentially came from an area excavated by Tetra Tech EC Inc. Any locations where scan results exceed the investigation level would require collection of biased samples." Please revise the Work Plan to reflect this step.

Text in the Executive Summary and throughout the work plan has been updated to include 100 percent surface gamma scan of all TUs and SUs.

The Navy believes that the USEPA's statistical approach of conducting 100 percent scanning and sampling of 33 percent of the trench units is conservative. Although this approach provides sufficient confidence to confirm potential exposure to future residents, additional sampling of the remainder of the parcel was also requested to provide additional confidence. However, the Navy has incorporated the regulators' approach in the interest of gaining concurrence of the work plan and collecting data as soon as possible. This will extend the fieldwork period. The Navy believes that the approach outlined in the draft work plan was compliant with the Parcel G ROD. In this matter, the Navy and regulatory agencies have agreed to disagree. In the interest of moving the project forward, the Navy's Parcel G Work Plan incorporates the regulatory agencies' position.

7. Section 1, Introduction: This section states that a separate Sampling and Analysis Plan (SAP) will be prepared for the investigation at Parcel G, however the SAP has not yet been provided for review. The revised and updated SAP should be issued for review by the Regulatory Agencies prior to initiation of work at Parcel G. Information provided in the Work Plan and the SAP and any other supplemental documents (e.g. any Task Specific Plans) should incorporate all of the technical, as well as quality control (QC) requirements for sample collection and analysis, data validation, assessment and reporting, along with copies of standard operating procedures for all of these processes. The technical information should include the method number, calibration information and quantitation parameters. The QC information should include daily/weekly efficiency, energy and background checks as applicable; and results for matrix spikes, duplicates, blanks, Laboratory Control Samples (LCS) samples, tracers (alpha spectroscopy), and the following method-specific parameters:
- Gross alpha/beta Scans for Buildings Scan minimum detectible concentrations (MDCs) are below Investigation Levels for all radionuclides of concern (ROCs)
 - Gamma Scans, Gross alpha/beta Scans Scan MDCs are below the Investigation Levels for all ROCs
 - Gamma Spectrometry Static measurements or laboratory analysis
 - Sample results should include all radionuclides detected along with count times, result, counting error, and isotope specific MDCs
 - Demonstration that radionuclide-specific MDCs that are 10% of the ROC remedial goals (RGs) can be achieved.
 - A copy of the gamma spectrometry analysis library
 - Alpha Spectrometry (See more detail in comment below)
 - All Uranium and thorium isotopes by alpha spectroscopy for samples with elevated Ra-226, count times, results, counting and total propagated uncertainty, MDC, tracer recovery
 - Demonstration that the (U)-234, U-235, U-238, Thorium (Th)-230, and Th-234 MDCs at 10% of the Radium (Ra)-226 RG can be achieved.

In summary, please ensure the Work Plan and SAP include all the specifics describing all radiation surveys, sample collection and analysis technical and QC requirements as described above. In addition, due to significant public interest, we recommend that the draft SAP be made available to the public for comment.

The Draft SAP was submitted for regulatory review on August 16, 2018. Information on analytical procedures and laboratory QC is provided in the SAP. For analytical methods (alpha spectrometry, gamma spectroscopy, and gas proportional counting for Sr-90), to the maximum extent practicable, MDCs will be below the RGs with a target of 10 percent to 50 percent of the RGs in accordance with MARSSIM. The MDCs are different for every sample (e.g., calculated per sample based on mass, activity, etc.), and any issues will be addressed on a case-by-case basis. For building surfaces, gross alpha and beta scan MDCs will be set at the RGs with a target of 50 percent of the RGs for static measurements. Also, see response to USEPA General Comment 19.

8. Section 3.1, Data Quality Objectives, Step 5 – Develop Decision Rules, Page 3-1 and Step 7 – Develop the Plan for Obtaining Data, Page 3-2; and Section 4.1, Data Quality Objectives, Step 5 – Develop Decision Rules, Page 4-1: The decision rules are not consistent with the EPA March 2018 comments and the requirements of the Parcel G ROD, which states, "Buildings, former building sites, and excavated areas will be surveyed after cleanup is completed to ensure that no residual radioactivity is present at levels above the remediation goals. Excavated soil, building materials, and drain material from radiologically impacted sites will be screened and radioactive sources and contaminated soil will be removed and disposed of at an off-site low-level radioactive waste facility." The ROD requires excavation of exceedances based on a point-by-point comparison with the RGs. This approach is consistent with past practice and with USEPA national guidance. Please revise the approach to require excavation of any exceedances based on a point-by-point comparison with the ROD RGs, excluding background and naturally occurring material.

See response to USEPA General Comment 2. Although neither the ROD nor MARSSIM state that excavation is required based on point-by-point exceedances of the RGs, the Navy has incorporated the comment in the interest of gaining concurrence of the work plan and collecting data as soon as possible.

9. Section 3.3 and 4.3, Remediation Goals for soil and buildings, respectively: These sections list the current ROD RGs. The HPNS's Five-Year Review occurring in 2018 is evaluating whether the current selected remedies, including these ROD RGs, are still protective and whether any changes are necessary to ensure continued protectiveness. Based on national practices directed by EPA headquarters, EPA expects this process to use the most current version of the EPA Preliminary Remediation Goal (PRG) Calculator and Building PRG Calculator to assess the ROD radiological RGs. The Work Plan should use only those cleanup goals confirmed through this analysis to be protective.

RGs are not proposed to be changed as part of this work plan. Future protectiveness will be evaluated in the Five-Year Review.

Responses to EPA General Comments 9 and 18 item a: The response to General Comment 9 states, "The Navy conducted preliminary calculations of the risk using the USEPA's Preliminary Remediation Goal (PRG) Calculator and found that the current RGs are within the risk management range of 10E-04 to 10E-06." However, documentation that demonstrates compliance with the risk management range has not been provided. Please provide the PRG calculator documentation that demonstrates the current RGs will fall within the Comprehensive Environmental Response, Liability, and Compensation Act (CERCLA) mandate that the excess lifetime cancer risk from carcinogenic substances does not exceed the risk range of 10E-04 – 10E-06.

The PRG calculator documentation will be provided as part of the Five-Year Review process. Reference to the preliminary calculations was removed from the response.

10. Section 3.3.1, Investigation Levels, Table 3-6, Soil Survey Measurement Investigation Levels: This section indicates that Investigation Levels are not applicable to the gamma scan surveys for Cesium (Cs)-137, and the footnote states that Cs-137 cannot be detected with the proposed gamma detector/gamma scan survey method at the RG of 0.113 pCi/g. Please describe how Cs-137 will be investigated in a manner that is compliant with a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) survey design for which gamma scanning of 100% of the land area is completed with a detector capable of achieving the project-required detection limit and data quality objectives for the project. If the investigation will use alternative gamma measurement detectors with a better sensitivity that will allow Cs-137 to be identified at the RG above background (e.g. lanthanum bromide detector), then please revise the Work Plan to propose such a radioanalytical detection system. Alternatively, please revise the Work Plan to list the gamma scan survey achievable detection limit for Cs-137 and discuss how the survey(s) and sample collection will meet the data quality objectives for demonstrating that the survey unit is compliant with the ROD RG for Cs-137.

Example scan MDCs were calculated for both Cs-137 and Ra-226, as described in Section 3.5. Using best available technology, including large-volume crystals equipped with gamma spectroscopy, to perform gamma scans will improve the scan MDCs compared with traditional 2-inch by 2-inch gross gamma walk-over surveys; however, achieving an MDC at or below the Cs-137 RG is not possible for individual scan measurements based on the limitations of instrument detection sensitivity and NORM variability. Therefore, the gamma scanning survey design is based on the detection of Ra-226 at the RG.

Demonstrating compliance with the Cs-137 RG will be based on soil sample analytical results in comparison to the RG and background.

Clarification text has been added throughout the work plan.

11. Section 3.3.1, Investigation Levels: The proposed investigation levels are inconsistent with the methodology proposed for the gamma scan surveys. Section 3.3.1, Investigation Levels, states gamma scan surveys will be performed using detector systems equipped with gamma spectroscopy to provide real-time radionuclide-specific measurements, and the spectra will be evaluated using regions of interest peak identification tools for the ROCs that correspond to gamma rays at 186 kiloelectron volt (keV) for Ra-226, 609 keV for Bismuth-214 (bi-214), and 662 keV for Cs-137. However, the text does not state how the gamma scan can achieve sufficient detection limits for Ra-226 using the Ra-226 energy line at 186 keV due to the low efficiency at this energy or the Bi-214 609 keV line without a 21-day ingrowth period, especially when the investigation level is the same as the RG of 1 pCi/g above background. Additionally, Table 3-6 contains a footnote that states the gamma scan cannot achieve the detection limit necessary to detect Cs-137 at the RG of 0.113 pCi/g above background; yet the preceding text states that the gamma scan will be used to flag locations where Cs-137 exceeds the investigation level, defined in Table 3-6 as 100% of the RG, or 0.113 pCi/g above background. Please revise the Work Plan to address these concerns.

The work plan was revised for clarification and to require investigation levels that correspond to assumptions used to develop the scan MDCs.

12. Section 3.4.1, Number of Samples: Although under some circumstances, 18 samples per survey unit could be acceptable as a default starting point before sampling results are available, once these results are available, then the number of samples for subsequent survey units should be based on calculations using variability found in actual data. For example, EPA's statistician used background data the Navy had previously collected from five reference areas and calculated that 25 samples per survey units would be needed to achieve your proposed 99% confidence level if soil from TUs/SUs are compared to reference background areas using a Wilcoxon Rank Sum (WRS) Test. EPA recommended starting with this default number of samples. Once new data are collected, they can also be used to recalculate the appropriate number of samples depending on the statistical tests which will be utilized to establish compliance. The new number of samples could be higher or lower than previously used.

Note that the variance from site investigative samples may be larger than the variance based on reference background samples, therefore the variance from samples collected in investigative survey units should be used to calculate the number of samples that should be collected in other investigative survey units. Also, variance should be determined using the same radioanalytical method as that which will be used for additional data collection. For instance, the variance for gamma spectrometry laboratory data should be used to determine the number of samples that are required for survey units where gamma spectrometry laboratory analysis will be conducted.

This section contains an inconsistent sampling scheme and does not comply with the requirements established in the Work Plan for number of samples required for each survey unit, as follows:

- a. It appears that the Work Plan does not provide the basis for the number of samples planned to be collected from TUs/SUs. The Navy previously issued a February 2018 Draft Work Plan, Radiological Survey and Sampling, which calculated the number of samples that would be collected from each SU using MARSSIM equation 5-1 for the WRS test. The Work Plan should use either the MARSSIM approach or other statistically based criteria for selecting the number of samples that will be collected from each SU so that conclusions based on evaluation of the SU data can be defined by a statistical level of confidence and as such, are usable for decision-making. Please revise the Work Plan to include this information.

See response to USEPA General Comment 5.

- b. This section specifies the collection of twenty-five subsurface samples from each RBA location and twenty-five surface soil samples from the off-site (RBA-Bayview) location, but only requires five surface samples be collected from each of the on-site RBAs. The text does not state how or why it is appropriate to collect only five surface samples from each of the on-site RBAs when twenty-five samples will be collected from the surface of the off-site location, and twenty-five samples will be collected from each of the RBA subsurface areas. For the Bayview park off-site location, an important reason for sampling at this site is to get an indication of potential Cs-137 levels from fall-out, and to provide data that provides meaningful comparisons to on-site reference area data. Since on-site data will be collected from the surface and subsurface, the Work Plan should specify that both surface and subsurface data be collected from the off-site Bayview park location to provide a more complete and thorough evaluation of Cs-137 deposition and background levels in the San Francisco Bay area/the Hunter's Point Naval Shipyard. EPA understands that using a drill rig may present practical challenges to obtaining subsurface samples at the Bayview park location; therefore, the depth of subsurface samples collected will be based on the depth to which a hand auger can be used to collect the soil at the Bayview park. EPA appreciates the Navy's commitment to consult with a USGS Cs-137 expert in this process and in the field during sample collection. Please include this in the next version of the Work Plan and provide any comments from that expert in the eventual report that will be prepared about the sampling results.

The work plan does not commit to USGS involvement; however, if the USGS or another agency is consulted and provides input, it will be included in the report detailing the RBA data collection and results. Text has been added to the Soil Reference Background Area Work Plan to describe the number of samples calculation for the RBAs. Twenty-five surface and 25 subsurface soil samples will be collected from the offsite location (tentatively within the 312.5-acre McLaren Park).

- c. The fifth bullet indicates that the total number of samples to be collected for surface soils in the on-site RBAs is twenty-five, but the text states that five samples from each of the four on-site RBAs will be collected, which is only twenty samples, not twenty-five. The text in this section and the bulleted information should be revised to provide a consistent number of samples.

The text was updated to indicate that 25 surface and 25 subsurface soil samples will be collected from each RBA location.

- d. Appendix A, Section 4.1.2, states that based on the statistical evaluations, the RBA report will include recommendations for combining similar data sets, recommendations for selecting values or data sets representing background in soil, and conditions identifying situations when specific values or data sets may not be appropriate. Since statistical testing will be completed to determine if each of the RBA data sets are sufficiently comparable to combine the data, please revise the Work Plan to discuss how/why five data points is sufficient for identifying a population that can reliably be compared to another five-point data set to determine if the difference is statistically significant or not.

Text has been added to the Soil Reference Background Area Work Plan to describe the number of samples calculation for the RBAs. Twenty-five surface and 25 subsurface soil samples will be collected from each RBA location. This will result in up to 10 reference area data sets of 25 samples each from 5 different RBA locations (1 surface and 1 subsurface soil data set from each RBA location). The NRC criteria for providing characterization of a complex site, found in NUREG 1505 (Section 13.5, page 13-11, last paragraph, second sentence), states that “four reference areas each with between 10 and 20 samples in each should generally be adequate” (NRC, 1998). Table 13.5, Power of the F-test when $\omega_2 = \sigma_2$ in NUREG-1505 guidance, shows that 20 samples collected from each of six reference area data sets will provide 95 percent confidence that the reference area data sets can be combined if they are similar. In this example, the power of this test is 99 percent, meaning there is a 1 percent probability that the data sets will be incorrectly combined when they are not similar. The proposed survey design includes collecting 25 samples from each of up to 10 reference area data sets, providing a power greater than 99 percent while maintaining 95 percent confidence that the RBA data sets can be combined if they are similar.

Please revise the Work Plan to address these concerns.

See responses to comments a through d above.

Responses to EPA General Comment 12 and Statistical Review Specific Comments: The responses should be clarified. The responses to statistical comments state that the Navy believes the MARSSIM methodology would best determine compliance but that MARSSIM will not be followed at the direction of the EPA. However, the responses appear to cite MARSSIM and other Nuclear Regulatory Commission (NRC) documentation (e.g., NUREG-1505) when those guidance documents justify the proposed methodology, such as background reference area sample sizes. The methodology to establish compliance/non-compliance for Parcel G proposed by the Regulatory Agencies provides a statistical basis and associated statistical confidence levels to support the decision-making process and incorporates MARSSIM components where they are applicable. It is not possible to apply MARSSIM in its entirety in a defensible manner when evaluating Parcel G at HPNS for the following reasons:

- MARSSIM only addresses surface contamination in soil and in buildings; it does not address contamination that may be present at depth, such as within the TUs in Parcel G.
- MARSSIM requires comparisons based on a modeled derived concentration guideline level (DCGL); however, the RAO for Parcel G is not based on a DCGL, but on not exceeding the RGs, which has been implemented as point-by-point comparisons to specified RGs as discussed above.

As such, the WP should be updated to ensure that it conforms to the previous implementation of the ROD definitions of the RGs in relation to background levels, which are expected to be statistically computed:

- The Executive Summary, DQOs (in Sections 3 and 4), and Section 5 should be revised to reflect the following:
 - If the investigation results demonstrate there are no exceedances determined from a point by point comparison with the statistically based RGs at agreed upon statistical confidence levels, or that site conditions are representative of background and naturally occurring material, then a remedial action completion report (RACR) will be developed.
 - If the investigation results demonstrate exceedances of the RGs determined from a point by point comparison with the statistically based RGs at agreed upon statistical confidence levels and are not representative of background and naturally occurring material, remediation will be conducted and a RACR will be developed.
 - The RACR will describe the results of the investigation and any remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel G Remedial Action Objectives through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.

The response to USEPA General Comment 2 and the draft final work plan were updated to reflect the requested DQO language above.

Further, the response to part d on Page 5 also requires further clarification with respect to the use of NUREG-1505. The Parcel G WP proposed the use of NUREG-1505, Table 13-5, as the appropriate reference for justification of sample sizes at background reference areas (RBAs). Regulatory Agency comments included the need for clarification of how NUREG-1505 was applied to derive sample sizes proposed for the RBAs. As such, the following clarifications are requested:

- The response states, “Text has been added to the Soil Reference Background Area Work Plan to describe the number of samples calculation for the RBAs. Twenty-five surface and 25 subsurface soil samples will be collected from each RBA location. This will result in up to 10 reference area data sets of 25 samples each from 5 different RBA locations (1 surface and 1 subsurface soil data set from each RBA location).”
 - Because some RGs are based on background levels of the ROCs, it is essential that statistically and technically sound methodology is adhered to when designing the reference background study, so as to obtain representative estimations of the true background levels present on HPNS. Adequate sample sizes are required to ensure the validity and defensibility of the final established background levels that will be used at HPNS. At this time, it is unclear whether surface and subsurface levels of ROCs will differ significantly, therefore the two depths should be treated as independent data sets until proven otherwise. It is also unclear how much the RBAs will differ in soil type both at surface and at depth and whether they will be representative of surface soils and within the TUs present on Parcel G. The WP should discuss how soil types will be evaluated and compared with soil types found at Parcel G.

Because the HPNS soil that will be investigated is mostly fill and has been homogenized, there is no current plan to collect background data/develop background data sets for individual soil types. However, because the background data may be used for other projects at HPNS, the soil lithology will be logged. Once data is available and evaluated, if there are significant differences in the analytical results by soil type, the work plan and SAP include the flexibility for collecting additional samples if needed for further characterization.

- The response states, “The NRC criteria for providing characterization of a complex site, found in NUREG 1505 (Section 13.5, page 13-11, last paragraph, second sentence), states that “four reference areas each with between 10 and 20 samples in each should generally be adequate” (NRC, 1998).”
 - The purpose of this text in the NUREG document is not to state that 4 RBAs are sufficient. Taken in context, the NRC is discussing the application/interpretation of Table 13.5 in the document which approximates the associated power of a Kruskal-Wallis test. The entire sentence states: “Although this is only an approximation, and the actual power of the Kruskal-Wallis test would be slightly lower, this table indicates that with four reference areas each with between 10 and 20 samples in each should generally be adequate.”

Comment noted.

- The response states “Based on Table 13.5, Power of the F-test when $\omega_2 = \sigma_2$ in NUREG-1505 guidance, 20 samples collected from each of six reference area data sets will provide 95 percent confidence that the reference area data sets can be combined if they are similar.”
 - The Navy and EPA have agreed that sample collection at the off-site RBA is being conducted to meet different objectives than the four on-site RBAs. Only the four on-site RBAs should be considered if Table 13.5 of NUREG-1505 is used to justify adequate sample sizes for the RBAs.

It is agreed that the objectives of sampling the onsite and offsite RBAs are different. The report documenting the RBA results will provide recommendations and justification for the combination of different data sets.

- The response states, “The power of this test is 99 percent, meaning there is a 1 percent probability that the data sets will be incorrectly combined when they are not similar. The proposed survey design includes collecting 25 samples from each of up to 10 reference area data sets, providing a power greater than 99 percent while maintaining 95 percent confidence that the RBA data sets can be combined if they are similar.”
 - The standard of the α -level and β -level = 0.01 in was set in the original WP. This implies that there is no more than a 1% chance determining two RBAs can be combined when they are not from the same background population and there is no more than a 1% chance of determining that two RBAs cannot be combined when they are actually from the same background population. Both decisions are equally important to establishing background levels at HPNS and the WP should discuss them equally.
 - The number of samples needed per RBA depends on both the probability of a Type I error (α) and the probability of a Type II error (β) that are deemed acceptable for the test. $1 - \beta$ = power.
 - Table 13.5 does not include sample sizes for $\alpha = 0.01$, however it can be extrapolated from the tabulated values for $\alpha = 0.05$, that at least 25 samples per each of the five on-site RBAs are needed to achieve the required power ($1 - \beta = 1 - 0.01 = 99\%$) for $\alpha = 0.01$. As documented above, NUREG-1505 recognizes “the actual power of the Kruskal-Wallis test would be slightly lower” than the tabulated values.

As noted in the original response, the draft final work plan has been revised to require a minimum of 25 surface and 25 subsurface samples per RBA. Please note that as described in the response to USEPA General Comment 5, the number of samples calculations provided in Sections 3.4.1 and 4.4.1.2 of the draft final work plan are based on a Type I decision error of 0.01 and Type II decision error of 0.05. Following discussion of the collected RBA data with regulators, additional discussion and justification for combining RBA data sets will be provided in the RBA report.

The adequacy of revisions to the forthcoming revised WP and SAP will need to be evaluated upon receipt by the regulators to ensure the revisions are consistent with the general intent of the suggested language and are commensurate with the Parcel G ROD requirements and the proposed data evaluations. Please ensure that these issues are addressed in the WP and SAP.

See responses to above comments.

13. Section 3.4.4, Phase 1 Trench Unit Design: The EPA, DTSC, and CDPH have prioritized trench units (TUs) for excavation using criteria listed in the EPA March 2018 Comments, e.g., Historical documentation of specific potential upstream sources, signs of potential falsification found in data evaluation, signs of data quality problems found in data evaluation, allegations from former workers, and regulators’ independent field testing. More details about these criteria are in the March 2018 EPA comments. In addition, EPA previously made comments to the Navy about the categories of concern in a letter to the Navy on February 27, 2017. The regulators’ prioritization is partially consistent with the Phase I Soil Trench Units identified in the Navy’s draft Work Plan. We concur with Phase I TUs 69, 76, 78, 99, 101, 103, 104, 107, 108, 109, and 124. However, four of our highest priority TUs (TUs 97, 98, 115, and 121) are not included. These four TUs should be substituted for four of the 10 other TUs (i.e., those not listed above) that were identified as Phase I Soil TUs. Please make this change. The remaining soil TU’s should be determined based on criteria such as those listed above, consistent with our March 2018 Comments and February 2017 letter that listed indicators of the highest likelihood of contamination. Choosing to prioritize a particular TU for logistical convenience due to TU’s being adjacent is not an acceptable justification without independent evidence that this TU is among 33% of trench units most likely to have contamination based on the information we have to date.

The Phase 1 Trench Units were updated to include TUs 97, 98, 115, and 121 as recommended.

14. Section 3.4.6, Phase 1 Survey Unit Design, and Section 3.4.7, Phase 2 Survey Unit Design: For the Soil Survey Units in former Building Sites, the same relevant comments already made on Sections 3.4.4 and 3.4.5 about trench units also apply to building site survey units.

For the building site SUs, because 100 percent surface scans were added for all TUs and SUs, the building site SUs will all be investigated consistently and concurrently, and there are no longer phases for surface soil SUs.

15. Section 4, Building Investigation Design and Implementation: This section does not provide sufficient information to conduct a full evaluation of the sufficiency of the buildings investigation. The Navy’s buildings data evaluation found significant enough extent of unreliable data that the Navy decided that none of the previous data could be used. Therefore, the presumption is that all previous work should be redone as a completely new investigation. Therefore, all specific details of a new building investigation/SAP should be provided in the Work Plan to adequately document the requirements of such an investigation. Please revise the Work Plan to specify a level of detail at least as thorough as typically done previously in Task Specific Plans for these buildings, as follows:

- a. Brief history of CSM along with a description of how survey units were identified and classified based on the CSM for each building, along with figures depicting the survey units and classifications, and sample locations.

The buildings selected for investigation will be those existing buildings in Parcel G identified as impacted in the HRA. Brief summaries of the operational history and potential for residual contamination for each building can be found in Table 2-1. A table was added to summarize SU classification for each building. Figures of the Class 1 SUs were included in Section 4 of the work plan and were updated to depict Class 2 and 3 SUs. Example sample locations are depicted on Figures 4-10 and 4-11.

- b. Complete listing of Data Quality Objectives (DQOs) for each Parcel, Survey Unit for land areas and for buildings

Building DQOs are provided in Section 4 and have been updated based on other comments.

- c. All MARSSIM Final Status Survey (FSS) design parameters, including the identification of the survey unit classifications and sizes, and number of samples required to be collected for the WRS test, and all the associated calculation inputs, including the Lower Bound of the Gray Region, standard deviation of previously collected data, relative shift, confidence level selected, etc. This information should also include the identification of investigation levels for all radiological survey types, elevated measurement comparison calculations, or any other inputs and decision rules associated with the FSS design. In addition, when multiple radionuclides may be present, the Work Plan should include the identification of the survey release limit and investigation level based on the sum of fractions and unity rule for all ROCs

Due to the lack of past investigation data and based on agency feedback, the survey unit boundaries and designations used in the previous surveys will be used for this investigation. As such, floor surfaces and the lower 2 meters of remaining wall surfaces will be designated Class 1 survey units and will not exceed 100 square meters in area. Remaining walls above 2 meters from the floor and remaining ceilings will be combined into Class 2 survey units and will not exceed 1,000 square meters in area. Additional building-specific detail has been added to the

discussion of survey unit designation and classification in Section 4.4. The determination of the number of static measurements per survey unit has been expanded in Section 4.4 to follow MARSSIM methodology and to include all assumptions and calculations. The calculations of scan and static investigation levels can be found in Section 4.5. Since both gross alpha and gross beta measurements are recorded simultaneously, an RG of unity was used to derive the required number of static measurements. The sum of fractions and unity rule are part of a traditional MARSSIM approach to use assumed ratios of site ROCs to determine contributions to an overall dose or risk-based criterion. Consistent with USEPA General Comment 8, the approach for Parcel G is to compare individual sample results above the expected range of NORM or anthropogenic background to the RGs on a point-by-point basis, and the RGs are not based on the same dose or risk. Therefore, the use of sum of fractions and unity rule to review total risk is not appropriate for this approach.

- d. Description of the Investigation Levels or other triggers that will be used in Gamma Scan Surveys that would require a biased sample to be collected

Gamma scanning is not included in building investigations because all the ROCs are alpha and beta emitters. The calculations of alpha and beta scan and static investigation levels can be found in Section 4.5.

- e. Listing of the specific radiological instrumentation that will be used for each scan and static survey, exposure rate measurements, and laboratory measurements with the associated achievable MDC, required scan rates, count times (statics), minimum detectable count rate (MDCR) for surveys; smear/wipe sample instrument MDCs, and laboratory instrument MDCs. MDCs should be 10% of the Remedial Goals for all ROCs

Calculations for commonly used instruments and for all requested parameters can be found in Section 4.5. This section has been reviewed and revised for clarity based on other comments. For explanation of the MDCs, see response to USEPA General Comment 7.

- f. Inclusion of all the technical, as well as QC requirements for sample collection and analysis, data validation, assessment and reporting, along with copies of standard operating procedures (SOPs) for all of these processes. The technical information should include the method number, calibration information and quantitation parameters for scans, wipes, and static measurements. The QC information should include daily/weekly efficiency, energy and background checks as applicable; and results for duplicates, blanks, Laboratory Control Samples (LCS) samples (laboratory analysis), or matrix spikes and tracer recovery (only for destructive laboratory analysis) for each analysis type and instrument.

Information for commonly used instruments can be found in Section 4.5 to include efficiencies, calibration requirements, and daily performance checks. Referenced SOPs can be found in Appendix C of the work plan and Attachment 3 of the SAP. Because building survey data are compared to gross alpha and gross beta activity limits based on the lowest RG for any of the ROCs for that building, sampling and analysis for individual radionuclide activities are not included or necessary.

- g. Copies of field and laboratory radioanalytical methods/Standard Operating Procedures (SOPs). SOPs should include the sample/aliquot size and count times needed to achieve the project-required detection limits at 10% of the RG, the error bars associated with the quantitation of all radionuclides, the nuclide library that will be used to identify the ROCs in the analysis, the data reduction and reporting procedures, and all instructions required to complete the analysis.

Referenced SOPs can be found in Appendix C of the work plan and Attachment 3 of the SAP. Because data are compared to gross alpha and gross beta activity limits, sampling and analysis for individual radionuclide activities are not included or necessary. Because data are compared directly to the RGs, instruments must only be capable of detecting activity at or below the RGs. The survey design includes the goal of achieving static and swipe measurement MDCs that are 50 percent of the applicable RG. Reporting procedures can be found in Section 5.

- h. Reference to the appropriate Quality Assurance Project Plan (QAPP)/Master SAP which define all technical and quality parameters for data collection.

The SAP establishes the QA/QC requirements for the project. References to the SAP have been included in the work plan.

One possible approach the Work Plan could choose is to incorporate by reference some portions of the original Task Specific Plans for individual Buildings that are still relevant today, e.g. building description, building history, locations of survey units, extent of testing in categories of these survey units, etc. However, some other aspects of previous Task Specific Plans may need new scrutiny and potential modification in light of remediation that has already occurred, updated CSM information, new questions about reliability of prior work by Tetra Tech EC Inc., or other newly identified information.

Please revise the Work Plan to address the above specific issues for the buildings investigation.

Response to EPA General Comment 15: The responses to items f and g state that the standard operating procedures (SOPs) are included in Appendix C; however, some SOPs for radio-analytical methods were not included in the original versions of the WP and SAP. Please ensure all sampling and laboratory-specific SOPs for all radio-analytical methods are included in the revised WP and SAP.

All referenced SOPs are included in the draft final work plan and SAP. Aptim's SOPs will be provided in an addendum to the work plan.

16. Section 4, Building Investigation Design and Implementation: The Work Plan appears to depart from the previous practice of using the MARSSIM approach for identifying the parameters of a FSS in order to demonstrate that a survey unit has met the release criteria. The parameters defined by the MARSSIM approach include the survey unit class and size, and include calculations for determining the number of samples that would need to be collected in each survey unit to meet the assumptions of the WRS statistical test with a specified level of confidence. The WRS test uses hypothesis testing to identify if the median of the site data is statistically the same or different than the median of the background data and as such provides a comparison of populations. This approach is well-established and accepted among many agencies for demonstrating that a survey unit has met the release criteria (derived concentration guidelines level [DCGL]) as determined by pathway modeling and exposure assessment.

However, the EPA regulates cleanups in accordance with the CERCLA statutes which require demonstrating that regulatory standards and/or risk-based target cleanup levels for hazardous substances will not exceed a specified limit, or pose an Excess Lifetime Cancer Risk to a reasonably maximally exposed (RME) individual that exceeds the CERCLA risk range of 1×10^{-4} to 1×10^{-6} . Therefore, EPA has Superfund national guidance that recommends a more protective approach than MARSSIM in applying a point-by-point comparison between the investigative sample results and the RGs and which requires every exceedance of the RGs to be remediated. The more protective point-by-point approach has been used at the HPNS and most EPA Superfund sites nationwide for many years for both chemical and radiological cleanups. This approach must be included in this Work Plan. Even though this approach is more protective than what MARSSIM prescribes, the Work Plan should still use the MARSSIM approach to design the parameters of the FSS, as it has for many years, for consistency and defensibility of the results. Please revise the Work Plan to use the MARSSIM approach to design the parameters of the FSS and to require a point-by-point comparison between investigative sample results and the RGs, with remediation of areas where sample results exceed the RGs.

See response to USEPA General Comment 5. Using a point-by-point comparison is inconsistent with MARSSIM design parameters. MARSSIM was designed to achieve risk-based release criteria that is within the CERCLA risk management range, and the Navy maintains that MARSSIM is

appropriate for the evaluation of data. However, the Navy has incorporated the comment in the interest of gaining concurrence of the work plan and collecting data as soon as possible.

17. Section 4, Buildings: The number of samples determined to be required for building survey units should be calculated using the MARSSIM approach for the design of an FSS, and should be based on parameters obtained from collection of site samples of the same media and survey or lab instrument. These parameters include an estimate of residual radionuclide concentrations and the variance (σ) of results within a given survey unit or units. The value of σ may be obtained from earlier surveys, limited preliminary measurements, or a reasonable estimate. The estimate of σ includes both the real spatial variability in the quantity being measured and the measurement method uncertainty of the measurement method. Therefore, the initial number of samples may be based on information from previously collected data or may be estimated; however as newly collected data is obtained under the Work Plan, the variance used to determine the appropriate number of samples needed to meet the assumptions of the WRS test should be updated based on the variance from the new data. In addition, since the variance is a measure of spatial variability and the measurement method uncertainty, it is important that the variance from the same radioanalytical technique be used to estimate the number of samples being collected for the same analysis type. For example, the variance from newly generated gamma static surveys should be used to calculate the number of static measurements required in other survey units where static measurements are will be used for the FSS data collection.

Likewise, the variance from laboratory analysis of survey unit samples should be used to calculate the required number of samples needed to be collected in other survey units where the samples collected for the FSS will be analyzed by the same method in the laboratory. If the variance from newly collected data is smaller than that obtained from historical data or assumptions made about the population, then fewer samples may be needed for sample collection in other survey units. Finally, the variance from scan, static, smear, or sample analyses in the laboratory can only be used for sample number calculations of the same media type. Therefore, the variance obtained from gamma static surveys on land areas should not be used to calculate the required number of samples that will need to be collected in buildings. Currently, the Work Plan does not discuss the specifics of what variance will be used to calculate the required number of samples, or how newly collected data will be used to update the variance and the required number of samples in the FSS for on-going survey unit investigations. Please revise the Work Plan to describe in detail how the required number of samples will be determined for building survey units.

See response to USEPA General Comment 5.

Response to EPA General Comment 17: The response does not address the original concern regarding the lack of specific discussions in the WP of what variance will be used to calculate the required number of samples, or how newly collected data will be used to update the variance and the required number of samples for on-going survey unit investigations and Final Status Surveys (FSS). Please ensure revisions to the WP, and as appropriate, the SAP include a discussion explaining how variance from newly collected data sets will be used to re-run the MARRSIM calculations for determining the statistically-required number of samples for future/on-going survey unit sampling for soil TUs/SUs and in building survey units.

The revised text in Sections 3.4.1 and 4.4.1.2 includes a discussion of the recalculation of the numbers of samples/measurements based on the observed variability in background.

18. Section 4, Building Investigation Design and Implementation: In addition to the aforementioned deficiencies in the Work Plan Buildings investigation documentation, the following additional concerns require additional discussion, as follows:

- a. Section 4.1 (Data Quality Objectives) Step 5 – Develop Decision Rules states “If the investigation results demonstrate that site conditions are not compliant with the Parcel G RAO, then the data will be evaluated to determine whether site conditions are protective of human health using USEPA’s current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014).” However, EPA Directive 9200.4-40 was issued as guidance only and is therefore not a regulatory requirement, nor does it satisfy the ROD- established cleanup level for the Hunter’s Point Naval Shipyard site in accordance with the CERCLA process as promulgated in 40 CFR §300.430. Please revise the Work Plan to state that only areas that demonstrate compliance with the Parcel G ROD requirements and are within the CERCLA risk range using the most recent version of the EPA PRG Calculator for radionuclides will be eligible for Regulatory Approval for release.

See response to USEPA General Comment 3 and 9.

- b. The Work Plan does not explain why some buildings or portions of buildings will receive surveys and others will not. The Historical Radiological Assessment (HRA) Volume II should be used to summarize information about all buildings within Parcel G to provide justification for which buildings/areas will be surveyed. In addition, the justification should also include documentation from the data evaluation forms and conclusions regarding allegations of misconduct and fraud by the previous contractor, as well as Regulatory Agency input to this analysis.

A summary of each building and survey unit has been added to Section 4, including the rationale for which areas will be surveyed.

- c. The text does not explain why MARSSIM Class 2 areas were not proposed around Class I areas when the entire building will not be surveyed.

See response to USEPA General Comment 15c.

- d. The Work Plan does not provide justification for selection of the area in Building 401 where background data will be collected.

The building RBA has been changed to Building 404. Background reference area(s) for each investigated surface material will be established in Building 404, which is an unoccupied and unimpacted former supply storehouse in Parcel G. Building 404 was constructed in 1943 (HRA Reference 1598), and is a single-story building with concrete floors, wooden superstructure, and prepared roll or composition roof. The dimensions are 243 feet by 209 feet with 22 feet with 43,695 square feet of floor space and a total volume of 779,900 cubic feet.

- e. The Work Plan does not discuss how the number of static measurements for each survey unit was calculated.

See response to USEPA General Comment 5.

- f. The Work Plan does not state if additional wipe samples may be sent to the laboratory for destructive analysis for speciation to determine which radionuclide is contributing to the radiation if release limits are exceeded for either gross alpha or gross beta.

Wipes will not be sent offsite for isotopic analysis but will be stored for potential future analysis. Locations found to exceed the RGs and not shown to be NORM or anthropogenic background will be remediated.

- g. The Work Plan includes a listing of the investigation levels but does not specify whether exceedance of the investigation levels will result in the collection of bias samples or static measurements in buildings.

Locations found to exceed the investigation levels will be investigated to determine the areal extent of that exceedance as described in Section 5.3.

- h. The Work Plan does not specify collecting data from locations where measurements and/or sampling may be necessary due to use of equipment, areas where potential cross contamination may have occurred, or where waste disposal practices may have resulted in contamination in sinks, or drains. Examples include items of equipment and furnishings, building fixtures, drains, ducts, and piping. Many of these items or locations have both internal and external surfaces with potential residual radioactive material which should be surveyed for removable and fixed contamination.

Surveys of impacted building materials and equipment are specified in Section 4.6.3.6. This section has been revised to add detail on the planned process for material and equipment surveys.

Please revise the Work Plan to address these concerns.

Responses to EPA General Comment 18, item e and f: The response to item e references the response to EPA General Comment 5 and does not address the concern. Please ensure that information explaining how the number of static measurements for each SU are calculated using the MARSIM equations is provided in the revised WP. Please also ensure that the WP requires inclusion of a listing of the variance used and reference to the data set that the variance was obtained from, as well as all equations and calculations when the results of the calculations are provided.

The revised text in Section 4.4.1.2 includes a discussion of the initial calculation of measurements, initial assumptions, and recalculation of the number of measurements based on the observed variability in background.

19. Section 5.4 NORM Background Evaluation: The proposed approach for performing a Naturally Occurring Radioactive Material (NORM) evaluation for site samples is insufficient for ensuring a complete and defensible analysis. The Executive Summary discussion of Data Evaluation and Reporting states "individual samples with gamma spectroscopy concentrations for Radium-226 (Ra-226) greater than the RG will be analyzed for Uranium-238 (U-238) and Ra-226 using comparable analytical methods. For that specific sample, the U-238 result will be used as a more representative estimate of the background value for Ra-226, and the Ra-226 concentration will be compared to the RG for Ra-226 using the revised background value." Per previous EPA comments, a sample with elevated Ra-226 above the RG should be analyzed for all uranium and thorium isotopes by alpha spectroscopy, and should be compared to data obtained in the gamma spectrometry analysis for all the radionuclides listed in the Appendix A, Table 3-6, Analytical Sample Summary. This information is required due to the following reasons:

- U-238 results often have a large error bar/uncertainty associated with the result; therefore, analysis of other radionuclides in the U-238 decay series should be performed to confirm the accuracy of the U-238 result.
- The alpha spectroscopy analysis for U-238 will also provide results for U-235 and U-234. All of the uranium isotopes reportable by alpha spectroscopy, including U-238, U-235, and U-234 should be reported in order to evaluate if the three uranium isotopes ratios indicate the uranium is present in natural abundance with uranium-238 at 99.2739–99.2752%, uranium-235 at 0.7198–0.7202%, and uranium-234 at 0.0050–0.0059%.
- Alpha spectroscopy analysis of thorium isotopes (Th-230 and Th-234) is requested to confirm the Uranium-238 result since Th-234 is the first daughter product of U-238. In addition, Th-230 is the immediate precursor to Ra-226 in this series; therefore, analysis of this isotope will help confirm whether the U-238 decay series is in equilibrium.
- Gamma spectrometry analysis for Bismuth and Lead isotopes that are part of the Thorium and Uranium decay series. Potassium-40 (K-40) will provide further evidence of whether the ROCs detected in the analysis are from naturally occurring background or represent contamination.

Please revise the Work Plan to require all samples with elevated Ra-226 results to be analyzed for all Uranium and Thorium decay series isotopes by alpha and gamma spectroscopy to provide sufficient documentary evidence regarding the NORM evaluation.

Section 5 has been revised to require alpha spectroscopy for U-238, U-234, Th-230, and Ra-226 to evaluate the equilibrium status of the uranium natural decay series in order to assist in the comparison of Ra-226 results with background for all samples exceeding the RG and background. Please note that U-235 is not part of the U-238 decay series and cannot be used to evaluate equilibrium conditions. While Th-234 is part of the uranium decay series, it is a beta-emitter and analyses will not provide comparable data.

Response to EPA General Comment 19: The response does not address the comment; however, it is understood from discussions with the Navy on Tuesday, October 15, 2018, that all reportable isotopes for Uranium (U-234, U-235, U-238) and Thorium (Th-230, Th-234) from the alpha spectroscopy analysis, as well as Radium-226 will be reported. Please ensure the revised WP includes this information.

Section 3.7 was updated to state that all detected isotopes will be reported. Th-234 is not an alpha-emitting radionuclide and will not be included in alpha spectroscopy reports. Th-234 will be reported via gamma spectroscopy. Due to the different analytical methods and sample preparation procedures, Th-234 results from gamma spectroscopy will not be directly comparable to the alpha spectroscopy results for other uranium decay series radionuclides.

20. Section 5.6, Reporting, Page 5-7: The text indicates that where a TU/SU exceeds the Parcel G ROD RAOs, the Removal Site Evaluation Report will include recommendations and options for further action, including the possibility of revising the Parcel G ROD to demonstrate the unit has met compliance criteria. However, the current compliance criteria are the Parcel G ROD RGs. Unless the Navy performs an analysis that demonstrates that the current RGs are no longer protective (for instance, by evaluating the RGs using the most current EPA PRG calculators), an amendment to the Parcel G ROD would be unnecessary. Therefore, please revise Section 5.6 to remove reference to revision of the Parcel G ROD as a potential solution to demonstrating a TU/SU meets the release criteria in the Work Plan.

The text regarding revisions to the Parcel G ROD was removed.

21. The Appendix A, Soil Reference Background Area: This section does not reference a Quality Assurance Project Plan (QAPP) or a task-specific work plan/sampling and analysis plan (TSP/SAP) which specifies the details of all quality and procedural requirements for this data collection project. Please revise Appendix A to include this information.

The SAP provides QA/QC requirements, and a reference was added to the text.

22. Appendix A, Soil Reference Background Area: It is unclear whether the proposed background locations are suitable for collection of background samples because the Work Plan does not provide details about these locations. For example, it is unclear if there were any previous excavations (e.g., exploratory excavations, remedial excavations, fuel line removals, or sanitary sewer/storm drain removal excavations) in these areas. If any of these areas have previously been excavated, then it would be unsuitable for use as a reference background area (RBA). In addition, the location proposed in Parcel D-2 is near the foot of a steep slope where erosion and run-off may have concentrated radionuclides found in atmospheric fallout like Cs-137; if this is the case, this location is unsuitable as a background location. Further, the location proposed for Parcel UC-2 is near or at the bottom of a hillside, where runoff may also have concentrated Cs-137 and be unsuitable for use as a background site. Although the text describes these areas as "non-impacted," a detailed justification for each proposed background area should be provided. Please revise the text to include a detailed justification for each proposed background location and exclude any locations where erosion and runoff may have concentrated radionuclides found in atmospheric fallout.

Text has been added to justify selection of the non-impacted RBAs. The proposed RBAs located in Parcels D-2 and UC-2 were previously accepted for use as suitable RBAs because of their status as unimpacted and representative of conditions across Hunters Point. These locations have been covered with asphalt (durable cover) following the previous characterization, preventing additional depositing of Cs-137 attributable to erosion. Erosion and runoff are natural processes that should be considered to establish variability in background. Characterization of erosion and runoff processes are not required for this investigation.

Response to EPA General Comment 22: The response should be clarified. Specifically, the response discusses the need for characterizing the impact of erosion and runoff in order to evaluate concentrations of background versus site contamination of Cesium-137; however this proposal was not

included in the original WP and SAP. The discussion on October 15, 2018 indicated that this characterization will not be done; however, the response should be clarified. Please explain the intent of the last sentence of this response and revise it as necessary.

Per the October 15, 2018 discussion, many impacted areas at HPNS include downslope soil areas; therefore, the reference areas should also include downslope soil areas to provide representative data for fallout radionuclides. The response above was revised for clarification.

23. All sections: EPA appreciates the multiple technical meetings with the Navy to discuss these comments and the verbal commitments from the Navy to revise the Work Plan to address many of these comments. We look forward to seeing the revised Workplan that incorporates these changes. EPA is making every effort to include in our formal comments every concern that we may have. If significant new information comes to light, including related to public comments, or significant new insights result from further evaluation, EPA may supplement these comments later.

Comment noted.

24. All Sections: Attached is a statistical review of the Work Plan that applies to all sections of the Workplan.

The Navy agrees with many of the points raised in the USEPA's statistical review. The rationale for the number of samples has been updated in the text. Multiple lines of evidence, including statistical and graphical comparisons with background, will be used for evaluating site data. Although the Navy agrees that MARSSIM statistics (e.g., the WRS test comparing two data sets to determine compliance with a release criterion), as indicated in the USEPA's statistician's review, are a valuable tool for evaluating data and decision-making, they are in conflict with USEPA General Comments 8 and 16, which require a point-by-point comparison with the ROD RGs, excluding background and naturally occurring radioactive material.

Statistical Review - Specific Comments – Parcel G

Executive Summary - Soil Investigations, 3rd paragraph, pg IV - "A phased investigation approach is presented in this work plan that was designed to provide a high level of confidence that current site conditions either comply or do not comply with the Parcel G ROD RAO (Navy, 2009)." As presented, the Draft Work Plan does not provide a means for quantifying the confidence associated with establishing compliance/non-compliance of Parcel G.

Discussion: Refer to Parcel G- General Comments of this TM for a detailed discussion. As stated earlier, it is widely recognized (MARSSIM 2002; NUREG-1505 Rev. 1) that statistical confidence is a critical component in establishing a defensible decision that a radiological site is in compliance. It is highly recommended that the Navy incorporate statistical testing into their data quality objectives (DQOs) so that conclusions drawn from this sampling effort can be substantiated and defended.

Although the Navy agrees that MARSSIM statistics (e.g., the WRS test comparing two data sets to determine compliance with a release criterion) are a valuable tool for evaluating data and decision-making, they are in conflict with USEPA General Comments 8 and 16, which require a point-by-point comparison with the ROD RGs, excluding background and naturally occurring radioactive material.

Response to EPA Statistical Review Specific Comment (Page 8, bottom): The response does not address the actual comment. The specific statistical hypothesis statements that will be tested to establish compliance should be provided. These statements should be incorporated into the data quality objectives (DQOs) for the project, including proposed confidence levels as well as alpha, beta, and power associated with the testing. The MARSSIM WRS test is not the only option for statistical testing. Point-by-point comparisons can be achieved with defined statistical confidence through the use of decision statistics such as Upper Tolerance Limits (UTLs). Please revise the work plan to include the specific decision statistic that will be used based on the distributional properties of the newly collected reference background data and subsequent sampling results of the TUs/SUs.

The approach, including the point-by-point comparisons and the number of samples, were based on USEPA General Comment 16. The DQOs were updated based on USEPA's recommended changes (see USEPA responses to General Comments 2 and 12) and Section 5 was updated to describe potential approaches for decision statistics to be used once reference area data is available. Please review the draft final work plan and advise on any text changes needed to address additional concerns if warranted.

Introduction - fourth paragraph, pg. 1-1: Additional information has been collected since the original Basewide Radiological Management Plan was designed. Historical data from background sampling can now provide a measure of expected variability for the soils on Parcel G and assist in the statistical design (sample sizes, statistical testing) of the Parcel G assessment and the reference background study. This historical information is relevant to the current conditions on the Parcel, including the Conceptual Site Model, and should be incorporated in the overall design of the assessment.

The background data were collected by Tetra Tech EC; therefore, collection of new background data is proposed to update the CSM.

Section 3.4 -Radiological Investigation, third paragraph: Please provide justification for how the number of TUs, to be excavated and undergo Phase I sampling, analysis, and scanning activities, was selected. What is the justification for only choosing 42 TUs of the 63 present in Parcel G? Similarly, how was the number of SUs determined for the Phase 1 investigation? The original assessment work conducted on Parcel G included the excavation of 100% of the TUs to meet the ROD RAO. Given the uncertainty of the historical sampling results and alleged data manipulation, what is the justification and supporting evidence for not excavating 100%?

See USEPA General Comment 2. The number of Phase 1 and Phase 2 trench units was provided by the USEPA.

Section 5.5 -Reference Background Area Soil Data: It is unclear to this reviewer how the proposed comparison of background data and TUs will establish if an RBA is representative of on-site soils. As presented, this methodology is used for comparing duplicate sample results per the Multi-Agency Radiological Analytical Protocols Manual (MARLAP) not for comparison of two populations. Please provide a reference/guidance document that supports the use of this test to indicate a measure of representativeness when comparing two populations.

Section 5 has been revised, and the referenced section was removed.

Statistical Review - Specific Comments – Establishing Background -Appendix A

Section 2. Purpose and Data Quality Objectives, pg. 2-2, 3rd and 4th bullets – The Kruskal-Wallis (KW) test is the non-parametric equivalent of a one-way analysis of variance (ANOVA) and is conducted on ranked data.

1. The KW test can be used on data sets which contain non-detect (ND) data if all the NDs are below the largest detected value.

Recommendation: Add text that this assumption will be verified prior to running the KW test and provide an alternate statistical test or methodology if current/historical information or professional experience regarding the laboratory analysis of the ROCs indicate this assumption will not be met.

2. The null and alternate hypotheses of the KW test are based on the median of the data. In this case, the null hypothesis for each ROC is that the medians of all RBAs are equal, with the alternative hypothesis being that the median of at least one group is not equal to the medians of the other groups. It does not identify which, if any, of the RBAs are different from the others.

Discussion: Please provide details on how the Navy will determine which RBA is statistically different from the others if the null hypothesis is rejected. Which post hoc test will be utilized?

RBA data will be reviewed graphically (e.g., histograms and box and whisker plots) to identify observed differences. Additional statistical testing between different data sets and populations may also be performed. Appendix A, Section 4.2, has been updated to provide additional details on the analysis of RBA data.

Section 3.1.4 Number of Samples, pt paragraph, pg 3-3 - "The NRC Criteria for providing characterization of a complex site, found in United States Nuclear Regulatory Commission Regulation (NUREG) 1505 (NRC, 1998) is at least 100 samples from at least 5 distinct locations."

Discussion: Please provide a specific page number/citation from NUREG 1505 that supports the sample size and number of distinct locations cited in the above statement. This reviewer cannot locate that recommendation within the NUREG cited. Further specification is required on how these numbers were derived: what assumptions were made, what inputs were used in the calculations, what data quality objective drives the sample size, cite a look-up table if one was used, etc.

See response to USEPA General Comment 12d.

Section 3.1.4 Number of Samples, Bulleted Sample Sizes, pg 3-3 - The proposed sample sizes include 25 subsurface samples from each on-site RBA, 5 surface samples from each on-site RBA and 25 surface samples from the off-site Bayview RBA.

Discussion: Section 2 of the Draft Soil RBA Work Plan states that the RBAs, on-site and off-site, will be compared using a KW test. The fact that the Bayview Area sample size is five times greater than the on-site RBAs will compromise the outcome of the comparison. As stated earlier in this document, it is recommended that 25 surface soil samples be collected from each RBA unless statistical calculations can be provided that support 18 samples are sufficient to achieve power and a 99% confidence level for TU to RBA comparisons. This also provides a sufficient number of samples for between RBA comparisons. See the discussion for Section 4.2.3 later in this document for further justification of increasing sample sizes within each on-site RBA.

Additionally, it is recommended that subsurface sampling also be conducted at the Bayview RBA to provide a comparison of the stratification of ROCs at depth with the on-site RBAs, visually and analytically.

See response to USEPA General Comments 12b and 12d.

Section 3.1.5.1 RBA-1 through RBA-4, 1'1 paragraph, pg 3-3 - The geographical dimensions of the RBAs have been reduced significantly from the initially proposed dimensions in the February 2018 Draft Work Plan. Reducing the size of the area also reduces the probability of capturing the variability of ROC concentrations that is present across the originally selected RBA area.

Discussion: It appears that the areas were reduced to justify the collection of only 5 surface soil samples within each area so as not to saturate the new 20 foot by 20 foot square RBAs. As stated earlier in this TM, sample sizes per RBA per soil depth should be consistent with the sample sizes of the individual TUs/SUs. The original sizes of the RBAs should be re-established allowing for the greater number of samples to be collected at surface in a systematic way that represents the entire RBA not just a 20 x 20 foot area.

See response to CDPH Specific Comment 65.

Section 4.2.3 Determine of Statistical Differences between Data Sets, 3rd paragraph, pg 4-4 - "The RBA data sets will be compared to each other by applying the KW test, detailed in Section 13.2 of NUREG-1505 (NRC, 1998) and described in Section 4.1.3, to determine whether the reference areas have similar or significantly different background levels. "

Discussion: Per NUREG-1505 Rev. 1 Table 13.5 shows that a minimum of 20 samples must be collected per RBA if 5 RBAs are selected for establishing background at an $\alpha=0.05$ and power =97.6%. The Draft Work Plan presented by the Navy in February 2018 indicated that confidence levels would be set at $\alpha=0.01$ and power=99%. To achieve those levels of confidence and power more than 30 samples would need to be collected per RBA per Table 13-5 of NUREG-1505, Rev. 1.

See response to USEPA General Comment 12d.

Specific Comments

1. Executive Summary: The next draft of the Work Plan will receive a great deal of attention from the public. Laypeople reading it would benefit from a summary that is more understandable to a general audience, e.g. similar to the fact sheet that the Navy already distributed June 2018 to accompany its draft Work Plan. EPA recommends that the Navy update its fact sheet to reflect the next draft version of the Work Plan, distribute that updated fact sheet to the public, and insert the updated fact sheet into the beginning of the next draft before the Executive Summary.

The fact sheet was updated in October 2018 and is available.

2. Executive Summary, p. iii, and Table 2-1, Conceptual Site Model – Uncertainties, Page 2-5: The Executive Summary references "Allegations of previous sample collection fraud, . . ." and the Table references "Potential for data manipulation or falsification." Yet some instances of these practices have been confirmed by the 2014 Tetra Tech EC Inc. Internal Investigation, the 2016 Nuclear Regulatory Commission concluded enforcement action, and the 2018 Department of Justice concluded criminal cases that sent two people to prison. Please add language to state that some fraud, manipulation, falsification, etc. have been confirmed.

The text has been updated throughout to clarify references to allegations.

3. Section 1, Introduction: For context to the reader, please clarify that other future work plans will address other aspects of the site where Tetra Tech EC Inc. has previously performed radiological work. For example, EPA commented in March 2018, "Tetra Tech EC Inc. also conducted radiological cleanup work in ship berths. The Navy should also address potential contamination in this and any other category of past radiological work by Tetra Tech EC Inc. at the HPNS." Please insert language into the Work Plan to convey this larger context into the introduction.

A sentence has been added to indicate that future work plans will address soil and buildings in the other parcels (B, C, D-2, E, UC-1, UC-2, and UC-3), including the North Pier and Ship Berths.

4. Table 2-1, Conceptual Site Model – Uncertainties, Page 2-5: The Uncertainties section of Table 2-1 states storm drains and sewer lines, including one foot of soil surrounding the pipes were removed to within 10 feet of all buildings, and impacted buildings had the remaining lines removed during surveys of the buildings. Non-impacted buildings are stated to have had surveys performed at ends of pipes and were capped. However, review of the Parcel G Data Evaluation Forms identified several instances of pipes being found in areas where they were thought to have previously been removed.

Please revise the uncertainty discussion in the Table 2.1 Conceptual Site Model to list this additional uncertainty.

Please clarify where "pipes being found in areas where they were thought to have previously been removed" or where in the Parcel G Data Evaluation Forms this information was found.

Response to EPA Specific Comment 4: The original EPA Specific Comment 4 was referencing information provided in the Parcel G Data Evaluation Forms. There are several forms that indicate that piping was not found north of a TU (e.g., TU 84) or east or west of a TU, when the associated figure indicates that piping should have been connected to another TU. For example, TU 151, Section 4, states that no piping was found to the east

or west of this TU, but the figure indicates that there is an east-west section of piping that was connected to TU 84 on the west and to TU 86 on the east. As such, it is unclear if all of the piping has been removed.

In addition, the concern is based on contradictory text in WP Section 2 (Conceptual Site Model) which states that open sanitary sewers and storm drains were left in place and were plugged during the removal process. Also, Table 2-1, Conceptual Site Model Uncertainties discussion states, "Sanitary sewers and storm drains, and 1 foot of soil surrounding the pipe removed. The sewer lines were removed to within 10 feet of all buildings. Impacted buildings had remaining lines removed during surveys of the buildings. Non-impacted buildings had surveys performed at ends of pipes, and pipes were capped." Please revise the Work Plan to address possible uncertainties about the extent of investigation of sanitary sewer and drain lines at Parcel G, and to also specifically state whether information exists to confirm whether sufficient investigation, and as needed, removal of piping and lines was completed at TUs 83, 84, and 123.

The text in the uncertainties section of Table 2-1 was updated to indicate that piping was removed to the extent practicable and this is consistent with Section 3.1.3 and Table 3-8 of the RACR. The statements in the data evaluation forms regarding where pipe was not found are directly from the RACR and do not seem to indicate that there should have been pipe there. For example, for TU 151 where it states that no piping was found to the east or west, looking at Figure 3-1 in this work plan, piping would not be expected to the east or west. TU 84 is north of TU 151 and TU 86 is southeast of TU 151.

5. Table 2-1, Conceptual Site Model – Uncertainties, Page 2-5: The "Uncertainties" section states that an example of a factor that results in a lower potential for radiological contamination is power washing. However, the "Potential Migration Pathways" section on Page 2-4 of the same table lists power washing also. Furthermore, the Navy's 2008 Technical Memo, Section 3b. Conceptual Site Model, states that power washing increases the potential for cracks in piping that could increase seepage of radiological material into the surrounding soil. These appear to contradict. Please remove power washing from the list of factors that could lower the potential for radiological contamination.

The text was removed as requested.

6. Section 3.3 and 4.3, Remediation Goals for soil and buildings, respectively: Please revise the Work Plan to explain how compliance with RGs will be evaluated when more than one ROC is identified. Cleanup goals should include an analysis of the sum of fractions and the unity rule to ensure total risk to the Reasonably Maximally Exposed (RME) individual posed by multiple ROCs in soil or buildings does not exceed the CERCLA risk range of 1×10^{-4} to 1×10^{-5} . Please note that "Consistent with existing Agency guidance for the CERCLA remedial program, . . . EPA generally uses 1×10^{-4} in making risk management decisions."

See USEPA response to General Comment 15c.

7. Section 3.3.1, Investigation Levels: This section defines investigation levels as media- specific, radionuclide-specific concentrations, or activity levels based on the remediation goals (RGs) that trigger a response, such as further investigation, if the investigation level is exceeded. The text also states that investigation levels are established for each instrument and vary with SU classification and measurement type. It is unclear, however, why the investigation levels may vary by survey unit. Please remove text that indicates that the investigation levels would vary by survey unit.

The text was removed.

8. Section 3.4, Radiological Investigation Design: The Parcel G Work Plan does not consider the need to investigate contamination associated with radiological objects containing Strontium-90. A gamma scan survey can be used to detect the bremsstrahlung radiation caused by Sr-90, but the text does not discuss collection of this data. Please revise the Parcel G Work Plan to discuss how the potential presence of Sr-90 in soil will be assessed.

Instrument-specific details on how gamma scan data will be evaluated have been added to the work plan. Sr-90 contamination in soil is not expected to produce bremsstrahlung radiation to be detected by gamma scanning; however, the bremsstrahlung radiation produced by an intact radioluminescent Sr-90 deck marker should be detected using a full energy spectrum window. The text has been revised to note the potential causes for gamma scan anomalies (e.g., Sr-90 or Ra-226 deck markers, localized soil contamination, and elevated NORM) and how they will be investigated.

9. Section 3.6.2.2, Site Preparation, Page 3-13: The second to the last bullet point states that after removal of the durable cover, "an additional 1 foot of durable cover buffer beyond the former excavation surface boundary will be removed," but the Navy response to EPA Specific Comment 16 states that "anything removed will be surveyed." Please revise the text to discuss whether excavation of this additional foot of soil is sufficient to account for regrading and clarify if this soil will be scanned and sampled or sorted.

To account for regrading, the removal of an additional 1 foot of asphalt on either side of the historical trench locations will allow for a sufficient buffer for excavation of trench materials. If trench boundaries extend laterally further than expected, additional asphalt will be removed. As noted in the text, durable cover materials, including asphalt, will be stockpiled and radiologically screened prior to disposal. The trench profile shown on the inset of Figure 3-4 has been updated to show the portions of the durable cover that will be removed.

10. Section 3.6.4, Phase 2 Trench Unit Investigation: Three samples should be collected at each core, including those less than 4 feet in depth below ground surface (bgs). Please revise this section to specify three samples will be collected for each core regardless of the depth of the core.

The text was revised to state that three samples will be collected from all borings. See response to USEPA General Comment 5.

11. Section 3.6.3.1, Automated Soil Sorting System Process, Page 3-15: It is unclear if a single sample of the diverted soil material will be sufficient to characterize this material, particularly if there is a large volume of diverted soil. Since soil can be diverted for reasons other than radiological alarms (e.g., low mass on the conveyor belt), it is important to collect sufficient samples to characterize this soil. Please revise the Work Plan to propose a volume-based sampling protocol with a one-sample minimum to characterize diverted soil.

Text has been added to clarify the sampling requirements. If soil material has been discharged to the "Diverted Pile," an investigation of the potential area of elevated activity (i.e., the "Diverted Pile" material) will be conducted. At a minimum, the soil sorting reporting software results will be reviewed to identify the causes for diverting material, and biased soil sample(s) will be collected. The biased soil sample(s) will be collected from the soil material that has been discharged to the "Diverted Pile" bin at a frequency equal to the volumetric frequency of sampling for ESU or SFU material. Using the current minimum number of systematic samples in a given unit (18), with a maximum size of 198 yd³, a sample is collected roughly every 11 yd³, with a minimum of 1 sample if the volume is less than 11 yd³.

12. Section 3.6.3.1, Automated Soil Sorting System Process: This section provides a description of one alternative for gamma scans to screen soils from TUs/SUs at Parcel G, but clarification is needed:
 - a. Please include a description of the detectors that will be used or the detection limits of those detectors.
 - b. The text states that soils will be sorted based on radiological properties. Please provide specifics about which radiological properties will be monitored and used for segregation. Please explain if the alarm will be set to an investigation level or if it will be set at multiple levels such that alarms occur when one of the ROC RGs or investigation level is exceeded.

- c. This section indicates the details of such an operation are included in the Soil Sorting Operations Plan, but this Plan was not included in the Work Plan. If this option is chosen, the Soil Sorting Operations Plan should be submitted for Regulatory Agency review and approval before soil sorting is implemented.

Please revise the Work Plan to address these concerns.

The minimum requirements for the soil sorting system detectors, MDCs, and diversion settings were added to the work plan. The specific soil sorting configuration will be provided by the contractor who is performing the Parcel G investigation in a separate Soil Sorting Operations Plan that will be submitted to the regulatory agencies for review and concurrence.

13. Section 3.6.4, Phase 2 Trench Unit Investigation, Page 3-17: It may not be possible to collect cored samples to 6 inches below the depth of the original excavation if gravel was used to bridge the water table when the original excavation when backfilling occurred. Many of the open trenches in Parcel G contained groundwater because the water table is relatively shallow, so it is likely that gravel may have been used as backfill in some or all of these trenches. Trenches where gravel was or may have been used to bridge the water table should be identified so that an alternative sampling method (e.g., potholing) can be used. Please identify trenches where gravel was or may have been used to bridge the water table and propose an alternative sampling method to obtain samples from 6 inches below the depth of the original excavation.

The intent of the subsurface sampling is to sample below the backfill material within the original trench surface, but in some cases the original excavation may have progressed to bedrock. It is unlikely that gravel used as bridging material will cause refusal. If direct-push drilling does pose an issue, other drilling methods will be used. Deviations from the work plan will be documented in the report, and the text was revised for clarification.

14. Section 3.6.4.1, Subsurface Soil Sample Collection, Page 3-18: The text indicates that "use of a 3-inch-internal-diameter sampler may be required" in order to obtain sufficient sample volume for analysis, but it is unclear why drilling a second borehole adjacent to the first is not included as a potential method to collect sufficient soil. If the soil is sandy, it may not be retained in a 3-inch sampler, but may be retained in a smaller diameter sampler with a bottom basket. Please propose multiple potential methods for collection of sufficient sample volume.

The first paragraph has been revised to read as follows: "...spoon sampling. When needed, other methods may be considered and applied. Specific sampling methods used will be documented in the field and work plan deviations will be described in the final report. Generally, drilling..."

15. Section 3.6.7.2, Decontamination and Release of Equipment and Tools, Page 3-21: The text discusses possible decontamination of equipment and tools at the completion of fieldwork, but this should not be optional because there could be chemical contamination in addition to radiological contamination. In addition, decontamination of equipment and tools is necessary between sampling locations (e.g., shovels, trowels, mixing bowls, coring equipment). Please revise the Work Plan to provide a more complete decontamination plan and to require decontamination of all equipment and tools before they are removed from the site.

The text was updated to require decontamination between sampling locations and for all equipment and tools before they are removed from the site.

16. Section 5.5, Reference Background Area Soil Data, Page 5-6: The text states that RBA data sets will be compared to each TU/SU data to demonstrate the RBA data set for soil is representative of soil in each TU/SU by comparing the median of the two data sets to determine if there is a statistical difference in the medians. However, the text does not state how it will be determined that the soil sample(s) collected from the TU or SU used for this comparison will represent only background and not site contamination. Further, it is unclear why the Work Plan proposes to compare the medians of data populations between background soil and investigation unit soil rather than to perform the evaluation recommended by the EPA. This evaluation includes analyzing the soil for the primordial naturally occurring parent and daughter radionuclides to determine if they are in secular equilibrium to identify whether the radionuclide ratios indicates the soil represents background. Please revise the Work Plan to require evaluation of secular equilibrium before any statistical comparisons are conducted.

See response to USEPA General Comment 19. In addition, the discussion concerning representativeness of RBA data sets has been removed from Section 5.5.

Responses to EPA Specific Comments 16 and 19: The responses do not address the comments; however, it is understood from discussions with the Navy on October 15, 2018, that all reportable isotopes for Uranium (U-234, U-235, U-238) and Thorium (Th-230, Th-234) from the alpha spectroscopy analysis, as well as Radium-226 will be reported. Please ensure the revised WP includes this information.

Section 3.7 was updated to state that all detected isotopes will be reported. Th-234 is not an alpha-emitting radionuclide and will not be included in alpha spectroscopy reports. Th-234 will be reported via gamma spectroscopy. Due to the different analytical methods and sample preparation procedures, Th-234 results from gamma spectroscopy will not be directly comparable to the alpha spectroscopy results for other uranium decay series radionuclides.

17. Appendix A, Section 2.0, Purpose and Objectives, Step 2 - Identify the Objective, Page 2-1: The text does not appear to distinguish between potential contamination and background levels. Step 2 states that the background study is being conducted to "establish representative background data sets for soil ROCs, NORM radionuclides, and fallout ROCs for comparison and evaluation of soil data collected from the HPNS." This statement seems to imply that soil ROCs may be present in background that are not present due to Naturally Occurring Radioactive Material (NORM) or from fallout associated with nuclear tests or reactor accidents. There is a similar statement under Step 3 - Identify Inputs to the Objective. Please revise the text to clarify that only ROCs that are present due to NORM or fallout may be considered background.

The text was revised for clarification.

18. Appendix A, Section 2.0, Purpose and Objectives, Step 4-Define the Study Boundaries, Page 2-1: Step 4 proposes an inconsistent sampling strategy. This section states that in Parcels B, C, D-1, and D-2, reference background surface soil samples will be collected from 0 to 6 inches below ground surface bgs, and subsurface soil samples will be collected from 1- to 2-foot intervals to a depth of up to 10 feet bgs. However, at the off-base location, surface soil samples will be collected from 0 to 6 inches bgs and subsurface samples to a depth of 10 feet bgs are not proposed. It is unclear why samples collected from on-base background locations will be obtained from the subsurface in 1- to 2- foot internals to a depth of up to 10 feet bgs, but off-site background samples will only be collected from 0 to 6 inches. Collecting subsurface samples from the off-site location will provide valuable information about the depth of deposition and transport of radionuclides from fallout, as well as the potential differing distribution of NORM at depth. In addition, a lithological profile of off-site subsurface soil should be completed to provide additional support to any correlation drawn from soil profiles and NORM collected at the HPNS. Please revise the off-site sampling approach to include collection of subsurface samples.

The text was updated to indicate that 25 surface and 25 subsurface soil samples will be collected from the offsite RBA location. Subsurface soil samples from the offsite RBA will be collected from 1 to 2 feet bgs using hand tools to minimize the impact of the characterization to the offsite RBA.

19. Appendix A, Section 2.0, Purpose and Objectives, Step 5 - Develop Decision Rules and Step 6 - Specify the Performance Criteria, Pages 2-1 and 2-1: The performance criteria discussion states that the background data sets will be evaluated for suitability based on statistical tests, but prior to

performing the statistical tests, an evaluation of whether the naturally occurring radionuclides that are also ROCs should be evaluated to determine if the U-238 parent and daughter radionuclides, and as applicable, Th-232 and daughter radionuclides are in secular equilibrium. This is necessary to ensure elevated ROCs that are present due to contamination are not eliminated as outliers. Please revise this discussion to address the need to evaluate whether the U-238 and Th-232 series radionuclides are in secular equilibrium before performing statistical tests to identify outliers or to derive population estimators for comparison to site data.

See response to USEPA General Comment 19. In addition, evaluation of secular equilibrium conditions has been added to the Soil Reference Background Area Work Plan.

20. Appendix A, Section 3.1.6, Field Instrumentation, Gamma Detectors, Page 3-5 and 3-6: The text provides a list of two gamma survey instruments that will be used in the RBA but does not provide the detection limits for each instrument. Please revise Appendix A to include the efficiency and detection limits for the gamma survey instruments and the required instrument sensitivities that meet the data quality objectives for identifying radionuclides at background levels.

Example scan MDC calculations have been added to the Soil Reference Background Area Work Plan for both Cs-137 and Ra-226 in Section 3.1.6.

21. Appendix A, Section 3.1.7, Laboratory Analysis, Pages 3-6 and 3-7: Section 3.1.7 lists the radionuclides that will be analyzed but does not reference the QAPP that contains the QC requirements or detection limits for such analysis. Please revise Appendix A to include this information or reference the QAPP that includes this information.

The SAP provides QA/QC requirements, and a reference was added to the text.

22. Appendix A, Section 3.2.4, Surface Soil Sampling Process, Pages 3-9 and 3-10 and Section 3.2.5.2, Subsurface Soil Sample Collection, Pages 3-11 and 3-12: Please specify the required sampling volume and sample container in Section 3.2.4 and Section 3.2.5.2. Similarly, please specify the type of container that will be used to store soil intervals not designated for sampling (e.g., will core boxes or sealed jars be used?).

The referenced sections provide the required sample amount (a minimum of 200 grams). The sample containers will be provided by the laboratory prior to sample collection.

Clarifying text was added to state that following core processing (i.e., logging, observing, and sampling), excess material that was not sampled will be returned to the borehole it was retrieved from or will be spread directly adjacent to the borehole location.

23. Appendix A, Section 3.2.4, Surface Soil Sampling Process, Pages 3-9 and 3-10 and Section 3.2.5.2, Subsurface Soil Sample Collection, Pages 3-11 and 3-12: Please provide decontamination procedures for drill rig tooling, hand tools, and bowls used for mixing should be specified in the text.

The following text has been added to the bulleted lists: “Decontamination of sampling equipment will be conducted using SOP RP-132, Radiological Protective Clothing Selection, Monitoring, and Decontamination (Appendix C).”

24. Appendix A, Soil Reference Background Area Work Plan, Section 4.2 Analytical Data Evaluation: The Work Plan in Appendix A should be revised to provide a more comprehensive strategy for selecting background values for comparison to site data and use in demonstrating compliance with the ROD RGs. For example, the strategy should consider the following inputs: the population distribution, characteristics (i.e. skewness) and variance for each background reference location or multiple locations; the frequency of detection; and site-specific factors (i.e. soil type, topography, depth, homogeneity or heterogeneity of the data set, or other). In addition, analysis of the background data set should include the appropriate statistical calculations or charts and graphs (such as quantile-quantile [Q-Q] Plots). The Work Plan should also describe how background data sets will be validated and at what frequency and should state that the complete data packages and data validation reports will be made available to the regulators for review prior to the selection of background values. Finally, one or more scoping and decision-making discussions between the regulators and the Navy should be conducted to select the most appropriate background values. Please provide a more comprehensive strategy for selecting background values that includes these issues. In addition, please revise Appendix A to specify that the full data packages, data summary tables, and data validation reports (from third-party data validators) will be given to the regulators for review.

The types of statistical analysis recommended were added. The results and recommendations for background values will be presented in the draft report that will be submitted for regulatory review. The draft background report will include full data packages, data summary tables, and data validation reports (from third-party data validators). Meetings will be held with the regulatory agencies to discuss the results and to facilitate consensus on appropriate background values. The text was updated to reflect this.

Response to EPA Specific Comment 24: The response addresses the comment; however, further details about how the electronic data will be managed and transmitted to EPA is requested. Please include this information in the forthcoming revised WP and as appropriate, SAP.

The electronic data deliverable that includes the analytical data will be uploaded into the Naval Installation Restoration Information Solution, the Navy’s centralized database and this is stated in the SAP. The electronic data deliverable can also be provided to the USEPA electronically once available. As stated above, the draft background report will include full data packages, data summary tables, and data validation reports (from third-party data validators) and this is included in the draft final work plan.

25. Appendix A, Section 4.2.2 Identify Outliers, Page 4-2: This section states that background data values will be evaluated to determine if any are outside of the expected distribution using Dixon’s and Rosner’s statistical outlier tests, both of which assume the data are normally distributed. However, the previous Section 4.1.2, Outliers Test, states, “Because environmental data tend to be right-skewed, a test that relies on an assumption of a normal distribution may identify a relatively large number of mathematical outliers.” Section 4.1.2 also states that outliers identified in statistical test will be reviewed to determine whether any suitable reasons (e.g., a potential analytical error) exist to exclude them from further calculations, and confirmed outliers will be removed from individual data sets. Therefore, please revise the Work Plan to specify that all background data sets should be evaluated using non-parametric statistical tests to evaluate population estimators (i.e., such as mean, standard deviation, and others) and potential outliers. Also, please ensure all naturally occurring radionuclides that are also ROCs undergo an evaluation to determine if the U-238 and Th-232 decay chains are in secular equilibrium prior to conducting any outlier evaluations to ensure ROCs that are present due to contamination are not eliminated.

The text has been revised to read as follows: “Graphs of analytical data will be reviewed for indications of data values outside of the expected distribution (i.e., potential outliers). In addition, outlier evaluations will be performed using Dixon’s and Rosner’s tests or other appropriate tests, including non-parametric methods. Dixon’s test is...” In addition, the bulleted list in Section 4.2 has been revised to add the following bullet: “Review equilibrium conditions of naturally-occurring radionuclides”.

26. Appendix A, Section 4.3, Reporting, Page 4-4: This section states that information from other San Francisco Bay Area radiological background studies may be referenced in the BRA report as appropriate. Please also revise the Work Plan to state how the Navy will determine if the other San Francisco background data sets are sufficiently comparable/representative of conditions/soils at the Hunters Point Shipyard.

Clarifying text has been added that describes how to determine whether other offsite background studies are comparable/representative. Specific points of comparison include, but are not limited to, having comparable/similar NORM constituents, analytical methods, lithology, and latitude.

DTSC Comments

General Comments

1. The Work Plan does not reflect the Regulatory Agency Approach. The Regulatory Agency Approach was provided to the Navy on February 6, 2018 during a conference call and again on February 16, 2018 at a meeting with the Navy and Agencies. The Regulatory Agency Approach requires that if a single radiological exceedance of the RG in a trench or building survey unit that was detected during the Phase I of the investigations cannot be shown to be naturally occurring radioactive material (NORM; also referred to as background), it triggers a 100% Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class 1 survey of all trench or building survey units in Parcel G. This requirement is based on a statistical review by US EPA to ensure a 95% confidence level that 95% of the survey units sampled are free of radiological exceedances associated with the Navy's past activities that are not NORM/background. DTSC acknowledges, as indicated in the draft Work Plan (Appendix A) that new background soil data will be collected and evaluated as part of this investigation to determine the appropriate background levels.

The Phase II sampling effort of the remainder of the soil survey units will provide additional confidence that the remaining survey units meet the 2009 Record of Decision (ROD) RGs, US EPA risk criteria, as well as meet the sampling requirements of CDPH. As indicated in the February 16, 2018 meeting, the Regulatory Agency Approach provides a scientifically supported alternative approach that will be acceptable to DTSC based on the scope of falsification of data and data quality issues identified at Parcel G. The Work Plan needs to be revised to reflect the Regulatory Agency Approach.

This comment was addressed; see response to USEPA General Comment 2.

DTSC accepts the response, but also requests that the last sentence be revised so that it is clear that 100% of the building site survey units will be investigated. We suggest the following revision: For the building site survey units, 100% surface scans were added to the work plan. 100% of the building site survey units will be investigated consistently and concurrently with the TUs. There is no longer a Phase II reduced sampling effort for the building site survey units.

Additionally, the terms Building Sites and Building soil appear to be used in the work plan to describe building soil survey units. We recommend using just one term throughout the document for consistency.

The response to USEPA General Comment 2 was revised as suggested.

The terms building sites and building soil were reviewed in the work plan and revised for correctness and consistency. The term "building soil" is no longer used in the document.

2. As mentioned above, the soil investigation is to be conducted in two phases under the Regulatory Agency Approach. Phase 1 requires 33% of the Trench Units (TUs) and 50% of the Building Soil Units (SUs) in Parcel G to be completely excavated and 100% of the soil surveyed. Phase 2 consists of a different survey and sampling effort of the remaining 67% of the TUs and SUs. Phase 2 would only be acceptable if there were no exceedances of the RAO/RGs, with the exception of NORM/background, in Phase 1. CDPH requires surveys and sampling in all TUs and SUs. Without the Navy's full acceptance of Phase I with respect to one failure leading to the requirement for 100% survey/sampling of all SUs or TUs, unless the Navy can demonstrate that the exceedance(s) are related to NORM/background, Phase I is no longer an option and 100% excavation and survey of all TUs and SUs would be required. The Regulatory Agency Approach is a scientifically supported alternative that is acceptable to the Agencies based on the scope of falsification of data and data quality issues at Parcel G. CDPH has indicated that it will not issue a recommendation for radiological unrestricted release to DTSC if the Navy does not fully accept the Regulatory Agency Approach or conducts 100% retesting. The Work Plan needs to be revised accordingly.

This comment was addressed; see response to USEPA General Comment 2.

3. The Work Plan indicates that if data collected are not compliant with certain objectives, then the data will be evaluated for protectiveness based on the US EPA's current guidance on Radiation Risk Assessment. The description of the objectives (Remedial Action Objectives (RAO)) is inconsistent throughout the Work Plan, e.g., the Parcel G RAO, the RAO and background levels, or the RGs. The Work Plan needs to be revised for consistency. DTSC believes that a data point that exceeds an RG does not meet the RAO unless the Navy can demonstrate that the data point is NORM/background.

The work plan was reviewed and updated for consistency. Also, see response to USEPA General Comment 2.

4. The Work Plan states that soil or structures that are not compliant with the RAO will be evaluated for protectiveness based on the US EPA's current guidance on Radiation Risk Assessment. DTSC defers to US EPA to interpret their own guidance and reiterates that the site investigation and remediation must meet the ROD RGs. Therefore, it is DTSC's position that the Work Plan needs to be revised accordingly.

See response to USEPA General Comment 3.

5. If data exceeds RAO/RGs, the Work Plan indicates that further evaluation would be conducted to determine whether Site conditions are protective of human health using US EPA's current guidance on Radiation Risk Assessment. This would not meet CDPH's requirement to obtain levels similar to naturally occurring levels and/or anthropogenic background levels. As stated in the enclosed CDPH memo, "a final status survey report that compares the distribution of data from the building/excavation sites with applicable reference area data and documents the remediation efforts" will be required. Soil concentrations that exceed RGs plus reference area data (background levels) cannot be left in place. If left in place, CDPH has indicated that it cannot issue a recommendation for radiological unrestricted release to DTSC. Therefore, the Work Plan needs to be revised accordingly.

See response to CDPH General Comment 1.

6. The Phase I TUs and SUs selected by the Navy for resampling need to be revised to reflect US EPA's recommendations for TUs and SUs to be resampled.

See response to USEPA General Comment 13.

It is not clear from the response if the 6 remaining TUs meet the US EPA criteria as indicated in US EPA General Comment #13. Clarification is needed.

As stated in Section 3.4.4 of the draft work plan, the TUs selected for Phase 1 were based on their location adjacent to (downstream/upstream) impacted buildings and considered the recommendations from the Radiological Data Evaluation Findings Report (Navy, 2017).

7. The Work Plan indicates that an additional 6 inches of soil beyond the trench walls will be removed and surveyed instead of conducting surveys of the walls within the trench. This method would not indicate where along the wall soil was obtained in order to investigate further if an exceedance of the RG is identified. The additional 6 inches of soil need to be segregated from the rest of the excavated soil from each trench and, if an exceedance of the RGs is identified that is not determined to be NORM/background, the sidewall or bottom of the trench from which that soil was removed needs to be surveyed. Additionally, soil should not be returned to the excavated area until the trench wall evaluation is completed. Therefore, the Work Plan needs to be revised accordingly.

See response to USEPA General Comment 4.

DTSC finds the response acceptable in regards to in situ investigation of open excavations if a radiological exceedance is found. However, it is unclear if the work plan will still include six inches of soil beyond the trench walls to be excavated, and if so, will that soil be segregated in order to identify locations in the excavated trench that may require additional investigation. Please revise the text for clarification.

Yes, following the excavation of the backfill soil to the original trench extent, six inches of soil will be excavated from the trench walls and floor. The backfill soil and trench wall/floor soil will be segregated and tracked to its approximately original location. Section 3.6.3 of the draft final work plan includes the discussion of the trench investigation process. Following an in situ investigation of the trench (if needed), additional excavation may be performed to remediate or further characterize the trench soil. This excavated material will be segregated so that it can be tracked to its original approximate location, similar to the initial excavation of trench wall or floor soil.

8. The Regulatory Agency Approach for Phase II required removal of the asphalt over TUs and SUs in order for surface surveys to be conducted in addition to core sampling. The Work Plan does not include these surface surveys. CDPH requires that all TUs and SUs be surveyed. CDPH has indicated that it cannot issue a recommendation for radiological unrestricted release to DTSC if surveys are not conducted at each TU and SU. Therefore, the Work Plan needs to be revised accordingly.

See response to USEPA General Comment 6.

DTSC accepts the response and appreciates the Navy's willingness to conduct 100% surface scanning of all TUs and SUs. However, it is unclear if the TUs in Phase II (67% of all TUs) will have the asphalt removed prior to conducting the surface scans? Please clarify.

The work plan includes removal of asphalt and any base material prior to surface scans for Phase 2 TUs.

9. Finally, throughout the Work Plan the Navy indicates that there have been various allegations of data manipulation or falsification committed by Tetra Tech EC employees and their subcontractors. In March and May of 2017, two former employees pleaded guilty to admitting falsification of documents in a United States Department of Justice case. In light of this, some allegations have now been proven. Further, and as indicated earlier, in addition to the falsifications of data, the Agencies identified various data quality issues, as well. Therefore, it is recommended that the Work Plan be revised to reflect these, accordingly.

See response to USEPA Specific Comment 2.

The response indicates that the Work Plan has been updated but provides no revised language for review. We will provide a response following review of the draft final work plan.

Comment noted.

10. Section 10.5 of the Work Plan indicates that air monitoring will be conducted and that the reporting of such is included in the SAP. SAP Worksheet #14, Data Evaluation and Reporting indicates that a report will be prepared to include a summary of the field activities. DTSC requests that the SAP clearly indicate that an air monitoring report, evaluating the dust and radiological data collected, will be included with the final Remedial Action Completion Report.

The requested language will be added to the SAP.

CDPH Comments**General Comments**

1. Please note that CDPH-EMB utilizes Section 30256 in Title 17 of the California Code of Regulations (17 CCR 30256) to render a decision to concur with a Radiological Unrestricted Release Recommendation (RURR). As a result, CDPH-EMB requires a final status survey report that compares the distribution of data from the building/excavation sites with applicable reference area data and documents the remediation efforts. The final status survey should document and explain reasonable efforts that have been made to remediate the site.

The final status survey results, including a comparison to background and discussion of remedial activities performed as part of the investigation, will be included as an attachment to the RACR.

2. This work plan seems to be drawn up without regard to United States Environmental Protection Agency (USEPA), California Department of Toxic Substance Control (DTSC) and California Department of Public Health (CDPH) proposal. CDPH worked collaboratively with DTSC and USEPA (collectively "Regulators") to develop, Regulators' Approach (<https://semspub.epa.gov/work/09/100009179.pdf>; pg. 36-38). This document establishes the minimum amount of resampling acceptable in order for the Environmental- Management Branch (EMB) of CDPH issue a radiological unrestricted release recommendation (RURR). Please note specifically the requirement that if one trench unit fails (soil concentration exceeds the cleanup goal, which is Remedial Goal [RG] plus reference background, and is not proven to be Naturally Occurring Radiological Material [NORM]), then 100% of Parcel G trench units must be excavated, scanned, and remediated if needed. This same clause applies to building site soil survey units.

See response to USEPA General Comment 2.

3. Please perform the following statistical analyses on the data collected from the Survey Units (SUs) with data collected from the background reference area: box plot, histogram, distribution analysis, normal (log) probability plot, Q-Q plot and comparison to material specific background.

Section 5.2.2 has been revised to include a discussion of box plots and potential distributions consistent with individual data sets including normal, lognormal, and gamma distributions.

4. Equations drawn from source texts, technical references or regulatory guides should include source citations to assist in the review process. Equations which are derived from source texts, technical references or regulatory guides should demonstrate derivation.

Specific equation references have been added.

5. CDPH-EMB is concerned that the re-excavation specified for the Phase 1 Trench Unit Design also represents a soil treatment due to movement and mixing of the potentially elevated trench soil prior to scanning. What steps will be taken to preserve the integrity of the soil sampling process?

Excavation does not constitute treatment of soil. Re-excavation of trenches is necessary to achieve the 100 percent scanning coverage required in the regulators' proposal. The appropriate equipment and sampling approach was selected to identify contamination, if it is within the excavated soil. An in situ scan of the sidewalls and bottom of the excavation will be conducted if contamination is identified. Also see responses to USEPA General Comment 4 and USEPA Specific Comments 11 and 12 regarding the soil sorting approach and the Navy's efforts to avoid mixing of potentially contaminated soil.

Specific Comments

6. Section 1, introduction page 1-1, paragraph one, sentence three, "The radiological characterization will be conducted in accordance with the general approach and methodologies that are provided in the Draft Parcel G Removal Site Evaluation Work Plan (Parcel G Work Plan) (Navy, 2018),

a separate Sampling and Analysis Plan (SAP), and a separate Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP)." Please provide the above cited documents for CDPH-EMB review prior to onset of survey activities. CDPH-EMB will not consider its comments closed until these documents are provided.

The draft SAP was submitted for review on August 16, 2018. The APP/SSHP is an internal Navy document to comply with NAVFAC safety standards, and it will be provided for reference.

7. Executive Summary, Project Purpose, page iii. paragraph two, sentence one, "Portions of soil or structures that are not compliant with the RAO will be evaluated for protectiveness based on the United States Environmental Protection Agency's (USEPA 's) current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014)". As noted above, CDPH-EMB requires a final status survey report that compares the distribution of data from the building/excavation sites with applicable reference area data in order to concur to issue a RURR; please include a statistical comparison to applicable reference area data as a part of the project purpose.

A statistical comparison of site data to applicable reference area data was added to the project purpose.

8. Executive Summary, Scope, page iiL paragraph one, sentence one, "The radiological investigation will be conducted at the following sites:

- Former Sanitary Sewer and Storm Drain Trenches
- Buildings 317/364/365 Former Building Site
- Building 351A
- Building 351
- Building 366
- Building 401
- Former Building 408 Concrete Pad
- Building 411
- Building 439

According to Regulators' Approach (<https://sempub.epa.gov/work/09/100009179.pdf>; pg. 36-38) a certain criteria has been established for the selection of priority survey units. Please refer to the United States Environmental Protection Agency (USEPA) Review of the Draft Parcel G Removal Site Evaluation Work Plan, Hunters Point Naval Shipyard, San Francisco, California, June 18, 2018, USEPA Review dated August 14, 2018; comments for specific areas to be surveyed.

The regulators' approach has been incorporated into the work plan and corresponding changes to the text have been added to the applicable sections.

9. Executive Summary, Conceptual Site Model. pages iii and iv. The section does not describe how the conceptual site model has changed due to previous remediation work. For example, based on the Historical Radiological Assessment, sewer and storm drain pipes were present and thought to be the source of contamination in trench units with the soil above the pipes being mostly not impacted. Currently, the pipes have been removed but the backfill soil may be contaminated or its status is unknown due to alleged activities.

Because the level of detail needed for a comprehensive CSM is not relevant to an Executive Summary, the referenced text was removed from the Executive Summary. A comprehensive CSM is provided in Section 2, which contains the information in the comment.

10. Executive Summary, Soil Investigations, page iv, paragraph one, sentence one, "Soil investigations will be conducted at the following areas:

- Former Sanitary Sewer and Storm Drain Trenches
- Buildings 317/364/365 Former Building Site
- Building 351A Crawl Space

Please refer to the United States Environmental Protection Agency (USEPA) Review of the Draft Parcel G Removal Site Evaluation Work Plan, Hunters Point Naval Shipyard, San Francisco, California, June 18, 2018, USEPA Review dated August 14, 2018; comments for specific areas to be surveyed.

The regulators' approach has been incorporated into the work plan and corresponding changes to the text have been added to the applicable sections.

11. Phase 1 Investigation, page iv, paragraph one, sentence one, "Phase 1 includes the radiological investigation on a targeted group of TUs and SUs. Twenty-one of the 63 former sanitary sewer and storm drain TUs were selected for the Phase 1 investigation. Fourteen of the 28 surface soil SUs from the Buildings 317/364/365 Former Building Site and Building 361A Crawl Space were selected for the Phase 1 investigation." Please refer to the United States Environmental Protection Agency (USEPA) Review of the Draft Parcel G Removal Site Evaluation Work Plan, Hunters Point Naval Shipyard, San Francisco, California, June 18, 2018, USEPA Review dated August 14, 2018; comments for specific areas to be surveyed.

The regulators' approach has been incorporated into the work plan and corresponding changes to the text have been added to the applicable sections.

12. Phase 1 Investigation, page v, paragraph one, sentence one, "Soil may be laid out on Radiological Screening Yard pads for a surface scan, or soil may be processed and scanned using soil segregation technology." Please be advised that CDPH-EMB has not yet been provided the information necessary to come to a decision on the use of soil segregation technology at HPNS.

Comment noted. See response to USEPA Specific Comment 12.

13. Phase 1 Investigation, page v, paragraph one, sentence two, "Following excavation to the original TU boundaries, additional excavation of approximately 6 inches of the trench sidewalls and floors will be performed to provide ex situ scanning and sampling of the trench sidewalls and floors." Please ensure that the over-excavation soils are sampled separately and stored separately from soils removed from the original TU. Please ensure the excavated soils are traceable back to their TU origin. If a radiological exceedance is found; CDPH-EMB requires a follow up Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class I survey be performed on the TU of the soil's origin.

As stated in Section 3.4.4, "The over-excavated material representing trench sidewalls and floors will be maintained as separate volumes (e.g., piles) of soil from the original excavated soil."

Text in the Executive Summary and throughout the work plan has been updated to describe an in situ investigation of the open excavation if an exceedance in sidewall or floor material is found.

Additional text has been added to Section 3.6 of the work plan to require additional excavation location tracking information for sidewall and floor material, including the former TU name and which sidewall or floor surface the material was excavated from.

14. Phase 1 Investigation, page v, paragraph three, sentence one, "Systematic and bias samples will be collected from the excavated soil from the TUs, within the surrounding soil of the TUs, and from the surface soil SUs." Please ensure that the over-excavation soils are sampled separately and

stored separately from soils removed from the original TU. Please ensure the excavated soils are traceable back to their TU of origin. If a radiological exceedance is found; CDPH-EMB requires a follow up MARSSIM Class I survey be performed on TU of the soil's origin.

See response to CDPH Specific Comment 13.

15. Building Investigations, page v, paragraph one, sentence one, "Investigations of interior surfaces will be performed for the following buildings:

- Building 351A
- Building 351
- Building 366
- Building 401
- Former Building 408 Concrete Pad
- Building 411
- Building 439

Please refer to the United States Environmental Protection Agency (USEPA) Review of the Draft Parcel G Removal Site Evaluation Work Plan, Hunters Point Naval Shipyard, San Francisco, California, June 18, 2018, USEPA Review dated August 14, 2018; comments for specific areas to be surveyed.

The regulators' approach has been incorporated into the work plan and corresponding changes to the text have been added to the applicable sections.

16. Data Evaluation and Reporting, page vi, paragraph two, bullet two, sentences one and two: "Individual samples reporting 226Ra gamma spectroscopy concentrations greater than the RG for 226Ra will be analyzed for uranium-238 (238U) and 226Ra using comparable analytical methods. For that specific sample, the 238U result will be used as a more representative estimate of the background value for 226Ra, and the alpha spectrometry 226Ra concentration will be compared to the RG for 226Ra using the revised background value." Please specify that the process outlined above is to establish that Ra-226 levels are within the naturally occurring radioactive material (NORM) range. Please refer reader to Section 5.4 for a fuller discussion of NORM Background Investigation.

The Executive Summary has been revised, and a reference to Section 5 was added.

17. Table ES-1. Soil and Building Trench and Survey Units: Figure ES-1. Soil and Building Sites. Please refer to the United States Environmental Protection Agency (USEPA) Review of the Draft Parcel G Removal Site Evaluation Work Plan, Hunters Point naval Shipyard, San Francisco, California, June 18, 2018, USEPA Review dated August 14, 2018; comments for specific areas to be surveyed.

The regulators' approach has been incorporated into the work plan and corresponding changes to the text have been added to the applicable sections.

18. Section 3.1 Data Quality Objectives, page 3-1, bullet five-Develop Decision Rules, paragraph one, sentence two, "The RACR will describe the results of the investigation and will provide a demonstration that radioactivity levels meet the Parcel G RAO or represent background conditions." Please see comment #1.

See response to CDPH General Comment 1.

19. Section 3.1 Data Quality Objectives, page 3-1, bullet five-Develop Decision Rules. paragraph two, sentence one, "If the investigation results demonstrate that site conditions are not compliant with the Parcel G RAO and exceed background levels, then the data will be evaluated to determine whether site conditions are protective of human health using USEPA's current guidance on Radiation Risk Assessment at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sites (USEPA, 2014)." As noted above, CDPH-EMB requires a final status survey report that compares the distribution of data from the building/excavation sites with applicable reference area data in order to concur to issue a RURR; this is irrespective of USEPA's current guidance on Radiation Risk Assessment at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sites (USEPA, 2014).

See response to CDPH General Comment 1.

20. Section 3.1 Data Quality Objectives, page 3-2, bullet one, sentences one and two: "Individual samples reporting 226Ra gamma spectroscopy concentrations greater than the RG for 226Ra will be analyzed for uranium-238 (238U) and 226Ra using comparable analytical methods. For that specific sample, the 238U result will be used as a more representative estimate of the background value for 226Ra, and the alpha spectrometry 226Ra concentration will be compared to the RG for 226Ra using the revised background value". Please see comment number 16.

See response to CDPH Specific Comment 16.

21. Section 3.3.1 Investigation Levels, page 3-3, paragraph three, sentence four. "The spectra will be evaluated using regions of interest peak identification tools for the ROCs that correspond to gamma rays at 186 kiloelectron volt (ke V) for 226Ra, 609 ke V (226Ra daughter bismuth-214 [214Bi]), and 662 keV for 137Cs." EMB notes that using gamma rays at 186 kiloelectron volt (keV) for 226Ra is a quicker, less accurate method of analyzing for 226Ra and is known to be biased high. This bias is noted in the discussion of the conceptual site model, page IV, paragraph one, bullet one, sentence two, "A large amount of soil (estimated 80 percent) was likely mischaracterized as contaminated (Argonne National Laboratory, 2011)." Also, for short scan counts it is doubtful that enough counts will be obtained in the selected peak region to provide adequate counting statistics to identify soils at the Ra-226 investigation level. Please explain the use of 186 kiloelectron volt (keV) as the identifying peak for 226Ra.

Scanning measurements collected with gamma spectroscopy (such as with the RS-700) will be evaluated using multiple regions of interest to determine the presence of Ra-226. The 186 keV energy peak will be one of several gamma energies associated with Ra-226 that will be evaluated. Section 3.5 of the work plan has been revised to include the data evaluation approach for scan data collected with the RS-700.

Will the RS-700 be the only instrument used for gamma scanning? For example, if there are follow ups, and in situ gamma scans are required to be performed in excavated trenches; will there be other gamma scan meter/detector units employed? If so, will the work plan be revised to include the data evaluation approach for scan data collected with the alternate gamma scan instruments?

No, the RS-700 will not be the only instrument used for gamma scanning. Section 3.5.1 of the draft final work plan provides a discussion of the typical gamma survey instruments that will be used. In addition, Sections 3.6.3 and 3.6.4 of the draft final work plan describe the survey follow up process using additional gamma instruments.

22. Section 3.4 Radiological Investigation Design, page 3-4, paragraph three, sentences two and three: "Phase 1 includes the radiological investigation of 21 previously established TUs and Phase 2 includes the remaining 42 TUs in Parcel G. Similarly, for surface soil areas associated with soil from building sites, Phase 1 includes the radiological investigation of 14 of the 28 SUs and Phase 2 includes the remaining 14 SUs in Parcel G."

Please refer to the United States Environmental Protection Agency (US EPA) Review of the Draft Parcel G Removal Site Evaluation Work Plan, Hunters Point naval Shipyard, San Francisco, California, June 18, 2018, USEPA Review dated August 14, 2018; comments for specific areas to be surveyed.

The text in Section 3.4 has been updated to reflect the regulators' approach. For the building site SUs, because 100 percent surface scans were added for all TUs and SUs, the building site SUs will all be investigated consistently and concurrently, and there are no longer phases for surface soil SUs.

23. Section 3.4.1, Number of Samples, page 3-4, paragraph one, sentence one, "Following the previously established protocol (TtEC, 2012), a minimum of 18 systematically located samples will be collected from each TU or SU."

- a. Please provide the calculations which will determine the number of soil samples to be collected reflective of new reliable data.

See response to USEPA General Comment 5.

The Navy's 's response to USEPA General Comment 5 appears to say that the Navy believes that while the MARSSIM approach for arriving at the number of soil samples to be collected is preferred, it will in this instance adopt USEPA methodology to speed regulators concurrence. However in this response the request of providing the calculations is not addressed.

The response to USEPA General Comment 5 includes the inputs for the MARSSIM calculations and the calculations are provided in Section 3.4.1 of the draft final work plan.

- b. Does this mean that for soils surveyed on a radiological survey yard (RSY) pad, a minimum of 18 (or otherwise determined number of samples) systematically located samples will be collected from each six inch lift of soil from TU or SU?

Correct.

- c. What trigger value will cause biased samples be collected and analyzed?

Section 3.4.6 states "Biased samples will be collected from potential areas of elevated activity displaying gamma scan survey results greater than the investigation level."

24. Section 3.4.4 Phase 1 Trench Unit Design, page 3-5, paragraph two, sentence two, "The excavated soil material will be investigated by gamma scan surveys and systematic and bias soil sample collection following either the automated soil sorting system process (Section 3.6.3.1) or the RSY process (Section 3.6.3.2)." Please see comment number 12.

See response to CDPH Specific Comment 12.

25. Section 3.4.5 Phase 2 Trench Unit Design, page 3-7, paragraph two, sentence one, "Within the backfill of each previous TU boundary, six systematic locations will be cored down to approximately 6 inches below the depth of previous excavation."

- a. According to Regulators' Approach (<https://semsub.epa.gov/work/09/100009179.pdf>; pg. 36-38) the number of core samples required within the trench will be determined based on new reliable data and statistical analysis.

See response to USEPA General Comment 5.

The Navy's 's response to USEPA General Comment 5 appears to say that the Navy believes that while the MARSSIM approach for arriving at the number of soil samples to be collected is preferred, it will in this instance adopt USEPA methodology to speed regulators concurrence. However in this response the request of providing the calculations is not addressed.

The response to USEPA General Comment 5 includes the inputs for the MARSSIM calculations and the calculations are provided in Section 3.4.1 of the draft final work plan. Although the Navy does not agree with USEPA's interpretation of relevant guidance and decision documents, USEPA's proposal has been incorporated into the work plan to expedite approval.

EMB asserts that the term, "core samples", refers to the entire soil column (plug) removed as a result of direct push technology. From this column of soil any number of individual soil samples may be obtained, the agreed upon number of samples appears from Appendix A is that five samples will be obtained from each core sample.

A minimum of five subsurface soil samples will be collected from each core location at the onsite RBAs. As noted in Section 3.6.4 of the draft final work plan, a minimum of 3 samples will be collected from each Phase 2 core location.

- b. EMB asserts that the term, "core samples", refers to the entire soil column (plug) removed as a result of direct push technology. From this column of soil any number of individual soil samples may be obtained. For example: if the value, "N", is calculated from new reliable data such that the resulting value of, "N", is 20; then 20 core sample soil columns (plugs) must be obtained. In this example, if 3 soil samples were obtained from each core sample soil column (plug); then the resulting number of soil samples to be collected is 60.

Text and figures throughout the work plan have been modified to reflect the requirement to have "N" (equal to the number of samples required in a unit) boreholes within the boundary of each Phase 2 TU.

26. Section 3.4.6 Phase 1 Survey Unit Design, page 3-7, paragraph one, sentence one, "Radiological investigations will be conducted on a targeted group of 14 of the 28 SUs associated with soil from building sites where only surface soil scanning and sampling was previously conducted (Figure 3-1)." Please refer to the United States Environmental Protection Agency (US EPA) Review of the Draft Parcel G Removal Site Evaluation Work Plan, Hunters Point naval Shipyard, San Francisco, California, June 18, 2018, USEPA Review dated August 14, 2018; comments for specific areas to be surveyed.

See response to CDPH Specific Comment 22.

27. Section 3.4.6 Phase 1 Survey Unit Design, page 3-7. paragraph two. Sentence four, "Gross gamma and gamma spectra obtained during the surface gamma scan surveys will be analyzed using region of interest peak identification tools for the ROCs." Please see comment number 21.

See response to CDPH Specific Comment 21.

28. Section 3.4. 7 Phase 2 Survey Unit Design. page 3-8. paragraph one. sentence one, "Phase 2 soil area SUs will be characterized by collecting systematic surface soil samples." Please include a 100% Gamma Walkover Survey (GWS) for phase 2 surface soil areas.

See response to CDPH Specific Comment 22. In addition, the work plan has been updated to include the 100 percent surface scan of all TUs and SUs.

29. Section 3.5.1 Soil Gamma Scanning Instruments, page 3-8, paragraph one, sentence four, "The spectra will be evaluated using regions of interest peak identification tools for the ROCs that correspond to gamma rays at 186 keV for 226Ra, 609 keV (226Ra daughter 214Bi), and 662 keV for 137Cs." Please see comment number 21.

See response to CDPH Specific Comment 21.

30. Section 3.5.2.2 Gamma Scan Minimum Detectable Concentration, page 3-9, paragraph one. sentence one, "Field instrument use will be evaluated and controlled to verify that MDCs less than the appropriate limit for scanning measurements are routinely achieved". This apparently contradicts Section 3.3.1 Investigation Levels, page 3-3, Table 3-6, Soil Survey Measurement Investigation Levels, Investigation Level (pCi/g), footnote, "a",

"Gamma scan surveys will not detect 137Cs at 0.113 pCi/g." Please explain how MDCs less than the appropriate limit for scanning measurements are routinely achieved.

See response to USEPA General Comment 10.

31. Section 3.5.2.2 Gamma Scan Minimum Detectable Concentration, Equation 3-1. CDPH-EMB believes this equation to be incorrectly stated. Table 6.4, NRC, 1998 applies to static one minute counts specific to U-238. The equation does not include both the weighted instrument and surface efficiencies in its calculation. Please review; and if necessary, correct.

The discussion has been revised to reflect updated gamma scan MDC calculations, and the reference to Table 6-4 has been removed.

32. Section 3.6.3 Phase 1 Trench Unit Investigation, page 3-13, paragraph two, sentence three, "One hundred percent of the Phase 1 ESU soils will undergo scan surveys using real-time gamma spectroscopy equipment in the soil sorting process or the RSY pad process." See comments numbers ten and 17.

See responses to CDPH Specific Comments 10 and 17.

33. Section 3.6.3 Phase 1 Trench Unit Investigation, page 3-13, paragraph three, sentence four, "Following completion of scanning activities, the ESU and SFU material will be returned to the same trench that the material originated from." What procedure will be followed if elevated radiological readings exceed the RGs or are not comparable to reference areas? Please explain.

Text in the Executive Summary and throughout the work plan has been updated to describe an in situ investigation of the open excavation if an exceedance not attributable to background in an SFU is found, and an in situ investigation and/or remediation will be performed prior to backfill.

34. Section 3.6.3.1 Automated Soil Sorting System Process, page 3-14. Please see comment number 12.

See response to USEPA Specific Comment 12.

35. Section 3.6.3.1 Automated Soil Sorting System Process, page 3-15, Soil Sampling, paragraph two, sentence one, "One bias soil sample will be collected from the soil material that has been discharged to the "Diverted Pile" bin." A soil survey aimed at representative sampling of diverted soil shall be performed on all soils discharged to the diverted soils bin and the design of that survey should be provided in the work plan. What other actions will be taken when soil is diverted to document the TU and areas from which the soil originated?

See response to CDPH General Comment 5.

36. Section 3.6.3.2 Radiological Screening Yard Pad Process, page 3-16, Investigation, paragraph one, sentence one, "A minimum of 18 systematic soil samples will be collected along with any bias samples based on the results of the gamma scan surveys." Please see comment number 23 (a).

See response to CDPH Specific Comment 23a.

37. Section 3.6.3.2 Radiological Screening Yard Pad Process, page 3-16, Investigation, paragraph two, sentence two, "The Bicon 3x5x16 Na/ detector coupled to a multi-channel analyzer (or equivalent system) will be equipped with spectral capabilities to provide isotopic identification and quantification in addition to gross gamma readings." At what threshold point will elevated gross gamma readings initiate additional investigation? Please explain.

See response to USEPA General Comment 11.

The response does not address the question of a threshold value for gross gamma readings. Please provide the requested information.

Additional text has been added as Section 3.5.1.1 in the draft final work plan describing the use of the RS-700 system for gamma scanning. A description of the data evaluation process and the threshold, or investigation levels, when additional investigation is initiated is also provided.

38. Section 3.6.3.2 Radiological Screening Yard Pad Process, page 3-17, Investigation, paragraph three, sentence one, "Datasets will be transferred from the data logger onto a personal computer to create spreadsheets and geographic information system-plotted maps." Please provide the contour information (contour method, dot size and appropriate defaults) as contour mapping can smooth over discrete elevated locations.

The referenced section describes posting plots rather than contour maps. A statement has been added to Section 5 requiring the Parcel G contractor to provide information on the contour method, dot size, and appropriate information on default values used if contour plots are included in the report.

39. Section 3.6.3.2 Radiological Screening Yard Pad Process, page 3-17, Investigation, paragraph three, sentence five, "Bias samples will be collected from potential areas of elevated activity displaying gamma scan survey results greater than the investigation level (Section 5.3.1)." Since the gamma scan instrumentation being employed cannot detect the RG 0.113 pCi/g value for Cs-137; does this mean that every identification of Cs-137 will necessitate a bias sample? Please explain. Will gross gamma concentrations trigger further investigation? Please explain.

Biased samples will be collected to investigate scan measurements that exceed investigation criteria within the regions of interest or in the gross count rate window. The gamma scanning system will detect Cs-137 photons; however, individual measurements are not intended to characterize Cs-137 at or below the RG. Therefore, biased soil sample collection will not be based on Cs-137; however, the soil samples will be analyzed for Cs-137. The text was updated for clarification.

40. Section 3.6.4 Phase 2 Trench Unit Investigation, page 3-17, paragraph one, sentence one, "Investigations of the Phase 2 TUs will consist of a combination of core scan surveys and soil samples". The Regulatory Agency Approach for Parcel G- March 23, 2018; offers relief from having to excavate 67% (43) trench units. However; the proposal is conditional in the sense that DON must fulfill the survey requirements outlined in the proposal. Please explain why only surface scans above cores are proposed for the Phase 2 TU investigation instead of 100% surface scans; and how this meets the requirements of Regulators' approach.

Text in the Executive Summary and throughout the work plan has been updated to include the 100 percent surface scan of all TUs.

41. Section 3.6.4 Phase 2 Trench Unit Investigation, page 3-18, paragraph two, sentences one and two: "An additional set of 18 systematic samples will be collected from 6 systematic locations representative of the trench sidewalls. The six core locations will be located within 1 meter of the previous sidewall excavation limits and Will extend to the maximum previous excavation depth." According to Regulators' Approach (<https://semsub.epa.gov/work/09/100009179.pdf>; pg. 36-38) the number of core samples required within the trench will be determined based on new reliable data and statistical analysis.

a. Please see comment number 23 (a),

b. Please note core sample locations are required every 50 linear feet, for trenches greater than 150 linear feet; how will 6 core sampling locations meet this sampling requirement?

See response to CDPH Specific Comment 23a. The sampling approach of the Phase 2 TU sidewall sampling has been modified to reflect the requirement to place a borehole every 50 linear feet, and the text and figures have been updated.

42. Section 3.6.5 Phase 1 Survey Unit Investigation, page 3-19. Please amend this section title so that it is clear that the section refers to building site soil units.
- The section was retitled Former Building Site and Crawl Space Soil Survey Unit Investigation.**
43. Section 3.6.5 Phase 1 Survey Unit Investigation, page 3-19, paragraph four, sentence one, "Datasets will be transferred from the data logger onto a personal computer to create spreadsheets and, if feasible, gamma scan survey results will be mapped." Please see comment number 38.
- See response to CDPH Specific Comment 38.**
44. Section 3.6.5 Phase 1 Survey Unit Investigation, page 3-19, paragraph four, sentence two, "Data obtained during the surface gamma scan surveys, including gross gamma, and individual radionuclide spectral measurements, will be analyzed to identify areas where surface radiation levels appear to be greater than the radionuclide-specific investigation levels using regions of interest-peak identification tools." Please ensure that gross gamma scan data; which is not the same as interest-peak identification, is analyzed to identify areas of elevated gamma activity, flagged for field verification and noted on a survey map.
- See response to USEPA General Comment 11.**
45. Section 3.6.5.1 Surface Soil Sample Collection, page 3-21. Please retain all soil samples for CDPH-EMB confirmatory analysis.
- The text was updated to state that soil samples will be retained, for possible CDPH-EMB confirmatory analysis, until the contractor for Parcel G soil work demobilizes from the site.**
- Please note CDPH-EMB does not analyze confirmatory soil samples until it has received a Draft Final Status Survey to review. Since the contractor may have already completed the work for this contract and decamped; CDPH-EMB believes all soil samples should be archived and maintained by the Navy until the Final Status Survey for Parcel G is finalized. Also is there a Navy policy for sample retention? If so, what is that policy?
- The Navy does not typically store samples beyond the field duration for a project. The Navy does not maintain facilities to store soil samples and therefore cannot guarantee the integrity of the samples after the contract ends. In this case, the Navy will hold the samples until the Final RACR is submitted and the work plan was updated accordingly.**
46. Section 3.6.7 Phase 2 Survey Unit Investigation, page 3-20. Please amend this section title so that it is clear that the section refers to building site soil units.
- For the building site SUs, because 100 percent surface scans were added for all TUs and SUs, the building site SUs will all be investigated consistently and concurrently, there are no longer phases for surface soil SUs, and the former Section 3.6.7 was removed.**
47. Section 3.7 Radiological Laboratory Analysis, page 3-21. Please include as appendices the laboratory procedures for analyzing the ROCs.
- The laboratory procedures are included in the draft SAP that was submitted for review on August 16, 2018.**
48. Section 3.7 Radiological Laboratory Analysis, page 3-21, paragraph two, sentence one. "Analysis will be based on the site-specific ROCs listed in Table 3- 4, and in accordance with the SAP. The soil samples will be assayed using gamma spectroscopy analysis for ¹³⁷Cs and ²²⁶Ra with at least 10 percent of samples receiving gas flow proportional analysis for ⁹⁰Sr." How will the 10 percent of soil samples to be examined for ⁹⁰Sr be selected? Please explain.
- The Sr-90 analyses for the systematic soil samples will be randomly selected for 10 percent of the samples from a survey unit. The text has been updated for clarification.**
49. Section 3.7 Radiological Laboratory Analysis, page 3-21, paragraph two, sentence four. "Additionally, if the laboratory results indicate concentrations of ¹³⁷Cs above its RG, the sample will be analyzed for ⁹⁰Sr. If the laboratory results indicated the presence of concentrations of ¹³⁷Cs or ⁹⁰Sr at or above the RG, additional analysis via alpha spectrometry for ²³⁹Pu will be performed." Please perform alpha spectrometry for ten percent of soil samples for ²³⁹Pu in addition to those samples whose concentrations of ¹³⁷Cs or ⁹⁰Sr are at or above the RG.
- Pu-239 is only an ROC at the Former Buildings 317/364/365 Site; therefore, analysis for Pu-239 will be performed for 10 percent of systematic soil samples associated with the former Buildings 317/364/365 Site. The 10 percent will be selected at random. Additional Pu-239 analyses will be performed on samples with Cs-137 or Sr-90 results at or above the RG. The text has been updated for clarification.**
50. Section 4.1 Data Quality Objectives, page 4-1, bullet 4, sentence one, Step 4- Define the Study Boundaries: "The study boundaries are accessible interior surfaces of Buildings 351, 351A, 366, 401, 411, and 439, and the concrete pad at former Building 408 (Figure 4-1)." Please refer to the United States Environmental Protection Agency (USEPA) Review of the Draft Parcel G Removal Site Evaluation Work Plan, Hunters Point naval Shipyard, San Francisco, California, June 18, 2018, USEPA Review dated August 14, 2018; comments for specific areas to be surveyed.
- The text in Section 4.1 has been updated to reflect the regulators' approach.**
51. Section 4.4.1 Number of Static Measurements, page 4-3, paragraph one, sentence two, "Following the previously established protocols (TtEC, 2012), a minimum of 18 measurements will be performed in each SU and on each RBA surface type." Please see comment number 23 (a).
- See response to USEPA General Comment 5.**
52. Section 4.4.2 Radiological Background, page 4-3, paragraph one, sentence three. "At least 18 static measurements will be taken on each surface material in the RBA that is representative of the material in the building SUs". Please provide the calculations which will determine the number of surface material samples to be collected reflective of new reliable data. Please see comment number 23 (a).
- See response to USEPA General Comment 5.**
53. Section 4.4.3 Survey Units, page 4-3, paragraph one, sentence one, "Parcel G buildings will be divided into identifiable SUs similar in area and nomenclature to the previous final status survey of each building." If the proposed Parcel G SUs design deviate from the previous Parcel G building SUs in area, nomenclature or material, please explain the reason for the deviation.
- The building survey unit boundaries and designations used in the previous surveys will be used for this investigation. Any building-specific variations have been indicated in Section 4, such as the reduction in Class 2 survey unit area sizes attributable to the removal of wall surfaces during recent lead and asbestos abatement activities.**
54. Section 4.4.3 Survey Units, page 4-3, paragraph one, sentence three, "The remaining upper wall surfaces and ceilings will form the remaining survey units of no more than 2,000 m² each".
- a. Please state clearly if the remaining 2,000 m² upper wall surfaces and ceilings will form either Class I or Class II MARSSIM SUs.
- Remaining walls above 2 meters from the floor and remaining ceilings will be combined into Class 2 survey units, and will not exceed 1,000 square meters in area. Section 4 has been revised to expand the discussion of the survey unit designation and classification.**
- b. For all Building Floor Plan Figures; Figure 4-2 through and including Figure 4- 8, please include the remaining 2,000 m² SUs in the figures.

These figures have been updated to include the remaining SUs.

- c. Please include the remaining 2,000 m² SUs as a part of Figure 4-10, "Example Building Survey Unit and Sample Locations".

A figure has been added to provide an example of Class 2 boundaries and measurement locations.

- d. For those buildings which are not surveyed in their entirety; please explain why only a portion of the building was subject to a MARSSIM survey.

See response to USEPA General Comment 18b.

- e. Please provide a Class II MARSSIM buffer survey around where Class I MARSSIM surveys performed.

See response to USEPA General Comment 15c.

USEPA General Comment 15(c) does not address question regarding buffer zones. Please address.

Class 2 surveys will be performed in buffer areas surrounding Class 1 survey units. For this investigation, survey unit boundaries and classifications will match the survey units previously established by TtEC to the maximum extent practicable.

- f. Please clarify if task specific plan or a work plan will be prepared for each individual building.

Building-specific TSPs or separate work plans are not planned because this work plan contains the information typically provided in TSPs. In addition, the methodology outlined in this work plan is applicable to all remaining impacted buildings in Parcel G.

55. Section 4.5.4 Instrument Efficiencies, page 4-4, Table 4-3. Survey Instrument Efficiencies and Background Count Rates from Manufacturers. Please include manufacture's name in table.

Manufacturers' names have been included for each model referenced.

56. Section 4.5.4 Instrument Efficiencies, page 4-4, Table 4-3. Survey Instrument Efficiencies and Background Count Rates from Manufacturers, Parameter. Alpha total efficiency (4π) for 235U, Model 3030, "0.39". EMB staff is unable to find this U-235 value on manufacture's website or in their product manual. Please describe origin of this value.

The value of 39 percent is the 4-pi efficiency for U-238 reported at <https://ludlums.com/products/all-products/product/model-3030>. The maximum alpha energy for U-235 is nearer to the maximum alpha energy for U-238 than for other reported radionuclides.

57. Section 4.5.7.3 Probability of Alpha Detection for High-background Detectors, page 4-7, Equation 4-2. This equation appears to have elements of two MARSSIM Appendix J equations; for P (n21) and for P (n22) comingled. Please review and correct if necessary.

The derivation has been revised to show all steps, and it references MARSSIM equations as applicable.

58. Section 4.5.7.4 Beta Scan Minimum Detectable Concentration, page 4-8, Equation 4-4. Please examine this term and correct if necessary.

This equation is correct, with the assumption that the time the detector is over a given area (i) is also the detector dwell time (t). The derivation has been revised to show all steps, and it references MARSSIM equations as applicable.

59. Section 4.5.7.4 Beta Scan Minimum Detectable Concentration, page 4-9, Table 4-6. Beta Scan Minimum Detectable Concentrations. Please examine these results and correct if necessary.

Beta Scan MDCs in Table 4-6 have been reviewed and updated as necessary.

60. Section 5, Data Evaluation and Reporting. Please add, where applicable, specifications for data evaluation such as those specified in comment number three.

See response to CDPH General Comment 3.

61. Section 5.3.1 Identify Potential Areas of Elevated Activity, page 5-4, paragraph one, sentence six, "In addition, SU areas with multiple lines of evidence indicating a potential increase in localized activity based on posting plots, histograms, and Q-Q plots of scan, static measurement, or sample data will be investigated as a potential area of elevated activity." Please quantify what is meant by the phrase, "... of evidence indicating a potential increase"; i.e., what level of increase will trigger additional investigation. Also please include normal (log) probability plot.

Interpretation of graphical representations of data are subjective and may differ between reviewers. Copies of graphs used to present survey data will be included in all reports so that these subjective interpretations can be reviewed. Conclusions will be drawn based on lines of evidence and will be made on a case-by-case basis, so a single trigger based on the graphical review cannot be established. Also, as stated in Section 5.2.2, a normal probability plot is another name for a Q-Q plot.

62. Section 5.3.2 Investigate Potential Areas of Elevated Activity, page 5-5, paragraph one, sentence five, "Determining the extent of elevated activity for ROCs without a significant gamma emission, such as 90Sr and 239Pu, will require collecting additional soil samples or establishing a correlation between the difficult-to-detect ROC and 226Ra." Please see comment number 49.

See response to CDPH Specific Comment 49.

63. Section 5.3.2 Investigate Potential Areas of Elevated Activity. page 5-5, paragraph three, sentence four, "If the revised 226Ra result exceeds background by more than 1.0 pCi/g, additional evaluation may be performed." Please delete indicated phrase and replace with, "and not shown to be NORM or anthropogenic background; then sample demonstrates non-compliance with Parcel G ROD RAO and is deemed a failure."

Section 5 has been revised to clarify the NORM evaluation process. See response to USEPA General Comment 2.

64. Section 5.5 Reference Background Area Soil, page 5-6, Equation 5-1. Equations drawn from source texts, technical references or regulatory guides should include source citations to assist in the review process

Equation 5-1 has been removed, along with the discussion on determining representativeness of RBA data sets.

65. Appendix A: Section 3.1.3 Reference Background Area Locations, page 3-2, paragraph one, sentence four, "In order to simplify the sampling design, an approximately 20-foot by 20-foot square has been established within each of the four historical RBA footprints."

- a. This area is too small to be completely representative of reference background area. Please resize and provide an explanation of the size provided.

- b. Please provide unique nomenclature for the, "footprints", as it is confusing to the reader if the text is referring to the larger RBA or the smaller internal footprint.

The onsite areas included in the RBA surface and subsurface sampling have been expanded to areas of approximately 2,500 square feet. The text and figures have been revised accordingly.

66. Appendix A: Section 3.1.4 Number of Samples, page 3-3, paragraph one, sentence two, "The NRC criteria for providing characterization of a complex site, found in United States Nuclear Regulatory Commission Regulation (NUREG) 1505 (NRC, 1998) is at least 100 samples from at least 5 distinct

locations." This appears to be a reference to Table 13.5 Power of the F-test When $w^2 = \sigma^2$. Data drawn from source texts, technical references or regulatory guides should include source citations to assist in the review process. The text notes that Table 13.5 is a step in the application of Scenario B, which in turn requires the application of the Quantile test to, " ... detect non-uniform concentrations of residual radioactivity that may be excess of the release criteria, but might be missed by the WRS test." Will the Quantile test be applied to the soil sample results drawn from Parcel G SUs and TUs?

See response to USEPA General Comment 12d.

There are not six reference areas, but five reference areas. Each reference area will have 25 surface samples and 25 sub-surface samples. Please check if the number of samples and the corresponding confidence level provided in Navy's response match with Table 13.5 of NUREG 1505.

The response to USEPA General Comment 12d has been revised to clarify that the discussion of six reference areas was using an example from Table 13.5 of NUREG 1505. As noted in the response, the numbers of samples and reference areas planned for the RBA study exceed those in the example and will therefore result in a power of greater than 99% if all 10 data sets (2 from each RBA) are combined. If fewer than all 10 data sets are combined, Table 13.5 will be used to evaluate the statistical power associated with the combined data sets.

67. Appendix A: Section 3.1.4 Number of Samples, page 3-3, paragraph one, sentence six, "Five surface soil samples will be collected from RBAs 1 through 4, for a total of 25 onsite surface soil samples." Please check the multiplication in this sentence and in bullet number four. In order to make a valid comparison between survey units (TUs or SUs) and their relevant reference background areas (RBAs); CDPH-EMB requires that the RBAs have a technically defensible number of systematically located soil samples. If it is the intent to have four separate RBAs established to represent four different kinds of SU or TU conditions, please explain how five surface soil samples from the selected RBA could be used to make a valid statistical comparison to the 18 or more samples drawn from the SU or TU.

The text was updated to indicate that 25 surface and 25 subsurface soil samples will be collected from each RBA location.

Thanks for the clarification. In the text also include the depth of sub-surface samples for the onsite RBA and offsite RBA.

The depths of the subsurface samples are included in the work plan.

68. Appendix A: Section 3.2.3, Scan Measurements, page 3-9, paragraph three, sentence two, "An instrument-specific SOP will be provided to the Navy prior to initiation of field activities." Please provide a copy to the regulatory agencies for review at the same time.

The instrument-specifics were added to the work plan.

69. Appendix B: Draft Radiation Protection Work Plan Radiological Data Evaluation and Confirmation Survey: Section 2.6, Radiological Control Technicians. page 6, paragraph one, sentences two and three: All RCT's shall be qualified as senior RCT's (\leq 5 years as a qualified and documented RCT, either U.S. Department of Energy core, North East Utility Exam, National Registry of Radiation Protection Technologists [NRRPT], etc.). On a case by case basis, Jr RCTs will be evaluated by CH2M.

- a. Is the intent of sentence two to require 5 or more years' experience to qualify as a Senior RCT? Please explain.

Yes, a minimum of 5 years' experience is required to qualify as a Senior RCT.

- b. Will work performed by Jr RCT's be countersigned by a Senior RCT? Will a promotion from Jr. RCT to Senior RCT on the project call for the same experience and training requirements to be met as technicians originally hired as Senior RCTs?

Yes, work by a Junior RCT will be countersigned by a Senior RCT, and the requirements for promotion to a Senior RCT title are the same as the new hire requirements.

SDFPH Comments

General Comments

1. It is hard to track the slightly scattered details in the plan regarding the radionuclides of concern (ROCs) and corresponding RGs that are applicable to individual areas and survey types. A number of specific comments regarding these possible inconsistencies have been included. Similarly, the plan also seems inconsistent regarding whether all samples will be analyzed for all ROCs or just subsets of samples for certain ROCs. It might help the reader to provide some clarification in summary tables?

Refer to Tables 3-4 and 4-1 for descriptions of the ROCs for each area or building in Parcel G. The discussion in Section 3.7 was updated to provide additional details on the radionuclide analyses that will be performed.

2. In our professional judgement, the use U-238 as a proxy for Ra-226 may cause problems in your evaluation. We have found that this equilibrium is not consistent between U-238 and Ra-226 in real-world environmental samples. Additional detail on that issue is provided in the specific comments.

Comment noted. See response to USEPA General Comment 19.

Specific Comments

3. Executive Summary, Background, Page III, and Section 1, Introduction, Page 1-1: The introduction paragraphs of the Executive Summary and Section 1 state "Radiological surveys and remediation were previously conducted at Hunters Point Naval Shipyard (HPNS) as part of a basewide Time-critical Removal Action (TCRA) in accordance with the Action Memorandum (Navy, 2006)." Please clarify this broad statement since radiological surveys and remediation activities were also performed at HPNS prior to 2006. For example, if true, the sentence could be clarified by inserting 'Parcel G': "Radiological surveys and remediation were previously conducted at Hunters Point Naval Shipyard (HPNS) [Parcel G] as part of a basewide Time-critical Removal Action (TCRA) in accordance with the Action Memorandum (Navy, 2006)." That way it is clear that Parcel G work was all done after 2006 (if true).

The text was simplified to eliminate confusion.

4. Executive Summary, Soil Investigations, Page IV and Figure ES-1, Soil and Building Sites: The text states that the approximate size and boundary of the TUs and SUs are shown on Figure ES-1. Please consider revising to state that the buildings and former buildings (of interest for this study) and the storm drain and sanitary sewer trench outlines are shown on Figure ES-1. Or consider deleting this sentence as TUs and SUs are not specifically identified on Figure ES-1. Or you could insert a Figure like 3-1 that does identify TUs and SUs?

The sentence was deleted.

5. Section 2, Conceptual Site Model, last sentence of the second paragraph: If the results were based on the 186 keV photopeak then, in our opinion, they were biased high in all cases from the presence of naturally-occurring U-235 and you could emphasize that point by striking the word "often".

Agreed. The text was revised as suggested.

6. Section 2, Conceptual Site Model, Table 2-1, last section on uncertainties, fourth main bullet: Please revise as follows to provide the important distinction that Navy activities “potentially” contributed: “... are present at HPNS because of global fallout..., in addition to being potentially present due to Navy activities”.

The text was revised as suggested.

7. Table 2-1, Conceptual Site Model, Radionuclides of Concern for Parcel G (from Table 8-2 of HRA): Table 2-1 identifies ROCs for interior surfaces at former Buildings 364 and/or 365 as ⁶⁰Co, ²³²Th, ²³⁵U, and ²³⁹Pu. Given that these buildings have been demolished is the intention that these ROCs be investigated as part of the planned soil survey unit investigation or will (some of) these ROCs be excluded from the proposed analytical suite? Please explain reasoning for including or excluding select ROCs. Table 3-4 identifies the ROCs for the Former Buildings 317/364/365 Site as ¹³⁷Cs, ²²⁶Ra, ⁹⁰Sr, ²³⁹Pu (excluding ⁶⁰Co, ²³²Th, and ²³⁵U). If these are the only ROCs being tested then Table 2-1 might need to state that sites where buildings have since been demolished will only be investigated for the Table 3-4 radionuclides and not this full historical list of radionuclides that might have been in the buildings before demolition.

A footnote has been added to Table 2-1 to note that the soil and building investigations are based on the ROCs in Table 3-4 and 4-1.

8. Table 2-1, Conceptual Site Model, Uncertainties:

- a. Bullet 1, sub-bullet 3: We note that the pipes were often reported as “crushed” or “disintegrated” and sent to the RSY pads along with soil. Therefore, it is unclear whether all pieces of pipelines were removed if they disintegrated and were indistinguishable from the soil. Although it might be difficult, is there a percent that can be attached to the report of “disintegrated” pipes so the sub-bullet can have that clarified?

The percentage of disintegrated pipes is assumed to be negligible, and if still present, disintegrated pipes will be investigated as part of this work plan.

- b. Bullet 1, sub-bullet 7: Can you clarify the implication that LLRW bins were tested by the Navy’s independent waste broker at an offsite laboratory using 5-point composites, and only 3 out of 1,411 bins had results with ²²⁶Ra above the RGs. Were these soils still disposed of as LLRW?

The discussion in sub-bullet 7 was meant to illustrate that the overall risk presented by the soil with elevated individual Ra-226 sample results is very low. Consistent with Navy procedures, the soils were disposed as LLRW.

9. Section 3.3, Remediation Goals: Table 3-5 includes a soil RG for Pu-239 and the accompanying text states that “soil data will be compared to the RGs ...” Table 3-4 implies that Pu-239 is a ROC for just soils associated with specific building sites. Please clarify whether Pu-239 is considered a ROC for all soils, or just some soils.

Pu-239 is only an ROC at the Former Buildings 317/364/365 Site, and a footnote was added to the table for clarification.

10. Section 3.3.1, Investigation Levels, second paragraph: An investigation level should indicate when a measurement indicates activity that is encroaching upon or exceeds an applicable RG. Why would that vary with a survey unit classification?

The text was removed.

11. Section 3.3.1: Investigation Levels: Please add some discussion somewhere in the work plan regarding compensatory measures that will be used to identify small areas of elevated activity or locations where biased samples should be collected for ROCs that cannot be detected via gamma scanning. The plan points out that the RG for Cs-137 is indistinguishable from the local background and cannot be detected as a contaminant because the scan techniques lack sufficient sensitivity. Sr-90 likewise cannot be detected by a gamma scan because it is a Beta-only emitter, however, when the Sr-90 is still contained within a metal housing the energy travelling through the metal can sometimes emit a signal that is detectable by the gamma scan technology.

Small areas of elevated activity will be identified by gamma scanning. Demonstrating compliance with the Cs-137 and Sr-90 RGs will be based on soil sample analytical results in comparison to the RGs and background. The text was updated for clarification.

12. Section 3.3.1, Investigation Levels, Page 3-3, and Section 3.6.3.1, Automated Soil Sorting System Process, page 3-14: Section 3.3.1 states soil gamma scan survey measurement investigation levels are not applicable for 137Cs based on a detection limit of less than 0.113 pCi/g (Residential Soil Remediation Goal (RG) prior to addition of background); however, Section 3.6.3.1 states that the large-volume gamma spectroscopy detectors proposed under the automated soil sorting system process are capable of monitoring 137Cs. Are the automated soil sorting system detectors capable of detecting 137Cs at the RG? If not, please clarify in the text the scanning capabilities.

The soil sorting system that is selected to perform the work must be capable of monitoring the gamma-emitting ROCs including Ra-226 and Cs-137. The minimum requirements for the soil sorting system detectors, MDCs, and diversion settings were added to the work plan. The specific soil sorting configuration will be provided in a separate Soil Sorting Operations Plan by the contractor who is performing the Parcel G investigation. It is not expected that the soil sorting system will be able to confidently detect Cs-137 at 0.113 pCi/g in an individual measurement; therefore, demonstrating compliance with the Cs-137 RG will be based on soil sample analytical results in comparison to the RG and background.

13. Section 3.4.4, Phase 1 Trench Unit Design, Page 3-5: We note that segregated over-excavated material may ultimately be mixed with soil from the TU following testing upon return to the origin trench.

Comment noted.

14. Section 3.4.4.1, Nomenclature of Phase 1 Trench Units, Page 3-5: Should the example for former TU-153 be “HPPG-SFU-153A” instead of “SFU-153A”?

Yes, and the text was corrected.

15. Section 3.5.1, Soil Gamma Scanning Instruments: Will the isotope-specific Region of Interest data from the gamma scanners be available in real-time, or via post-processing? It seems unlikely that a scan measurement would have sufficient sensitivity for the Bi-214 peak or for Cs-137 at a concentration near the RG. Indeed, Section 3.1.1 states that the Cs-137 RG cannot be detected by scanning. How will scan data for those Region of Interest be interpreted or used?

See response to USEPA Specific Comment 11.

16. Section 3.6.3.2, Radiological Screening Yard Pad Process: states excavated soil will be screened for compliance with the RGs given in Table 3-5. The ROCs in Table 3-5 include Sr-90 and Pu-239, in addition to Cs-137 and Ra-226. Elsewhere in the work plan it is stated that the ROCs for trench unit soils are limited to Sr-90, Cs-137, and Ra-226. Please clarify whether Pu-239 is considered a ROC for trench unit soils (presumably not), and the role of scanning with respect to showing compliance for Sr-90. Will all soil samples be analyzed for Sr-90 in addition to gamma spectrometry?

Per Table 3-4, Pu-239 is considered a ROC only for surface soil associated with the Former Buildings 317/364/365 Site. As described in Section 3.7, a minimum of 10 percent of systematic samples will be analyzed for Sr-90. Demonstrating compliance with the Sr-90 RG will be based on soil sample analytical results, and this was clarified in the work plan.

17. Section 3.7, Radiological Laboratory Analysis: This section of the plan states that only 10% of the samples will be analyzed for Sr-90, plus any that show Cs-137 at or above the RG. It also states that Pu-239 analyses will only be done if both Cs and Sr are found to be above their respective RGs. Elsewhere it is implied that all samples will be analyzed for all ROCs. It would be helpful if the plan did a better job specifying which RGs are applicable to which soils and how compliance with those concentrations is going to be demonstrated.
- The work plan was reviewed and updated for consistency.**
18. Section 3.7, Radiological Laboratory Analysis: Unless separate analyses are intended, clarify that the 21-day ingrowth is only germane for the Ra-226 analysis via gamma spectroscopy, but that analysis will also include concurrent quantification of Cs-137.
- Section 3.7 has been revised to note that the gamma spectroscopy data for all gamma-emitting ROCs (including Cs-137) will be reported following the 21-day ingrowth.**
19. Section 3.7, Radiological Laboratory Analysis, Page 3-21: Please support the decreased frequency of analysis for the site-specific ROCs 90Sr and 239Pu.
- The analysis frequency of Sr-90 and Pu-239 is based on the assumption that, if present, they will be collocated with Cs-137. Elevated Cs-137 results will trigger Sr-90 and Pu-239 analysis for the sample.**
20. Table 4-2: Can you clarify that the RG for structures for Th-232 is less than that for Pu-239?
- Per the 2006 Action Memorandum for HPNS, the structures RG for Th-232 is 36.5 dpm/100 cm² and that for Pu-239 is 100 dpm/100 cm².**
21. Section 4.5.7.2, Scan Investigation Levels: If the SCM to be used would it not make more sense to use the images from the SIMS output to identify areas where static measurements should be collected? It is recognized that data would not be available in real-time, but it can be produced in a reasonable amount of time and would be a more reliable indicator.
- True, and that is the intended approach. During the investigation, alpha and beta scan data will be collected in buildings and will be reviewed. The data will be used to calculate the survey unit-specific number of static samples required to provide enough prospective power as if the WRS test were going to be used. The work plan has been revised to provide more clarity on this topic.**
22. Section 5, Data Evaluation and Reporting: Where recorded, spatially-correlated data should also include modern visualizations and not just be limited to “dumbed-down” plots to match the antiquated methods described in the MARSSIM. Spatial visualizations provide much better sensitivity with respect to identifying artifacts.
- The text was updated to include spatial visualizations of spatially correlated data in the report.**
23. Section 5.3.1, Identify Potential Areas of Elevated Activity, states “Any sample or measurement exceeding a ROC-specific RG will be investigated as an area of elevated activity.” Elsewhere in the work plan it is stated that such exceedances will be deemed a non-conformance with the remedial action objectives rather than treated as an area warranting further investigation. This appears to be an inconsistency that needs to be reconciled.
- The investigation process will proceed as described in the revised DQOs in Sections 3 and 4, and language in Section 5 and throughout the document has been updated to be consistent with this approach.**
24. Section 5.4, NORM Background Evaluation: Any sampling area that represents the background concentration will necessarily have individual results that exceed the average. Indeed, roughly 50% of them will. We think it is scientifically valid to compare the two data sets (reference area and the area under test) as distributions.
- Comment noted. Section 5 has been revised to clarify the NORM evaluation process.**
25. Section 5.4, NORM Background Evaluation, first sentence of second paragraph: We suggest strengthening the statement that the Ra-226 background varies all over the site with the fact the Ra-226 background varies all over the Bay Area and all over the United States. There are numerous examples of data that can be cited to further emphasize that point.
- Agreed. Discussion of other background data sources that may be applicable to HPNS and criteria for their use have been added to the Soil Reference Background Area Work Plan, Section 4.**
26. Section 5.4, NORM Background Evaluation: The statement that U-238 is an “acceptable representative” of uranium series decay progeny cannot be tacitly assumed. That is an oversimplification based in a textbook situation where equilibrium exists. Uranium series disequilibria are common in reality. Radium, thorium, and uranium have different solubilities, and their solubility or soil adhesion characteristics can vary with pH. Any loss of decay progeny through a process other than radioactive decay will break the equilibrium. Preferential depletion or enrichment of U-234 relative to U-238 in geological samples is a well-known phenomenon. Geologic studies showing Th-230 concentrations in excess of the corresponding U-234 concentrations are reported in the literature, as are cases of substantial enrichment of radium relative to the local uranium concentrations. Assuming equilibrium between Ra-226 and U-238 to determine whether or not a given Ra-226 assay represents background has not played out for samples we have reviewed. Indeed, we have seen data from verified clean import samples from the Half Moon Bay area (i.e. available in public documents) that showed Ra-226 concentrations that exceeded the uranium concentration by a wide margin. The samples we are referring to were analyzed via different analysis methods and involved disparate sample volumes so that may factor into the apparent non-equilibrium. In contrast, non-impacted soil samples collected from Treasure Island (i.e. available in public documents) have shown the opposite, i.e. uranium and thorium concentrations that were significantly higher than the corresponding Ra-226. At a minimum we urge that the proposed NORM analyses should include Th-230 and U-234, in addition to U-238 and Ra-226, for the same aliquant. That would at least provide a better indication if an equilibrium condition existed.
- See response to USEPA General Comment 19.**
27. Section 5.5, Reference Background Area Soil Data, Equation 5-1: It seems there should be some evaluation of the median relative to the mean or other consideration of the shape of the underlying distribution before applying its median in this fashion.
- Equation 5-1 has been removed with the discussion on determining representativeness of RBA data sets. Section 5 has been revised to clarify the process for data evaluation.**
28. Section 7.1, Project Waste Descriptions: Consider revising the first sentence to state that wastes generated “may” be radiological in nature instead of “will be.” Or will wastes be deemed radiological by default, without verification?
- Agreed. The text was revised as suggested.**
29. Appendix A, Soil Reference Background Area Work Plan: Selecting additional offsite areas for sampling would go a long way toward demonstrating the variability in background. These additional characterizations would not be for the purpose of defining reference areas, but would serve to emphasize the range of local backgrounds and the fact the current RGs might fall within those ranges. The Bay Area was blessed with a remarkably low average background, but instead of using that as an advantage it sometimes has been turned into a detriment for this project when the true range of background variability was not always analyzed. We have reviewed two sets of samples collected from Half Moon Bay that provide a good example. The results showed very different Ra-226 concentrations, with the concentrations from the first set significantly exceeding those from the

second. The first set of five samples averaged 1.65 pCi/g Ra-226. The second set, consisting of two composite samples, averaged 0.63 pCi/g, more than a factor of two less than the first set. That sort of variability is not unusual and should be accounted for in any radiological evaluations performed at HPNS.

Additional research will be performed to identify other offsite areas that may be suitable as RBAs. If additional areas are selected for sampling, or if other background data sets are identified, justification will be provided in the report.

30. Appendix A, Soil Reference Background Area Work Plan: We recommend including some brief discussion why a RBA was not identified for Parcel G, e.g. ground covering, not an impacted area, etc.

Parcel G was initially part of Parcel D and is adjacent to the Parcel D-2 RBA; therefore, the Parcel D-2 RBA is assumed to be representative of site conditions. The text has been revised to provide additional information on the suitability of the selected RBA areas including this explanation.

31. Appendix A, Soil Reference Background Area Work Plan, DQOs Step 5: If RBA data sets end up being combined that would seem to counter the argument that HPNS is comprised of materials from various origins. Will additional RBAs be identified if the initial data sets are found to be statistically indistinguishable?

Additional RBAs may be identified and sampled if necessary.

32. Appendix A, Section 3.1, Survey Design, third paragraph: The samples from the offsite RBA location should also be analyzed for primordial isotopes and decay series in addition to fallout radioisotopes. Offsite areas should be a focal point to emphasize the variabilities that exist in natural radioelement concentrations. Any primordial series disequilibria observed in the offsite sample data should likewise be emphasized.

Agreed. See Table 3-6.

33. Appendix A, Section 3.1, Survey Design, third paragraph: An evaluation of the relative amounts of the uranium series isotopes U-238, U-234, Th-230, and Ra-226 for each RBA soil sample should be included in addition to the statistical evaluations described so that any departures from equilibrium conditions are identified and accounted for. These assays should be performed from the same or similar-sized aliquants to minimize biases.

Agreed. Where possible, alpha spectroscopy analyses on the uranium decay series alpha emitters should originate from the same sample aliquot. The SAP specifies this requirement.

34. Appendix A Table 3-1 seems to contradict earlier statements that RBA soils will be analyzed for Sr-90, Cs-137, and Ra-226. The table implies that Pu-239 will also be included in those analyses.

Table 3-1 has been removed.

35. Appendix A Section 3.1, Survey Design: If the isotopes and RGs listed in Table 3-2 do not apply globally to all soil units at HPNS then that needs to be discussed and clarified. The ROCs in Table 3-2 differ from those cited in the main body of the Parcel G work plan, which itself seems inconsistent regarding the applicable ROCs for various areas.

Clarification text has been added to indicate that the RBA characterization is intended to analyze ROCs across all parcels at HPNS.

36. Appendix A, Section 3.1.7, Laboratory Analysis: Please confirm if all RBA samples are to receive all of the analyses listed in Table 3-6. If not, then the specific analyses intended for each sample needs to be documented in the SAP or the work plan or both.

Yes, confirmed.

37. Appendix A, Section 4, Data Evaluation and Reporting: The background data analyses and conclusions for each data set or combination of data sets should also address the observed degree of equilibrium (or magnitude of any disequilibria) for the important members of primordial series decay chains (e.g. U-238, U-234, Th-230, and Ra-226).

The Soil Reference Background Area Work Plan Section 4 has been revised to require alpha spectroscopy for U-238, U-234, Th-230, and Ra-226 to evaluate the equilibrium status of the uranium natural decay series in order to assist in the comparison of Ra-226 results with background.

Minor Comments

38. Table 2-1, Conceptual Site Model, Site Location Section: Typo "comer" should be "corner".

This typo has been corrected.

Responses to Comments

Draft Final Parcel G Removal Site Evaluation Work Plan

Former Hunters Point Naval Shipyard, San Francisco, California

The purpose of this document is to address comments on the Draft Final Parcel G Removal Site Evaluation Work Plan, dated November 2018, for Former Hunters Point Naval Shipyard, San Francisco, California. The United States Environmental Protection Agency (USEPA) comments received December 13, 2018, April 25, 2019, and May 22, 2019 and Department of Toxic Substances Control (DTSC) and California Department of Public Health (CDPH) received December 14, 2018 are listed below and responses to comments are provided in bold. The work plan will be updated to address these comments and a final version will be submitted.

USEPA Comments (December 13, 2018)

Evaluation of the Responses to Comments

1. Responses to EPA General Comments 10 and 11 and Appendix C Soil Reference Background Area Work Plan Section 3.1.6.4, Example Gamma Scan Minimum Detectable Concentrations: The responses partially address the comments. The responses refer to the example minimum detectable concentration (MDC) calculations provided in the Work Plan Section 3.5.2.3 (Example Gamma Scan Minimum Detectable Concentrations); however, the calculations include assumptions in identifying the gamma scan achievable MDC of 0.93 picoCuries per gram (pCi/g) for radium-226 (Ra-226) and 2.3 pCi/g for cesium-137 (Cs-137) using a Ludlum 44-20 detector and MDCs of 0.21 pCi/g for Ra-226 and 0.46 pCi/g for Cs-137 using a Bicon 3SSL-X. The following clarifications will make the text more accurate and complete:
 - a. The MDC calculations assume a background level of 18,000 counts per minute (cpm) with 95 percent correct detections and 95 percent (%) false positive rates resulted in a d' of 3.28. However, the calculations were performed assuming a 95% chance of correct detections and a 5% chance of false positives. Please revise the text to correct the reference of 95% false positives to 5%.

The typo will be corrected in Section 3.5.2.3.

- b. The MDC calculations assume a surveyor efficiency of 100% using an automated data logger. Because of the variability of scan speed and distance from the detector to the surface inherent in human operation of such equipment, the efficiency of 100% is often considered to be not achievable. Please revise the text to explain how a 100% efficiency can be achieved or to correct this estimate to a percentage achievable by operators.

For surveys utilizing logging equipment and post-processing, it is common to use a surveyor efficiency of 1. As described in NUREG-1507 Section 6.7, estimated values for surveyor efficiency in the 0.5 to 0.75 range are based on the surveyor's ability to respond to instrument audio response and decide when a measurement requires further investigation. The variability of scan speed and detector distance are not factors in that variable. When using a data logger and post-processing, the surveyor no longer has a decision in determining when investigation is necessary. Therefore, it is reasonable to set a value of 1 to the surveyor efficiency when a data logger is used.

- c. The contaminated zone is assumed to be present in a circular area over 1 meter squared with a depth of 15 centimeters (cm); however, Ra-226 or Cs-137 contamination, if it exists, may not be present in an evenly distributed circular area over 1 m² and 15 cm deep. Therefore, detection of discreet locations of Ra-226 or Cs-137 at or below the remedial goals (RGs) using the gamma scanning may not be realistically achievable. Please revise the text to acknowledge that contamination in this configuration may not be detectable.

The text in the last paragraph of Section 3.5.2.3 will be updated to read as follows (new text is underlined): “... a concentration of 0.113 pCi/g. Note that the measurement geometry and parameters modeled are meant to illustrate an assumption for the calculation. Contamination, if present, may not exist in the same modeled configuration, and the modeled scan MDCs may not apply.”

- d. The MDC for the gamma instrument RS-700 is listed as 0.036 pCi/g, but the calculation for this MDC is not provided. Please revise the Work Plan to include this calculation.

Additional information about the RS-700 referenced in Section 3.5.2 has been provided by the Parcel G soil contractor (Aptim) in the Parcel G Work Plan Addendum.

2. Response to EPA General Comment 10: The response partially addresses the comment. Table 3-7 (A Priori Scan MDCs) does not list the Scan MDCs for the soil sorting system. Please provide this information prior to finalizing the Draft Final Work Plan, if the sorting system will be used.

Implementation of the soil investigation outlined in this work plan will be performed by Aptim. The Soil Sorting Operations Work Plan is provided as Appendix F of the Parcel G Work Plan Addendum (prepared by Aptim). The soil sorting operations plan contains the scan MDCs for the system.

3. Response to EPA General Comment 15, item a: The response addresses the comment. Please also revise Figure 4-4, Building 366 Floor Plan, to include the Class 3 Survey Unit (SU) #69.

A note will be added to work plan Figure 4-4 and SAP Figure 11-7 to state, “SU 69 consists of the building exterior surfaces.”

4. Response to EPA General Comment 15, item b: The response partially addresses the comment. Section 3.7 (Radiological Laboratory Analysis) states that analyses will be based on the site-specific radionuclides of concern (ROCs) as listed in Table 3-4. According to Table 3-4, the ROCs associated with Buildings 317/364/365 site include Cs-137, Ra-226, Sr-90, and Pu-239. In addition, please see the Historical Radiological Assessment (HRA) and the information provided in Section 2, the Conceptual Site Model (CSM), which show additional ROCs. The exception is Cobalt 60. EPA previously wrote the following: “Cobalt 60 (Co-60): The Navy ceased Shipyard operations in 1974, 42 years ago. The half-life of Co-60 is 5.26 yrs. After seven to ten half-lives (i.e., 37 to 53 years), remaining radiological activity would be at levels similar to background. Therefore, Co-60 is not a priority health and safety concern, and any Co-60 sampling conducted would not be a helpful indicator of potential prior falsification.” According to the HRA and CSM, for Building 364, uranium-235 (U-235) is also a ROC; for Building 365, U-235 is also a ROC; for Building 351, thorium-232 (Th-232) is an ROC in addition to Cs-137, Ra-226, and Sr-90; and for Building 351A, plutonium-239 (Pu-239), Ra-226 and Th-232 are also ROCs. For consistency

please revise Section 3.7 to include analyzing all samples for all ROCs, except Co-60, from current and former building areas where the HRA indicates those ROCs were used. For instance, Section 3.7 includes the following rules regarding analysis requirements:

- a. At the former Buildings 317/364/365 where Pu-239 is an ROC, at least 10 percent of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for Pu-239.
- b. At least 10 percent of randomly selected samples will be analyzed by gas flow proportional counting for Sr-90.
- c. If laboratory results indicate a concentration of Strontium-90 (Sr-90) above the RG in a sample, the sample will be analyzed via alpha spectroscopy for Pu-239.

As such, the Draft Final Work Plan should be revised to state that all samples should be analyzed for all ROCs that are applicable to a particular building or building site (except Co-60). In addition, soil samples from all SUs and trench units (TUs) in the vicinity of and downstream of these sites and buildings should also be analyzed for all of ROCs associated with that building or building site (except Co-60). Please revise the Draft Final Work Plan to include these requirements. Please also revise the Draft Work Plan to include analyzing samples from SUs/TUs immediately surrounding and downstream of these building areas for all identified associated ROCs.

Also, Section 4.2 (Radionuclides of Concern) and Table 4-1 (Building Radionuclides of Concern), list Th-232 as a ROC for Building 408 (demolished). Please revise the Draft Final Work Plan to ensure that samples from surrounding or downstream SUs and TUs are analyzed for all ROCs identified for an existing or former building.

The text in Section 3.7 will be updated to include the following:

- **At the Former Buildings 317/364/365 Site and adjacent TUs 95, 117, 118, and 153 (Figure 3-1), where ^{239}Pu and ^{235}U are ROCs, at least 10 percent of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for ^{239}Pu and ^{235}U . A footnote was added to Table 3-4 to clarify that " ^{239}Pu is only an ROC for former Buildings 364 and 365 (NAVSEA, 2004); however, it is included as an ROC for soil at the Former Buildings 317/364/365 Site, that includes former Building 317 based on the location and proximity."**
 - **At the Building 351A Crawl Space and adjacent TUs 115 and 97 (Figure 3-1), where ^{239}Pu and ^{232}Th are ROCs, at least 10 percent of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for ^{239}Pu and ^{232}Th .**
 - **At TU 107 (Figure 3-1), adjacent to Building 408 where ^{232}Th was an ROC, at least 10 percent of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for ^{232}Th .**
5. Response to EPA General Comment 15c: The response states "the RGs are not based on the same dose or risk. Therefore, the use of sum of fractions and unity rule to review total risk is not appropriate for this approach." That is true. Therefore, instead, if have multiple ROCs are present above background concentrations in one location, the Work Plan should include an evaluation to ensure the combined residual risk does not exceed 1×10^{-4} . This evaluation should apply the current version of the EPA PRG Calculator using inputs, assumptions, and

approaches supported by regulatory agencies, as described in the forthcoming final version of the Fourth Five Year Review.

This evaluation will be conducted as part of the Five-Year Review process.

6. Response to EPA General Comment 19: The response partially addresses the comment. Section 3.7 (Radiological Laboratory Analysis) and Section 5 (Data Evaluation and Reporting) still state that if the gamma spectroscopy laboratory results indicate a concentration of Ra-226 above the RG, the sample will be analyzed using alpha spectroscopy for U-238, U-234, Th-230, and Ra-226. Please include all of the uranium and thorium isotopes reportable by alpha spectroscopy. This section and all other sections and figures (i.e. Figure 3.2, Performance Criteria for Demonstrating Compliance with the Parcel G ROD) in the Draft Final Work Plan and the Sampling and Analysis Plan (SAP) (i.e. Worksheets 11 and 15) that list the uranium and thorium isotopes that will be reported for site samples should be revised to list all of the uranium and thorium isotopes reportable by alpha spectroscopy. For consistency and completeness, please revise the Draft Final Work Plan to include the requirement to analyze and report uranium isotopes U-238, U-235, and U-234 and thorium isotopes Th-232, Th-230, and Th-228 by alpha spectroscopy in all relevant sections and figures.

The following sections will be updated to clarify U-238, U-235, and U-234 and Th-232, Th-230, and Th-228 will be reported for all alpha spectroscopy samples analyzed.

Work Plan:

The second sub-bullet under the second bullet under Step 6 of Section 3.1 will be revised to read as follows (new text underlined): “If any ^{226}Ra gamma spectroscopy concentration exceeds the ^{226}Ra RG and the range of expected NORM concentrations, then the soil sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , and ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra to evaluate equilibrium conditions.”

The first sub-bullet under the first bullet in Section 3.7 will be revised to read as follows (new text underlined): “...– If the gamma spectroscopy laboratory results indicate a concentration of ^{226}Ra above the RG in a sample, the sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , and ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra to evaluate equilibrium conditions. Additional...”

The last sub-bullet on Page 5-1 in Section 5 will be revised to read as follows (new text underlined): “Samples with gamma spectroscopy results that exceed the RG and the expected range of background for ^{226}Ra will be analyzed by alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra to evaluate the equilibrium status of the uranium natural decay series to determine whether ^{226}Ra is NORM as described in Section 5.6.”

SAP (Appendix B):

The applicable bullet in Step 6 in Worksheet 11 will be revised to read as follows (new text underlined): “If any ^{226}Ra gamma spectroscopy concentration exceeds the ^{226}Ra RG and the range of expected NORM concentrations, then the soil sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , and ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra to evaluate equilibrium conditions.”

The applicable bullet in Step 7 in Worksheet 11 will be revised to read as follows (new text underlined): Gamma spectroscopy data will be reported by the laboratory after a full 21-day in-growth period. If the laboratory results indicate a concentration of ^{226}Ra above the RG (Worksheet #15a), the sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra .

Worksheet 17 will be revised to read as follows (new text underlined): “...the sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , and ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra .”

RBA Work Plan (Appendix C):

The last paragraph of Section 4.2.4 will be revised to read as follows (new text underlined): “Alpha spectroscopy will be performed for uranium isotopes (^{238}U , ^{235}U , ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra .”

7. Response to SAP General Comments 1: The response addresses the comment. In addition, please fully implement it in the Appendix B SAP. Specifically, the Soil Investigation section of Worksheet #17 states, “Evaluation of the results of Phase 1 may lead to re-excavation of Phase 2 TUs if contamination is identified in Phase 1 trenches.” To make Worksheet #14 and #17 more clear to the reader, please include a firm commitment to excavate 100 percent (%) of the Phase 2 TUs if contamination is found in any Phase 1 TU in both Worksheets.

This commitment is stated throughout the work plan.

8. Response to SAP General Comment 6: The response addresses the comment, and to be more clear to the reader, please revise Worksheet #17 to discuss investigation and remediation of contamination, similar to the approach discussed in Worksheet #11.

Text will be added to Worksheet 17 to state, “An in situ investigation and/or remediation of the trench sidewalls and floor will be performed prior to backfill.”

9. Response to SAP General Comments 7, 8 and 14, items d and p: The responses address the comments, and to be more clear to the reader, please revise Worksheet #11, Step 6 to state that isotopic analyses for uranium isotopes U-238, U-235, and U-234; thorium isotopes Th-232, Th-230, and Th-228; as well as Ra-226 will be analyzed by alpha spectroscopy for performing background evaluations to identify whether detections of Ra-226 in site samples are the result of Naturally Occurring Radioactive Material (NORM) or site sources/contamination.

The applicable bullet in Step 6 in Worksheet 11 will be revised to read as follows (new text underlined): “If any ^{226}Ra gamma spectroscopy concentration exceeds the ^{226}Ra RG and the range of expected NORM concentrations, then the soil sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , and ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra to evaluate equilibrium conditions.” Additional text revisions are described in the response to comment 6 above.

10. Response to SAP General Comment 14 item h: The response partially addresses the comment. To fully address the comment, please revise the Draft Final Work Plan and SAP to include the soil sorting system detector specifications and ensure that a Soil Sorting Operations Plan is submitted to the regulatory agencies prior to finalizing the Parcel G Work Plan.

Implementation of the soil investigation outlined in this work plan will be performed by Aptim. The Soil Sorting Operations Work Plan is provided as Appendix F of the Parcel G Work Plan Addendum (prepared by Aptim). The soil sorting operations plan contains the detector specifications for the system.

11. Response to SAP General Comment 14, item o: The response partially addresses the comment. The comment requested the SAP be revised to specify that background data sets be evaluated using non-parametric statistical tests to evaluate population estimators. The response states that graphs of analytical data will be reviewed for indications of data values outside of the expected distribution (i.e., potential outliers) and will evaluate potential outliers using the Dixon's and Rosner's tests or other appropriate tests, including non-parametric methods. Please recall that the Dixon's and Rosner's tests are only appropriate for normally distributed data sets. To fully address the comment, please revise the Draft Final Work Plan and SAP to state that data set distributions will be tested for normality and/or non-parametric statistical tests will be used for all evaluations if normality is not confirmed. Please also revise the SAP to include other non-parametric tests for calculating the mean and standard deviation, or to identify outliers.

Steps 5 and 6 in Worksheet 11 will be updated to clarify that tests for outliers will include, "(other appropriate tests, including non-parametric methods)".

New General Comments

1. The Draft Final Work Plan, Section 2 Conceptual Site Model, Footnote 3 states that comparisons between the onsite laboratory screening results and the offsite laboratory definitive results for Ra-226 demonstrate that the onsite laboratory results were consistently biased high and resulted in false exceedances of the RGs and that remediation may have been avoided had decisions been based on the off-site laboratory analysis data. However, the HRA and CSM for the Hunter's Point Naval Shipyard identified the widespread use and site contamination resulting from the use and disposal (through sanitary and sewer lines) of Ra-226 at the site. In addition, in some parcels, some of the off-site laboratory results exceeded both the on-site laboratory results and the cleanup criteria and resulted in the need for additional excavation. Furthermore, several enforcement actions have confirmed that soil samples were swapped, so even if off-site data gave more precise and accurate results, those results may not represent the true levels of contamination at a given location. In addition, according to the Navy's radiological data evaluation reports, significant numbers of biased soil samples were collected from locations that avoided the areas with highest scan results, so they would not represent the true levels of contamination. Please revise the Draft Final Work Plan to remove or to modify footnote 3 to more accurately reflect the lack of data integrity obtained from both on-site and off-site laboratories during previous investigations.

The footnote will be removed.

2. Section 3.2 (Radionuclides of Concern) Table 3-4, footnote b to Table 3-5, Soil Remediation Goals from Parcel G ROD and various other references throughout the Draft Final Work Plan include a list of the radionuclides ROCs that is inconsistent with the conceptual site model (CSM) in Section 2. The CSM in Section 2 lists Pu-239 as a ROC for Buildings 351A, 364, and 365, however Table 3-4 and footnote b of Table 3-5 list Pu-239 as a ROC for the Buildings 317/364/365 Site only. The HRA also indicates that Pu-239 is a ROC for Building 351A. In addition, the soil area entry in Table 3-4 that includes the Building 351A crawl space does not list Pu-239 as a ROC for this area. All references to buildings where Pu-239 is a ROC should be

revised to provide consistent information. Please revise the Draft Final Work Plan to include Pu-239 as a ROC for Building 351A in all applicable sections.

The ROCs in Section 3.2, Table 3-4 will be updated as follows:

Table 3-4. Soil Radionuclides of Concern

Soil Area	Radionuclide of Concern
Former Sanitary Sewer and Storm Drain Lines	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr
Former Buildings 317/364/365 Site	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr, ²³⁹ Pu, ²³⁵ U
Building 351A Crawl Space	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr, ²³⁹ Pu, ²³² Th

- Section 3.3.1 (Investigation Levels) states that the spectra will be evaluated using region of interest (ROI)-peak identification tools for the ROCs that correspond to gamma rays at 186 kiloelectron volts (keV) for Ra-226, and 609 for daughter Bismuth-214 (Bi-214). Please clarify how identifying the presence of Ra-226 near the RG without allowing for ingrowth of the daughter products Bi-214 and Lead-214 (Pb-214) and/or using the 186 keV energy line which is unreliable for quantifying Ra-226, will be sufficient for identifying Ra-226 in soil. Further, please list the investigation levels (ILs) for Ra-226 to clarify if the ILs will be significantly higher than the detection limits for scanning.

The scan MDC calculation uses a Microshield model which assumes that the Ra-226 daughter products have been allowed to ingrow for a period of approximately 40 years. As noted in Section 3.3.1, ILs are typically equal to an upper estimate of the instrument- and material-specific background, such as the mean plus three standard deviations. ILs will be determined in the field and are not available to include in the work plan.

- Section 3.4.6 (Former Building Site and Crawl Space Survey Unit Design) states that SUs 27 (peanut spill) and 28 (LWTS) at the Former Buildings 317/364/365 will be excavated to 2 and 10 feet below grade surface (bgs), respectively, and all other SUs will receive surface sampling only. For more clarity to the reader, the Draft Final Work Plan should explain why all SUs except for 27 and 28 will only receive surface sampling and will not be excavated.

The text in Section 3.4.6 will be updated to read as follows (new text is underlined): “At the Former Buildings 317/364/365 Site, SUs 27 (peanut spill) and 28 (LWTS) will be excavated to 2 and 10 feet bgs, respectively, for consistency with the previous excavation boundaries (Figure 3-1).”

- Footnote B to Table 8-1, Derived Air Concentrations, indicates Th-232 is not a ROC; therefore the Derived Air Concentration (DAC) for Pu-239 is the most restrictive. However according to the HRA, Th-232 is a ROC for Building 351A and former Building 408. Please revise the Draft Final Work Plan to require the Th-232 DAC to be the limiting standard for Building 351A.

The footnote(s) for the table will be revised to state the following:

The most protective DACs for alpha and beta-emitting nuclides will be used as determined by the ROCs in that work area.

6. The Appendix C Soil Reference Background Area Work Plan (Background WP), Section 2 (Purpose and Data Quality Objectives), Step 7, should be revised to explain how reference background areas (RBAs) will be determined to be suitable for use in the background analysis. This section states gamma scanning measurements will be performed within the RBAs to confirm the areas are free of elevated gamma levels and are suitable for sampling; for clarity for the reader, please explain how elevated gamma levels will be determined (e.g., three standard deviations from mean or another method). Additionally, please state whether specific alternative background sites have been identified for sampling in the event that one of the currently identified RBA sites is determined to be contaminated.

Gamma scan data will be evaluated as described in Section 4.1 and a reference to the section will be added in Section 2 to the bullet describing Step 3 of the DQOs. Alternative RBAs have not been identified at this time.

7. In Appendix C Soil Reference Background Area Work Plan Section 4.1.1 (Conduct a Preliminary Data Review), please explain how the background data set distributions will be evaluated for statistical testing. This section states that radionuclide-specific (spectra) and gross gamma data set information will be gleaned by compiling basic statistics, including mean, median, minimum, maximum, and standard deviation, and by creating plots, such as histograms, box plots, and normal probability plots, from each RBA. Please also state whether the distribution of the data sets will be tested to determine whether they represent a normal distribution or exhibit skewness or other population distributions, and/or if non-parametric tests for calculating the mean and standard deviation will be used. Please revise this and any other relevant sections of the Draft Final Work Plan to include this information.

Note that Section 4.1.1 applies to the evaluation of gamma scan data and the suggested revisions are not applicable. Section 4.2.1 includes the discussion of the evaluation of analytical data from the RBAs.

8. Appendix C Soil Reference Background Area Work Plan Sections 4.1.2 (Identify Outliers) and Section 4.2.2 (Identify Outliers) propose to conduct parametric outlier tests (i.e. Rosners' and Dixon's) for background data sets to identify population outliers; however, these tests assume data set normality and therefore may not be appropriate given the actual data distribution. In order to ensure the data evaluation is technically correct and defensible, please revise the Draft Final Work Plan to propose non-parametric outlier tests that are not dependent on the distribution of the data set.

Testing and validations of the assumptions in a statistical test, such as the assumption of normality in the use of the referenced outlier tests, is part of the evaluation process. Distribution testing will be performed to confirm the appropriate statistical tests are being performed. Section 4.2.2 of the text states that non-parametric methods may be used.

9. Appendix C Soil Reference Background Area (RBA) Work Plan would be more clear if the text included additional explanation of the criteria for background soil sample collection and analysis. For example, Step 6 (Specify the Performance Criteria) states that RBA soil groups will be compared using the Kruskal-Wallis (KW) test and comparing data against different identified soil groups and against each RBA depth. Please explain in detail how this comparison will be used to establish background values. For example, please discuss the minimum number of samples needed to specify a separate background profile per soil type. Further, responses to

comments on the SAP indicate that background data sets will not be developed for different soil types. Please revise the Draft Final Work Plan, including Appendix C, to describe how distinct soil types will be identified, what the minimum requirements for establishing a separate background data set/profile for use in comparing such data to site samples. Alternatively, please define the term “soil groups.” Additionally, please revise the Draft Final Work Plan to provide consistent information in the main sections of the Work Plan, the Appendix B SAP and the Background Work Plan that explains how the background analysis will be conducted.

Observed soil types will be recorded during the sampling process and will be reported. The site geologist will log the soil classification and lithologic characteristics for use in further evaluating RBA data. How the data are grouped (by Parcel, by soil type, etc.) will be a subject for discussion following the collection of data. The requested information regarding the planned process will be determined over the course of the study and subsequent data evaluation. The term “soil groups” was intended to be a general term describing different observed soil types and will be updated to “types”.

10. Section 3.1.7 (Laboratory Analysis) indicates all uranium and thorium isotopes reportable by alpha spectroscopy will be analyzed and reported to determine if the radionuclide concentrations indicate the U-238 decay chain is in equilibrium. For consistency, please revise the Appendix C Section 4.2.4 to list U-234, U-235, and U-238, as well as Th-228, Th-230, and Th-232 isotopes as those that will be analyzed and reported by alpha spectroscopy for all RBA samples to ensure that sufficient evidence of the U-238 and Th-232 decay chain equilibrium conditions are provided.

The last paragraph of Section 4.2.4 of Appendix C will be revised to read as follows (new text underlined): “Alpha spectroscopy will be performed for uranium isotopes (^{238}U , ^{235}U , ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra .” Additional text revisions are described in the response to comment 6 above.

USEPA Comments (April 25, 2019)

1. Section 3.2.1.3, Pre-Construction Meeting: Add the oversight agencies (U.S. EPA, CA DTSC, CA DPH) to the list of attendees of the pre-construction meeting.

The oversight agencies will be added to the list of attendees for the preconstruction meeting in Section 3.2.13 of Appendix C.

2. Section 3.2, Survey Implementation: The following bullet points in this section mention field duplicate samples:
- a. Section 3.2.4, 5th bullet
 - b. Section 3.2.5.2, 4th paragraph, 6th bullet
 - c. Section 3.2.6 8th bullet

Please note in the Work Plan that EPA and DTSC/DPH will also be taking duplicate samples at some of the sample locations. This is in addition to duplicate samples taken by the Navy’s contractor.

The text in Appendix C, Sections 3.2.4, 3.2.5.2, and 3.2.6 will be updated to add that “USEPA and DTSC/CDPH will also be taking duplicate samples at some of the sample locations”.

3. Section 3.2.7, Sample Identification: For duplicate samples taken by EPA, the sample location number “DD” will be given the additional letters “P” and “E” [DDPE].

A footnote will be added in Appendix C, Section 3.2.7 to indicate that “For duplicate samples taken by USEPA, the sample location number “DD” will be given the additional letters “P” and “E” (e.g., DDPE).

4. Section 3.4, Radiological Investigation Design: In EPA’s March 26, 2018, comments (General Comment 20 on Section 4.3.3 of the Draft Work Plan), we recommended starting with a sample density of 25 sample per survey unit. EPA, DTSC, and CDPH recommend using 25 samples per survey unit initially for the following:

- First 3 Trench Units, each RSY pad or equivalent area
- First 3 Building Site Soil Survey Units
- First 1 Survey Unit (statics and swipes) for each building material type (e.g. concrete, wood, drywall)

After that, we should have enough more reliable data to update calculations to generate the appropriate sample density using the MARSSIM approach. Priorities for selecting the first trench units to sample should include likelihood of finding contamination, highest potential variability, representativeness, etc. EPA, CDPH, and DTSC recommend sampling in 25 locations at the following high priority survey units:

- a. First 3 Trench Units (TUs), each Radiological Screening Yard (RSY) pad or equivalent soil sorter volume
 - i. TU 153 – This trench unit (TU) showed the following characteristics: low variability gamma static data that were inconsistent with gamma scan data; uninvestigated gamma scan exceedance(s); the manhole with highest Cs-137 in sediment located along this TU (which is in the vicinity of former building 364 and the Cs-137 peanut spill; which could lead to a higher probability of finding Cs-137 contamination); five rounds of excavation (which could have provided incentive to falsify to avoid future rounds of excavation); evidence of multiple populations on the Ac-228, Bi-214, K-40 Final Status Survey (FSS) Quintile-Quintile (Q-Q) plots; and Navy identification of falsification.
 - ii. TU 98 – This Trench Unit showed these characteristics: low variability gamma static results that were inconsistent with gamma scan data; six rounds of excavation; location along Cochrane Street (where the Navy’s Radiological Affairs Support Office suspected historic Cs-137 contamination in storm drains and sanitary sewers); and evidence of multiple populations on the Ac-228, Bi-214, K-40 FSS Q-Q plots.
 - iii. TU 103 - This Trench Unit showed these characteristics: low variability gamma static data that were inconsistent with gamma scan data, three rounds of excavation, evidence of multiple populations on the Ac-228, Bi-214, K-40 FSS Q-Q plots, for Ac-228; and the standard deviation exceeds the mean.
- b. First 3 Building Site Soil Survey Units (SUs)
 - i. Bldg 364 SU 23 - CDPH identified concerns in this survey unit because data showed many exceedances of the investigation level of three standard deviations (sigma)

above the remedial goal, a one-year delay in sample analysis, and issues with the FSS systematic (FSS_SYS) data set for Bi-214 and K-40.

- ii. Bldg 364 SU 28 – This SU is the location of former liquid waste transfer system excavation (which could mean a higher probability of finding contamination). Additional excavation was done by Tetra Tech EC Inc. This SU also shows evidence of multiple populations on the Ac-228, Bi-214, K-40 FSS Q-Q plots,
- iii. Building 351A S000B – This SU has strong evidence of multiple populations on the Ac-228, Bi-214, K-40 FSS Q-Q plots. However, it appears that SU R may have been the one where excavation was done as it is surrounded by two other SUs. SU E also has strong evidence of multiple populations on the Ac-228, Bi-214, K-40 FSS Q-Q plots.

The text in the last paragraph of Section 3.4.1 of the Parcel G work plan will be updated to state “The USEPA has requested that initially, a minimum of 25 samples be collected in each survey unit. Therefore, 25 samples will be a placeholder until data from the RBA study become available.” with a footnote that states “The initial sampling will be conducted in the TU and SU locations USEPA, Department of Toxic Substances Control (DTSC), and California Department of Public Health (CDPH) identified with the likelihood of finding contamination, highest potential variability, representativeness, etc. For the TUs, TU 153, TU 98, and TU 103 were identified. For the Former Building Site and Crawl Space SUs, Former Buildings 317/364/365 Site SUs 23 and 28, and Building 351A Crawlspace SU B were identified.”

- 5. Section 3, Soil Investigation Design and Implementation: Gamma scan results would include radiation from Ra-226, Th-232, and Cs-137. So the MDC for scans will depend on the reference background levels of these three radionuclides. However, previous data collected by Tetra Tech EC Inc., including for reference background, are unreliable. Therefore, for the potentially impacted soil areas (the trench and building site survey units), EPA will need to obtain further information on the reference area data (i.e. soil sample results) to determine if the proposed Scan MDCs for the survey unit are sufficient.

Reference background soil sample results will be provided when data are available.

- 6. Chapter 3, Soil Investigation Design and Implementation, and Appendix C, Soil Reference Background Area Work Plan: We understood that at the time of the draft final Work Plan, some details were not ready for inclusion and would be provided later. As discussed on a conference call in November, 2018, below is a more detailed list of what we need from the Navy prior to finalizing the soil reference background study. The draft final only provided example instruments and example MDC calculations. We need the final versions. Please note that we have not completed review of the Addendum that arrived April 17, 2019, and we understand that some of this information may be contained in that document.

- a. Gamma Scan and Static Surveys, including of the background reference areas:
 - i. Identify the Contractor that will be conducting field investigation/radiological surveys and data collection and submit contractor-specific standard operating procedures (SOPs) for field investigation, including SOPs for all radiological surveys.

In the last paragraph of Section 1 in the Parcel G work plan, the following text will be added for clarification: “CH2M and Perma-Fix will be conducting the work outlined in Section 4 and Appendix C. A separate contractor, Aptim, has been

selected to conduct the work outlined in Section 3, and this work plan and the SAP will be amended for contractor-specific information, as needed.”

- ii. Provide calculations documenting how the minimum detectable counts (MDCs) listed in Parcel G Work Plan Table 3-7 (A Priori Scan MDCs) for gamma walk-over surveys using the RS-700 instrument were determined. For example, Section 3.5.2.2 (Gamma Scan Minimum Detectable Concentration) provides example calculations for the Model 44-20 (3-inch by 3-inch) Sodium Iodide (NaI) detectors, but it does not provide information about the RS-700 system. Note that CDPH provided a technical basis document for documenting how the RS-700 system was calibrated for the gamma scans conducted at Parcel A-1 using the MicroShield modeling program. Such information should be included in the Parcel G Work Plan, as follows:

1. Modeling used to correlate gamma fluence rates to detector performance/efficiency
2. Efficiency of detectors using calibration sources
3. Detection limits for identification of discrete sources versus soil contamination

The MDC calculations for the RS-700 system are described in Section 3.3.2 of the Parcel G Work Plan Addendum (prepared by Aptim). Modeling of gamma fluence rates from different source geometries are presented in Appendix G of the Parcel G Work Plan Addendum (prepared by Aptim).

- iii. Copy of nuclide library including the energy lines that will be used for quantitation of individual radionuclides

Aptim performs the evaluation of gamma data from the RS-700 using the exported raw data from the system, without the use of a specific gamma energy library. The energy lines used for Ra-226 and progeny are 351 keV, 609 keV, and 1764 keV. The energy line for Cs-137 is 662 keV. Abnormal or anomalous energy peaks are identified during RS-700 data processing.

- iv. Identify the size of the detectors used for the RS-700 system, the mounting configuration, and information demonstrating how 100% of the land areas scanned will be covered by the RS-700 gamma scan instruments based on the size and mounting configuration.

The dimensions of the RS-700 detectors are 4 inches by 4 inches by 16 inches. This information will be added to Table 3-6 of the Parcel G Work Plan. Section 3.1 of the Parcel G Work Plan Addendum (prepared by Aptim) describes the mounting configuration and scan coverage as follows: “...The detectors are mounted end-to-end lengthwise with a gap of approximately 4 inches between the detectors. The detectors are maintained at a constant distance above the ground of approximately 15.24 centimeters (cm), with each pass offset by approximately 112 cm from the previous pass to ensure complete gamma scan coverage.”

- v. Specify that global positioning system (GPS)/positional data collection will occur during the RS-700 system scanning surveys.

As noted in Section 3.5.1 of the Parcel G Work Plan, the “gamma scanning instrument will also be equipped with a positioning sensor and software that is able to simultaneously log continuous radiation and position data.” To further

clarify this text will be revised to read as follows: "...the gamma scanning instrument will also be equipped with a GPS positioning sensor..."

- vi. Provide a listing of the static measurement MDCs for the Ludlum 2221 with Model 44-20 NaI detectors and the RS-700 system. Example scanning MDCs were provided in Table 3-7 (A Priori Scan MDCs) but MDCs for statics were not provided. Please note that the soil reference background area work plan calls for 25 samples per reference background area. The laboratory can reliably test to Minimum Detectable Concentrations (MDCs) that are below the ROD RGs. Per MARSSIM, a background reference area is, by definition, a non-impacted area. Therefore a background reference area does not need to be scanned. However, scanning is a wise additional optional precautionary step that can help identify potential signs of contamination. At the stated scan MDC, gamma emitting radiological objects can be detected.

For the RBAs, Perma-Fix will be using Ludlum Model 44-20s (3 inch by 3 inch NaI detectors) listed in Table 3-3 in Appendix C coupled to an MCA with automated data logging for the gamma scans of the background areas prior to sampling. For soil investigations, static measurements with gamma instruments are collected to investigate observed scan anomalies compared with the gamma scan background. Typically, static measurements are compared qualitatively with background and are not used for direct comparison with RGs. Using the NUREG-1507 methodology an observation interval increase from 2 second (for a scan) to 60 seconds (for a static) would reduce the MDC by a factor of approximately 5.5 (i.e., a scan MDC of 2.30 pCi/g with a 2 second observation interval would be reduced to 0.42 pCi/g).

The objective of the reference background area scans is to identify anomalous radiological conditions that may affect an area's use as a reference area.

- vii. Include a listing of instruments, calibration and MDCs (if different) for gamma scanning of core samples since this may present a different geometry than scanning excavated soils and different detectors may be used.

As noted in Table 3-2 of Appendix C of the Parcel G Work Plan and Table 3 of the Parcel G Work Plan Addendum (prepared by Aptim), soil core scanning surveys will be performed with Ludlum Model 44-20 3x3 NaI detectors. Core scanning measurements will be compared with observed background to determine if anomalies exist and additional soil samples from within the core should be collected. The MDCs for this process are assumed to be the same as land area MDCs. If unexpected conditions are observed during the core scans, the MDCs will be re-evaluated.

b. Investigation parameters

- i. Revise the Work Plan to include the listing of all radionuclides of concern (ROCs) for some survey units/trench units and buildings based on the Historical Radiological Assessment, Volume II (HRA) per previous comment submittals.

See responses to USEPA Evaluation of Response to Comments number 4 and USEPA New General Comments number 2, above.

- 7. Section 4, Building Investigation Design and Implementation. Similar to comment 4 about soil above, we recommend first collecting 25 systematic samples at one Survey Unit (statics and

swipes) for each building material type, e.g., concrete, wood, drywall, etc. CDPH, DTSC, and EPA have reviewed building history, previously collected data, and other information about Building survey units. We therefore recommend choosing from among these priority survey units to test first using 25 samples per survey unit: Building 351 SUs 7 and 46, Building 351A SUs 7 and 26, and Building 366 SU 62.

The text in the last paragraph of Section 4.4.1.2 of the Parcel G work plan will be updated to state “The USEPA has requested that initially, a minimum of 25 static measurements be collected. Therefore, 25 static measurements will be collected as a placeholder until background data are available.” with a footnote that states “The initial sampling will include 25 systematic samples at one SU (statics and swipes) for each building material type, e.g., concrete, wood, drywall, etc. Based on USEPA, DTSC, and CDPH review of building history, previously collected data, and other information about the building SUs, either Building 351 SU 7, Building 351 SU 46, Building 351A SU 7, Building 351A SU 26, or Building 366 SU 62 were identified.”

8. Section 4, Building Investigation Design and Implementation. EPA and the Navy are still addressing basic remedy design and implementation issues related to Chapter 4 of Parcel G Workplan. Therefore, we expected a revised version of this chapter in the future that will address ongoing issues. Meanwhile, EPA is proposing that the Navy use a more current method, ISO-7503, for calculating efficiencies rather than the conventional 4pi geometry method. The ISO-7503 method, as well as MARSSIM, uses the terminology of “4pi;” however, 4pi is calculated by taking into account both instrument efficiency (i.e. 2pi emission rate) and surface efficiency—not 4pi efficiency listed by the instrument manufacturer, as done in the conventional method. EPA will review total efficiency calculations, including radionuclide parent and progenies, in the future, after other larger issues are addressed.

The use of surface efficiency to determine total 4 pi efficiency per ISO-7503 was intended throughout Section 4 but was only specified in the calculation for the beta scan MDC (Section 4.5.8.5). The efficiencies and calculations in Section 4 will be clarified to reflect the use of the 2 pi instrument efficiency and an appropriate surface efficiency for the calculation of total 4 pi efficiency.

9. Section 8.5 Air Quality and Dust Control. We have received more details in the Site-Specific Dust Management Plan and Project Environmental Plan portion of the Draft Parcel G Removal Site Evaluation Work Plan Addendum, dated April 17, 2019. We will provide comments separately later.

The Parcel G Dust Management Plan is provided as Appendix E of the Parcel G Work Plan Addendum (prepared by Aptim). Comments on the Dust Management Plan will be addressed as part of the response to comments on the Work Plan Addendum.

10. Appendix C, Section 3.1.3 Reference Area Background Locations. The off-site Background Reference Area (BRA) is likely to be moved to another less disturbed site. During the February 11, 2019, site walk it was agreed that this change could be made after the Work Plan Appendix C is finalized using the Field Change Request (FCR) process and that this FCR would be submitted to the Regulatory Agencies before sampling of this area is conducted so that Regulatory Agency representatives can be present to observe and collect split samples. Split samples will be collected from approximately 10% of the locations. Also, as discussed during the site walk, it was agreed that the off-site BRA would not be located at or near the bottom of a slope where fallout radionuclides could have been concentrated in run-off and that it would be located in an

area that had been undisturbed since the 1940s, based on aerial photograph review and discussion with people familiar with the history of the site. Finally, it is unclear if a second off-site BRA would be selected, as that was discussed during the site walk. Please ensure that the off-site BRA(s) is/are not located at the bottom of a slope and is/in a relatively undisturbed area. Please also ensure that any FCR changing the off-site BRA location is submitted prior to collection of samples at the BRA and that the Regulatory Agencies are notified in time to allow scheduling an observer who will collect split samples. In addition, please ensure that the Work Plan is revised to include detailed procedures for split sampling. Finally, please consider selecting a second off-site BRA.

Sampling is planned at the off-site RBA identified at San Bruno Mountain Park during the February 2019 site walk and a copy of the Field Change Request will be provided to the regulators. Alternative RBAs have not been identified at this time. The detailed procedures for regulatory agency duplicate/split sampling are not known and it is assumed that the regulatory agencies would follow their respective procedures/work plans.

11. Appendix C, Section 3.1.3 Reference Area Background Locations. Please revise the Work Plan to state that if elevated radiological contamination or a radiological object are found during the sampling or gamma scans of a BRA or during sampling, or if any BRA shows any other signs that it is contaminated, then an alternate BRA will be selected.

This is included in the work plan, see Section 4.1.2 that states “Areas with elevated scan measurements that are attributed to contamination or discrete radiological objects will not be sampled, and alternate locations will be selected.”

12. Appendix C, Section 4.1, Gamma Scan Data Evaluation. The soil reference background area work plan calls for 25 samples per reference background area. The laboratory can reliably test to Minimum Detectable Concentrations (MDCs) that are below the ROD RGs. Per MARSSIM, a background reference area is, by definition, a non-impacted area. Therefore a background reference area does not need to be scanned. However, scanning is a wise additional optional precautionary step that can help identify potential signs of contamination. At the stated scan MDC, gamma emitting radiological objects can be detected.

As noted in the response to comment 6, the objective of the reference background area scans is to identify anomalous radiological conditions that may affect an area’s use as a reference area.

USEPA Comments (May 22, 2019)

1. Response to General Comment (GC) 1 (Original GCs 10 and 11, and Appendix C, Section 3.1.6.4): The response addresses the questions regarding the calculation of the theoretical Minimum Detectable Concentrations (MDCs) for gamma walk-over scanning. Please add text that commits that later field measurement (empirical) data will be provided to regulatory agencies to demonstrate the actual achievable MDCs for the project.

Text will be added to Section 3.5.2.3 of the work plan to state, “After field mobilization, MDC calculations will be revised using actual site-and instrument-specific data. Observed MDCs will be provided to regulatory agencies and will be documented in the RACR.”

Text will be added to Section 3.1.6.4 of Appendix C to state, “After field mobilization, MDC calculations will be revised using actual site-and instrument-specific data. Observed MDCs will be provided to regulatory agencies and will be documented in the background report.”

2. Response to GC 2 (Original GC 10): The response states that the MDCs for the soil sorting system are provided in Appendix F of the Parcel G Work Plan Addendum; however, the information provided includes calculations of theoretical MDCs only. Please add text to commit that after running soil from reference background location(s) through the soil sorter, actual field measurement (empirical) data will be provided to the regulatory agencies after it is collected to demonstrate the actual achievable radioisotope-specific MDCs at the start of the field project.

Text will be added to the work plan addendum to state, “After field mobilization, MDC calculations will be revised using actual site-and instrument-specific data. Observed MDCs will be provided to regulatory agencies and will be documented in the RACR.”

3. Response to GC 3 (Original GC 15a): The response indicates a note will be added to state that Survey Unit (SU) 69 consists of building exterior surfaces; however the note that is proposed for addition to Figure 11-7 does not indicate that the SUs for the exterior of Building 366 are designated as Class 3. Please revise the appropriate figures in the Parcel G Work Plan and in the Sampling and Analysis Plan (SAP) to indicate which SUs will be investigated as Class 3 areas.

The note in Figure 4-4 of the work plan will be updated to state, “SU 69 consists of the building exterior surfaces, designated as Class 3.” Changes to the SAP at this time would require additional and unnecessary reviews and cause further lengthy project delays.

4. Response to GC 5 (Original comments): This response partially addresses the comment. The Five-Year Review should indeed evaluate the potential that if multiple radionuclides are present at the same location, even if they meet an individual remedial goal that is below 1×10^{-4} risk, a combination of the risks from multiple radionuclides could still exceed this overall risk. We agree that the Five-Year Review should recommend followup action to ensure long-term protectiveness under this scenario. One potential action could be that the remedial goals should be set at more protective levels to prevent this scenario from occurring. If that is the case, then the Work Plan should be revised to adopt any recommended changes to accomplish this goal. Alternatively, another potential action could be that if multiple radionuclides are present at a location, then the combination of risks should be evaluated to determine whether further cleanup beyond the original remedial goals could be necessary to ensure the combined risk remains below 1×10^{-4} . Either action would require revision to the Work Plan. Thank you for discussing these possibilities by phone on May 21, 2019. As we discussed, please add text that commits that the Work Plan will be revised as necessary to incorporate future recommendations from the Five-Year Review process to address this potential concern.

This comment is related to the Five-Year Review. After retesting data has been collected, site protectiveness will be evaluated as part of the Five-Year Review process. A response action and/or Record of Decision change may be necessary if results indicate further actions are required.

5. Response to GC 7 (Original Sampling and Analysis Plan [SAP] GC 1): The response addresses the comment, but based on the Final SAP included as attachment 1 to the SAP in the Work Plan Addendum, it was not implemented. Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, should document all decision criteria for the project, and Worksheets #14 – Summary of Project Tasks and #17 – Sampling and Survey Design and Rationale are expected to contain a description of all major project activities. As such, Worksheets #11, #14, and #17 in the SAP should be revised to reflect the requirement to excavate 100 percent (%) of the Phase 2 trenches if contamination is found in any Phase 1

Trench Units (TUs). Please ensure that the SAP is updated to reflect the commitment to excavate 100% of the Phase 2 trenches if contamination is found in any Phase 1 trench.

Comment noted. This commitment is stated throughout the work plan to which the SAP is an appendix. Changes to the SAP at this time would require additional and unnecessary reviews and cause further lengthy project delays.

6. Response to SAP GC 11 (Original GC 14, item o: This response partially addresses the request to update language. Please also revise the text to do the following:

- to state that distributional properties of the data will be tested and the data set confirmed to follow a normal distribution prior to employing Dixon/Rosner's tests,
- to identify the processes for identifying outliers that will be used if the data set proves not to be normally distributed (some type of distributional assumption has to be made to apply a statistical outlier test such as Dixon/Rosner's), and
- to detail the non-parametric/alternate methods that would be employed to calculate the mean and standard deviation of the data sets if they are not normally distributed.

Please provide this information.

Please note that for both Rosner and Dixon tests, it is the data set obtained after removing the outliers (and not the data set with outliers) that needs to follow a normal distribution (*ProUCL Version 5.1.002 Technical Guide*). Data review will be conducted initially using the current version of the EPA's ProUCL tool, which uses Dixon's and Rosner's tests as well as box plots and Q-Q plots to identify outliers. Tests for normality will be performed both prior to and following treatment for outliers. If data sets do not appear normally distributed following removal of outliers and more robust outlier detection methods beyond the scope of ProUCL are required, USEPA will be consulted. This text will be added to Section 4.2.2 of Appendix C.

7. Response to GC 2: The revised Table 3-4 does not include Th-232 as an ROC for "Former Sanitary Sewer and Storm Drain Lines." For example, at Trench Unit 115, "One additional radionuclide of concern (ROC) was identified (thorium-232 [^{232}Th])." (Final Survey Unit 115 Project Report, Parcel G Sanitary Sewer and Storm Drain Removal Project, Hunters Point Shipyard, DCN: ECSD-3211-0018-0115, Section 2.0, p. 2-1.) Please check original ROCs to ensure that the lists of ROCs in Table 3-4 includes all the relevant radionuclides.

^{232}Th will be added as an ROC for TU 115 in Table 3-4 of the work plan.

8. Response to GC 3: The Response addresses the comment. For confirmation, please add language in the Work Plan that specifies that once field work begins, empirical data should be submitted to regulatory agencies that substantiate the investigation levels (ILs).

Text will be added to Section 3.3.1 of the work plan to state, "...Appropriate instrument and site-specific gamma scan ILs for site ROC and gross gamma (i.e., full-energy spectrum) measurements will be determined following mobilization and provided to regulatory agencies."

9. Response to GC 5: The response addresses the comment. Please revise the text of the Work Plan to commit that the site-specific DACs for any ROC's are submitted to the regulatory agencies before initiating field work. In addition to the locations listed in the previous EPA comment,

please note that Th-232 is a ROC for Trench Unit 115. Please add Th-232 to the table and specify that Th-232 applies to areas where it is an ROC, such as the those listed above.

The DACs in Table 8-1 of the work plan are based on published regulatory values and are the values that will be used. ²³²Th is included in Table 8-1. ²³²Th will be added as an ROC for TU 115 in Table 3-4 of the work plan.

10. Response to GC6: This response partially addresses the comment. Thank you for discussing this comment by phone on May 21, 2019. As we discussed, please clarify in the text of the revised Work Plan that if any RBA is found to have signs of contamination then an alternate RBA will be proposed to regulatory agencies as a replacement.

A footnote will be added in Section 2 of Appendix C to state, “If any RBA is found to have signs of contamination then an alternate RBA will be proposed to regulatory agencies as a replacement.”

11. Response to GC 7: The response does not address the comment. Based on the text cited in the response, the original EPA comment is applicable. Please state whether the distribution of the data sets will be tested to determine whether they represent a normal distribution or exhibit skewness or other population distributions, and/or if non-parametric tests for calculating the mean and standard deviation will be used. It is important to know the data distribution to be able to properly model the data using kriging functions as proposed later in the Section. Please revise this and any other relevant sections of the Draft Final Work Plan to include the requested information.

Text will be added to Section 4.1.1 of Appendix C to include “reviewing the distribution of the data”.

12. Response to GC 8: The response partially addresses the comment. Section 4.2.2 currently states, “or other appropriate tests, including non-parametric methods.” may be used. Emphasis is then placed on detailing the Dixon and Rosner’s outlier tests. Please provide more detail within the text on the possible “other appropriate tests” that may be used. Please also revise the Draft Final Work Plan to propose a plan for identifying outliers if the data proves not to be normally distributed.

See response to USEPA Comment (May 22, 2019) 6 above.

13. Response to GC 9: Because the planned process will be determined over the course of the study, please add language that the planned process will be determined in consultation with the EPA and the other Regulators upon data evaluation. A flow diagram of the process questions could be designed to address the possibilities, identifying how the decisions would branch based on the situations that are encountered, for inclusion in the SAP and Work Plan. Also, as initially requested, please revise the Draft Final Work Plan to provide consistent information in the main sections of the Work Plan, the Appendix B SAP and the Background Work Plan that explains how the background analysis will be conducted.

A sentence will be added to the beginning of Appendix C, Section 4 to state, “Once data is obtained and evaluated, the statistical data evaluation process will be presented to the regulatory agencies for concurrence.” Also see response to USEPA Comment (May 22, 2019) 6 above.

14. Response to GC2 (April 25, 2019): This response partially addresses the comment. To clarify, EPA intended to state that USEPA and DTSC/CDPH will request split samples from the Navy's contractor. We apologize for the confusion. Therefore, please specify in the revised text that the contractor will provide split samples to regulatory agencies.

The updated text will be revised in Appendix C, Sections 3.2.4, 3.2.5.2, and 3.2.6 to state, "Split samples will be available to USEPA and DTSC/CDPH to take for independent analysis either real-time during field activities, from the laboratory during analysis and storage, or after laboratory analysis from on-site storage."

15. Response to GC 3 (April 25, 2019): The response addresses the comment. Please note this update: depending on the laboratory selected for Strontium-90 analyses, EPA may have to use a different numbering scheme for split samples that will be submitted for regulators' independent analysis. We will let you know once we finalize plans.

The updated footnote will be revised in Appendix C, Section 3.2.7 to indicate that "For USEPA and DTSC/CDPH split samples, the sample location number "DD" will be given additional letters."

16. Response to GC 6a iii, vi, and vii (April 25, 2019): The responses partially address these comments. Please revised the text of the Work Plan to commit that once fieldwork begins, empirical data should be submitted to regulatory agencies to demonstrate the achievable MDCs in the field.

See responses to USEPA Comments (May 22, 2019) 1, 8, and 9 above.

17. Response to GC 6a iii (April 25, 2019): This response partially addresses the comment. Please also provide the energy lines for any other ROCs that will be analyzed using gamma spectroscopy, e.g. Th-232.

Aptim performs the evaluation of gamma data from the RS-700 using the exported raw data from the system, without the use of a specific gamma energy library. The energy line used for thorium is via TI-208 (2614 keV).

DTSC Comments (December 14, 2018)

1. DTSC provided general comments on the draft Work Plan and revised draft final in letters to the Navy dated March 26, 2018 and August 14, 2018, respectively. Additionally, follow-up comments were provided by email on October 19, 2018. Our comments have been addressed except for comment number eight of the August 14, 2018 letter. This comment has been partially addressed. The Work Plan indicates that Phase 2 of the fieldwork includes radiological surface scans. However, the language is not clear that the durable cover will be removed as was previously discussed with the Navy. Please clarify this in the Work Plan.

Yes, the durable cover will be removed as part of the Phase 2 activities. The following sentence will be added to the work plan in the Executive Summary and Section 3.4: "For both Phase 1 TUs and Phase 2 TUs, the durable cover (including asphalt, asphalt base course, concrete, gravel, debris, or obstacles) will be removed to expose the target soils." In addition, the following sentence will be added to the second sub-bullet under Step 7 in Section 3.1: "Prior to the survey, the durable cover (including asphalt, asphalt base course, concrete, gravel, debris, or obstacles) will be removed to expose the target soils."

2. The revised Work Plan Section 8.5 discusses air monitoring to be conducted at Parcel G. We understand that a site-specific air monitoring plan and associated Standard Operating Procedures (SOPs) are being prepared and will be submitted to the regulatory agencies for review.

The air monitoring plan should adhere to the 2010 Basewide Dust Control Plan, which includes monitoring of COCs (total suspended particulates [TSP], arsenic, manganese, lead, particulate matter smaller than 10 microns in diameter [PM10], and asbestos) and radionuclides of concern (ROCs) to ensure worker and community safety.

Due to the proximity of the new Parcel A residential units, we request the development of dust action levels based on a residential exposure scenario. The DTSC Human Health Risk Office (HERO) has previously prepared dust action levels for various cleanup sites. Upon request, we can provide you with a recent HERO dust action level memorandum. Please refer to DTSC Human Health Risk Office (HERO) Note 3 when developing COC dust action levels (<https://dtsc.ca.gov/AssessingRisk/upload/HHRA-Note-3-June-2018.pdf>).

Additionally, the primary objectives of air monitoring and sampling must be as follows:

- Continual air monitoring during work activities to determine if airborne concentrations of particulate matter and COCs are more than action levels or regulatory limits established for the Site;
- Develop a relationship between fugitive dust levels and concentrations of COCs, so that direct-reading particulate measurements can be used as a surrogate for COC concentrations in dust and, appropriate actions can be taken to reduce exceedances if necessary;
- Develop a relationship between total Volatile Organic Compounds (VOCs) levels and concentrations of COCs, so that direct-reading total VOC measurements can be used as a surrogate for site VOC concentrations (if necessary); and
- Ensure that engineering controls and work practices are effective to minimize potential off-site impacts.

The air monitoring plan must be approved by the regulatory agencies prior to the start of the re-evaluation of the soil survey units' fieldwork at Parcel G.

The Parcel G Dust Management Plan is provided as Appendix E of the Parcel G Work Plan Addendum (prepared by Aptim).

CDPH Comments (December 14, 2018)

Previous SAP Comments

1. EMB's original Specific Comment #11 was not adequately addressed. This comment is one of a series of comments where EMB requested the removal of the word "allegation(s)" from any reference of Tetra-Tech E.C (TtEC) data manipulation due to the two guilty pleas and admission of falsified data. Sampling and Analysis (SAP) Worksheet #10 ("Conceptual Site Model"), Page 39, Paragraph two, Sentence one, still contains the word "allegation."

The sentence referred to states **“Following the investigation and removal actions, there were allegations that TtEC potentially manipulated and falsely represented data, and some allegations have since been confirmed.”** and is accurate as written.

2. EMB’s Specific Comments #25, #26, and #27. All of these comments question minimal detectable concentration (MDC) discrepancies between off-site laboratory SOPs and stated project MDCs. Most notably, the comments stated project MDCs are well below laboratory SOP “typically” observed MDC values. SAP Worksheets #15 “A”, “B”, and “C” still list the project MDCs which are below the laboratory observed MDC values. Please explain.

In Worksheet 15 of the draft final SAP, the laboratory MDCs for this project (listed in the last column of the tables) are below the project RGs (listed in the 3rd column of the tables). The laboratory SOPs listed in Worksheet 23 and provided in Attachment 3 of the SAP reflect standard method MDCs that are the default values if a project does not specify specific detection limits. This explanation is also included as footnote “g.”

3. EMBs Specific Comment #39 addressed survey units (SUs) identified in previous final status surveys (2009 and 2010) that appear to be missing from the current work plan. The following SUs are still not addressed in the current document:

Building ID:	Unaddressed SU(s):
351A	Crawlspace “S”, “R”, and “U”
366	69 and 70
411	1

For Building 351A, in the Executive Summary and in Worksheets 11, 14, and 17 of the Draft Final SAP, there is a footnote that states “...For the Building 351A Crawl Space, former SU R, SU S, and SU U overlap SU M, SU N, and SU O and will be investigated as SU M, SU N, and SU O.”

For Building 366, a note will be added to work plan Figure 4-4 and SAP Figure 11-7 to state, “SU 69 consists of the building exterior surfaces. SU 70 is a mezzanine level in the southwest corner of the building. If it can be safely accessed, it will be surveyed as a Class 1 SU.” In addition, the following text will be added to the end of the first paragraph of Section 4.4.3.3 of the work plan: “...The building exterior (SU 69) is a Class 3 SU. The mezzanine level in the southwest corner of the building is SU 70, which will be surveyed as a Class 1 SU if it can be safely accessed.”

For Building 411, Section 4.4.3.6 of the draft final work plan included text about SU 1, which states “The third floor and mezzanine are no longer accessible because of concerns about structural stability; therefore, the Class 3 SU 1 that was previously surveyed is not included in this investigation. Access points to that area will be included with surveys of adjacent SUs.” This statement will be added as a note on work plan Figure 4-7 and SAP Figure 11-10.

4. EMB Specific Comment #40 recognized that all of the listed utilities clearance subcontractors were located in the Virginia, Maryland, and New Jersey areas and requested possible local

(California) subcontractors. No changes appear to have been made in the DRAFT FINAL to address this.

The referenced SOP is general and will be removed.

New Specific Comments

5. Section 3, Table 3.2, “Phase 2 Soil Trench Units”: This Table does not include a sum for column 4, “Number of Samples in Original Trench Material”. The sum for column 4 is 548 soil samples. Please correct.

The total number of samples shown at the bottom of Table 3-2 in the draft final work plan represents the total number of samples from borings in original TU material plus the number of samples from sidewall/bottom borings. Subtotals for the number of samples from borings in original TU material and the number of samples from sidewall/bottom borings will be added to the table.

6. Section 3.54.6, Former Building Site and Crawl Space Unit Design. page 3-10, paragraph four, sentence one: At the former Building Sites: SU 27 (peanut spill) and SU 28 ((LWTS) will be excavated to 2 and 10 feet bgs, respectively (Figure 3-1)."Please make clear in the text that these excavations will also receive MARSSIM based soil sampling/surveys. Additionally, please clarify if the crawl space below the building 351A will be excavated prior to MARSSIM based soil sampling/surveys.

The text in Section 3.4.6 will be updated to read as follows (new text is underlined): “At the Former Buildings 317/364/365 Site, SUs 27 (peanut spill) and 28 (LWTS) will be excavated to 2 and 10 feet bgs, respectively, for consistency with the previous excavation boundaries (Figure 3-1).” The excavations will receive MARSSIM based soil sampling/surveys. The Building 351A crawl space is not planned for excavation prior to soil sampling/surveys.

7. Section 4.4.1.2, Static Measurements. page 4-4. paragraph three, sentence one: The number of systematic measurements performed will be based on the guidance described in MARSSIM Sections 5.5.2.2 and 5.2.2.5 (USEPA et al., 2000) using the unity rule as the example basis for calculating the minimum static measurement frequency." It is noted that the unity rule is discussed in MARSSIM Section 4.3.3, "Use of DCGLs for Sites with Multiple Radionuclides". MARSSIM Section 5.2.2.5 is titled, "Determining Survey Location", and does not address the use of the unity rule in determining number of static sample locations. Please provide citation(s) for use of the unity rule in determining number of static sample locations. Please provide example equation for the use of the unity rule in determining number of static sample insert.

The reference to MARSSIM Section 5.5.2.5 in the referenced text is in error and will be removed from the text as follows: “The number of systematic static measurements performed will be based on the guidance described in MARSSIM Sections 5.5.2.2 and ~~5.5.2.5~~ (USEPA et al., 2000)...”. As noted in the referenced text, the use of the unity rule is an example to show the calculation to determine the number of required samples. The values described in the calculation are all multiples of the DCGLw. The use of unity allows the variables to be more clearly expressed in the absence of site specific data to evaluate – i.e., the DCGLw equals one, the standard deviation is equal to 25% of the DCGLw, or 0.25. Survey gross alpha or gross beta measurement data will be corrected for a material-specific background and compared to the worst-case alpha or beta RG applicable to the building. The unity rule will not be used in evaluation of survey data against the RGs.

Appendix B

Sampling and Analysis Plan

SAP Worksheet #1—Title and Approval Page



**Naval Facilities Engineering Command Southwest
BRAC PMO West
San Diego, CA**

**FINAL
PARCEL G REMOVAL SITE EVALUATION
SAMPLING AND ANALYSIS PLAN**

FORMER HUNTERS POINT NAVAL SHIPYARD,
SAN FRANCISCO, CA

March 2019

Prepared for:



**Department of the Navy
Naval Facilities Engineering Command Southwest
1220 Pacific Highway
San Diego, CA 92132**

Prepared by:
**CH2M HILL, Inc.
San Diego, CA**
Contract Number: N62470-16-D-9000; Task Order No. FZ12
DCN: CH2M-9000-FZ12-0013

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Approval Signatures

The following person(s) hereby state that they have reviewed this document and approved this document.

Review Signatures:



11/12/2018

Anita Dodson/CH2M HILL, Inc. Program Chemist/Date



11/12/2018

Theresa Rojas, CQA CQMN/CH2M HILL, Inc. Corporate Quality Assurance Manager/Date

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Joseph Arlauskas/Naval Facilities Engineering Command Southwest Quality Assurance Officer/Date

Approval Signatures

The following person(s) hereby state that they have reviewed this document and approved this document.

Review Signatures:



3/21/2019

Anita Dodson/CH2M HILL, Inc. Program Chemist/Date



3/21/2019

Theresa Rojas, CQA CQMN/CH2M HILL, Inc. Corporate Quality Assurance Manager/Date

Other Approval Signatures:

Joseph Arlauskas/Naval Facilities Engineering Command Southwest Quality Assurance Officer/Date

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Executive Summary

This document presents the Uniform Federal Policy (UFP) Sampling and Analysis Plan (SAP) for the radiological investigation at Parcel G at Hunters Point Naval Shipyard (HPNS), located in San Francisco, California. This document was prepared in accordance with the Department of the Navy's (Navy's) UFP-SAP policy guidance to help ensure that environmental data collected are scientifically sound, of known and documented quality, and suitable for intended uses. The laboratory information cited in this SAP is specific to GEL Laboratories, LLC in Charleston, South Carolina. If additional laboratory services are requested requiring modification to this SAP, revised SAP worksheets will be submitted to the Navy for approval.

Sites that will be addressed under this SAP include former radiologically impacted areas in Parcel G, which occupies 40 acres in the middle of HPNS. Radiological surveys and remediation were previously conducted at HPNS as part of a basewide time-critical removal action (TCRA). Tetra Tech EC, Inc. (TtEC), under contracts with the Navy, conducted a large portion of the basewide TCRA, including Parcel G. Data manipulation and falsification were committed by TtEC employees during the TCRA. An independent third-party evaluation of previous data identified additional potential manipulation and falsification at Parcel G and data quality issues with data collected (Navy, 2017, 2018). As a result, the Navy will conduct investigations at radiologically impacted soil and building sites in Parcel G that were surveyed by TtEC. Future SAPs will address soil and buildings in the other parcels (B, C, D-2, E, UC-1, UC-2, and UC-3), including the North Pier and Ship Berths.

The purpose of the investigation presented in this SAP is to determine whether current site conditions are compliant with the remedial action objective (RAO) in the Parcel G Record of Decision (ROD) (Navy, 2009). The RAO for radiologically impacted soil and structures is to prevent exposure to radionuclides of concern (ROCs) in concentrations that exceed remediation goals (RGs) for potentially complete exposure pathways. Additional reference background areas (RBAs) will also be identified to confirm, or update as necessary, estimates of naturally occurring and man-made background levels for ROCs not attributed to Naval operations at HPNS. A statistical comparison of site data to applicable reference area data will be conducted.

The sampling and analysis activities at Parcel G will be conducted in accordance with this SAP, the separate Parcel G Work Plan, and a separate accident prevention plan/site safety and health plan (APP/SSHP). Project requirements, including personnel roles and responsibilities, required training, and health and safety protocols are based on CH2M HILL, Inc. and its subcontractor, Perma-Fix Environmental Services, leading and conducting the field activities. If another contractor performs the field activities, this SAP will be amended with contractor-specific information, as needed.

Soil Investigations

Soil investigations will be conducted in a phased approach at the following areas in Parcel G:

- Former Sanitary Sewer and Storm Drain Trenches
- Buildings 317/364/365 Former Building Site
- Building 351A Crawl Space

Soil investigation areas will be divided into trench units (TUs) and surface soil survey units (SUs). The size and boundary of the TUs and SUs will be based on previous plans and reports.

Former Sanitary Sewer and Storm Drain Trench Units

For the TUs associated with former sanitary sewers and storm drains (from 1 to 22 feet deep), a phased investigation approach was designed based on a proposal by the regulatory agencies to achieve a high level of confidence that the Parcel G ROD RAO has been met for soil. For Phase 1, 100 percent of soil will be re-excavated

and characterized at 33 percent of TUs in Parcel G. Soil sampling and scanning at the remaining 67 percent of TUs will be performed as part of Phase 2 to increase confidence that current site conditions comply with the Parcel G ROD RAO. The Navy will re-excavate 100 percent of Phase 2 TUs if contamination is identified in Phase 1 TUs. For both Phase 1 TUs and Phase 2 TUs, the durable cover (including asphalt, asphalt base course, concrete, gravel, debris, or obstacles) will be removed to expose the target soils.

Phase 1

Phase 1 includes investigation of a targeted group of TUs. Of the 63 former sanitary sewer and storm drain TUs, 21 were selected for the Phase 1 investigation. The targeted TUs were selected based on the highest potential for radiological contamination in light of historical documentation of specific potential upstream sources, spills, or other indicators of potential contamination (NAVSEA, 2004), and signs of potential manipulation or falsification from the soil data evaluation (Navy, 2017). The Phase 1 soil investigation will include collection of systematic soil samples from each TU, gamma scan of 100 percent of soil, and collection of biased soil samples, where necessary, based on the gamma scan measurements.

All of the soil (100 percent) will be excavated to the original TU boundaries, as practicable, and gamma scans of the excavated material will be conducted during Phase 1. Excavated soil will be gamma-scanned by one of two methods. Soil may be laid out on Radiological Screening Yard pads for a surface scan, or soil may be processed and scanned using soil segregation technology. Following excavation to the original TU boundaries, additional excavation of approximately 6 inches of the trench sidewalls and floors will be performed to provide ex situ scanning and sampling of the trench sidewalls and floors. The excavated soil from within each trench and the over-excavation will be tracked separately, and global positioning system (GPS) location-correlated results will be collected.

Systematic and biased samples will be collected from the excavated soil from the TUs and within the surrounding soil of the TUs. A minimum of 18 systematic samples will be collected from each excavated soil unit and TU. The soil samples will be analyzed for the applicable ROC analysis by accredited offsite laboratories. Soil sample locations will be surveyed using GPS. If the investigation results collected during the gamma scan surveys and systematic and biased soil samples of the over-excavated material demonstrate exceedances of the RGs and are not attributed to naturally occurring radioactive material (NORM) or anthropogenic background, the material will be segregated for further evaluation, and an in situ investigation and/or remediation of the trench sidewalls and floor will be performed prior to backfill.

Phase 2

At the remaining 42 TUs, 100 percent radiological surface gamma scan of accessible areas and soil sampling will be conducted. Subsurface soil samples will be collected via borings, with a minimum of 18 borings within the trench and 1 boring every 50 linear feet along the sidewalls of the trench. The borings will be advanced beyond the floor boundary of the trench or to the point of refusal. Gamma scans of the core will be conducted. Borehole locations will be surveyed using GPS.

The soil samples will be analyzed for the applicable ROC analysis by accredited offsite laboratories.

Former Building Site and Crawl Space Soil Survey Units

At the 28 surface soil SUs¹ from the Former Buildings 317/364/365 Site and Building 351A Crawl Space, the radiological investigation of soil is based on a proposal by the regulatory agencies and includes the following:

¹ Previously, 32 SUs were investigated at Former Buildings 317/364/365 Site and Building 351A Crawl Space; however, some SU areas overlapped. For the Buildings 317/364/365 Former Building Site, former SU 22 overlaps TU 153 and will be investigated as part of TU 153. For the Building 351A Crawl Space, former SU R, SU S, and SU M, SU N, and SU O and will be investigated as SU M, SU N, and SU O.

- Collection of a minimum of 18 systematic soil samples from each SU
- Gamma scan of 100 percent of the soil
- Collection of biased soil samples, where necessary, based on the gamma scan measurements

For all the surface soil SUs, a surface gamma scan of 100 percent of surface soil will be conducted as walk-over or drive-over surveys. GPS location-correlated results will be collected. Systematic and biased samples will be collected from the surface soil SUs. The soil samples will be analyzed for the applicable ROCs by accredited offsite laboratories. Soil sample locations will be surveyed using GPS.

Reference Background Area

Soil sampling will be conducted in RBAs to establish representative background data sets for comparison and evaluation of soil data collected from HPNS, including Parcel G. Four onsite RBAs, located at HPNS, and one undisturbed offsite RBA are planned for radiological background characterization. Gamma scans of accessible surface areas will be performed within the RBAs to confirm that the areas are free of elevated gamma levels and are suitable for sampling. The background characterization will include surface subsurface soil sampling. Soil samples will be analyzed for ROCs. The data will be compared and evaluated to provide representative RBA data sets with a description to assist in determining applicability for specific projects at HPNS. The data evaluation process is summarized in Appendix C of the Parcel G Work Plan.

Building Investigations

Building investigations will be performed at the following structures in Parcel G:

- Building 351A
- Building 351
- Building 366
- Building 401
- Former Building 408 Concrete Pad
- Building 411
- Building 439

Buildings will be divided into SUs, and the size and boundary of the SUs will be based on the previous plans and reports. Radiological investigations at the buildings will include collection of a minimum of 18 systematic static alpha-beta measurements from each SU; alpha-beta scanning of surfaces; collection of biased static alpha-beta measurement, where necessary, based on the alpha-beta scan measurements; collection of swipe samples to assess removable contamination levels; and collection of material samples as needed to further characterize areas of interest.

Data Evaluation

Data from the radiological investigation will be evaluated to determine whether the site conditions are compliant with the Parcel G ROD RAO. If the residual ROC concentrations are below the RGs in the Parcel G ROD or are shown to be representative of NORM or anthropogenic background, then the site conditions are compliant with the Parcel G ROD RAO. Various methods will be used to determine whether the residual ROC concentrations comply with the Parcel G ROD RAO:

- Each sample and measurement result will be compared to the corresponding RG. If all residual ROC concentrations are less than or equal to the corresponding RG, then site conditions comply with the Parcel G ROD RAO.

- Sample and measurement data will be compared to appropriate RBA data and multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include, but is not limited to, population-to-population comparisons, use of a maximum likelihood estimate or background threshold value, graphical comparisons, and comparison with regional background levels. If all residual ROC concentrations are determined to be consistent with NORM or anthropogenic background, then site conditions comply with the Parcel G ROD RAO.
- Each radium-226 (^{226}Ra) sample result exceeding both the corresponding RG and the expected range of background will be compared to concentrations of other radionuclides in the uranium natural decay series. If the concentrations of radionuclides in the uranium natural decay are consistent with the assumption of secular equilibrium, then the ^{226}Ra concentration is NORM, and site conditions comply with the Parcel G ROD RAO.

If the investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically-based² RGs at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a remedial action completion report (RACR) will be developed. If the investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically-based² RGs at agreed upon statistical confidence levels and are not shown to be NORM or anthropogenic background, remediation will be conducted, followed by a RACR. The RACR will describe the results of the investigation, explain remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel G ROD RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.

Organization of the SAP

This SAP consists of 37 worksheets specific to the scope of work for the Parcel G Removal Site Evaluation. Tables are embedded within the worksheets. Figures are presented at the end of the document. The project scoping meeting minutes and responses to comments are included in **Attachment 1**. The field standard operating procedures are provided in **Attachment 2**. Laboratory Department of Defense (DoD) Environmental Laboratory Standard Operating Procedures are provided in **Attachment 3**. DoD Environmental Laboratory Accreditation Program accreditation letters are included in **Attachment 4**. The technical systems audit checklist is included in **Attachment 5**.

² The RGs are statistically based because they are increments above a statistical background.

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Acronyms and Abbreviations

⁴⁰ K	potassium-40
⁶⁰ Co	cobalt-60
⁹⁰ Sr	strontium-90
¹³⁷ Cs	cesium-137
²⁰⁸ Tl	thallium-208
²¹² Bi	bismuth-212
²¹² Pb	lead-212
²¹⁴ Bi	bismuth-214
²¹⁴ Pb	lead-214
²²⁶ Ra	radium-226
²²⁸ Ac	actinium-228
²²⁸ Th	thorium-228
²³⁰ Th	thorium-230
²³² Th	thorium-232
²³⁴ Pa	protactinium-234
²³⁴ Th	thorium-234
²³⁴ U	uranium-234
²³⁵ U	uranium-235
²³⁸ Pu	plutonium-238
²³⁸ U	uranium-238
²³⁹ Pu	plutonium-239
²⁴⁰ Pu	plutonium-240
²⁴¹ Am	americium
%R	percent recovery
APP	Accident Prevention Plan
ASTM	American Society for Testing and Materials
BEC	BRAC Environmental Coordinator
bgs	below ground surface
BLTL	Business Line Team Leader
BMP	best management practice
BRAC	Base Realignment and Closure
BSC	Background Subtraction Count
BTV	background threshold value
CA	corrective action
CAS	Chemical Abstracts Service
CCV	continuing calibration verification
CDPH	California Department of Public Health
CFR	<i>Code of Federal Regulations</i>
CH2M	CH2M HILL, Inc.
CLEAN	Comprehensive Long-Term Environmental Action – Navy
CLP	Contract Laboratory Program
cm ²	square centimeter(s)
cm/s	centimeter(s) per second
CSM	conceptual site model

DoD	Department of Defense
DOT	Department of Transportation
dpm/100 cm ²	disintegration(s) per minute per 100 square centimeters
DQA	Data Quality Assessment
DQI	data quality indicator
DQO	data quality objective
DTSC	California Department of Toxic Substances Control
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
EPM	Environmental Program Manager
ESU	excavated soil unit
ft ²	square feet
FWHM	full width at half maximum
GEL	GEL Laboratories, LLC
GFPC	gas flow proportional counting
GPS	global positioning system
HP	Hunters Point
HRA	Historical Radiological Assessment
HPNS	Hunters Point Naval Shipyard
ICAL	initial calibration
ICALE	initial calibration – efficiency
ICALV	Initial calibration – voltage plateau
ICC	instrument contamination check
ICV	initial calibration verification
IECV	efficiency calibration verification
ID	identification
keV	kiloelectron volt
KW	Kruskal-Wallis
LCL	lower control limit
LCS	laboratory control sample
LLRW	low-level radioactive waste
LRPM	Lead Remedial Project Manager
LWTS	liquid waste transfer system
m ²	square meter(s)
MARLAP	<i>Multi-Agency Radiological Laboratory Analytical Protocols Manual</i>
MARSSIM	<i>Multi-Agency Radiation Survey and Site Investigation Manual</i>
MB	method blank
MDA	minimum detectable activity
MDC	minimum detectable concentration
MLE	maximum likelihood estimate
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NAVFAC	Naval Facilities Engineering Command
NAVSEA	Naval Sea Systems Command
Navy	Department of the Navy
NORM	naturally occurring radioactive material

NRC	Nuclear Regulatory Commission
NRDL	Naval Radiological Defense Laboratory
OCII	Office of Community Investment and Infrastructure
ORR	Operational Readiness Review
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
pCi/g	picocurie(s) per gram
pCi/L	picocurie(s) per liter
Perma-Fix	Perma-Fix Environmental Services
POC	point of contact
PM	Project Manager
PPE	personal protective equipment
QA	quality assurance
QAO	Quality Assurance Officer
QC	quality control
QL	quantitation limit
QSM	<i>Quality Systems Manual for Environmental Laboratories</i>
RACR	remedial action completion report
RASO	Radiological Affairs Support Office
RAO	remedial action objective
RBA	reference background area
RER	relative error ratio
RG	remediation goal
ROC	radionuclide of concern
ROD	record of decision
ROICC	Resident Officer in Charge of Construction
RPD	relative percent difference
RPM	Remedial Project Manager
RSO	Radiation Safety Officer
RSY	radiological screening yard
RTC	Response to Comment
SAP	sampling and analysis plan
SB	subsurface soil
SCM	surface contamination monitor
SFDPH	San Francisco Department of Public Health
SFU	sidewall floor unit
SOP	standard operating procedure
SS	surface soil
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
STC	Senior Technical Consultant
SU	survey unit
TBD	to be determined
TCRA	time-critical removal action
TSA	Technical Systems Audit
TtEC	Tetra Tech EC, Inc.

TU	trench unit
UCL	upper control limit
UFP	Uniform Federal Policy
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
VSP	Visual Sampling Plan
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region

SAP Worksheet #2—SAP Identifying Information

Site Name/Number: Former Hunters Point Naval Shipyard (HPNS), San Francisco, California

Operable Unit: Not Applicable (N/A)

Contractor Name: CH2M HILL, Inc. (CH2M)

Contract Number: N62470-16-D-9000

Contract Title: Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard

Work Assignment Number: Contract Task Order Number FZ12

1. This Sampling and Analysis Plan (SAP) was prepared in accordance with Naval Facilities Engineering Command (NAVFAC), Southwest Division Work Instructions and the following guidance documents:
 - *Guidance for Quality Assurance Project Plans* (USEPA, 2002)
 - *Uniform Federal Policy for Quality Assurance Project Plans* (USEPA, 2005)
 - *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)
 - *Quality Systems Manual for Environmental Laboratories, Version 5.1* (DoD, 2017)
2. Identify regulatory program:
 - Comprehensive Environmental Response, Compensation, and Liability Act
3. This SAP is a project-specific SAP.
4. List dates of scoping sessions that were held:
 - The Department of the Navy (Navy) Base Realignment and Closure (BRAC) Project Management Office held project kickoff meetings on November 17 and 22, 2016, and a meeting with the regulators, including the United States Environmental Protection Agency (USEPA), California Department of Toxic Substances Control (DTSC), Office of Community Investment and Infrastructure (OCII), San Francisco Department of Public Health (SFDPH), and California Regional Water Quality Control Board, San Francisco Bay Region (Water Board) on December 7, 2016.
 - The Navy assembled a Technical Team (a group of technical experts) that includes representatives from the Navy, USEPA, DTSC, California Department of Public Health (CDPH), and the City of San Francisco. The Technical Team conducted an evaluation of previous HPNS data in light of the claims made and is developing an approach for follow-up investigations. The Technical Team meets at least bi-weekly to discuss project updates and review documents. To date, several work plan iterations have been submitted and reviewed. For soil, a phased approach was designed based on a proposal by the regulatory agencies on an initial draft work plan. For buildings, the approach was designed based on regulatory comments on an initial draft work plan to conduct surveys based on the Parcel G Record of Decision (ROD). The approaches for soil and buildings are included in the Draft Parcel G Removal Site Evaluation Work Plan, herein referred to as the Parcel G Work Plan, which has been submitted and is currently in review.
5. List dates and titles of documents that are relevant to the current investigation:
 - Previous site work relevant to the current investigation is summarized in **Table 2-1. Worksheet #10** includes a summary of the findings from previous investigations.

SAP Worksheet #2—SAP Identifying Information (continued)

Table 2-1. Previous Site Work

Reference Title	Date	Author
Final Historical Radiological Assessment, Volume II, Use of General Radioactive Materials, 1939-2003	2004	NAVSEA
Basewide Radiological Removal Action, Action Memorandum, HPS, San Francisco, California, Revised Final	2006	TtEC
Basewide Radiological Removal Action, Action Memorandum-Revision 2006, HPNS, San Francisco, California	2006	TtEC
Addendum 1 to the Final Sampling and Analysis Plan for the Base-Wide Sewer Systems (Field Sampling Plan and Quality Assurance Project Plan), Base-wide Storm Drain and Sanitary Sewer Removal, HPS, San Francisco, California	2006	TtEC
Base-wide Radiological Work Plan, HPS, San Francisco, California, Revision 1	2007	TtEC
Project Work Plan, Basewide Storm Drain and Sanitary Sewer Removal, HPNS, San Francisco, California, Revision 3	2008	TtEC
Record of Decision for Parcel G	2009	Department of the Navy
Project Work Plan, Base-wide Storm Drain and Sanitary Sewer Removal, HPS, San Francisco, California, Revision 4	2010	TtEC
Basewide Radiological Management Plan	2012	TtEC
Work Plan, Basewide Radiological Support, HPNS, San Francisco, California	2015	TtEC
Radiological Data Evaluation Findings Report for Parcels B and G Soil	2017	Department of the Navy
Building Data Initial Evaluation Report, Draft	2018	Department of the Navy

Notes:

NAVSEA = Naval Sea Systems Command
 TtEC = Tetra Tech EC, Inc.

6. Organizational partners (stakeholders) and connection with lead organization:

- USEPA – Regulatory Stakeholder
- California DTSC – Regulatory Stakeholder
- CDPH – Regulatory Stakeholder
- California Environmental Protection Agency State Water Resources Control Board – Regulatory Stakeholder
- City of San Francisco – Future Property Owner
- Surrounding HPNS Community – Public Stakeholder

7. Lead organization:

- United States Department of the Navy (Navy) – NAVFAC Southwest, BRAC Program Management Office West

8. If any required SAP elements or required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below:

- No worksheets are excluded from this SAP.

SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number	E-mail Address or Mailing Address
Danielle Janda	Lead Remedial Project Manager (LRPM)	Navy BRAC	(619) 524-6041	danielle.janda@navy.mil
Joe Arlauskas	Quality Assurance Officer (QAO)	NAVFAC Southwest	(619) 532-4125	joseph.arlauskas@navy.mil
George (Patrick) Brooks	Navy Project Supervisor	Navy BRAC	(619) 524-5724	george.brooks@navy.mil
Stephen Banister	Navy Remedial Project Manager (RPM)	Navy BRAC	(619) 524-6040	stephen.banister@navy.mil
Derek Robinson	BRAC Environmental Coordinator (BEC)	Navy BRAC	(619) 524-6026	derek.robinson@navy.mil
Zachary Edwards	Director of Environmental Program Division	NAVSEA Radiological Affairs Support Office (RASO)	(757) 887-7762	zachary.edwards@navy.mil
Matthew Slack	Environmental Program Manager (EPM), Health Physicist	NAVSEA RASO	(757) 887-4212	matthew.slack@navy.mil
Matthew Liscio	EPM, Health Physicist	NAVSEA RASO	(757) 887-4354	matthew.liscio@navy.mil
Lily Lee	RPM, Staff Technical Lead	USEPA	(415) 847-4187	lee.lily@epa.gov
John Chesnutt	Section Manager, U.S. Army, Navy	USEPA	(415) 972-3005	chesnutt.john@epa.gov
Janet Naito	Branch Manager, Cleanup	DTSC	(510) 540-3833	janet.naito@dtsc.ca.gov
Nina Bacey	RPM	DTSC	(510) 540-2480	juanita.bacey@dtsc.ca.gov
Sheetal Singh	Environmental Management Branch	CDPH	(916) 449-5691	sheetal.singh@cdph.ca.gov
Matt Wright	Environmental Management Branch	CDPH	(916) 210-8550	matthew.wright@cdph.ca.gov
Tina Low	RPM/Technical Staff Lead	Water Board	(510) 622-5682	tina.low@waterboards.ca.gov
Amy Brownell	Staff Lead Technical SFDPH	SFDPH	(415) 252-3967	amy.brownell@sfdph.org
Anita Dodson	Program Chemist/SAP Reviewer/QAO	CH2M	(757) 671-6218	anita.dodson@ch2m.com
Janna Staszak	SAP Reviewer	CH2M	(757) 518-9666	janna.staszak@ch2m.com
Kim Henderson	Project Manager (PM)	CH2M	(619) 272-7209	kimberly.henderson@ch2m.com

SAP Worksheet #3—Distribution List (continued)

Name of SAP Recipients	Title/Role	Organization	Telephone Number	E-mail Address or Mailing Address
John Hackett	Senior Radiological Technical Consultant	CH2M	(303) 589-7217	John.hackett@ch2m.com
Mark Cichy	Project Chemist	CH2M	(530) 229-3274	mark.cichy@ch2m.com
Loren Kaehn	Health and Safety Manager	CH2M	(208) 383-6212	loren.kaehn@ch2m.com
Kevin Smallwood	Field Team Leader	CH2M	(970) 250-5441	kevin.smallwood@ch2m.com
Rachel Zajac-Fay	Site Safety and Health Officer (SSHO)	CH2M	(916) 286-0235	rachel.zajac-fay@ch2m.com
Theresa Rojas	Corporate Quality Assurance Manager	CH2M	(678) 530-4297	theresa.rojas@ch2m.com
Scott Hay	Radiological Senior Technical Consultant (STC)	Cabrera	(702) 236-8401	shay@cabreraservices.com
Alex Lopez	Radiological Support PM /License Radiation Safety Officer (RSO)	Perma-Fix Environmental Services (Perma-Fix)	(970) 778-0449	alopez@perma-fix.com
Valerie Davis	Analytical Laboratory PM	GEL Laboratories, LLC (GEL)	(843) 556-8171	team.davis@gel.com
Bob Pullano	Laboratory QAO	GEL	(843) 556-8171	rlp@gel.com
TBD	Data Validation PM	TBD	TBD	TBD
TBD	Utility Locator	TBD	TBD	TBD
TBD	Driller	TBD	TBD	TBD
TBD	Direct-push Technology Provider	TBD	TBD	TBD
TBD	Surveyor	TBD	TBD	TBD

Notes:

TBD cells will be populated with information after personnel are selected, prior to fieldwork.

SAP Worksheet #4—Project Personnel Sign-off Sheet

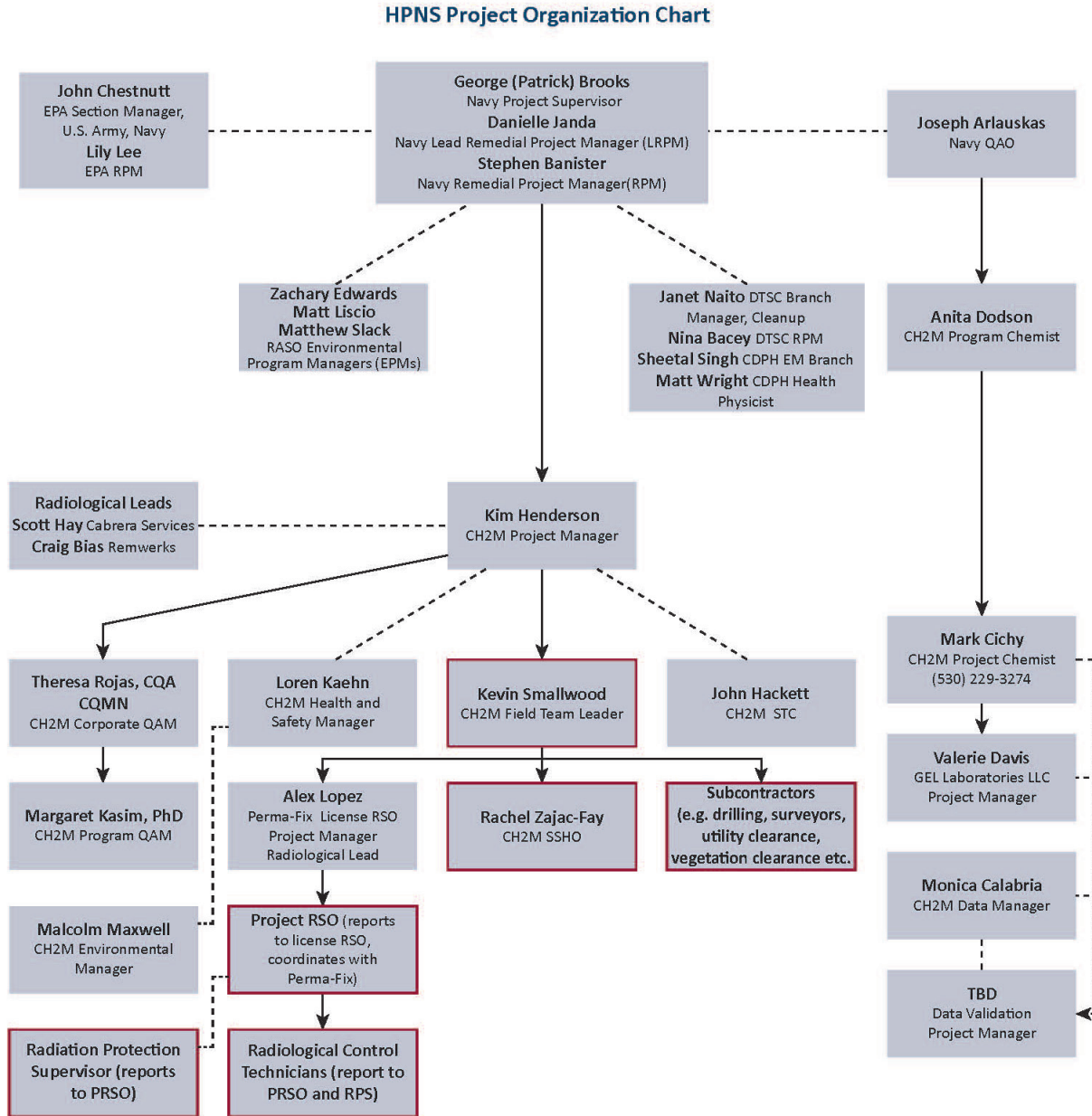
Name	Organization/Title/Role	Telephone Number (optional)	Signature/e-mail receipt	SAP Section Reviewed	Date SAP Read
Kim Henderson	CH2M/PM	(619) 272-7209			
John Hackett	CH2M/STC	(303) 589-7217			
Kevin Smallwood	CH2M/Field Team Leader	(970) 250-5441			
Mark Cichy	CH2M/Project Chemist	(530) 229-3274			
Monica Calabria	CH2M/Data Manager	(610) 399-3860			
Rachel Zajac-Fay	CH2M/SSHO	(916) 286-0235			
Valerie Davis	GEL/Laboratory PM	(843) 556-8171			
TBD	TBD/Data Validation PM	TBD			
TBD	CH2M/Sampling Personnel	TBD			

Notes:

The sampling personnel will read the appropriate sections of this document before performing activities related to this SAP. The completed sign-off worksheet will be maintained in the project file.

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SAP Worksheet #5—Project Organizational Chart³



LEGEND

- Denotes In Field Role
- Lines of Authority
- - - Lines of Communication

EN050516113SD0

³ Project personnel for the Parcel G soil investigation will be updated with an addendum to this SAP.

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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure (timing, pathway to and from, etc.)
Communication with Navy (lead agency)	Navy LRPM	Danielle Janda	(619) 524-6041	Primary points of contact (POCs) for Navy; can delegate communication to other internal or external POCs. PM will communicate either verbally or by e-mail with earliest schedule possible for fieldwork to commence. Navy will provide PM with written instruction to proceed upon completing coordination with Contracting Officer. Navy will notify USEPA, DTSC, CDPH, and SDPH by e-mail or telephone call for significant field changes effecting the scope or implementation of the design.
	Navy Project Supervisor	George (Patrick) Brooks	(619) 524-5724	
	NAVSEA RASO, Director of Environmental Program Division	Zachary Edwards	(757) 887-7762	
	NAVSEA RASO, EPM, Health Physicist	Matthew Slack	(757) 887-4212	
	NAVSEA RASO, EPM, Health Physicist	Matt Liscio	(757) 887-4354	
Communication with USEPA	USEPA	TBD	TBD	Primary POC for USEPA; can delegate communication to other internal or external POCs. Upon notification of field changes, USEPA will review significant field changes. Reports and other project-related information are submitted by the Navy for review and comments by the agency.
Communication with DTSC	DTSC Branch Manager, Cleanup	Janet Naito	(510) 540-3833	Primary POCs for DTSC; can delegate communication to other internal or external POCs. Upon notification of field changes, DTSC will review significant field changes. Reports and other project-related information are submitted by the Navy for review and comments by the agency.
	DTSC RPM	Nina Bacey	(510) 540-2480	
Communication with Water Board	RPM, Technical Lead Staff	Tina Low	(510) 622-5682	Primary POCs for Water Board; can delegate communication to other internal or external POCs. Upon notification of field changes, Water Board will review significant field changes. Reports and other project-related information are submitted by the Navy for review and comments by the agency.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure (timing, pathway to and from, etc.)
Communication with SFDPH	SFDPH Staff Lead	Amy Brownell	(415) 252-3967	Primary POCs for SFDPH; can delegate communication to other internal or external POCs. Reports and other project-related information are submitted by the Navy for review and comments by the agency.
Communication regarding overall project status and implementation, and primary POC with Navy, USEPA, DTSC, Water Board, SFDPH	CH2M PM	Kim Henderson	(619) 272-7209	Oversees project and will be informed of project status by the field team. If field changes occur, PM will work with the Navy to communicate in-field changes to the regulatory agencies by e-mail. Materials and information about the project are forwarded to the Navy by the PM.
Communication with the Comprehensive Long-Term Environmental Action – Navy (CLEAN) program	CH2M Deputy Program Manager	Doug Dronfield	(703) 376-5090	Oversees the CLEAN program for CH2M as needed. Will be notified if field changes occur that require program support.
Technical communications for project implementation and data interpretation	CH2M Radiological Lead Cabrera Radiological Lead Perma-Fix Lead PM/RSO	John Hackett Scott Hay Alex Lopez	(303) 589-7217 (702) 236-8401 (970) 778-0449	Contact STC regarding questions/issues encountered in the field, input on data interpretation, as needed. STC will have 24 hours to respond to technical field questions as necessary. Additionally, STC will review the data as necessary during report preparation.
Communications regarding the SAP	CH2M SAP reviewer	Janna Staszak	(757) 671-6256	Changes/revisions to the SAP will be reviewed by the SAP reviewer, as soon as possible, and as necessary.
SAP amendments	CH2M Program Chemist	Anita Dodson	(757) 671-6218	Any changes to the SAP are submitted in writing to the Navy QAO, who must approve the changes prior to implementation. The appropriate regulatory agencies will also be notified when SAP amendments are issued.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure (timing, pathway to and from, etc.)
SAP amendment approvals	Navy QAO	Joseph Arlauskas	(619) 532-4125	Issues final approval of SAP amendments to Program Chemist via signed approval form (portable document format is acceptable). Concurrence from the Navy LRPM/Business Line Team Leader (BLTL).
Communication with Navy QAO	CH2M Program Chemist	Anita Dodson	(757) 671-6218	Quality-related materials and information about the project are forwarded to the Navy QAO by the Program Chemist.
Health and safety	CH2M HSM	Loren Kaehn	(208) 383-6212	Responsible for generation of the Health and Safety Plan and approval of the activity hazard analyses prior to the start of fieldwork. The PM will contact the HSM as needed regarding questions/issues encountered in the field.
Health and safety	CH2M SSHO	Rachel Zajac-Fay	(916) 286-0235	Responsible for the adherence of team members to the site safety requirements described in the Health and Safety Plan. Will report health and safety incidents to PM as soon as possible.
Field progress reports	Field Team Leader CH2M	Kevin Smallwood	(970) 250-5441	Daily field progress reports will be prepared by the Field Team Leader and submitted to the PM by phone or e-mail.
Stop work issues	Field Team Leader CH2M	Kevin Smallwood	(970) 250-5441	Field Team leader notifies PM about any stopped work that occurs. All field personnel have stop work authority based on the Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP). Joseph Arlauskas, Navy QAO, or representative, has authority to stop work if quality-related compliance issues are identified, or if there is noncompliance with field quality control (QC) protocols, as specified in this SAP.
	Navy QAO	Joseph Arlauskas	(619) 532-4125	

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure (timing, pathway to and from, etc.)
Revising sampling program (adding or removing sampling location or revising analytical suite)	CH2M PM	Kim Henderson	(619) 272-7209	Changes to the sampling program are submitted in writing as a field change request or proposed SAP amendment to the Navy QAO, who must approve the changes prior to implementation.
Field deviations from the SAP	Field Team Leader	Kevin Smallwood	(970) 250-5441	Documentation of deviations from the SAP will be made in the field logbook, and the PM will be notified immediately. Deviations will be made only with approval from the PM. The appropriate regulatory agencies will also be notified of significant field deviations from the SAP as appropriate.
Release of field data	Field Team Leader CH2M	Kevin Smallwood	(970) 250-5441	Field data are reviewed by the Field Team Leader and are transmitted by e-mail or hard copy shipping to the PM.
Reporting analytical data quality issues	GEL PM	Valerie Davis	(843) 556-8171	Quality assurance (QA)/QC issues with project field samples will be reported within 2 days to the Project Chemist by the laboratory.
Field or analytical corrective actions (CAs)	Program Chemist CH2M	Anita Dodson	(757) 671-6218	CAs for field and analytical issues will be determined by the Field Team Leader and/or the Project Chemist and reported to the PM within 4 hours. If serious laboratory issues are discovered, the Navy will be notified.
Data tracking from field collection to database upload Release of analytical data	Project Chemist CH2M	Mark Cichy	(530) 229-3274	Tracks data from sample collection through database upload daily. No analytical data can be released until validation of the data is completed and has been approved by the Project Chemist. The Project Chemist will review analytical results within 7 days of receipt for release to the project team. The Project Chemist will inform the CLEAN Program Chemist who will notify the Navy QAO of any laboratory issues that would prevent the project from meeting project quality objectives or would cause significant delay in project schedule.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure (timing, pathway to and from, etc.)
Reporting data quality issues	Data Validation PM TBD	TBD	TBD	The data validator reviews and qualifies analytical data as necessary. The data along with a validation narrative are returned to the Project Chemist within 14 calendar days.
Field CAs	CH2M Field Team Leader CH2M PM	Kevin Smallwood Kim Henderson	(970) 250-5441 (619) 272-7209	Field and analytical issues requiring CA will be determined by the Field Team Leader and/or PM on an as-needed basis; the PM will ensure Quality Assurance Project Plan requirements are met by field staff for the duration of the project. The Field Team Leader will notify the PM via phone of any need for CA within 4 hours. The PM may notify the LRPM of any field issues that would negatively affect schedule or the ability to meet project data quality objectives (DQOs).
Changes in the field	Utility Locater Driller Direct-push Technology Provider Surveyor Investigation- derived waste Transportation and Disposal Provider	TBD	TBD	Documentation of deviations from planned field procedures during project work will discussed with PM prior to implementation. Deviations will only be made with approval from the PM.

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SAP Worksheet #7—Personnel Responsibilities and Qualifications

Name	Title/Role	Organizational Affiliation	Responsibilities
Danielle Janda	Navy LRPM	Navy BRAC	Oversees Project.
George (Patrick) Brooks	Navy Project Supervisor	Navy BRAC	Oversees Project.
Zachary Edwards	EPM, Health Physicist	NAVSEA RASO	Provides radiological technical support for the Navy.
Matthew Slack	EPM, Health Physicist	NAVSEA RASO	Provides radiological technical support for the Navy.
Matt Liscio	EPM, Health Physicist	NAVSEA RASO	Provides radiological technical support for the Navy.
Lily Lee	USEPA RPM	USEPA	USEPA POC.
Nina Bacey	RPM	DTSC	DTSC POC.
Janet Naito	Branch Manager, Cleanup	DTSC	DTSC POC.
Sheetal Singh	Environmental Management Branch	CDPH	CDPH POC
Matt Wright	Environmental Management Branch	CDPH	CDPH POC
Tina Low	RPM/Technical Staff Lead	Water Board	Water Board POC.
Amy Brownell	Staff Lead Technical SFDPH	SFDPH	SDPH POC.
Kim Henderson	PM	CH2M	Oversees project activities.
Doug Dronfield	Deputy Program Manager	CH2M	Oversees program.
Scott Hay	Radiological Lead	Cabrera	Provides subject matter support for project approach and execution.
John Hackett	Radiological Lead	CH2M	Provides subject matter support for project approach and execution.
Loren Kaehn	Health and Safety Manager	CH2M	Provides subject matter support for project approach and execution.
Anita Dodson	Program Chemist	CH2M	Provides Uniform Federal Policy (UFP)-SAP project delivery support, reviews and approves UFP-SAPs, and performs final data evaluation and QA oversight.
Janna Staszak	UFP-SAP Reviewer	CH2M	Reviews and approves changes or revisions to the UFP-SAP.

SAP Worksheet #7—Personnel Responsibilities and Qualifications (continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
Mark Cichy	Project Chemist	CH2M	Data management: Performs data evaluation and QA oversight, is the POC with laboratory and validator for analytical issues.
Kevin Smallwood	Field Team Leader	CH2M	Coordinates all field activities and sampling.
TBD	Field Staff	CH2M, Perma-Fix	Conducts field activities.
Valerie Davis	Analytical Laboratory PM	GEL	Manages samples tracking and maintains good communication with Project Chemist.
Bob Pullano	Laboratory QAO	GEL	Responsible for audits, CA, and checks of QA performance within the laboratory.
TBD	Analytical Data Validation PM	TBD	Validate laboratory data from an analytical standpoint prior to data use.

SAP Worksheet #8—Special Personnel Training Requirements

Project Function	Specialized Training by Title or Description of Course	Training Provider	Training Date	Personnel/ Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates
Radiological	General Employee Radiological Training	See Appendix D of the Parcel G Work Plan	Prior to initiation of fieldwork	All workers	All workers	Project File
	Radiological Worker Training and Certification	See Appendix D of the Parcel G Work Plan	Prior to initiation of fieldwork	All workers performing radiological work	Radiation Control Technician	Project File
	Radiological Control Technician Training and Certification	U.S. Department of Energy core, North East Utility Exam, National registry of Radiation Protection Technologists, etc. (Appendix D of Parcel G Work Plan)	Prior to initiation of fieldwork	All workers performing radiological work	Radiation Control Technician	Project File

Notes:

In addition to health and safety-related training, other training may be required as necessary as outlined in the APP/SSHP.

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SAP Worksheet #9—Project Scoping Session Participants Sheet

Project Name:	Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Radiological Data Evaluation and Confirmation Survey, Former Hunters Point Naval Shipyard				Site Name: HPNS
Projected Date(s) of Sampling: 2018-2019					Site Location: San Francisco, California
Project Manager: Kim Henderson (619) 272-7209					
Date of Session: December 7, 2016					
Scoping Session Purpose:	To introduce team members, discuss radiological data evaluation and community outreach activities, and gain feedback, input, and buy-in from stakeholders.				
Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Danielle Janda	LRPM	Navy BRAC	(619) 524-6041	danielle.janda@navy.mil	LRPM
Derek Robinson	BEC	Navy BRAC	(619) 524-6026	derek.robinson@navy.mil	BEC
Pat Brooks	BLTL/PM	Navy BRAC	(619) 524-5724	george.brooks@navy.mil	PM and BLTL
Bill Franklin	Public Affairs Officer	Navy BRAC	(619) 524-5433	william.d.franklin@navy.mil	Com Inv Lead
Lily Lee	RPM	USEPA	(415) 947-4187	lee.lily@epa.gov	Staff Lead Technical USEPA
Jackie Lane	Com Inv Coordinator	USEPA	(415) 972-3236	lane.jackie@epa.gov	Staff Lead Com Inv USEPA
David Yogi	Manager, Com Inv	USEPA	(415) 972-3350	yogi.david@epa.gov	Mid Manager Com Inv USEPA
Tamsen Drew	Senior PM/OCII Staff Lead	OCII (San Francisco)	(415) 749-2539	tamsen.drew@sfgov.org	Senior PM/OCII Staff Lead
Amy Brownell	Engineer	SFDPH	(415) 252-3967	amy.brownell@sfdph.org	Staff Lead Technical SFDPH
Scott Hay	Principal Health Physicist	Cabrera Services	(410) 332-8177	shay@cabreraservices.com	Principal Health Physicist
Janet Naito	Branch Manager, Cleanup	DTSC	(510) 540-3833	janet.naito@dtsc.ca.gov	Mid Manager Technical DTSC
Nina Bacey	RPM	DTSC	(510) 540-2480	juanita.bacey@dtsc.ca.gov	Staff Lead Technical DTSC
Sheetal Singh	Mid Manager CDPH	CDPH Environment al Health Branch	(916) 449-5691	sheetal.singh@cdph.ca.gov	Mid Manager CDPH

SAP Worksheet #9—Project Scoping Session Participants Sheet (continued)

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Robert Kirkbright	Program Manager	CH2M	(619) 687-0120 x37276	robert.kirkbright@ch2m.com	Program Manager
Jeff Wong	--	CDPH Radiological Health Branch	--	jeff.wong@cdph.ca.gov	--
Tina Low	RPM	Water Board	(510) 622-5682	tina.low@waterboards.ca.gov	Staff Lead Technical Water Board
Kellie Koenig	Vice President	CH2M	(619) 272-7217	kellie.koenig@ch2m.com	Vice President
Adam Engel	Health Physicist	CH2M	(619) 272-7286	adam.engel@ch2m.com	Data Reviewer
LCDR Soric	--	NAVSEA RASO	--	--	--
Lindsey Land	--	--	--	--	--
Matthew Slack	Environmental PM	NAVSEA RASO	(757) 887-4212	matthew.slack@navy.mil	Technical Expert Navy
Dr. Stephen Doremus	Former Director	NAVSEA RASO	--	--	--
Zachary Edwards	Manager, Health Physicist	NAVSEA RASO	(757) 887-7762	zachary.edwards@navy.mil	Technical Expert Navy
Jana Dawson	Health Physicist (Techlaw Contractor)	USEPA	--	jdawson@techlawinc.com	Technical Expert USEPA
Karla Brasaemle	Geologist (Techlaw Contractor)	USEPA	--	kbrasaemle@techlawinc.com	Technical Expert USEPA
Mark Luckhardt	--	Five Point	--	--	--

Comments/Decisions:

A detailed summary of the meeting is included in **Attachment 1**.

SAP-specific Action Items:

- Determine whether pre-2006 data were used for decision making.
- Provide library of compiled questions and answers on community outreach to share with team.

SAP Worksheet #9—Project Scoping Session Participants Sheet (continued)

Consensus Decisions:

- USEPA, DTSC, and the project team agreed that if the pre-2006 data were superseded by other work done after 2006, the pre-2006 data do not need to be analyzed.
- Statistical tests will identify anomalies in the data, including running tests designed to identify instances where data may have been falsified. It was agreed that areas of highest potential risk should be the priority.

Follow-up:

The Navy assembled a Technical Team (a group of technical experts) that includes representatives from the Navy, USEPA, DTSC, CDPH, and the City of San Francisco. The Technical Team conducted an evaluation of previous HPNS data in light of the claims made and is developing an approach for follow-up investigations. The Technical Team has met twice a month beginning in 2017 to discuss project updates and review documents. As an outcome of the ongoing working meetings, it was concluded that the evaluation may not have identified all instances of potential data manipulation or falsification. Through review of previously submitted iterations of the work plan, it was determined that the investigation approach for collection and evaluation of data will be based on the Parcel G ROD (Navy, 2009) and the Basewide Radiological Management Plan (TtEC, 2012).

To achieve a high level of confidence that ROD RGs have been met for soil (Attachment 2.1 in Appendix A of the Parcel G Work Plan and **Attachment 1** of this SAP), a phased approach was designed based on a proposal by the regulatory agencies. For Phase 1, 100 percent of soil will be re-excavated and characterized at 33 percent of TUs in Parcel G. Soil sampling and scanning at the remaining 67 percent of TUs will be performed as part of Phase 2 to increase confidence that current site conditions comply with the Parcel G ROD remedial action objective (RAO). The Navy will re-excavate 100 percent of Phase 2 TUs if contamination is identified in Phase 1 TUs. At the surface soil SUs from the Buildings 317/364/365 Former Building Site and Building 351A Crawl Space, and for building surfaces, the work plan details an approach that was designed based on regulatory comments on the draft work plans.

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SAP Worksheet #10—Conceptual Site Model

This section provides an updated conceptual site model (CSM) (**Table 10-1**). The CSM summarizes the site description, history, and current status related to radiologically impacted buildings and former building areas, and former sanitary sewers and storm drains identified in the Historical Radiological Assessment (HRA) (NAVSEA, 2004). The sanitary sewers and storm drains were once a combined system identified as radiologically impacted because of the possibility that radioactive waste materials had been disposed of in sinks and drains, and the potential for the surrounding soil to be impacted by leakage and soil mixing during repairs. A removal action was initiated in 2006 to remove the sanitary sewers and storm drains. The removal action included excavation of overburden soil, removal of pipelines, plugging of open sanitary sewers and storm drains left in place during the removal process, ex situ radiological screening and sampling of the pipeline, and performance of final status surveys of the excavated soil and exposed excavation of trench surfaces. Soil was removed to a minimum of 1 foot below and to the sides of the sanitary sewer and storm drain piping.

Following the investigation and removal actions, there were allegations that TtEC potentially manipulated and falsely represented data, and some allegations have since been confirmed. In addition, the onsite laboratory used a screening method to analyze radium-226 (^{226}Ra) that may have reported at levels higher than actual radioactivity. TtEC presented CSMs in remedial action completion reports (RACRs) that were based on potentially falsified data and screening results for ^{226}Ra reported by the onsite laboratory (results were biased high).

As a result, the Navy will conduct investigations at radiologically impacted soil and buildings in Parcel G that were surveyed by TtEC. The results of additional investigation activities presented in this SAP and the Parcel G Work Plan will be used to update the CSM as needed.

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SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Conceptual Site Model

Site Name	Former Hunters Point Naval Shipyard (Parcel G)
Site Location	Located on San Francisco Bay near the southeastern boundary of San Francisco, California. HPNS encompasses approximately 848 acres, including approximately 416 acres on land, at the point of a high, rocky, 2-mile-long peninsula projecting southeastward into San Francisco Bay. Parcel G occupies 40 acres in the middle of HPNS (Figure 10-1).
Site Operations and History	<ul style="list-style-type: none"> • NRDL activities associated with analyzing samples from nuclear weapons tests, scientific studies (fallout, plant, animal, materials), and production and use of calibration sources. • The HRA also documents in Table 5-1 that the Navy had five radioactive licenses with the Atomic Energy Commission for ¹³⁷Cs, one for a quantity of 3,000 curies and a separate quantity of 20 curies of ¹³⁷Cs. Two licenses indicate that ¹³⁷Cs was in sources. In some cases, the Navy made their own sources with ¹³⁷Cs. Use of radiography sources. • Use and potential disposal of radiological commodities, including discrete devices removed from ships (deck markers, radium dials) and welding rods. • Historical radiological material use documented in the HRA (NAVSEA, 2004) lists “impacted sites” – sites with potential for radioactive contamination. • Former surface soil impacted by fallout may be subsurface soil today because of fill activities.
Historical Site Conditions	<p>Facility created from fill with some background levels of radionuclides (e.g., NORM and fallout). Dredge spoils from local berths were used as fill for some areas. Trenches were backfilled following removal of sewer lines. Trench backfill is mixed, but documentation of source is available (onsite fill, offsite fill, or mixture). Bay mud or bedrock marks bottom extent of fill material.</p> <p>Site drainage system was designed in the 1940s to discharge to San Francisco Bay and was separated into sanitary sewers and storm drains in 1958, 1973, and 1976, but never completed.</p>
	<p>Potential Historical Sources of Radiological Contamination</p> <ul style="list-style-type: none"> • Potential spills and releases from the following: <ul style="list-style-type: none"> – Storage of samples from nuclear weapons tests at various NRDL facilities – NRDL waste disposal operations: <ul style="list-style-type: none"> ▪ Liquid waste stored in tank and processed at Building 364 ▪ Animal research at Building 364 • Incidental disposal of radioluminescent commodities (e.g., dials, deck markers) during maintenance, individually or attached to equipment. • Leaking radiography and calibration sources could affect buildings listed in HRA Table 6-1 related to production and maintenance of calibration sources. • Small amounts of low-level radioactive liquid waste were authorized for release with dilution to sanitary sewers based on regulations in place at the time.
	<p>Release Areas in Parcel G</p> <p>Known Release Areas (from Section 6.4 of the HRA):</p> <ul style="list-style-type: none"> • Building 351A: <ul style="list-style-type: none"> – Contaminated sinks and drain lines in Room 47 were removed • Buildings 317/364/365 Site: <ul style="list-style-type: none"> – “Peanut Spill” (small peanut-shaped spill adjacent to Building 364) – Liquid waste tanks removed – Contamination identified in yard and removed – Contaminated sinks and drain lines connected to the liquid waste tanks, not to the sanitary sewer, were removed <p>Potential Releases Identified after the HRA:</p> <ul style="list-style-type: none"> • Building 366 ventilation and potential releases to soil.
Potential Source Areas	<p>Impacted Buildings with High Contamination Potential (from Table 8-2 of HRA):</p> <ul style="list-style-type: none"> • Building 364 (demolished) - Previously a concrete structure, measuring approximately 40 feet by 50 feet, used as an animal irradiation and research facility, for isotope processing and decontamination studies, and as a general research laboratory. Building 364 also contained a hot cell used to perform some of these processes. A liquid radioactive waste collection area was previously located at the rear of the building. Following closure of HPNS, it was leased to a laboratory company, which performed assay operations and has since been demolished. <p>Impacted Buildings with Moderate Contamination Potential (from Table 8-2 of HRA):</p> <ul style="list-style-type: none"> • Building 351 - Vacant three-story reinforced-concrete shop building with a five-story tower at the northwestern corner, covering approximately 35,166 square feet (ft²) of floor space. Building 351 was previously used as an electronics work area/shop, optical laboratories, Navy Bureau of Medicine and Surgery storeroom, machine shop (first floor), sampling laboratory, general research laboratories, and biological research laboratories. The NRDL also used the building as materials and accounts division, technical information division, office services branch, thermal branch, engineering division, and library. • Building 351A - Vacant one-story concrete building, covering approximately 35,166 ft² of floor space, constructed in 1952 over a crawl space that abuts the southern end of the building. Building 351A was used as a radiation detection, indication and computation repair facility and electronics shop for radiation detection equipment and a facility for the calibration, repair, and reconditioning of other instruments. The NRDL also used the building as a chemistry laboratory, applied research branch, administrative offices, nuclear and physical chemistry laboratory, and chemical technology division. • Building 366 - Vacant, one-story, raised-ceiling structure composed of an exterior “sheet metal” shell with interior room constructed of traditional wood and sheetrock materials, measuring approximately 280 feet by 130 feet. The building was built over a full-floor concrete pad with isolated areas of asphalt patching. Building 366 was used as administrative offices, applied research and technical development branches, radiological safety branch, management planning division, nucleonics division, instruments evaluation section, general laboratories, chemical research laboratory, shipyard radiography shop, boat/plastic shop, and other military/navy branch project officers station. NRDL also used the building for instrument calibration and management engineering and comptroller department. • Building 408 (demolished) – Previously a steel-framed structure enclosing two free-standing furnaces, used for smelting, that were constructed in 1947. The building was the equivalent of three stories at its northern end, dropping to one story at its southern end, and open-sided on the north. A firebrick-lined hearth occupied most of the open area at the north. Natural gas burners were present on the eastern and western sides of the hearth, and a pair of smokestacks extended from the lower rear segment of the building. The building has been demolished, and the concrete building pad is all that remains.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Conceptual Site Model

<p>Potential Source Areas</p>	<p>Impacted Buildings in Parcel G</p>	<p>Impacted Buildings with Low or No Contamination Potential (from Table 8-2 of HRA):</p> <ul style="list-style-type: none"> • Building 317 (demolished) - Previously a concrete structure measuring approximately 30 feet by 40 feet, used by NRDL personnel for temporary animal quarters. • Building 365 (demolished) - Previously a wooden structure with a concrete foundation that measured approximately 30 feet by 40 feet. Building 365 was used as a personnel decontamination facility, change house, and storage building. The NRDL also used the building as a small animal facility. • Building 411 - Vacant curtain-walled, steel-framed building with a flat roof and includes a saw-toothed series of rooftop monitors as well as bands of steel industrial sash and large glazed industrial doors, measuring approximately 185,000 ft². Building 411 was used for source storage, as a civilian cafeteria, shipfitters and boilermakers shop, and ship repair shop. A leading enclosure measuring approximately 25 feet by 15 feet was in the building and housed an x-ray machine used for radiography. <p>Buildings Identified after the HRA:</p> <ul style="list-style-type: none"> • Building 401 - Vacant two-story building measuring approximately 100 feet by 250 feet. Building 401 was previously used as a supply storehouse, trades shop, and general stores, and by public works as a maintenance shop and offices. In 2005, the civilian tenant had been made aware of the presence of gauges and dials containing ²²⁶Ra and provided the gauges and dials to the Navy. • Building 439 - Vacant one-story building measuring approximately 250 feet by 400 feet. Building 439 was previously used by the Navy as an equipment storage facility. Following closure of HPNS, the building was leased by a skateboard company for use as a manufacturing and assembly plant. In 2002, Young Laboratories, a civilian tenant, was relocated to a 40-foot by 50-foot enclosed area in the northwestern corner of the building with a separate outside entrance. Young Laboratories processed and analyzed metals and other materials containing metals as part of its assay operations. Previous investigations in Building 364 identified an old kiln that was assumed to have been used by Young Laboratories and a subsequent survey identified slag material inside containing ²²⁶Ra. Additional surveys within Building 364 identified areas of elevated ¹³⁷Cs activity. The Navy identified Building 439 as potentially impacted based on potential cross-contamination from Building 364 during relocation. <p>The Navy has found radiological contamination in portions of Parcel G, such as in the southeastern corner (associated with the buildings and the peanut spill) and in the sewers along Cochrane Street because of previous testing during the Phase I through Phase V radiological investigations/cleanups. The HRA indicates that ¹³⁷Cs was found at high concentrations in sediment from a manhole along Cochrane Street. The HRA documents that the Navy used ¹³⁷Cs, resulting in liquid waste releases in Building 364 in piping, sinks, and the peanut spill behind the building.</p>
<p>Radionuclides of Concern for Parcel G (from Table 8-2 of HRA)⁴</p>	<ul style="list-style-type: none"> • ²²⁶Ra • ¹³⁷Cs • ⁹⁰Sr • ⁶⁰Co (only for interior surfaces of former Buildings 364 and 365 and Building 411) • ²³²Th (only building interior surfaces of Buildings 351, 351A, and 408) • ²³⁵U (only for interior surfaces of former Buildings 364 and 365) • ²³⁹Pu (only for interior surfaces of Building 351A and former Buildings 364 and 365) 	
<p>Potential Migration Pathways</p>	<ul style="list-style-type: none"> • Releases to soil and air. • Releases to sanitary sewer lines. <ul style="list-style-type: none"> – Buildings with known releases • Releases to storm drains. <ul style="list-style-type: none"> – Incomplete separation from sanitary sewer lines • Runoff from surface spills. • Releases from potentially leaking storm drain and sanitary sewer lines to surrounding soil (now removed). • Release of sediments from breaks or seams during power washing of drain lines. <div style="text-align: right;"> <p>The diagram is a cross-sectional view of a trench. It shows a layer of soil at the top, a trench in the middle, and a drain line at the bottom. The trench is filled with a material, and the drain line is a circular pipe. Labels include 'Soil', 'Trench', and 'Drain Line'. Below the diagram is the caption 'Conceptual Cross Section of Drain Lines'.</p> </div>	

⁴ The site-specific ROCs for the soil and building investigations are listed in **Worksheet #17**.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Conceptual Site Model

<p>Potential Exposure Pathways</p>	<ul style="list-style-type: none"> • Soil: <ul style="list-style-type: none"> – External radiation from ROCs – Incidental ingestion and inhalation of soil and dust with ROCs for intrusive activities disturbing soil beneath the durable cover (only construction worker receptor) • Building surfaces: <ul style="list-style-type: none"> – External radiation from ROCs – Inhalation and incidental ingestion of resuspended radionuclides
<p>Current Status</p>	<ul style="list-style-type: none"> • HPNS is not an active military installation. In 1991, HPNS was selected for closure pursuant to the terms of the Defense BRAC Act of 1990. For more than 20 years, the Navy leased many HPNS buildings to private tenants and Navy-related entities for industrial and artistic uses. Current leases include art studios and a police department facility. Parcels A, D-2, UC-1, and UC-2 have been transferred to the City and County of San Francisco for nondefense use, and the remaining areas of HPNS are also planned to be transferred. • All known sources of radiological material removed by Navy using standards at the time. <ul style="list-style-type: none"> – Follow-up investigations resulted in removal of small volumes of soil to meet current RGs. • Sanitary sewer and storm drain removal investigation conducted at Parcel G from 2007 to 2011. <ul style="list-style-type: none"> – More than 4 miles of trench lines and 50,000 cubic yards of soil investigated and disposed of or cleared for use as onsite fill. – Trench excavations that have been backfilled now contain homogenized soil from onsite fill, offsite fill, or a mixture of both.
<p>Uncertainties</p>	<ul style="list-style-type: none"> • Lower potential for radiological contamination than originally described in historical CSMs based on the following lines of evidence: <ul style="list-style-type: none"> – Known sources have been removed. – Sanitary sewers and storm drains, and 1 foot of soil surrounding the pipe removed to the extent practicable. The sewer lines were removed to within 10 feet of all buildings. Impacted buildings had remaining lines removed during surveys of the buildings. Non-impacted buildings had surveys performed at ends of pipes, and pipes were capped. – Any residual concentrations may be modified by radiological decay (shorter-lived radionuclides, such as ¹³⁷Cs and ⁹⁰Sr) or remobilization (including weathering and migration). – Sediment data from inside pipe not indicative of a large quantity disposal or contamination (maximum ²²⁶Ra concentration of 4.2369 pCi/g and maximum ¹³⁷Cs concentration of 0.87795 pCi/g in Parcel G). – Overestimate of ²²⁶Ra concentrations in soil by the onsite laboratory using an imprecise measurement method. – LLRW bins were tested by the Navy's independent waste broker at an offsite laboratory using 5-point composites, and only 3 out of 1,411 bins had results with ²²⁶Ra above the RGs. • Data manipulation or falsification. • Data quality deficiencies. • ¹³⁷Cs and ⁹⁰Sr are present at HPNS because of global fallout from nuclear testing or accidents, in addition to being potentially present as a result of Navy activities. Because of backfill activities, ¹³⁷Cs and ⁹⁰Sr from fallout and Navy activities are not necessarily only on the surface and may be present in both surface and subsurface soil. • Potential for isolated radiological commodities randomly distributed around the site. • Trenches where scan data exceeded the investigation level and biased soil samples were not collected.

Notes:

- ⁶⁰Co = cobalt-60
- ⁹⁰Sr = strontium-90
- ¹³⁷Cs = cesium-137
- ²³²Th = thorium-232
- ²³⁵U = uranium-235
- ²³⁹Pu = plutonium-239
- LLRW = low-level radioactive waste
- NORM = naturally occurring radioactive material
- NRDL = Naval Radiological Defense Laboratory
- pCi/g = picocurie(s) per gram
- RG = remediation goal
- ROC = radionuclide of concern

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SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
State the Problem	Identify the Objective	Identify Inputs to the Objective	Define the Study Boundaries	Develop Decision Rules	Specify the Performance Criteria	Develop the Plan for Obtaining Data
<p>Data manipulation and falsification were committed by a contractor during past sanitary sewer and storm drain removal actions and current and previous soil and building investigations in Parcel G. The Technical Team evaluated soil and building survey data and found evidence of potential manipulation and falsification. The findings call into question the reliability of soil and building data, and there is uncertainty whether radiological contamination was present or remains in place. Therefore, the property is unable to be transferred as planned. Based on the uncertainty and the description of radiological activities in the HRA, there is a potential for residual radioactivity to be present in soil and on building interior surfaces. Furthermore, HPNS was expanded over time using fill materials with a range of concentrations of NORM. Construction and remediation projects over the past 60 years have disturbed the surface soil, making a determination of background concentrations for anthropogenic radionuclides from fallout difficult. Previous HPNS soil background values did not provide ²²⁶Ra concentrations representative of all fill materials found at HPNS and did not include other</p>	<p>The primary objectives of the study are as follows:</p> <ul style="list-style-type: none"> To determine whether site conditions in soil and building surfaces are compliant with the Parcel G ROD RAO (Navy, 2009). To establish representative background soil data sets for comparison and evaluation of soil data collected from HPNS. 	<p>The inputs for each component of the study are as follows:</p> <ul style="list-style-type: none"> Soil Investigation: <ul style="list-style-type: none"> Surface soil and subsurface soil analytical data for the applicable ROCs provided by an accredited offsite laboratory. The ROCs for the soil investigation are listed below and are presented in Worksheet #17. <ul style="list-style-type: none"> ROCs for the Former Sanitary Sewer and Storm Drain Lines are ¹³⁷Cs, ²²⁶Ra, and ⁹⁰Sr. ROCs for the Former Buildings 317/364/365 Site are ¹³⁷Cs, ²²⁶Ra, ⁹⁰Sr, ²³⁹Pu⁵, and ²³⁵U. ROCs for the Building 351A Crawl Space are ¹³⁷Cs, ²²⁶Ra, ⁹⁰Sr, ²³⁹Pu, and ²³²Th. Gamma scan survey measurements to identify biased soil sample locations. Soil Reference Background Area (RBA) Investigation: <ul style="list-style-type: none"> Soil analytical data for ROCs provided by an accredited offsite laboratory. All RBA samples will be analyzed by the respective method for the radionuclides listed in Worksheets #15a, #15b, #15c, and #15d. Gamma scans of accessible surface areas performed within the RBAs to confirm the areas are free of elevated 	<p>The study boundaries for each component of the study are as follows:</p> <ul style="list-style-type: none"> Soil Investigation: <ul style="list-style-type: none"> Phase 1 and Phase 2 trench units (TUs) and Former Building Site and Crawl Space soil survey units (SUs) listed in Worksheet #17 and shown on Figure 11-1. Soil RBA Investigation: <ul style="list-style-type: none"> RBAs at HPNS in Parcels B, C, D-1, D-2 (Figure 11-2), and an undisturbed off-base location (Figure 11-3) will provide a range of background estimates. Building Investigation: <ul style="list-style-type: none"> Accessible interior surfaces of Buildings 351, 351A, 366, 401, 411, and 439, the concrete pad at former Building 408, and Building 404, which will be used as the primary RBA (Figure 11-4). The building floor plans (i.e., Class 1 and 2SUs) are depicted on 	<ul style="list-style-type: none"> If the building and soil investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically-based⁶ RGs at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a RACR will be developed. If the building and soil investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically-based⁶ RGs at agreed upon statistical confidence levels and are not shown to be NORM or anthropogenic background, then remediation will be conducted, followed by a RACR. <ul style="list-style-type: none"> If one Phase 1 TU does not meet the Parcel G ROD RAO, all Phase 2 TUs will be excavated. If all Phase 1 TUs meet the Parcel G ROD RAO, Phase 2 will be initiated for TUs. If any Former Building Site and Crawl Space Soil SU or Phase 2 TU does not meet the Parcel G ROD RAO, the SU or TU will be excavated. The RACR will describe the results of the investigation, explain remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant 	<p>The performance criteria for each component of the study are as follows:</p> <ul style="list-style-type: none"> The soil investigation data evaluation process for demonstrating compliance with the Parcel G ROD RAO is summarized below and depicted on Figure 11-12: <ul style="list-style-type: none"> Compare each ROC concentration (Worksheet #17) for every sample to the corresponding RG (Worksheet #17). <ul style="list-style-type: none"> If all concentrations for all ROCs for all samples are less than or equal to the RGs, then compliance with the Parcel G ROD RAO is achieved. Compare sample data to appropriate RBA data from HPNS as described in the Parcel G Work Plan. Multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include, but is not limited to, population-to-population comparisons, use of a maximum likelihood estimate (MLE) or background threshold value (BTV), graphical comparisons, and comparison with regional background levels. <ul style="list-style-type: none"> If all residual ROC concentrations are consistent with NORM or anthropogenic background, site conditions comply with the Parcel G ROD RAO. If any ²²⁶Ra gamma spectroscopy concentration exceeds the ²²⁶Ra RG and the range of expected NORM concentrations, then the soil sample will be analyzed using alpha spectroscopy for uranium isotopes (²³⁸U, ²³⁵U, ²³⁴U), thorium isotopes (²³²Th, ²³⁰Th, and ²²⁸Th), and ²²⁶Ra to evaluate equilibrium conditions. If the concentrations of the radionuclides in the uranium natural decay series are consistent with the assumption of secular equilibrium, then the ²²⁶Ra concentration is NORM and site conditions comply with the Parcel G ROD RAO. If any result is greater than the RG and cannot be attributed to NORM or anthropogenic background, remediation will be performed prior to backfill. 	<p>Data for each component of the study will be obtained through the following methods:</p> <ul style="list-style-type: none"> Soil Investigation: <ul style="list-style-type: none"> For the TUs associated with former sanitary sewers and storm drains (from 1 to 22 feet deep), a phased investigation approach was designed based on a proposal by the regulatory agencies to achieve a high level of confidence that the Parcel G ROD RAO has been met for soil. For Phase 1, 100 percent of soil will be re-excavated and characterized at 33 percent of TUs in Parcel G. Soil sampling and scanning at the remaining 67 percent of TUs was proposed as part of Phase 2 to increase confidence that current site conditions comply with the Parcel G ROD RAO. Evaluation of the results of Phase 1 may lead to re-excavation of Phase 2 TUs. For both Phase 1 TUs and Phase 2 TUs, the durable cover (including asphalt, asphalt base course, concrete, gravel, debris, or obstacles) will be removed to expose the target soils. <ul style="list-style-type: none"> Phase 1 TUs – The radiological investigation will be conducted on a targeted group of 21 of the 63 TUs (from 1 to 22 feet deep) associated with former sanitary sewers and storm drains (Figure 11-1). The Phase 1 TUs will be investigated using gamma scan surveys and soil sampling as described in Worksheets #14 and #17. Phase 2 TUs – Gamma scan surveys, soil sampling, and scanning of soil cores will be conducted on the remaining 42 TUs (from 1 to 22 feet deep) in Parcel G (see Figure 11-1). The Phase 2 TUs will be investigated as described in Worksheets #14 and #17. Phase 2 will only be performed if no contamination is found during Phase 1. If contamination is found during Phase 1, then all of the Phase 2 TUs will be excavated and investigated following the process described for the Phase 1 TUs. Former Building Site and Crawl Space Soil SUs - The radiological investigation will be conducted at the 28 SUs⁷ associated with surface soil at building sites in Parcel G (Figure 11-1). The SUs will be investigated using gamma scan surveys and soil sampling as described in Worksheets #14 and #17. <ul style="list-style-type: none"> At the Former Buildings 317/364/365 Site, SUs 27 (peanut spill) and 28 (liquid waste transfer system [LWTS]) will be excavated to 2 and 10 feet below ground surface (bgs), respectively, for consistency with the previous excavation boundaries. The two SUs will be excavated to the original excavation boundaries, as practicable, and gamma scans of the excavated material will be conducted following the process described for Phase 1 TUs (Worksheets #14 and #17)

⁵ ²³⁹Pu is only an ROC for former Buildings 364 and 365 (NAVSEA, 2004); however, it is included as an ROC for soil at the Former Buildings 317/364/365 Site, that includes former Building 317 based on the location and proximity.

⁶ The RGs are statistically based because they are increments above a statistical background.

⁷ Previously, 32 SUs were investigated at Buildings 317/364/365 Former Building Site and Building 351A Crawl Space; however, some SU areas overlapped. For the Buildings 317/364/365 Former Building Site, former SU 22 overlaps TU 153 and will be investigated as part of TU 153. For the Building 351A Crawl Space, former SU R, SU S, and SU U overlap SU M, SU N, and SU O and will be investigated as SU M, SU N, and SU O.

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements (continued)

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
State the Problem	Identify the Objective	Identify Inputs to the Objective	Define the Study Boundaries	Develop Decision Rules	Specify the Performance Criteria	Develop the Plan for Obtaining Data
<p>NORM or fallout radionuclides.</p>		<p>gamma levels and are suitable for sampling.</p> <ul style="list-style-type: none"> • Building Investigation: <ul style="list-style-type: none"> – Alpha-beta static, alpha and beta scan, and alpha-beta swipe data collected by radiological survey instruments on buildings and reference area surfaces. <p>Radioactivity concentration data for material or swipe samples provided by an accredited offsite laboratory (if needed).</p>	<p>Figures 11-5 through 11-11.</p>	<p>with the Parcel G ROD RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.</p> <p>RBA data sets will be compared and evaluated to provide representative RBA data sets with a description to assist in determining applicability for specific projects at HPNS. The data evaluation process is summarized below and detailed in Appendix C of the Parcel G Work Plan:</p> <ul style="list-style-type: none"> – Identify outliers graphically or statistically using Dixon and Rosner’s tests for outliers (or other appropriate tests, including non-parametric methods) by comparing the calculated Q values or R values to the critical value, corresponding to a confidence level of 95 percent. <ul style="list-style-type: none"> ▪ If outliers are identified graphically or statistically (Q value or R value is greater than critical value), the outlier will be investigated to attempt to determine whether the outlier is the result of contamination, data quality issues, an environmental issue (e.g., different soil type), or an unidentified issue. ▪ If no outliers are identified, the entire data set will be used in its entirety. – Determine statistical difference between data sets using the non-parametric Kruskal-Wallis (KW) test by comparing the calculated p-value 	<ul style="list-style-type: none"> • The soil RBA investigation statistical data evaluation will be conducted to identify appropriate soil background data sets and calculate descriptive statistics to facilitate future comparisons with site-specific data. The purposes of the data evaluation are summarized below. Additional detail is provided in the Parcel G Work Plan. <ul style="list-style-type: none"> – Identify outliers using Dixon and Rosner’s tests for outliers (or other appropriate tests, including non-parametric methods). – Determine statistical differences between soil types using the KW test. – Compare soil data sets from surface gamma scan surveys, and surface and subsurface analytical concentrations against different identified soil types and against each RBA per sample depth. – Establish one or more representative reference area data sets. • The building investigation data evaluation process for demonstrating compliance with the Parcel G ROD is presented as follows and depicted on Figure 11-13: <ul style="list-style-type: none"> – Compare each net alpha and net beta result to the corresponding RG from Worksheet #17: <ul style="list-style-type: none"> ▪ If all results are less than or equal to the RGs, then compliance with the ROD RAO is achieved. – Compare survey data to appropriate RBA data from HPNS as described in the Parcel G Work Plan. Multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include population-to-population comparisons, use of an MLE or BTV, and graphical comparisons. <ul style="list-style-type: none"> ▪ If survey data are consistent with NORM or anthropogenic background, then site conditions comply with the Parcel G ROD RAO. ▪ If any result is greater than the RG and cannot be attributed to NORM or anthropogenic background, remediation will be conducted. 	<ul style="list-style-type: none"> – The soil samples collected will be analyzed as described below for the applicable ROCs by accredited offsite laboratories and the results will be evaluated as described in Step 6. The excavated soil from within each trench and over-excavation will be tracked separately, and global positioning system (GPS) location-correlated results will be collected or surveying conducted. <ul style="list-style-type: none"> ▪ All soil samples at a minimum will be assayed by gamma spectroscopy for ¹³⁷Cs and ²²⁶Ra. Gamma spectroscopy data will be reported by the laboratory after a full 21-day in-growth period. If the laboratory results indicate a concentration of ²²⁶Ra above the RG (Worksheet #15a), the sample will be analyzed using alpha spectroscopy for uranium isotopes (²³⁸U, ²³⁵U, ²³⁴U), thorium isotopes (²³²Th, ²³⁰Th, and ²²⁸Th), and ²²⁶Ra. If the laboratory results indicate concentrations of ¹³⁷Cs above its RG (Worksheet #15a), the sample will be analyzed for ⁹⁰Sr and by alpha spectroscopy for ²³⁹Pu. ▪ Additionally, at least 10 percent of randomly selected samples will receive gas flow proportional analysis for ⁹⁰Sr. If the laboratory results indicate the presence of concentrations of ⁹⁰Sr at or above the respective RG (Worksheet #15c), the sample will be analyzed by alpha spectroscopy for ²³⁹Pu (Worksheet #15b). Furthermore, a minimum of 10 percent of systematic soil samples collected from the Former Buildings 317/364/365 Site will be randomly selected for alpha spectroscopy analysis for ²³⁹Pu. • Soil RBA Investigation: <ul style="list-style-type: none"> – The soil RBAs will be investigated using gamma scan surveys of the accessible surface soil and collection of systematic surface and subsurface soil samples as described in Worksheets #14 and #17. <ul style="list-style-type: none"> ▪ Soil samples will be analyzed for the applicable ROCs along with NORM radionuclides and fallout radionuclides by accredited offsite laboratories (Worksheets #15a, #15b, #15c, #15d). • Building Investigation: <p>Building investigations will be conducted on floors, wall surfaces, and ceiling surfaces, and will consist of alpha and beta scan surveys, alpha-beta static measurements, and alpha-beta swipe samples as described in Worksheets #14 and #17.</p>

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements (continued)

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
State the Problem	Identify the Objective	Identify Inputs to the Objective	Define the Study Boundaries	Develop Decision Rules	Specify the Performance Criteria	Develop the Plan for Obtaining Data
				<p>against 0.05 significance level.</p> <ul style="list-style-type: none"> ▪ If the results of the KW test indicate that two or more data sets are statistically similar (p-value is greater than significance level), those data sets may be combined to form a larger data set representing more of HPNS, such as a larger area, multiple soil depths, or additional soil types. ▪ If the results of the KW test indicate that a data set is statistically different from other data sets (p-value is less than significance level), that data set will not be combined with other data sets and will be representative of a specific area, soil depth, or soil type. ▪ Evaluate secular equilibrium conditions. 		

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SAP Worksheet #12—Field Quality Control Samples – Soil Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria
Field Duplicate	Radiological (alpha and gamma spectroscopy, Gas Flow Proportional Counting [GFPC], radon emanation)	One per every 10 field samples collected.	Precision	Relative percent difference (RPD) < 25 percent
Equipment Blank		One per day of field sampling for decontaminated equipment.	Bias/Contamination	No target analytes detected > minimum detectable concentration (MDC)
Field Blank		One per source water per sampling event.	Bias/Contamination	No target analytes detected > MDC
Split Sample ^a		All soil samples will be retained for possible CDPH confirmatory analysis until the final RACR for Parcel G is issued.	N/A	None

Notes:

^a May be collected if requested by other stakeholders (USEPA or CDPH) and will be evaluated by the stakeholder. Measurement and performance criteria will be outlined in the stakeholder guidance documents.

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SAP Worksheet #13—Secondary Data Criteria and Limitations

Secondary Data	Data Source (originating organization, report title, and date)	Data Generators (originating organization, data types, data generation/collection dates)	How Data Will be Used	Limitation on Data Use
Remediation Goals	Department of the Navy <i>Basewide Radiological Removal Action, Action Memorandum—Revision 2006</i> April 2006 (Navy, 2006)	Navy, RGs for soil and surfaces	To determine whether site conditions in soil and building surfaces are compliant with the Parcel G ROD RAO (Navy, 2009), analytical and building data will be compared to the RGs for Parcel G ROCs.	The RGs will be applied as concentrations above background.
Trench Unit, Survey Unit Boundaries and Depths	TtEC <i>Multiple plans and reports and the Parcel G Remedial Action Completion Report</i> 2010 - 2011	TtEC, site figures, building layouts, floor plans	Data will be used as the boundaries for TUs and SUs included in the Soil and Building Investigations.	Electronic versions of previous excavations and are not available. Alterations of building interiors may have taken place. Therefore, best management practices (BMPs) will be used to locate and mark the boundaries of former TUs and SUs.

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SAP Worksheet #14—Summary of Project Tasks

This worksheet contains procedures for field activities as a supplement to the Parcel G Removal Site Evaluation Work Plan, which contains detailed information on the radiological support activities that will be conducted during the soil and building investigation activities outlined in this SAP. Field standard operating procedures (SOPs) specific to the soil sampling and building investigation discussed in this SAP are presented in **Worksheet #21**. All radiological support work will be performed in accordance with the radiological SOPs, which are included as Appendix D of the Parcel G Work Plan.

Premobilization Activities

Before initiating field investigations, several premobilization steps will be completed to ensure that the work can be conducted in a safe and efficient manner. The primary premobilization tasks include procurement of subcontractor services, training of field personnel, permitting and notification, a pre-construction meeting, offsite RBA access, and building walkthroughs, as described below.

Procurement of Subcontractor Services

A list of the various support services that are anticipated to be required are as follows:

- Radiological analytical laboratory services
- Drilling subcontractor
- Civil surveying subcontractor
- Utility location subcontractor
- Vegetation clearance subcontractor
- Transport (trucking) subcontractor
- Concrete coring subcontractor

Permitting and Notification

Before initiation of field activities for the radiological investigation, the contractor will notify the Navy RPM, Resident Officer in Charge of Construction (ROICC), RASO, Caretaker Site Office, and HPNS security as to the nature of the anticipated work. Any required permits to conduct the fieldwork will be obtained before mobilization.

The contractor will notify the CDPH at least 14 days before initiation of activities involving the Radioactive Material License.

Pre-Construction Meeting

A pre-construction meeting will be held before mobilization of equipment and personnel. The purpose of the meeting will be to discuss project-specific topics, roles, and responsibilities of project personnel, project schedule, health and safety concerns, and other topics that require discussions before field mobilization. Representatives of the following will attend the pre-construction meeting:

- Navy (RPM, RASO, ROICC, and others as applicable)
- Contractor (PM, Site Construction Manager, Project QC Manager, RSO, and SSO)
- Subcontractors as appropriate

Offsite Reference Background Area Access

Prior to initiation of the RBA investigation, coordination with the City of San Francisco will be conducted to facilitate access and approval for sampling and ground disturbance activities at McLaren Park. Sampling at McLaren Park will be conducted only if access and approval are granted.

SAP Worksheet #14—Summary of Project Tasks (continued)

Building Walkthroughs

Prior to the start of building survey activities, a walk-through of Parcel G buildings will be completed to accomplish the following:

- Establish building access points and assess security requirements.
- Assess survey support needs such as power, lighting, ladders, or scaffolding.
- Verify the types of materials in each SU.
- Identify safety concerns and inaccessible or difficult-to-survey areas.
- Identify radiological protection and control requirements.
- Identify materials requiring removal or disposal, and areas requiring cleaning.
- Assess methods for marking survey scan lanes and static measurement locations.

Impacted areas that are deemed unsafe for access or surveying, such as the mezzanine of Building 411 (SU 1), will be posted, secured, and noted in reports.

Mobilization Activities

At least 2 weeks before mobilization, the appropriate Navy personnel, including the Navy RPM and ROICC and Caretaker Site Office, will be notified regarding the planned schedule for mobilization and site investigation activities. Upon receipt of the appropriate records and authorizations, field personnel, temporary facilities, and required construction materials will be mobilized to the site.

The applicable activity hazard analysis forms will be reviewed prior to starting work. The temporary facilities will include restrooms, hand-washing stations, and one or more secure storage (Conex) boxes for short- and long-term storage of materials, if needed.

The mobilization activities are summarized below and are described in detail in the Parcel G Work Plan.

Soil Investigation

The mobilization activities for the soil investigation will include the following:

- Locating and confirming soil TU and SU boundaries.
- Establishing a radiologically controlled area.
- Implementation of stormwater, sediment, and erosion control measures.
- Implementation of dust control methods and air monitoring.
- Underground Service Alert will be contacted at least 72 hours before initiating intrusive activities.
- Removal and survey of the durable cover of Phase 1 TUs and Phase 2 TUs.
- Movement of equipment and materials to the site. All equipment mobilized to the site will undergo baseline radioactivity surveys in accordance with the Parcel G Work Plan. Surveys will include direct scans, static measurements, and swipe samples. Equipment that fails baseline surveying will be removed from the site.

Reference Background Area Investigation

The mobilization activities for the RBAs will include the following:

- Vegetation clearance
- Utility location and clearance
- Surface debris removal
- Locating and marking the planned sample locations (Sample locations are detailed in **Worksheet #17.**)

SAP Worksheet #14—Summary of Project Tasks (continued)

Building Investigation

The mobilization activities for the building investigation will include the following:

- Removal of loose, residual debris to prepare the buildings for cleaning.
- Implementation of dust control methods and air monitoring, if warranted.
- Cleaning of floors, walls, and other surfaces.
- Evaluation and disposal of waste generated from cleaning activities.
- Movement of equipment and materials to the site. All equipment mobilized to radiologically controlled areas will undergo baseline radioactivity surveys in accordance with the Parcel G Work Plan. Surveys will include direct scans, static measurements, and swipe samples. Equipment that fails baseline surveying will be removed from the site.

Investigation Activities

Once site preparation activities are completed, investigation activities will commence. The following sections describe the field activities specific to each component of the investigation. The survey design for each component is described in detail in the Parcel G Work Plan and summarized in **Worksheet #17**.

Soil Investigation

There are two types of Parcel G soil investigations, including surveys of the following:

- Surface and subsurface soil associated with former sanitary sewer and storm drain lines (TUs)
- Surface soil areas associated with soil from building sites (SUs)

A two-phased approach is planned for the investigation of surface and subsurface TU soil associated with former sanitary and storm drain lines. For surface soil areas associated with soil from building sites, radiological investigation will be conducted at 28 SUs⁸ in Parcel G.

The size and boundary of the TUs and SUs will be based on the previous plans and reports. Locating and marking the boundaries of the former TUs and SUs will be accomplished by using BMPs to identify boundaries and depths of the former TUs and SUs based on the previous TtEC reports (e.g., survey reports, drawings, and sketches), field observations (such as GPS locations from geo-referencing, borings, and visual inspection), and durable cover as-built records (**Worksheet #13**). Once the boundaries are located, the areas will be marked with paint or pin flags.

Phase 1 Trench Unit

Each Phase 1 TU (**Worksheet #17**) will be excavated to the original excavation limits and evaluated in approximately 152-cubic-meter (~200-cubic-yard) excavated soil units (ESUs). Once the excavation to the original excavation limits has been complete, over-excavation of at least an additional 6 inches outside the estimated previous boundaries of the sidewalls and bottom will be initiated. This exhumed over-excavated material will be maintained separately from the ESUs and will represent the trench sidewalls and floor (sidewall floor unit or SFU).

⁸ Previously, 32 SUs were investigated at Buildings 317/364/365 Former Building Site and Building 351A Crawl Space; however, some SU areas overlapped. For the Buildings 317/364/365 Former Building Site, former SU 22 overlaps TU 153 and will be investigated as part of TU 153. For the Building 351A Crawl Space, former SU R, SU S, and SU U overlap SU M, SU N, and SU O and will be investigated as part of SU M, SU N, and SU O.

SAP Worksheet #14—Summary of Project Tasks (continued)

The excavated material (ESUs and SFUs) will undergo radiological assay following either the automated soil sorting process (if approved by CDPH and USEPA) or Radiological Screening Yard (RSY) pad process. Excavated TU materials will be transported to the soil sorting area or RSY pad by dump truck or other conventional means. Excavated soil entering an RSY must be accompanied by a truck ticket (paper or digital), to facilitate transfer of the material for radiological processing along a designated truck route. This ticket will provide the RSY staff with the following information:

- Location of excavation, including former TU name
- From which TU sidewall or floor surface material was excavated (if applicable)
- Load number
- Estimated volume of soil
- Date and time of excavation

The RSY personnel will direct the driver to the appropriate RSY pad for soil placement. The truck ticket will be amended with the assigned unique RSY pad number for tracking purposes. Placement of soil on an RSY pad will continue until the soil placed on the RSY pad reaches capacity as identified by the RSY manager (or designee) and is ready for processing.

One hundred percent of the Phase 1 ESU and SFU soils will undergo scan surveys using real-time gamma spectroscopy equipment in the soil sorting process or the RSY pad process. Following completion of investigation activities, the ESU and SFU material will either be returned to the same trench that the material originated from or will be segregated for further investigation.

The soil sorting system process and RSY pad process are summarized in the following sections. These processes, including associated scanning instrumentation, are described in further detail in the Parcel G Work Plan. A summary of the sampling design and rationale associated with these processes is included in **Worksheet #17**.

Automated Soil Sorting System

Because soil sorting systems are designed to be deployed on a flexible and scalable platform, the system will be tailored to achieve the project-specific requirements and objectives. The configuration details, including detectors, MDCs, and specific operating set points will be provided under separate cover, in a Soil Sorting Operations Plan. The Soil Sorting Operations Plan will be submitted to the regulatory agencies for review and concurrence.

Generally, soil sorting systems are radiological monitoring and processing systems designed to perform real-time segregation of soil into two distinct bins based upon the soil's radiological properties. The material is sorted into two distinct bins (piles), commonly referred to as the "Below Criteria" and "Diverted Pile" bins. The basis upon which the soil material is sorted and segregated into distinct volumes is controlled by the establishment of diversion control setpoints that automatically trigger the diverting mechanism, sorting the material into the appropriate bin. The diversion control setpoints will be chosen as described in the Parcel G Work Plan. Using typical earth moving equipment, such as a front-end loader or excavator, soil from the ESU or SFU will be fed to the soil sorting system. The material will move past the active area of the detectors, and the system's software will interpret the spectroscopy data to determine whether the volume of soil exceeds the specified alarm point. As the material continues to travel up the conveyor, it is automatically sorted in one of two bins.

SAP Worksheet #14—Summary of Project Tasks (continued)

A minimum of 18 systematic soil samples will be collected from each ESU and SFU during assay with the soil sorting system. Additionally, a minimum of one biased soil sample will be collected from the soil material that has been discharged to the Diverted Pile bin. If the soil material discharged to the Diverted Pile originates from an SFU and is confirmed to contain contamination, an in situ investigation of the open trench will be performed at the excavation location of the soil. Material discharged to the Diverted Pile will remain segregated until completion of the investigation activities. The trench under investigation will remain open until investigation and remediation activities are completed. If necessary, additional samples may be collected from diverted material to support characterization for waste disposal.

Soil processed by the soil sorter system and subsequently staged for offsite disposition or onsite reuse will be staged pending evaluation of offsite analytical results and Navy approval for disposition or reuse.

Soil pending offsite analytical results may be staged in stockpiles smaller than 152 m³, which would permit the re-evaluation of smaller soil volumes should elevated soil sample results be received from the offsite laboratory.

If elevated sample results are identified by offsite analysis, the contractor notify the Navy and determine a suitable soil rescreening process, either by RSY pad or by the soil sorter. SFU sampling locations with concentrations that exceed RGs and background will be remediated by additional soil excavation.

Radiological Screening Yard Pad

If a conveyor-based automatic soil sorting system process is not used, excavated TU material will be assayed using the RSY pad process. RSY pad processing has previously been used at HPNS as described in the Basewide Radiological Management Plan (TtEC, 2012). If no existing RSY pads are available for use, pads will be constructed to meet the requirements specified in the Basewide Radiological Management Plan (TtEC, 2012), RSY Construction Details (TtEC, 2009b), or other current Navy guidance. RSY pads will be constructed with a size limit of 1,000 square meters (m²). Before construction, the area where the RSY pads will be constructed will be radiological scan-surveyed to document the existing conditions.

Excavated TU materials will be transported to the RSY pad by dump truck or other conventional means and spread approximately 6 to 9 inches thick. Processing activities in the RSY pads include gamma scan surveys, systematic and biased soil sampling and analyses, follow-up investigation activities (as necessary), radiologically clearing the materials for reuse or disposal, and transport of the materials off the RSY pads.

If gamma scan surveys indicate areas of potentially elevated activities as identified in the Parcel G Work Plan, additional investigation will be initiated. At a minimum, the contractor will further evaluate the gamma scan data and collect biased soil samples. Material with potentially elevated concentrations will remain segregated until completion of the investigation activities. If SFU soil sampling indicates areas of potentially elevated activity above the RGs, and it is confirmed that the soil contains contamination, an in situ investigation of the open trench will be performed at the excavation location of the soil. The in situ investigation will include the performance of a gamma scan over the trench surface requiring investigation and additional biased and systematic sampling as described in the Parcel G Work Plan.

Soil processed by the RSY process and subsequently staged for offsite disposition or onsite reuse will be staged pending evaluation of offsite analytical results and Navy approval for disposition or reuse. If elevated sample results are identified by offsite analysis, the contractor shall notify the Navy and determine a suitable soil rescreening process, either by RSY pad or by the soil sorter. SFU sampling locations with concentrations that exceed RGs and background will be remediated by additional soil excavation.

SAP Worksheet #14—Summary of Project Tasks (continued)

Following completion of scan surveys, sampling, and any potential investigation activities, the excavated material will be returned to the same trench that the material originated from.

Phase 2 Trench Unit

Each Phase 2 TU (**Worksheet #17**) will be investigated using a combination of gamma surface scan, soil core scan surveys, and subsurface soil sample collection. Subsurface soil samples will be collected as described in **Worksheet #21** and **Attachment 2**).

The systematic boring locations will be cored down to approximately 6 inches below the depth of previous excavation within each TU boundary. Sanitary sewer and storm drain lines were sometimes installed on bedrock. In these situations, sampling of bedrock will not be performed. If refusal is encountered within 6 inches of the expected depth of the trench, the soil sample will be collected from the deepest section of the core. If refusal is encountered more than 6 inches above the expected depth of the trench, the sample location will be moved to avoid the subsurface obstruction.

To acquire three samples from each boring, one surface and one floor sample will be collected from each sample core. The sample cores will be scanned for gamma radiation along the entire length of each core, and the scan data will be evaluated to determine whether collection of a biased sample is required as described in the Parcel G Work Plan. If evaluation of scan data does not identify the need for collection of a biased sample, a biased sample will be collected from the core segment with the highest gamma scan reading that was not already sampled, for a total of at least three samples from each core.

Additionally, systematic samples will be collected from sidewall locations every 50 linear feet, representative of each of the trench sidewalls. The boring locations will be located within 1 meter of the previous sidewall excavation limits and will extend to the maximum previous excavation depth. In the same action described in the previous paragraph, core sections will then be retrieved, scanned, and sampled such that at least three samples will be collected from each of the six boring locations.

If GPS reception is available, soil sample locations will be position-correlated with GPS data and recorded. If GPS reception is not available, a reference coordinate system will be established to document gamma scan measurement results and soil sample locations. The reference coordinate system will consist of a grid of intersecting lines referenced to a fixed site location or benchmark. If practical, the GPS coordinates of the fixed location or benchmark will be recorded.

Remediation of soil with analytical results above the RGs and background will be performed by excavation of the identified location of the elevated activity or the by excavation of the complete TU for further processing using the RSY pad or soil sorting processes. Following excavation, a minimum of five bounding confirmation samples will be collected at the lateral and vertical extents to confirm the removal of contaminated soil. If a Phase 2 TU is excavated in its entirety, it will be investigated following the process described for a Phase 1 TU. Material with potentially elevated concentrations will remain segregated until completion of the investigation activities.

Scanning instrumentation used during the investigation of the Phase 2 TUs are described in further detail in the Parcel G Work Plan. A summary of the sampling design and rationale is included in **Worksheet #17**.

Former Building Site and Crawl Space Soil Survey Unit

Surface soil SUs will be characterized in a similar fashion as the RSY process, using a combination of gamma scan surveys and systematic and biased surface soil sampling. Surface soil samples will be collected in accordance with the *Soil Sampling* SOP (**Worksheet #21** and **Attachment 2**).

SAP Worksheet #14—Summary of Project Tasks (continued)

Gamma scan surveys will be performed as described in the Parcel G Work Plan. If GPS reception is available, gamma scan surveys will be position-correlated with GPS data. If GPS reception is not available, which is likely for SUs located within the Building 351A Crawl Space, a reference coordinate system will be established to document gamma scan measurement locations. The reference coordinate system will consist of a grid of intersecting lines referenced to a fixed site location or benchmark. If practical, the GPS coordinates of the fixed location or benchmark will be recorded.

Gamma scanning data sets will be transferred from the data logger onto a computer to create spreadsheets, and if feasible, gamma scan survey results will be mapped. Data obtained during the surface gamma scan surveys will be evaluated to identify areas of potentially elevated activity and locations of biased samples as described in the Parcel G Work Plan.

Following the completion of the gamma scan surveys, a minimum of 18 systematic samples will be collected from each soil SU. A summary of the sampling design and rationale is included in **Worksheet #17**.

At the Former Buildings 317/364/365 Site, SUs 27 (peanut spill) and 28 (LWTS) will be excavated to 2 and 10 feet bgs, respectively, for consistency with the previous excavation boundaries (**Figure 11-1**). The two SUs will be excavated to the original excavation boundaries, as practicable, and gamma scans of the excavated material will be conducted following the process described for Phase 1 TUs.

Reference Background Area Investigation

Each RBA (**Worksheet #17**) will be investigated using a combination of gamma scan measurements, and surface and subsurface soil sampling. Surface and subsurface soil samples will be collected in accordance with the *Soil Sampling SOP* (**Worksheet #21** and **Attachment 2**).

At each RBA, 100 percent of the accessible surface (i.e., ground level surface) will be scanned for gamma activity using the instruments and procedures specified in Appendix C of the Parcel G Work Plan. Both gross gamma and gamma spectral measurements will be collected simultaneously during the gamma scan. Gamma scan measurements will be reviewed and accepted as described in Appendix C of the Parcel G Work Plan.

Fifty soil samples, consisting of 25 surface and 25 subsurface soil samples will be collected from each of RBA-1, RBA-2, RBA-3, and RBA-4 (for a total of 200 samples), and 25 surface and 25 subsurface soil samples will be collected from the offsite RBA. The sampling design and rationale are described in detail in Appendix C of the Parcel G Work Plan and summarized in **Worksheet #17**.

Building Investigation and Remediation

Buildings will be divided into SUs, and the size and boundary of the SUs will be based on the previous plans and reports (**Worksheet #17**). BMPs will be used to identify boundaries of SUs based on previous TtEC reports (e.g., survey reports, drawings, and sketches) and field observations. Upon receipt of survey instruments for the building investigations and completion of performance checks, background measurements will be obtained in the RBA for each instrument and on each surface type (e.g., concrete, wood, and sheet rock) that is also present in the SUs. The background measurements will consist of alpha-beta scanning and a minimum of 18 static measurements on each surface to match the number performed in each SU.

SAP Worksheet #14—Summary of Project Tasks (continued)

Radiological investigations at these SUs will be conducted to include the following:

- Alpha-beta scan of surfaces and a preliminary data review.
- Collection of systematic alpha-beta static and swipe measurements and preliminary data review. A minimum of 18 static alpha-beta static measurements will be taken in each SU.
- Collection of biased alpha-beta static and swipe measurements where necessary based on the alpha-beta scan measurements, and preliminary data review.
- Delineation and remediation of residual contamination, if present.
- Collection of building material samples, if necessary.

The building investigation activities, including scanning instrumentation, are presented in detail in the Parcel G Work Plan. A summary of the survey design and rationale for the building investigation is included **Worksheet #17**.

Assessment of Residual Materials and Equipment

Several buildings contain residual materials and equipment from past operations, such as piping, ventilation, shelving, or machinery, that will undergo radioactivity surveys in accordance with Appendix D of the Parcel G Work Plan. These surveys may include a combination of surface scans, static measurements, swipe samples, and material samples. Where possible, sampling or survey points accessed during previous surveys will be used as a starting point. Surveys of impacted building material and equipment will be incorporated into the building SU. After data evaluation, disposition decisions, and subsequent investigation of the surfaces below the materials and equipment, will be coordinated with the Navy.

Remediation of Contaminated Building Surfaces

Following the identification and characterization of contaminated building surfaces, remediation of building surfaces may be performed to ensure that residual radioactivity meets the Parcel G ROD RAO. Specific remediation or decontamination techniques will depend on contaminant, type of surface, and other site-specific factors. Types of decontamination that may be performed include concrete scarifying or scabbling, application of strippable surface coatings, and bulk removal of building components. Remediation will be conducted in building areas with activity that exceed RGs and background. Confirmation measurements will be collected where remediation is performed to verify that contamination has been removed.

Decontamination and Release of Equipment and Tools

Decontamination of mobilized materials and equipment will be conducted at completion of fieldwork. Disposable equipment will be used whenever applicable and will be disposed of immediately after use. Numerous decontamination methods are available for use. If practical, manual decontamination methods should be used. Abrasive methods may be necessary if areas of fixed contamination are identified. Chemical decontamination can also be accomplished by using detergents for nonporous surfaces with contamination present. Chemicals should be selected for decontamination that will minimize the creation of mixed waste. Decontamination activities will be conducted as described in Appendix D of the Parcel G Work Plan.

Management of Investigation-derived Waste

It is anticipated that the following waste streams will be generated and managed as indicated in the Parcel G Work Plan.

SAP Worksheet #14—Summary of Project Tasks (continued)

Site Restoration and Demobilization

The open excavations will be backfilled with the excavated soil upon concurrence from RASO. The excavated material will be returned to the same trench from which the material originated. If additional backfill is required to complete backfill requirements, DTSC's guidance, *Information Advisory Clean Imported Fill Material*, must be used (DTSC, 2001). If the trench excavations are waterlogged, crushed rock or gravel will be placed as bridging material. With Navy concurrence, radiologically cleared recycled fill materials may be used for backfill. The backfill will be compacted to 90 percent relative density by test method ASTM International D1557. Once the excavated areas have been backfilled, the durable cover will be repaired "in kind" to match pre-excavation action conditions.

Deconstruction of Radiological Screening Yard Pads

Following completion of radiological screening and with Navy approval, the RSY pads will be deconstructed. Before deconstruction, the RSY pads will be radiologically screened and released. The area will be down-posted for the deconstruction activities. The RSY pad material will be consolidated onsite for offsite disposal at an approved disposal facility. If the RSY pad buffer material cannot be reused onsite, it will be disposed offsite at an approved disposal facility as indicated in the Parcel G Work Plan. Following deconstruction, the area will be restored to pre-removal action conditions.

Demobilization

Demobilization will consist of surveying, decontaminating, and removing equipment and materials used during the investigations, cleaning the project site, inspecting the site, and removing temporary facilities. Demobilization activities will also involve collection and disposal of contaminated materials, including decontamination water and disposable equipment for which decontamination is inappropriate.

Data Management, Verification, and Validation

Data Management

Radiological survey and environmental data will be maintained in accordance with Appendix D of the Parcel G Work Plan and **Worksheet #29**. Analytical data will be uploaded into the Navy's centralized database (Naval Installation Restoration Information Solution) and will be included in final reports.

Data Verification

A Senior QA/QC manager with knowledge of radiological QA/QC will be present in the field for the duration of soil confirmation sampling activities. The QA/QC manager's sole responsibility will be to ensure that the QC measures in the project plans are performed. The QA/QC manager will maintain all QA/QC records for review and provide copies in the final report.

The contractor will conduct weekly QC meetings to keep Navy personnel informed of field progress. The contractor will prepare all meeting materials, including agenda, figures, data, and look-ahead calendar, and provide copies to all participants 24 hours in advance of the meeting. Meeting minutes will be provided to the Navy within 48 hours of the meeting.

Additionally, the Navy has contracted an independent, third-party contractor to oversee and monitor all field activities and ensure that the activities are in compliance with the Parcel G Work Plan and this SAP.

Additional details regarding data verification are presented in **Worksheets #36-36** and **#37**.

SAP Worksheet #14—Summary of Project Tasks (continued)

Data Validation

Analytical data validation will be conducted by an independent third-party data validation subcontractor in accordance with **Worksheets #34-#36** and consistent with Navy Environmental Work Instruction No. 1, *Data Validation Guidelines for Chemical Analysis of Environmental Samples* (NAVFAC SW, 2001), *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARLAP) (USEPA et al., 2004), and *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (USEPA et al., 2000). *USEPA National Functional Guidelines for Inorganic Superfund Data Review* (ISM02.2) (USEPA, 2017) may also be applicable.

The data validation findings are summarized in a data validation report. The report content will include an introduction that includes validation guidance used, a summary of the QC elements reviewed, a description of deficiencies, and a summary of the data qualification.

Data Evaluation and Reporting

Reference Background Area Investigation

Various types of radiological data will be collected from multiple RBAs, representing soils with potentially different distributions of naturally occurring and fallout radionuclides. Gamma scan data and analytical sample results will be evaluated as detailed in Appendix C of the Parcel G Work Plan. Analytical data (i.e., soil sample results) will be compiled and validated in accordance with this SAP.

Following completion of RBA soil data evaluation, a report will be prepared to include a summary of the field activities, any deviations from the work plan, results of gamma scan surveys, and analytical and geotechnical data evaluation (including full data packages from the analytical laboratory and third-party data validation reports), along with the results of the data evaluation. Based on the statistical evaluations, the report will include recommendations for combining similar data sets, and recommendations for selecting values or data sets representing background in soil, and conditions identifying situations when specific values or data sets may not be appropriate. Information from other San Francisco Bay Area radiological background studies may be referenced in the report as appropriate. If additional areas are selected for sampling, if other background data sets are identified, or if the U.S. Geological Survey is involved and provides input, details and justification will be provided in the report. The draft report will be submitted for regulatory review, and meetings will be held to discuss the results and facilitate consensus on appropriate background values prior to finalizing the report.

Soil and Building Investigation

Data from the radiological investigation will be evaluated to determine whether the site conditions are compliant with the Parcel G ROD RAO. The details pertaining to the data evaluation process are summarized below and presented in detail in the Parcel G Work Plan.

Figures 11-12 and **11-13** present an overview of how decisions for soil and building data, respectively, are combined to draw a conclusion on compliance with the Parcel G ROD RAO. Each sample and static measurement result will be compared to the corresponding RG. If the residual ROC concentrations are below the Parcel G ROD RGs or are shown to be NORM or anthropogenic background, then the site conditions are compliant with the Parcel G ROD RAO.

SAP Worksheet #14—Summary of Project Tasks (continued)

Radiological surveys will include scan measurements of accessible surfaces combined with collection and analysis of samples and static measurements on building interior surfaces. Scan measurements are used to identify potential areas of elevated radioactivity for investigation using biased samples and static measurements and are not used to directly demonstrate compliance with the Parcel G ROD RAO. Sample and static measurement results at systematic, random, and biased locations are used to evaluate compliance with the Parcel G ROD RAO. A separate compliance decision will be made for each ROC for each sample and static measurement.

If the investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically-based⁹ RGs at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a RACR will be developed. If the investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically based⁹ RGs at agreed upon statistical confidence levels and are not shown to be NORM or anthropogenic background, remediation will be conducted.

Results of radiological investigations for buildings and TUs/SUs complying with the Parcel G ROD RAO will be documented in a RACR, and the buildings and TUs/SUs will be recommended for unrestricted radiological release. The RACR will describe the results of the investigation, include an air monitoring report to evaluate dust and radiological data collected, provide visualizations of spatially correlated data, describe any remediation performed, compare the distribution of data from sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel G ROD RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data. The final status survey results¹⁰, including a comparison to background and discussion of remedial activities performed as part of the investigation, will be included as an attachment to the RACR.

The reports generated from work outlined in this SAP will be submitted as preliminary draft, draft, draft final, and final versions. The Navy will be provided with each version for review and comment, and documents will be reviewed and approved by the Navy prior to submittal to regulatory agencies. Response to comment (RTC) matrices will be prepared for each comment set received. The RTCs will be used at each review step to facilitate concurrence of responses.

⁹ The RGs are statistically based because they are increments above a statistical background.

¹⁰ Reported radiological results will, at a minimum, include count times, results, counting uncertainty, and total propagated uncertainty.

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SAP Worksheet #15a—Reference Limits and Evaluation Soil Gamma Spectroscopy

Matrix: Soil

Analytical Group: Radiological (gamma spectroscopy) – USEPA Method 901.1

Analyte	CAS	Project Remediation Goal ^a (pCi/g)	Project Remediation Goal Reference	Project QL Goal ^b (pCi/g)	Laboratory-Specific Limits ^{c,d,e,f,g}
					MDC (pCi/g)
¹³⁷ Cs	10045-97-3	0.113	ROD	0.05	0.05
²²⁶ Ra ^h	13982-63-3	1.0	ROD	0.1	0.1
Bismuth-214 (²¹⁴ Bi)	14913-49-6	none	--	0.1	0.1
Lead-214 (²¹⁴ Pb)	15067-28-4	none	--	0.1	0.1
Potassium-40 (⁴⁰ K)	13966-00-2	none	--	0.5	0.5
Actinium-228 (²²⁸ Ac)	14331-83-0	none	--	0.3	0.3
Bismuth-212 (²¹² Bi)	14913-49-6	none	--	1.0	1.0
²¹² Pb	15092-94-1	none	--	0.1	0.1
Americium-241 (²⁴¹ Am)	14596-10-2	none	--	0.3	0.3
Protactinium-234 (²³⁴ Pa)	15100-28-4	none	--	0.75	0.75
²³² Th	7440-29-1	1.69	ROD	0.3	0.3
Thallium-208 (²⁰⁸ Tl)	14913-50-9	none	--	0.1	0.1

Notes:

- ^a The project RGs are based on those provided in the Parcel G ROD, (Navy, 2009). The RGs will be applied as concentrations above background.
- ^b Project Quantitation Limit (QL) goals for individual samples are equal to the MDC and will be a maximum of 90 percent of the RG.
- ^c Results for non-aqueous samples are reported on a dry-weight basis.
- ^d The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that results in a 95 percent probability of detection, given a detection criterion that includes a 5 percent probability of false detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits that affect the project SAP objectives must be approved by the Navy RPM and QAO in writing in advance of sample testing.
- ^e Gamma spectroscopy analyses will be based on meeting the MDCs for ¹³⁷Cs and ²²⁶Ra. MDCs for other radionuclides analyzed by gamma spectroscopy are not required to be achieved unless specifically requested on the applicable contaminant of concern. All detected radionuclides will be reported by the laboratory.
- ^f Daughter products and naturally occurring isotopes will be reported in the gamma spectroscopy results, which may include, ⁴⁰K, ²⁰⁸Tl, ²¹²Bi, ²¹²Pb, ²¹⁴Bi, ²¹⁴Pb, radium-223, radium-224, thorium-227, ²²⁸Ac, Thorium-228 (²²⁸Th), Protactinium-231, ²³⁴Pa, Protactinium-234m.
- ^g The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. The MDCs listed in this worksheet can be achieved with larger aliquots or longer count times within the constraints of the method in order to achieve project objectives. MDC is the minimum detectable concentration, which is an equivalent calculation to the minimum detectable activity (MDA).
- ^h ²²⁶Ra background will be established as described in this SAP and the Parcel G Work Plan. The ²¹⁴Bi 609 kiloelectron volt (keV) energy peak will be used to quantify ²²⁶Ra following a 21-day in-growth period.

CAS = Chemical Abstracts Service

SAP Worksheet #15b—Reference Limits and Evaluation Soil Alpha Spectroscopy

Matrix: Soil

Analytical Group: Radiological (alpha spectroscopy) – United States Department of Energy (USDOE) Method HASL-300 A-01-R

Analyte	CAS	Project Remediation Goal ^a (pCi/g)	Project Remediation Goal Reference	Project QL Goal ^b (pCi/g)	Laboratory-Specific Limits ^{c, d, e}
					MDC (pCi/g)
²²⁶ Ra ^f	13982-63-3	1.0	ROD	0.1	0.1
²⁴¹ Am	14596-10-2	none	--	0.5	0.5
Plutonium-238 (²³⁸ Pu)	13981-16-3	none	--	0.5	0.5
^{239/240} Pu ^g	15117-48-3	2.59	ROD	0.5	0.5
²³⁴ U	13966-29-5	none	--	0.5	0.5
^{235/236} U ^h	15117-96-1	0.195	ROD	0.1	0.1
²³⁸ U	7440-61-1	None	--	0.5	0.5
²²⁸ Th	14274-82-9	None	--	1.0	1.0
²³⁰ Th	14269-63-7	None	--	0.5	0.5
²³² Th ⁱ	7440-29-1	1.69	ROD	1.0	1.0

Notes:

- ^a The RGs are based on those provided in the Parcel G ROD (Navy, 2009). The RGs will be applied as concentrations above background.
- ^b Project QL goals for individual samples are equal to the MDC and will be a maximum of 90 percent of the RG.
- ^c Results for non-aqueous samples are reported on a dry-weight basis.
- ^d The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that results in a 95 percent probability of detection, given a detection criterion that includes a 5 percent probability of false-detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits that affect the project SAP objectives, must be approved by the Navy RPM and QAO in writing in advance of sample testing.
- ^e The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. The MDC listed in this worksheet can be achieved with larger aliquots or longer count times within the constraints of the method in order to achieve project objectives. MDC is the minimum detectable concentration, which is an equivalent calculation to the MDA.
- ^f Where possible, isotopic analysis for ²²⁶Ra will be performed using the same dissolution/digestion as ²³⁸U to ensure comparability of results. If analysis of ²²⁶Ra is not possible due to interferences, radon emanation (**Worksheet #15d**) will be performed. All detected radium isotopes will be reported.
- ^g ²³⁹Pu is listed in the above table as ^{239/240}Pu because the alpha energy peaks for the isotope of plutonium cannot be separated in alpha spectroscopy. Therefore, the laboratory will report as listed above in the table. All detected plutonium isotopes will be reported.
- ^h ²³⁵U is listed in the above table as ^{235/236}U because the alpha energy peaks for the isotope of uranium cannot be separated in alpha spectroscopy. Therefore, the laboratory will report as listed above in the table. All detected uranium isotopes will be reported.
- ⁱ All detected thorium isotopes will be reported.

SAP Worksheet #15c—Reference Limits and Evaluation Soil Gas Flow Proportional Counting

Matrix: Soil

Analytical Group: Radiological (GFPC) – USEPA Method 905.0 mod

Analyte	CAS	Project Remediation Goal ^a (pCi/g)	Project Remediation Goal Reference	Project QL Goal ^b (pCi/g)	Laboratory-Specific Limits ^{c,d,e}
					MDC (pCi/g)
⁹⁰ Sr	10098-97-2	0.331	ROD	0.15	0.15

Notes:

- ^a The RGs are based on those provided in the Parcel G ROD, (Navy, 2009). The RGs will be applied as concentrations above background.
- ^b Project QL goals for individual samples are equal to the MDC and will be a maximum of 90 percent of the RG.
- ^c Results for non-aqueous samples are reported on a dry-weight basis.
- ^d The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95 percent probability of detection, give a detection criterion that includes a 5 percent probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits that affect the project SAP objectives must be approved by the Navy RPM and QAO in writing in advance of sample testing.
- ^e The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. The MDC listed in this worksheet can be achieved with larger aliquots or longer count times within the constraints of the method in order to achieve project objectives. MDC is the minimum detectable concentration, which is an equivalent calculation to the MDA.

SAP Worksheet #15d—Reference Limits and Evaluation Soil Radon Emanation

Matrix: Soil

Analytical Group: Radiological (Radon Emanation) – USEPA Method 903.1 mod

Analyte	CAS	Project Remediation Goal ^a (pCi/g)	Project Remediation Goal Reference ^a	Project QL Goal ^b (pCi/g)	Laboratory-Specific Limits ^{c,d,e}
					MDC (pCi/g)
²²⁶ Ra ^e	13982-63-3	1.0	ROD	0.1	0.1

Notes:

- ^a The RGs are based on those provided in the Parcel G ROD, (Navy, 2009). The RGs will be applied as concentrations above background.
- ^b The Project QL goals for individual samples are equal to the MDC and will be a maximum of 90 percent of the RG.
- ^c Results for non-aqueous samples are reported on a dry-weight basis.
- ^d The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that results in a 95 percent probability of detection, given a detection criterion that includes a 5 percent probability of false detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits that affect the project SAP objectives must be approved by the Navy RPM and QAO in writing in advance of sample testing.
- ^e The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. The MDC listed above can be achieved with larger aliquots or longer count times within the constraints of the method in order to achieve project objectives. MDC is the minimum detectable concentration, which is an equivalent calculation to the MDA.
- ^f ²²⁶Ra background will be established as described in the Parcel G Work Plan.

SAP Worksheet #15e—Reference Limits and Evaluation Water Gamma Spectroscopy

Matrix: Water (for field blanks only)

Analytical Group: Radiological (gamma spectroscopy) – USEPA Method 901.1

Analyte	CAS	Project Remediation Goal ^a (pCi/L)	Project Remediation Goal Reference	Project QL Goal ^b (pCi/L)	Laboratory-Specific Limits ^{c,d}
					MDC (pCi/L)
¹³⁷ Cs	10045-97-3	none	--	15	15
²²⁶ Ra	13982-63-3	none	--	75	75
²¹⁴ Bi	14913-49-6	none	--	75	75
²¹⁴ Pb	15067-28-4	none	--	75	75
⁴⁰ K	13966-00-2	none	--	150	150
²²⁸ Ac	14331-83-0	none	--	150	150
²¹² Bi	14913-49-6	none	--	300	300
²¹² Pb	15092-94-1	none	--	30	30
²⁴¹ Am	14596-10-2	none	--	75	75
⁶⁰ Co	10198-40-0	none	--	30	30
²³⁴ Pa	15100-28-4	none	--	150	150
²³² Th	7440-29-1	none	--	450	450

Notes:

- ^a The RGs are not applicable for this matrix (i.e., field blanks)
- ^b Project QL goals are equal to the MDC.
- ^c The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95 percent probability of detection, give a detection criterion that ensures on a 5 percent probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits that affect the project SAP objectives must be approved by the Navy RPM and QAO in advance of sample testing.
- ^d An MDC at or less than the value listed must be achieved for ¹³⁷Cs and ²²⁶Ra for all samples for this project. MDCs for other radionuclides analyzed by gamma spectroscopy are not required to be achieved unless specifically requested on the applicable contaminant of concern.

pCi/L = picocurie(s) per liter

SAP Worksheet #15f—Reference Limits and Evaluation Water Alpha Spectroscopy

Matrix: Water (for field blanks only)

Analytical Group: Radiological (alpha spectroscopy) – USDOE Method HASL-300 A-01-R

Analyte	CAS	Project Remediation Goal ^a (pCi/L)	Project Remediation Goal Reference	Project QL Goal ^b (pCi/L)	Laboratory-Specific Limits ^c
					MDC (pCi/L)
²⁴¹ Am	14596-10-2	none	--	1.0	1.0
²³⁸ Pu	13981-16-3	none	--	1.0	1.0
^{239/240} Pu ^d	15117-48-3	none	--	1.0	1.0
²²⁶ Ra ^f	13982-63-3	none	--	1.0	1.0
²³⁴ U	13966-29-5	none	--	1.0	1.0
^{235/236} U ^e	15117-96-1	none	--	1.0	1.0
²³⁸ U	7440-61-1	none	--	1.0	1.0
²²⁸ Th	14274-82-9	none	--	1.0	1.0
²³⁰ Th	14269-63-7	none	--	1.0	1.0
²³² Th	7440-29-1	none	--	1.0	1.0

Notes:

- ^a The RGs are not applicable for this matrix (i.e., field blanks).
- ^b Project QL goals are equal to the MDC.
- ^c The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95 percent probability of detection, give a detection criterion that ensures on a 5 percent probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits that affect the project SAP objectives must be approved by the Navy RPM and QAO in advance of sample testing.
- ^d ²³⁹Pu is listed in the above table as ^{239/240}Pu because the alpha energy peaks for the isotope of plutonium cannot be separated in alpha spectroscopy. Therefore, the laboratory will report as listed above in the table.
- ^e ²³⁵U is listed in the above table as ^{235/236}U because the alpha energy peaks for the isotope of plutonium cannot be separated in alpha spectroscopy. Therefore, the laboratory will report as listed above in the table.
- ^f Where possible, isotopic analysis for ²²⁶Ra will be performed using the same dissolution/digestion as ²³⁸U to ensure comparability of results. If analysis of ²²⁶Ra is not possible due to interferences, radon emanation (**Worksheet #15h**) will be performed.

SAP Worksheet #15g—Reference Limits and Evaluation Water Gas Flow Proportional Counting

Matrix: Water (for field blanks only)

Analytical Group: Radiological (GFPC) – USEPA Method 905.0 mod

Analyte	CAS	Project Remediation Goal ^a (pCi/L)	Project Remediation Goal Reference	Project QL Goal ^b (pCi/L)	Laboratory-Specific Limits ^c
					MDC (pCi/L)
⁹⁰ Sr	10098-97-2	none	--	2.0	2.0

Notes:

- ^a The RGs are not applicable for this matrix (i.e., field blanks).
- ^b Project QL goals for individual samples are equal to the MDC and will be a maximum of 90 percent of the RG.
- ^c The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that results a 95 percent probability of detection, give a detection criterion that includes a 5 percent probability of false detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits that affect the project SAP objectives must be approved by the NAVFAC Southwest RPM and QAO in writing in advance of sample testing.

SAP Worksheet #15h—Reference Limits and Evaluation Water Radon Emanation

Matrix: Water (for field blanks only)

Analytical Group: Radiological (Radon Emanation) – USEPA Method 903.1 mod

Analyte	CAS	Project Remediation Goal (pCi/g)	Project Remediation Goal Reference	Project QL Goal ^b (pCi/L)	Laboratory-Specific Limits ^c
					MDC (pCi/L)
²²⁶ Ra	13982-63-3	None	--	0.1	0.1

Notes:

- ^a The RGs are based on those provided in the Parcel G ROD, (Navy, 2009).
- ^b The Project QL goals are equal to the MDC.
- ^c The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95 percent probability of detection, give a detection criterion that ensures on a 5 percent probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits that affect the project SAP objectives must be approved by the Navy RPM and QAO in advance of sample testing.

SAP Worksheet #16—Project Schedule/Timeline

Activities	Organization	Dates		Deliverable
		Anticipated Date of Initiation	Anticipated Date of Completion	
Draft SAP preparation	CH2M	June 2018	July 2018	Draft SAP
Navy BRAC/RASO SAP review	Navy BRAC and RASO	July 2018	August 2018	Comments and responses
Navy QAO SAP review	Navy QAO	August 2018	September 2018	Comments and responses, Navy Chemist signature
Regulatory review	USEPA, DTSC, CDPH, City of San Francisco	September 2018	October 2018	Comments and responses
Draft Final SAP	Navy and regulatory agencies	October 2018	November 2018	Draft Final SAP, comments and responses
Final SAP	Navy and regulatory agencies	December 2018	March 2019	Final SAP, comments and responses, and signature
Subcontracting and chartering	CH2M	October 2018	February 2019	Subcontractor contracts
Utility locating	CH2M, Perma-Fix, subcontractor	TBD	TBD	None
Field investigations	CH2M, Perma-Fix	TBD	TBD	None
Laboratory analyses, data validation and verification, and data management	GEL, TBD, CH2M	TBD	TBD	Analytical and DV reports
Draft report preparation	CH2M	TBD (within 60 days of completion of the field investigation)	TBD	Draft reports
Navy BRAC/RASO report review	Navy BRAC and RASO	TBD	TBD	Comments and responses
Regulatory report review	USEPA, DTSC, CDPH, City of San Francisco	TBD	TBD	Comments and responses
Report	Navy and regulatory agencies	TBD	TBD	Final report

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SAP Worksheet #17—Sampling and Survey Design and Rationale

The proposed Parcel G Evaluation survey, sampling, and analytical program, as well as the rationale for selecting sample locations, is described below.

Soil Investigation

This section describes the design of radiological investigations, including gamma scanning and soil sample collection in soil. The radiological investigation design and rationale are primarily based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012), with the ultimate requirement to demonstrate compliance with the Parcel G ROD RAO (Navy, 2009).

A two-phased approach is planned for the investigation for surface and subsurface TU soil associated with former sanitary and storm drain lines. The approach is based on a proposal by the regulatory agencies to achieve a high level of confidence that the Parcel G ROD RAO has been met for soil. For Phase 1, 100 percent of soil will be re-excavated and characterized at 33 percent of TUs in Parcel G. Soil sampling and scanning at the remaining 67 percent of TUs will be performed as part of Phase 2 to increase confidence that current site conditions comply with the Parcel G ROD RAO. Evaluation of the results of Phase 1 may lead to re-excavation of Phase 2 TUs if contamination is identified in Phase 1 trenches. For surface soil areas associated with soil from building sites, radiological investigation will be conducted at 28 SUs¹¹ in Parcel G. The name, size, and boundary of the TUs and SUs will be based on the previous plans and reports.

The ROCs for the soil areas are listed in **Table 17-1**, and RGs are listed in **Worksheets #15a, #15b, and #15c**. Samples collected in support of the TU and SU investigation are provided in this worksheet.

Table 17-1. Soil Radionuclides of Concern

Soil Area	Radionuclide of Concern
Former Sanitary Sewer and Storm Drain Lines	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr
Former Buildings 317/364/365 Site	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr, ²³⁹ Pu ¹² , ²³⁵ U
Building 351A Crawl Space	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr, ²³⁹ Pu, ²³² Th

Analysis will be based on the site-specific ROCs listed in **Table 17-1**. All soil samples will be analyzed by gamma spectroscopy for ²²⁶Ra and ¹³⁷Cs with at least 10 percent of randomly selected samples receiving gas flow proportional analysis for ⁹⁰Sr. Additionally:

- A minimum of 10 percent of systematic soil samples collected from the Former Buildings 317/364/365 Site and adjacent TUs 95, 117, 118, and 153 will be randomly selected for alpha spectroscopy analysis for ²³⁹Pu and ²³⁵U.

¹¹ Previously, 32 SUs were investigated at Buildings 317/364/365 Former Building Site and Building 351A Crawl Space; however, some SU areas overlapped. For the Buildings 317/364/365 Former Building Site, former SU 22 overlaps TU 153 and will be investigated as part of TU 153. For the Building 351A Crawl Space, former SU R, SU S, and SU U overlap SU M, SU N, and SU O and will be investigated as part of SU M, SU N, and SU O.

¹² ²³⁹Pu is only an ROC for former Buildings 364 and 365 (NAVSEA, 2004); however, it is included as an ROC for soil at the Former Buildings 317/364/365 Site, that includes former Building 317 based on the location and proximity.

SAP Worksheet #17—Summary and Survey Design and Rationale (continued)

- A minimum of 10 percent of systematic of systematic soil samples collected from the Building 351A Crawl Space and adjacent TUs 97 and 115 will be randomly selected for alpha spectroscopy analysis for ^{239}Pu and ^{232}Th .
- A minimum of 10 percent of systematic of systematic soil samples collected from TU 107, adjacent to Building 408, will be randomly selected for alpha spectroscopy analysis for ^{232}Th .

Gamma spectroscopy data will be reported by the laboratory after a full 21-day in-growth period. If the laboratory results indicate a concentration of ^{226}Ra above the RG (**Worksheet #15a**), the sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U , ^{235}U , and ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra . If the laboratory results indicate concentrations of ^{137}Cs above its RG (**Worksheet #15a**), the sample will be analyzed for ^{90}Sr and by alpha spectroscopy for ^{239}Pu . If the laboratory results indicate the presence of concentrations of ^{90}Sr at or above the respective RG (**Worksheet #15c**), the sample will be analyzed by alpha spectroscopy for ^{239}Pu (**Worksheet #15b**).

Soil samples will be collected on a systematic sampling grid or biased to locations identified by the gamma scanning surveys. The number of systematic soil samples collected will be based on the guidance described in MARSSIM Section 5.5.2.2 (USEPA et al., 2000) using ^{226}Ra as the example basis for calculating the minimum sample frequency. Even if the MARSSIM-recommended or other statistical tests are not used to evaluate site data, these calculations serve as a basis for determining the number of samples per SU to be collected. The number of biased samples will be determined based on results of scan surveys, and a minimum of one biased sample will be collected in every TU and SU.

The methods for calculating the number of samples in an SU are provided in the Parcel G Work Plan. Eighteen samples are recommended as a placeholder until data from the RBA study become available. The minimum number of samples per SU will be developed based on the variability observed in the RBA data. A retrospective power curve will be prepared to demonstrate that the number of samples from each SU was sufficient to meet the project objectives. If necessary, additional samples may be collected to comply with the project objectives.

Phase 1 Trench Unit

Radiological investigations will be conducted on a targeted group of 21 of the 63 TUs associated with former sanitary sewer and storm drain lines (**Figure 11-1** and **Worksheet #18**) to evaluate whether concentrations of ROCs are compliant with the RAO in the Parcel G ROD (Navy, 2009). The former TUs selected for Phase 1 investigation were based on their location adjacent to (i.e., downstream and upstream from) impacted buildings and considered the recommendations from the Radiological Data Evaluation Findings Report (Navy, 2017). The Phase 1 TUs will be re-excavated to the previous excavation limits by making reasonable attempts to ensure accuracy in relocating the former TU boundaries. Excavated material from ESUs and SFUs will be maintained separately (**Worksheet #14**). If the investigation results demonstrate potential exceedances of the RGs and background, the material will be segregated for further evaluation as described in the Parcel G Work Plan. An in situ investigation and/or remediation of the trench sidewalls and floor will be performed prior to backfill. An example Phase 1 TU location is presented on **Figure 17-1**.

Surveys and sampling will be completed through one of the following methods:

- If the automated soil sorting system process is used, a minimum of 18 systematic soil samples will be collected from each ESU or SFU during assay with the soil sorting system. Systematic samples will be collected during a given time period, the frequency of which is determined to provide a systematic distribution of sample collection throughout each ESU or SFU. Systematic samples will be collected by compositing material within

SAP Worksheet #17—Summary and Survey Design and Rationale (continued)

each 10-minute interval. Samples will be collected from material moving through the soil sorter before discharging into each bin. A minimum of one biased soil sample will be collected from the soil material that has been discharged to the diverted pile bin.

If the soil material discharged to the Diverted Pile originates from an SFU and is confirmed to contain contamination, an in situ investigation of the open trench will be performed at the excavation location of the soil. The SFU in situ investigation will include the performance of a gamma scan over the trench surface requiring investigation and additional biased and systematic sampling. The gamma scan will be performed in two stages. The first stage is a 100 percent gamma scan of the accessible areas. Review of the gamma scan data will determine whether further investigation is warranted. If further investigation is not warranted, the second stage is not necessary, and systematic samples will be collected. If further investigation is warranted, biased samples may be collected. A minimum of 18 systematic soil samples will be collected from each SFU requiring investigation. Each 1,000 m² trench SFU will be plotted using Visual Sample Plan (VSP) software (or equivalent) to determine the location of the 18 systematic soil samples. The systematic soil samples will be plotted using a random start triangular or square grid using the VSP software. Soil samples will be collected from the trench surface at a depth of 0 to 6 inches.

The systematic and biased soil samples will be containerized and submitted to the offsite laboratory with appropriate chain-of-custody documentation as described in **Worksheets #21, #26, and #27**.

- If RSY pads are used for screening soil, excavated TU material (ESUs and SFUs) will be assayed using the RSY process. The objective of the processing activities on the RSY pads is to characterize the material. Material that meets the RGs identified in **Worksheet #15a** will be used as backfill material or shipped offsite as non-LLRW. The RSY pad investigation will include gamma scans over 100 percent of the surface area and systematic and biased soil sampling.

A minimum of 18 systematic soil samples will be collected. Data obtained during the surface gamma scan surveys, including gross gamma and individual radionuclide spectral measurements, will be analyzed to identify areas where surface radiation levels appear to be greater than the radionuclide-specific investigation levels using regions of interest-peak identification tools. Elevated areas will be noted on a survey map and flagged in the field for verification. Biased samples will be collected from potential areas of elevated activity displaying gamma scan survey results greater than the investigation level, as described in the Parcel G Work Plan. Each 1,000 m² RSY pad area will be plotted using VSP software (or equivalent) to determine the location of the 18 systematic soil samples. Soil samples will be collected from the surface at a depth of 0 to 6 inches.

If gamma scan surveys or soil sampling indicate areas of potentially elevated activity in soil material originating from an SFU, an in situ investigation of the open trench will be performed at the excavation location of the soil. The SFU in situ investigation will include the performance of a gamma scan over the trench surface requiring investigation and additional biased and systematic sampling. The gamma scan will be performed in two stages. The first stage is a 100 percent gamma scan of the accessible areas. Review of the gamma scan data will determine whether further investigation is warranted. If further investigation is not warranted, the second stage is not necessary, and systematic samples will be collected. If further investigation is warranted, biased samples may be collected. A minimum of 18 systematic soil samples will be collected from each SFU requiring investigation. Each 1,000 m² trench SFU will be plotted using VSP software (or equivalent) to determine the location of the 18 systematic soil samples. The systematic soil samples will be plotted using a random start triangular or square grid using the VSP software. Soil samples will be collected from the trench surface at a depth of 0 to 6 inches.

SAP Worksheet #17—Summary and Survey Design and Rationale (continued)

The systematic and biased soil samples will be containerized, labeled, and shipped to the laboratory, as described in **Worksheets #21, #26, and #27**.

Phase 2 Trench Unit

Radiological investigations will be conducted the remaining 42 TUs in Parcel G associated with former sanitary sewer and storm drain lines (**Figure 11-1** and **Worksheet #18**). Investigations of the Phase 2 TUs will consist of a combination of gamma scan surveys and soil samples.

Each Phase 2 TU will undergo a 100 percent radiological surface gamma scan of accessible areas using an appropriate instrument. Elevated areas will be noted on a survey map and flagged in the field for verification.

Manual scans may be performed to further delineate suspect areas in the TU. Biased samples will be collected from potential areas of elevated activity as described in the Parcel G Work Plan.

Within the backfill of each previous TU boundary, VSP software (or equivalent) will be used to determine the location of the systematic soil boring locations. Each location will be cored down to approximately 6 inches below the depth of previous excavation. Each retrieved core will be scan-surveyed along the entire length of the core. Scan measurement results of the retrieved core will be evaluated to investigate the potential for small areas of elevated activity in the fill material. A sample will be collected from the top 6 inches of material, and a second sample will be collected from the 6 inches of material just below the previous excavation depth. Additionally, a third sample will be collected from the core segment with the highest scan reading that was not already sampled. A total of at least three samples will be collected from each of the 18 borings, for a total of 54 samples per previous TU boundary.

In addition, systematic cores will be placed every 50 linear feet on each trench sidewall in order to collect samples from locations representative of the trench sidewalls. The systematic boring locations will be located approximately 6 inches outside of the previous sidewall excavation limits and will extend 6 inches past the maximum previous excavation depth on both sidewalls in every trench. In the same fashion described in the previous paragraph, core sections will be retrieved, scanned, and sampled such that at least three samples will be collected from each of the boring locations.

An example graphic showing the systematic sample locations and sample locations representing the TU sidewalls is provided on **Figure 17-2**. Systematic soil samples will be located using VSP software (or equivalent). Each TU will be mapped in VSP, such that at a minimum, 18 systematic soil samples will be collected in each TU. The systematic soil samples will be plotted using a random start triangular grid using the VSP software with GPS coordinates for each systematic sample. The systematic and biased soil samples will be containerized and submitted to the offsite laboratory with appropriate chain-of-custody documentation as described in **Worksheets #21, #26, and #27**

Former Building Site and Crawl Space Survey Unit

Radiological investigations will be conducted at the 28 SUs¹³ associated with soil from building sites where only surface soil scanning and sampling were previously conducted (**Figure 11-1** and **Worksheet #18**). Investigation of the building site and crawl space SUs will be performed in a similar fashion as the RSY process, using a combination of surface soil gamma scan surveys and systematic and biased surface soil sampling.

¹³ Previously, 32 SUs were investigated at Buildings 317/364/365 Former Building Site and Building 351A Crawl Space; however, some SU areas overlapped. For the Buildings 317/364/365 Former Building Site, former SU 22 overlaps TU 153 and will be investigated as part of TU 153. For the Building 351A Crawl Space, former SU R, SU S, and SU U overlap SU M, SU N, and SU O and will be investigated as part of SU M, SU N, and SU O.

SAP Worksheet #17—Summary and Survey Design and Rationale (continued)

Each SU will undergo a 100 percent surface gamma scan of accessible areas using an appropriate instrument as described in the Parcel G Work Plan. The instrument will be composed of a gamma scintillation detector equipped with spectroscopy coupled to a data logger that logs the resultant data in conjunction with location. Gross gamma and gamma spectra obtained during the surface gamma scan surveys will be analyzed using region of interest peak identification tools for the ROCs (**Table 17-1**). Elevated areas will be noted on a survey map and flagged in the field for verification. Manual scans using a hand-held instrument may be performed to further delineate suspect areas in the SU. Biased samples will be collected from potential areas of elevated activity displaying gamma scan survey results as described in the Parcel G Work Plan.

Following the completion of the gamma scan surveys, systematic soil samples will be located using VSP software (or equivalent). Each SU will be mapped in VSP, such that at a minimum, 18 systematic soil samples will be collected in each SU. The systematic soil samples will be plotted using a random start triangular grid using the VSP software with GPS coordinates for each systematic sample. An example graphic showing the sample locations is provided on **Figure 17-1**. The systematic and biased soil samples will be containerized and submitted to offsite laboratory with appropriate chain-of-custody documentation as described in **Worksheets #21, #26, and #27**.

At the Former Buildings 317/364/365 Site, SUs 27 (peanut spill) and 28 (LWTS) will be excavated to 2 and 10 feet bgs, respectively, for consistency with the previous excavation boundaries (**Figure 11-1**). The two SUs will be excavated to the original excavation boundaries, as practicable, and gamma scans of the excavated material will be conducted following the process described in **Worksheet #14** for Phase 1 TUs.

Reference Background Area Investigation

The RGs (**Worksheet #15a, #15b, and #15c**) are incremental concentrations above background; therefore, RBA samples and measurements will be collected and evaluated to provide generally representative data sets estimating levels in natural background and fallout for the majority of soils at HPNS. The RBA characterization will incorporate three survey techniques: gamma scans, surface soil sampling, and subsurface soil sampling to support data evaluations.

Four of the previously established RBA soil areas with adjustments to the shape and size of the areas will be used for the RBA investigation. These four historical RBAs are still considered non-impacted, representative of much of the soil at HPNS, and suitable for use as RBAs. The four historically non-impacted RBAs are identified as the following:

- RBA-1, located on Parcel B
- RBA-2, located on Parcel C
- RBA-3, located on Parcel D-1
- RBA-4, located on Parcel D-2

These four RBAs are shown on **Figure 11-2**. Following characterization of each RBA, a detailed data evaluation will be performed to confirm its suitability as an appropriate RBA.

In addition to the four onsite RBAs, an undisturbed land area within the City of San Francisco's McLaren Park has been selected as a potential location for an offsite RBA (RBA-McLaren). The approximate location of the McLaren Park RBA is shown on **Figure 11-3**. Additional details about McLaren Park are provided in Appendix C of the Parcel G Work Plan. The exact sample locations within McLaren Park may be adjusted based on consultation with the City of San Francisco. Other locations in the San Francisco Bay Area that have been similarly undisturbed may also be used as potential offsite RBA locations. Both surface gamma scan surveys and surface soil samples will be collected from RBA-McLaren to provide a surface soil data set representative of undisturbed surface soil areas. Additional

SAP Worksheet #17—Summary and Survey Design and Rationale (continued)

sample locations at McLaren Park or additional RBA locations may be added as necessary to characterize different soil types and depositional areas.

RBA investigations will be conducted at five locations (**Worksheet #18**). **Figures 17-3** through **17-6** show the planned sample locations from RBAs 1 through 4. **Figure 17-7** shows the planned sample locations for the offsite RBA. The investigation of the RBAs will be performed using a combination of gamma scan measurements and surface and subsurface soil sampling. The gamma scan methodology is included in detail in the Parcel G Work Plan.

The sampling design is considered representative of the SU sampling designs in terms of sample depths, spatial distribution, and number of samples to be collected.

The minimum number of samples to be collected was determined based on U.S. Nuclear Regulatory Commission (NRC) criteria, NUREG 1505 Section 13.5 that states four reference areas each with between 10 and 20 samples in each should generally be adequate (NRC, 1998). The Parcel G Work Plan provides a number of samples calculation and indicates that a minimum of 18 samples be collected in each SU and each RBA data set. The USEPA has requested that a minimum of 25 samples be collected in each survey unit. Therefore, 25 samples will be a placeholder until data from the RBA study become available. For the RBAs, to satisfy both the NRC criteria and the Parcel G Work Plan, the number of samples in each data set was increased to 25 to ensure that sufficient analytical data will be available. Therefore, 25 surface soil samples and 25 subsurface soil samples will be collected from RBAs 1 through 4 for a total of 100 onsite surface soil samples and 100 onsite subsurface soil samples (**Worksheet #18**). Additionally, 25 surface soil samples and 25 subsurface soil samples will be collected from RBA-McLaren (**Worksheet #18**). Overall, a minimum of 250 soil samples will be collected. Additional samples may be collected, if needed, to characterize observed conditions. This will result in up to 10 RBA data sets of 25 samples each from 5 different RBA locations. Additional data sets may be defined based on soil type or other visual observations of the soil samples.

To simplify the sampling design, the area of each onsite RBA was modified to establish approximately 2,500-ft² areas within each of the four historical RBA footprints. For the surface soil sample locations within RBA-1 through RBA-4, a triangular grid will be used to place 25 systematic sample locations. Surface soil samples will be collected from the top 6 inches of soil material at each location for the surface soil data set (**Figure 17-8**). For the purposes of this investigation, onsite surface soil is defined as the uppermost 6-inch interval of soil beneath the asphalt and road base materials installed as part of the durable cover. Within each 2,500-ft² surface area, 5 subsurface sampling locations have been established using 5 of the 25 systematic surface sample locations: 1 at the approximate center of each area, and the other 4 located near each of the 4 corners of the area. Subsurface soil samples will be collected from the five sampling locations. Subsurface soil samples will be collected by drilling to a depth of approximately 10 feet bgs from which five subsurface soil samples will be extracted (**Figure 17-8**). The proposed subsurface sample depth intervals are the 1- to 2-foot interval, the 3- to 4-foot interval, the 5- to 6-foot interval, the 7- to 8-foot interval, and the 9- to 10-foot interval. If the geologist determines that lithologic characteristics support modification of the proposed depth increments, additional samples may be collected, or the proposed sample depth may be adjusted to match the lithologic characteristics of the soil column. Additional information is provided in Appendix C of the Parcel G Work Plan.

The planned area for RBA-McLaren, located offsite within McLaren Park, is a square area measuring approximately 75 feet by 75 feet. Within the estimated 5,600-ft² surface area (520 m²), 25 surface sampling locations have been established using a random start systematic triangular grid pattern. Surface soil samples will be from the top 6 inches of soil at each location for the surface soil data set. Subsurface soil samples will be collected from the approximately 1- to 2-foot interval at each location for the subsurface soil data set. Additional samples may be

SAP Worksheet #17—Summary and Survey Design and Rationale (continued)

collected from other locations if areas of relatively undisturbed surface soil with varying geological properties are identified during field sampling activities.

Soil sampling will occur at various depths from 0 to 10 feet bgs in accordance with **Worksheet #21** and **Attachment 2**. The soil samples collected from each of the RBAs will be containerized and submitted to the offsite laboratory with appropriate chain-of-custody documentation as described in **Worksheets #21, #26, and #27**. RBA samples and measurements will be collected and evaluated to establish representative data sets defining natural background and fallout levels of anthropogenic radionuclides, including the full suite of radionuclides listed in **Worksheets #15a, #15b, #15c, and #15d**.

Building Investigation

This section describes the design of radiological investigations, including scan and static measurements on building surfaces. The radiological investigation design and rationale is based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012), with the ultimate requirement being to demonstrate compliance with the Parcel G ROD RAO (Navy, 2009). Previous methodology will be reproduced using BMPs. The ROCs for the building investigation are listed in **Table 17-2**.

Table 17-2. Building Radionuclides of Concern

Building	ROCs	Reference
Building 351	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr, ²³² Th	NAVSEA, 2004
Building 351A	¹³⁷ Cs, ²³⁹ Pu, ²²⁶ Ra, ⁹⁰ Sr, ²³² Th	NAVSEA, 2004
Building 366	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr	NAVSEA, 2004
Building 401	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr	TtEC, 2009c
Building 408	¹³⁷ Cs, ²²⁶ Ra, ⁹⁰ Sr, ²³² Th	NAVSEA, 2004
Building 411	¹³⁷ Cs, ⁶⁰ Co, ²²⁶ Ra	NAVSEA, 2004
Building 439	¹³⁷ Cs, ²²⁶ Ra	TtEC, 2009a

Radiological investigations will be conducted on impacted buildings, presented on **Figure 11-4**, to evaluate whether site conditions are compliant with the RAO in the Parcel G ROD (Navy, 2009). The RAO is to prevent receptor exposure to ROCs in concentrations that exceed RGs for all potentially complete exposure pathways. These RGs for structures, equipment, and waste are presented in **Table 17-3** for each of the ROCs identified for the applicable buildings. Also identified for each ROC is the primary particle type emitted during the ROC's decay, or the ROC's radioactive progeny's decay.

Table 17-3. Building Remediation Goals from Parcel G ROD

ROC	Particle Emission(s)	RGs for Structures (dpm/100 cm ²)	RGs for Equipment, Waste (dpm/100 cm ²)
¹³⁷ Cs	β	5,000	5,000
⁶⁰ Co	β	5,000	5,000
²³⁹ Pu	α	100	100
²²⁶ Ra	α, β	100	100
⁹⁰ Sr	β	1,000	1,000
²³² Th	α, β	36.5	1,000

Note:

dpm/100 cm² = disintegration(s) per minute per 100 square centimeters

SAP Worksheet #17—Summary and Survey Design and Rationale (continued)

Data collected from building surfaces during this investigation represent the total (fixed and removable) gross activity on the surface, which may result from radiations from multiple radionuclides. Because these survey data are radiation-specific (α and β) but not radionuclide-specific, they cannot be attributed to a particular ROC. Instead, the survey data will be compared to the most restrictive building-specific RG_{α} and RG_{β} as presented in **Table 17-4**. For each building, the RG_{α} is chosen as the structure’s lowest RG for an alpha-emitting ROC and the RG_{β} is chosen as the structure’s lowest RG for a beta-emitting ROC.

Table 17-4. Building-specific Remediation Goals from Parcel G Work Plan

Building	RG_{α} (dpm/100 cm ²) and ROC	RG_{β} (dpm/100 cm ²) and ROC
Building 351	36.5 (²³² Th)	1,000 (⁹⁰ Sr)
Building 351A	36.5 (²³² Th)	1,000 (⁹⁰ Sr)
Building 366	100 (²²⁶ Ra)	1,000 (⁹⁰ Sr)
Building 401	100 (²²⁶ Ra)	1,000 (⁹⁰ Sr)
Building 408 slab	36.5 (²³² Th)	1,000 (⁹⁰ Sr)
Building 411	100 (²²⁶ Ra)	5,000 (¹³⁷ Cs)
Building 439	100 (²²⁶ Ra)	5,000 (¹³⁷ Cs)

Parcel G buildings will be divided into identifiable SUs similar in area and nomenclature to the previous final status survey of each building. Generally, impacted floor surfaces and the lower 2 meters of remaining impacted wall surfaces will form Class 1 SUs of no more than 100 m² each. The remaining impacted upper wall surfaces and ceilings will generally form the remaining Class 2 SUs of no more than 2,000 m² each. Example building Class 1 and Class 2 SUs are presented on **Figure 17-9** and **Figure 17-10, respectively**. Class 3 SUs consist of floor areas in Building 411 and the exterior of Building 366, which were investigated as part of past scoping surveys. Additional information, including SU classifications, is provided in the Parcel G Work Plan. Alpha-beta scan, systematic alpha-beta static and swipe measurements, and biased alpha-beta static and swipe measurements where necessary will be collected from each SU. Building material samples will be collected if necessary.

SUs will be scanned to detect alpha and beta emitters using average scan rates that ensure an alpha probability of detection of approximately 90 percent where feasible, and that the beta scan MDC is less than or equal to the RG_{β} for the building (**Table 17-4**). Scanning will cover a total area of each SU according to its classification. The total surface area of remaining, accessible impacted surfaces to be scanned will be 100 percent in Class 1 SUs, 50 percent in Class 2 SUs, and up to 10 percent in Class 3 SUs. SU scan lanes and static measurement locations will be marked using a consistent reference coordinate system throughout the building. In the absence of other technologies, locations will reference from the southernmost and westernmost points in the SU.

SAP Worksheet #17—Summary and Survey Design and Rationale (continued)

A minimum of 18 alpha-beta static measurements will be taken in each SU. The Parcel G Work Plan provides a number of samples calculations, and the 18 static measurements are recommended as a placeholder until background data become available. The minimum number of static measurements per SU will be developed based on the variability observed in the RBA data. The data quality assessment (DQA) of SU data will include a retrospective power curve (based on the MARSSIM Appendix I guidance) to demonstrate that enough static measurements were performed to meet the project objectives. If necessary, additional static measurements may be performed to comply with the project objectives. Biased static measurements will be used to further investigate areas with potential elevated surface activity as described in the Parcel G Work Plan. Swipe samples will be taken at all locations of systematic and biased static measurements. They will be taken dry, using moderate pressure, over an area of approximately 100 cm². Swipe samples will be measured for gross alpha and beta activity using instrumentation described in the Parcel G Work Plan. Swipe samples may be sent offsite if detectable activity exceeds criteria for removable contamination and does not appear to be attributable to radon progeny. Material samples may be collected to further characterize surface materials if scan and static survey measurements exceed RGs. The surface activity on the sample will be compared to the total surface activity measured by the static measurement to assess the removable fraction of surface activity. This information may be used in any dose or risk assessment performed. Building material samples may be collected for offsite analysis to further characterize areas of interest. Remediation will be conducted in building areas with activity that exceed RGs and background as described in **Worksheet #14** and the Parcel G Work Plan.

Background measurements will be obtained in the building RBAs for each instrument and on each surface type (e.g., concrete, wood, and sheet rock) that is also present in the SUs. At least 18 static measurements will be taken on each surface material in the RBA that is representative of the material in the building SUs. The mean instrument- and surface-specific background count rates will be used to update the instrument detection calculations and static count times in the Parcel G Work Plan. Building 404 will serve as the primary RBA in the investigation of Parcel G buildings (**Figure 11-4**). Building 404 is a non-impacted, unoccupied former supply storehouse constructed in 1943 (NAVSEA, 2004). Alternate RBAs may be identified and used if needed based on site-specific conditions identified during the building investigations.

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SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements

Sampling Location	Sample ID ^a	Matrix	Depth (feet bgs) ^b	Analytical Group	Number of Samples	Sampling SOP Reference
Phase 1 Trench Unit						
TU69	HPPG-ESU-069A-001; HPPG-SFU-069A-001	Soil	Excavated material; Excavated material representing the sidewalls and bottoms of TU (depth varies depending on historical excavated depth)	Refer to Worksheets #15a, #15b, #15c, and #15d	144	See Worksheet #21
TU70	HPPG-ESU-070A-001; HPPG-SFU-070A-001				180	
TU76	HPPG-ESU-076A-001; HPPG-SFU-076A-001				198	
TU77	HPPG-ESU-077A-001; HPPG-SFU-077A-001				252	
TU78	HPPG-ESU-078A-001; HPPG-SFU-078A-001				126	
TU79	HPPG-ESU-079A-001; HPPG-SFU-079A-001				162	
TU95	HPPG-ESU-095A-001; HPPG-SFU-095A-001				126	
TU97	HPPG-ESU-097A-001; HPPG-SFU-097A-001				90	
TU98	HPPG-ESU-098A-001; HPPG-SFU-098A-001				90	
TU99	HPPG-ESU-099A-001; HPPG-SFU-099A-001				108	
TU100	HPPG-ESU-100A-001; HPPG-SFU-100A-001	36				

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements (continued)

Sampling Location	Sample ID ^a	Matrix	Depth (feet bgs) ^b	Analytical Group	Number of Samples	Sampling SOP Reference
TU101	HPPG-ESU-101A-001; HPPG-SFU-101A-001	Soil	Excavated material; Excavated material representing the sidewalls and bottoms of TU (depth varies depending on historical excavated depth)	Refer to Worksheets #15a, #15b, #15c, and #15d	36	See Worksheet #21
TU103	HPPG-ESU-103A-001; HPPG-SFU-103A-001				54	
TU104	HPPG-ESU-104A-001; HPPG-SFU-104A-001				108	
TU107	HPPG-ESU-107A-001; HPPG-SFU-107A-001				54	
TU108	HPPG-ESU-108A-001; HPPG-SFU-108A-001				72	
TU109	HPPG-ESU-109A-001; HPPG-SFU-109A-001				180	
TU115	HPPG-ESU-115A-001; HPPG-SFU-115A-001				54	
TU121	HPPG-ESU-121A-001; HPPG-SFU-121A-001				90	
TU124	HPPG-ESU-124A-001; HPPG-SFU-124A-001				90	
TU153	HPPG-ESU-153A-001; HPPG-SFU-153A-001				90	

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements (continued)

Sampling Location	Sample ID ^a	Matrix	Depth (feet bgs) ^b	Analytical Group	Number of Samples	Sampling SOP Reference
Phase 2 Trench Unit						
TU66	HPPG-ESU-066-0102-01-001; HPPG-SFU-066-0102-01-001	Soil	Backfill of the excavation limits of former TUs (depth varies depending on historical excavated depth); Within 1 meter of the previous sidewallexcavation limits of former TUs every 50 linear feet (depth varies depending on historical excavated depth)	Refer to Worksheets #15a, #15b, #15c, and #15d	102	See Worksheet #21
TU67	HPPG-ESU-067-0102-01-001; HPPG-SFU-067-0102-01-001				90	
TU68	HPPG-ESU-068-0102-01-001; HPPG-SFU-068-0102-01-001				108	
TU71	HPPG-ESU-071-0102-01-001; HPPG-SFU-071-0102-01-001				162	
TU72	HPPG-ESU-072-0102-01-001; HPPG-SFU-072-0102-01-001				123	
TU73	HPPG-ESU-073-0102-01-001; HPPG-SFU-073-0102-01-001				120	
TU74	HPPG-ESU-074-0102-01-001; HPPG-SFU-074-0102-01-001				78	
TU75	HPPG-ESU-075-0102-01-001; HPPG-SFU-075-0102-01-001				96	
TU80	HPPG-ESU-080-0102-01-001; HPPG-SFU-080-0102-01-001				87	
TU81	HPPG-ESU-081-0102-01-001; HPPG-SFU-081-0102-01-001				120	
TU82	HPPG-ESU-082-0102-01-001; HPPG-SFU-082-0102-01-001				117	

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements (continued)

Sampling Location	Sample ID ^a	Matrix	Depth (feet bgs) ^b	Analytical Group	Number of Samples	Sampling SOP Reference
TU83	HPPG-ESU-083-0102-01-001; HPPG-SFU-083-0102-01-001	Soil	Backfill of the excavation limits of former TUs (depth varies depending on historical excavated depth); Within 1 meter of the previous sidewallexcavation limits of former TUs every 50 linear feet (depth varies depending on historical excavated depth)	Refer to Worksheets #15a, #15b, #15c, and #15d	87	See Worksheet #21
TU84	HPPG-ESU-084-0102-01-001; HPPG-SFU-084-0102-01-001				84	
TU85	HPPG-ESU-085-0102-01-001; HPPG-SFU-085-0102-01-001				105	
TU86	HPPG-ESU-086-0102-01-001; HPPG-SFU-086-0102-01-001				102	
TU87	HPPG-ESU-087-0102-01-001; HPPG-SFU-087-0102-01-001				99	
TU88	HPPG-ESU-088-0102-01-001; HPPG-SFU-088-0102-01-001				105	
TU89	HPPG-ESU-089-0102-01-001; HPPG-SFU-089-0102-01-001				111	
TU90	HPPG-ESU-090-0102-01-001; HPPG-SFU-090-0102-01-001				75	
TU91	HPPG-ESU-091-0102-01-001; HPPG-SFU-091-0102-01-001				93	
TU92	HPPG-ESU-092-0102-01-001; HPPG-SFU-092-0102-01-001				69	
TU93	HPPG-ESU-093-0102-01-001; HPPG-SFU-093-0102-01-001				84	
TU94	HPPG-ESU-094-0102-01-001; HPPG-SFU-094-0102-01-001				102	

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements (continued)

Sampling Location	Sample ID ^a	Matrix	Depth (feet bgs) ^b	Analytical Group	Number of Samples	Sampling SOP Reference
TU96	HPPG-ESU-096-0102-01-001; HPPG-SFU-096-0102-01-001	Soil	Backfill of the excavation limits of former TUs (depth varies depending on historical excavated depth); Within 1 meter of the previous sidewallexcavation limits of former TUs every 50 linear feet (depth varies depending on historical excavated depth)	Refer to Worksheets #15a, #15b, #15c, and #15d	105	See Worksheet #21
TU102	HPPG-ESU-102-0102-01-001; HPPG-SFU-102-0102-01-001				66	
TU105	HPPG-ESU-102-0105-01-001; HPPG-SFU-105-0102-01-001				87	
TU106	HPPG-ESU-102-0106-01-001; HPPG-SFU-106-0102-01-001				99	
TU110	HPPG-ESU-110-0102-01-001; HPPG-SFU-110-0102-01-001				99	
TU111	HPPG-ESU-111-0102-01-001; HPPG-SFU-111-0102-01-001				93	
TU112	HPPG-ESU-112-0102-01-001; HPPG-SFU-112-0102-01-001				99	
TU113	HPPG-ESU-113-0102-01-001; HPPG-SFU-113-0102-01-001				99	
TU114	HPPG-ESU-114-0102-01-001; HPPG-SFU-114-0102-01-001				63	
TU116	HPPG-ESU-116-0102-01-001; HPPG-SFU-116-0102-01-001				84	

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements (continued)

Sampling Location	Sample ID ^a	Matrix	Depth (feet bgs) ^b	Analytical Group	Number of Samples	Sampling SOP Reference
TU117	HPPG-ESU-117-0102-01-001; HPPG-SFU-117-0102-01-001				69	
TU118	HPPG-ESU-118-0102-01-001; HPPG-SFU-118-0102-01-001				102	
TU119	HPPG-ESU-119-0102-01-001; HPPG-SFU-119-0102-01-001				99	
TU120	HPPG-ESU-120-0102-01-001; HPPG-SFU-120-0102-01-001				108	
TU122	HPPG-ESU-122-0102-01-001; HPPG-SFU-122-0102-01-001				126	
TU123	HPPG-ESU-123-0102-01-001; HPPG-SFU-123-0102-01-001				126	
TU129	HPPG-ESU-124-0102-01-001; HPPG-SFU-129-0102-01-001				84	
TU151	HPPG-ESU-151-0102-01-001; HPPG-SFU-151-0102-01-001				69	
TU204	HPPG-ESU-204-0102-01-001; HPPG-SFU-204-0102-01-001				111	

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements (continued)

Sampling Location	Sample ID ^a	Matrix	Depth (feet bgs) ^b	Analytical Group	Number of Samples	Sampling SOP Reference
Former Building Site and Crawl Space Soil Survey Unit						
Building 351A Crawl Space	HPPG-351A-SUA0-001	Soil	0 – 0.5	Refer to Worksheets #15a, #15b, #15c, and #15d	18	See Worksheet #21
	HPPG-351A-SUB0-001				18	
	HPPG-351A-SUC0-001				18	
	HPPG-351A-SUD0-001				18	
	HPPG-351A-SUE0-001				18	
	HPPG-351A-SUF0-001				18	
	HPPG-351A-SUG0-001				18	
	HPPG-351A-SUH0-001				18	
	HPPG-351A-SUI0-001				18	
	HPPG-351A-SUJ0-001				18	
	HPPG-351A-SUK0-001				18	
	HPPG-351A-SUL0-001				18	
	HPPG-351A-SUM0-001				18	
	HPPG-351A-SUN0-001				18	
	HPPG-351A-SUO0-001				18	
HPPG-351A-SUP0-001	18					
HPPG-351A-SUT0-001	18					

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements (continued)

Sampling Location	Sample ID ^a	Matrix	Depth (feet bgs) ^b	Analytical Group	Number of Samples	Sampling SOP Reference
Buildings 317/364/365 Site	HPPG-317364365-SU20-001				18	
	HPPG-317364365-SU21-001				18	
	HPPG-317364365-SU23-001				18	
	HPPG-317364365-SU24-001				18	
	HPPG-317364365-SU25-001				18	
	HPPG-317364365-SU26-001				18	
	HPPG-317364365-SU27-001				18	
	HPPG-317364365-SU28-001				18	
	HPPG-317364365-SU29-001				18	
	HPPG-317364365-SU30-001				18	
HPPG-317364365-SU31-001				18		

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements (continued)

Sampling Location	Sample ID ^a	Matrix	Depth (feet bgs) ^b	Analytical Group	Number of Samples	Sampling SOP Reference
Reference Background Area						
RBA-1	HPRBA1-SS01-000H-0718	Soil	0.0 – 0.5	Refer to Worksheets #15a, #15b, #15c, and #15d	25	See Worksheet #21
	HPRBA1-SB01-0102-0718		1 – 2; 3 – 4; 5 – 6; 7 – 8; 9 - 10		25	
RBA-2	HPRBA2-SS0-000H-0718	Soil	0.0 – 0.5		25	
	HPRBA2-SB01-0102-0718		1 – 2; 3 – 4; 5 – 6; 7 – 8; 9 - 10		25	
RBA-3	HPRBA3-SS01-000H-0718	Soil	0.0 – 0.5		25	
	HPRBA3-SB01-0102-0718		1 – 2; 3 – 4; 5 – 6; 7 – 8; 9 - 10		25	
RBA-4	HPRBA4-SS01-000H-0718	Soil	0.0 – 0.5		25	
	HPRBA4-SB01-0102-0718		1 – 2; 3 – 4; 5 – 6; 7 – 8; 9 - 10		25	
RBA-McLaren	HPRBAM-SS01-000H-0718	Soil	0.0 – 0.5	25		
	HPRBAM-SB01-0102-0718		1 – 2	25		
Building Interior Surfaces						
Interior surfaces, as needed ^d	TBD	TBD	NA	Refer to Worksheets #15a, #15b	TBD	Refer to Parcel G Work Plan

Notes:

^a Example sample IDs for sampling have been provided. The site IDs, locations and number of samples collected per site/location are presented in **Worksheets #17** and **#20**. Sample ID instructions are as follows:

Sample IDs from the Phase 1 soil TU investigation will use the following format: AABB-CCC-NNNA-DDD, where AA = facility; BB = site location; CCC = sample type; NNN = former trench unit number; A = alpha-numeric digit of each “batch” (beginning with A, in sequential order, followed by B, C, etc.), DDD = numeric sample digit (beginning with 001, in sequential order, followed by 002, 003, etc.).

Sample IDs from the Phase 2 soil TU investigation will use the following format: AABB-CCC-NNN-EEFF-GG-DDD where AA = facility; BB = site location; CCC = sample type; NNN = former trench unit number; EEFF = two-digit sample interval in feet bgs (EE feet = top of sample interval / FF feet = bottom of sample interval); GG = soil boring number within the TU (beginning with 01, in sequential order); DDD = numeric sample digit (beginning with 001, in sequential order). Note that EE and FF are whole numbers such that a value of “01” represents “1 foot bgs.” Also note that surface samples (samples collected from the 0.0- to 0.5-foot depth interval) will be designated as 000H; H for half foot. If the surface sample is collected from a depth other than a half foot, the H designation will still be used; however, a note will be included in the field book to indicate the actual depth sampled).

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements (continued)

For equipment blanks, use the following format: AABBBB-CCXX-XXYY where AA = facility; BBBB = site location; CC = sample type; XX = numerical sample number; DD/MM/YYYY = two-digit day/month and four-digit year.

Sample IDs from the Former Building Site and Crawl Space Soil Survey Unit investigation will use the following format: AABB-CCCC-SUNN-DDDA, where AA = facility, BB = site location; CCCC = Building Site name; SUNN = survey unit number; DDD = numeric digit (beginning with 001, in sequential order, followed by 002, 003, etc.).

Sample IDs from the RBA investigation will use the following format – AABBBB-CCDD-EEFF-MMY Y where AA = facility; BBBB = site location; CC = sample type; DD = numerical sample location number; EEFF = two-digit sample interval in feet bgs; and MMY Y = the two-digit month and year. For equipment blanks the following format – AABBBB-CCXX-XXYY where AA = facility; BBBB = site location; CC = sample type; XX = numerical sample number; DD/MM/YYYY = two-digit day/month and 4 digit year.

- ^b Example depths have been provided for corresponding sample ID. Depths of samples and ID are provided in **Worksheet #14**.
- ^c These values represent the minimum number of sample locations. Additional biased samples may be collected.
- ^d To further characterize site conditions, interior survey measurements may be supplemented by the collection of building material samples or the offsite analysis of swipe samples.

Field QC counts are dependent upon the duration of the field event. Frequency of QA/QC collection is as follows:

- Field Blank - One per water source for each sampling event
- Equipment Blank - For decontaminated equipment, one per type of sampling equipment, per site location; for disposable equipment, one per lot.
- Field duplicates are collected at a frequency of 1 per 10 samples per matrix sent to the laboratory.
- Additional information on sample IDs is presented in **Worksheet #27**

000H = surface sample collected from 0.0- to 0.5-foot depth interval; H for half foot.

HP = Hunters Point

SS = surface soil

ID = identification

P = field duplicate identifier

ESU = excavation soil unit

PG = Parcel G

SFU = sidewall floor unit

NA= not applicable

SB = subsurface sample

SAP Worksheet #19—Field Sampling Requirements

Matrix	Analytical Group	Analytical and Preparation Method/ SOP Reference	Container ^a (number, size, and type)	Sample volume (units)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time
Soil	Radiological (gamma spectroscopy)	USEPA 901.1/ GL-RAD-A-013	Gallon size resealable plastic bag or equivalent container	~200 grams	N/A	180 days (21 days for in-growth for gamma spectroscopy to be completed within 180 days)
Soil	Radiological (alpha spectroscopy)	HASL 300 A-01-R/ GL-RAD-A-011				
Soil	Radiological (GFPC)	USEPA 905.0 mod/ GL-RAD-A-004				
Soil	Radiological (radon emanation)	USEPA 903.1 mod/GL-RAD-A-008				

Notes:

^a One container for all analyses. Separate containers not required.

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SAP Worksheet #20—Field Quality Control Sample Summary

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs	No. of Field Blanks	No. of Equipment Blanks ^a	No. of Proficiency Test Samples	Total No. of Samples to Lab ^b
Phase 1 TU^b								
Soil	Radiological (gamma spectroscopy)	2,340	234	NA	NA	TBD	NA	2,574
	Radiological (alpha spectroscopy)	TBD	TBD	NA	NA	TBD	NA	TBD ^{cd}
	²²⁶ Ra (radon emanation)	TBD	TBD	NA	NA	TBD	NA	TBD
	⁹⁰ Sr (GFPC)	234	24	NA	NA	TBD	NA	258
Phase 2 TU^b								
Soil	Radiological (gamma spectroscopy)	4,107	411	NA	NA	TBD	NA	4,518
	Radiological (alpha spectroscopy)	TBD	TBD	NA	NA	TBD	NA	TBD ^{cd}
	²²⁶ Ra (radon emanation) ^d	TBD	TBD	NA	NA	TBD	NA	TBD ^d
	⁹⁰ Sr (GFPC)	411	42	NA	NA	TBD	NA	453
Former Building Site and Crawl Space Soil Survey Unit^b								
Soil	Radiological (gamma spectroscopy)	504	51	NA	NA	TBD	NA	555
	Radiological (alpha spectroscopy)	20	2	NA	NA	TBD	NA	22 ^{bcd}
	²²⁶ Ra (radon emanation)	TBD	TBD	NA	NA	TBD	NA	TBD ^d
	⁹⁰ Sr (GFPC)	51	6	NA	NA	TBD	NA	57

SAP Worksheet #20—Field Quality Control Sample Summary (continued)

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs	No. of Field Blanks	No. of Equipment Blanks ^a	No. of Proficiency Test Samples	Total No. of Samples to Lab ^b
Reference Background Area								
Soil	Radiological (gamma spectroscopy)	250	25	NA	NA	TBD	NA	275
	Radiological (alpha spectroscopy)	250	25	NA	NA	TBD	NA	275
	²²⁶ Ra (radon emanation)	250	25	NA	NA	TBD	NA	275
	⁹⁰ Sr (GFPC)	250	25	NA	NA	TBD	NA	275
Building Investigation								
Building Surfaces	Alpha-beta static	18 per SU	TBD ^e	NA	NA	NA	NA	TBD ^f
	Radiological (gamma spectroscopy)	TBD	NA	NA	NA	NA	NA	TBD ^g
	Radiological (alpha spectroscopy)	TBD	NA	NA	NA	NA	NA	TBD ^g

Notes:

- ^a Equipment Blank - For decontaminated equipment, one per type of sampling equipment, per site location; for disposable equipment, one per lot.
- ^b The minimum number of sampling locations are provided. Additional biased samples may be collected.
- ^c The number of samples will be based on the results of the gamma spectroscopy analysis for ¹³⁷Cs and GFPC analysis for ⁹⁰Sr, as described in **Worksheets #11 and #17**.
- ^d The number of samples will be based on the results of the gamma spectroscopy analysis for ²²⁶Ra, as described in **Worksheets #11 and #17**.
- ^e QC of radiological survey measurements will be performed in accordance with the Radiation Protection Plan (Appendix D of the Parcel G Work Plan). In addition, field duplicate measurements will be performed on 5 percent of systematic static measurements.
- ^f The total number of measurements will be based on the number of SUs within each building. A minimum of 18 static measurements will be collected. Additional biased measurements may be performed.
- ^g Samples of building materials may be collected to further investigate areas of interest.

MS/MSD not applicable to radiological testing

TBD = To be determined

SAP Worksheet #21—Project Sampling SOP References

Radiological SOPs are specific to the activities being performed, the companies performing the work, and the radioactive material license used. These SOPs include radiological testing activities such as, radiation dose measurements, personnel monitoring, and radiological postings. Further, each company’s SOPs may be different based on the requirements of their radioactive material license. Therefore, a comprehensive list and copies of radiological SOPs will be provided by CH2M and Perma-Fix as Attachment B of the Parcel G Work Plan. The following table includes a list of the CH2M field SOPs that apply to the activities in this SAP. For clarity, a comprehensive list of applicable SOPs for each sampling location are provided in the Parcel G Work Plan and this SAP as appropriate. Refer to **Worksheet #14** for project-specific procedural details.

Title	Date, Revision and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
<i>Soil Sampling</i>	10/2018	CH2M	Hand Auger, Stainless Bowl, Spoon	No	None
<i>Logging of Soil Borings</i>	10/2018	CH2M	Indelible pen, ruler, logbook, spatula, soil color chart, grain size chart, hand lens, Unified Soil Classification System index charts	No	None
<i>Decontamination of Equipment and Samples</i>	10/2018	CH2M	Buckets	No	None
<i>Preparing Field Logbooks</i>	10/2018	CH2M	Logbook and Indelible Pen	No	None
<i>Chain-of-Custody</i>	10/2018	CH2M	chain-of-custody form	No	None
<i>Packaging and Shipping Procedures for Low-Concentration Samples</i>	10/2018	CH2M	Laboratory-supplied coolers	No	None

Notes:

Field SOPs are presented in **Attachment 2**.

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SAP Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference	Comments
<i>No field instruments for chemical screening will be used for this project.</i>							
Ludlum Model 2221 Meter (or equivalent) or Osprey Multi-channel analyzer with Bicron 3x5x16 detector (or equivalent); Ludlum Model 2221 Meter (or equivalent) or multi-channel analyzer with Ludlum 44-20 (or equivalent); Ludlum Model 2360 meter (or equivalent) with Ludlum Model 43-37 detector (or equivalent); Ludlum Model 3030 Alpha-Beta Sample Counter (or equivalent); Automated soil sorting system (model to be determined); Surface Contamination Monitor (model to be determined).	Calibrate at lab featuring Nation Institute of Standards and Technology traceable standards		Radiological controls portable instrument procedures are described in detail in Attachment B of the Parcel G Work Plan		Project RSO, Field Team Lead, or qualified designee	Radiological controls portable instrument procedures are described in detail in Attachment B of the Parcel G Work Plan	If equipment is deemed inoperable or is malfunctioning, it will be removed from use and replaced.
	Efficiency Check						
	Operational checks and verifications						
	Maintenance/Inspection						

Notes:

Additional instrumentation may be used as described in the Parcel G Work Plan.

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SAP Worksheet #23—Analytical SOP References

Lab SOP Number ^a	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
GL-LB-E-012	Standard Operating Procedure for Verifying the Maintenance of Sample Integrity, Revision 7, September 2016	N/A	N/A	N/A	GEL	N
GL-RAD-A-004	The Determination of Strontium 89/90 in Water, Soil, Milk, Filters, Vegetation and Tissues, Revision 18, February 2017	Definitive	Soil - Radiological (GFPC)	Gas Flow Proportional Counter	GEL	N
GL-RAD-A-008	The Determination of Radium-226, Revision 15, January 2018	Definitive	Soil - Radiological (Radon Emanation)	Scintillation Counter	GEL	Y, modified to accommodate determination from soil matrix
GL-RAD-A-011	The Isotopic Determination of Americium, Curium, Plutonium, and Uranium, Revision 26, October 2015	Definitive	Soil - Radiological (alpha spectroscopy)	Alpha Spectrometer	GEL	N
GL-RAD-A-013	The Determination of Gamma Isotopes, Revision 26, February 2017	Definitive	Soil - Radiological (gamma spectroscopy)	Gamma Spectrometer	GEL	N
GL-RAD-A-015	Standard Operating Procedure for Digestion of Soil, Revision 10, February 2017	N/A	Soil - Radiological	N/A	GEL	N
GL-RAD-A-038	Standard Operating Procedure for the Isotopic Determination of Thorium, Revision 17, February 2016	Definitive	Soil - Radiological (alpha spectroscopy)	Alpha Spectrometer	GEL	N
GL-RAD-A-046	The Determination of Radium-224 and Radium-226 by Alpha Spectroscopy, Revision 9, July 2016	Definitive	Soil - Radiological (alpha spec)	Alpha Spectrometer	GEL	N
GL-RAD-I-001	Gamma Spectroscopy System Operation, Revision 21, February 2017	N/A	Soil - Radiological (gamma spectroscopy)	Gamma Spectrometer	GEL	N
GL-RAD-I-004	Standard Operating Procedure for Beckman LS 6000/6500	N/A	Soil - Radiological (Radon Emanation)	Scintillation Counter	GEL	N

SAP Worksheet #23—Analytical SOP References (continued)

Lab SOP Number ^a	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
GL-RAD-I-007	Standard Operating Procedure for Ludlum Lucas Cell Counter, Revision 12, March 2017	N/A	Soil - Radiological (Radon Emanation)	Scintillation Counter	GEL	N
GL-RAD-I-009	Standard Operating Procedure for Alpha Spectroscopy System, Revision 15, May 2015	N/A	Soil - Radiological (alpha spectroscopy)	Alpha Spectrometer	GEL	N
GL-RAD-I-010	Procedure for Counting Room Instrumentation Maintenance, Revision 20, July 2014	N/A	Soil - Radiological	N/A	GEL	N
GL-RAD-I-012	Managing Statistical Data in the Radiochemistry Laboratory, Revision 26, April 2016	N/A	Soil - Radiological	N/A	GEL	N
GL-RAD-I-016	Multi-Detector Counter Operating Instructions, GL-RAD-I-016, Revision 10, April 2015	N/A	Soil - Radiological	N/A	GEL	N

Notes:

^a Laboratory SOPs and the gamma spectroscopy library are provided in **Attachment 3**.

SAP Worksheet #24—Analytical Instrument Calibration

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for CA	SOP Reference ¹
Gamma Spectrometer	Initial Calibration (ICAL) (Energy, efficiency and Full Width at Half Maximum [FWHM] peak resolution)	Prior to initial use, following repair or loss of control and upon incorporation of new or changed instrument settings.	The energy difference should be within 0.05% for all calibration points or within 0.2 keV. Peak energy difference is within 0.1 keV of reference energy for all points. Peak FWHM < 3 keV at 1332 keV. The efficiency difference should be within 8% of the true value for each point unless T.C.C. calibration is performed.	Correct problem, then repeat ICAL.	Analyst/Supervisor	GL-RAD-I-001
	Initial Calibration Verification (ICV)	After ICAL for energy/efficiency and prior to analysis of samples.	Observed peaks of second source standard fall within $\pm 10\%$ of ICAL value relative to the true value.	Verify second source standard and repeat ICV to check for errors. If that fails, identify and correct problem and repeat ICV or ICAL and ICV as appropriate.		
	Continuing Calibration Verification (CCV) Daily Check	Daily or prior to use. When working with long count times or batch sequences that run more than a day, CCV is performed at the beginning and end of each analytical batch as long as if not longer than a week.	<u>Energy:</u> ± 0.5 keV at 60 keV; $\pm .75$ keV at 1332 keV <u>FWHM:</u> $\pm 1.2x$ at 60 keV; $\pm 1.8x$ at 662 keV; $\pm 2.3x$ at 1332 keV <u>Activity Difference:</u> %difference between the source activity and the reported activity $\pm 5\%$	Correct problem, rerun CCV. If CCV rerun fails, repeat ICAL. Reanalyze all samples since the last successful calibration verification.		
	Background Subtraction Count (BSC) Measurement (Long count for subtracting background from blanks or test sources)	Immediately after ICAL and then performed on at least a monthly basis.	Background count rate of the entire spectrum with $\pm 3\sigma$ of the average.	Recount and check control chart for trends. Determine cause, correct problem, re-establish BSC. If background activity has changed, re-establish BSC and reanalyze or qualify all impacted samples since last acceptable BSC.		
	Instrument Contamination Check (ICC) (Short count for controlling gross contamination)	Daily or when working with long count times before and after each analytical batch. Check after counting high activity samples.	No extraneous peaks identified (i.e., no new peaks in the short background spectrum compared to previous spectra); Background count rate of the entire spectrum with $\pm 3\sigma$ of the average.	Recount the background. If still out of control, locate and correct problem; reanalyze or qualify all impacted samples since last acceptable ICC. If background activity has changed, re-establish BSC and reanalyze samples.		
Alpha Spectrometer	ICAL (Energy, efficiency, and FWHM peak resolution)	Prior to initial use, following repair or loss of control and upon incorporation of new or changed instrument settings.	3 isotopes within energy range of 3-6 MeV Energy vs. channel slope equation <15 keV per channel. FWHM ≤ 100 keV for each peak used for calibration. Final peak energy within 20 keV of reference energy Minimum of 3,000 net counts in each peak.	Correct problem, then repeat ICAL.	Analyst/Supervisor	GL-RAD-I-009
	ICV	After ICAL.	FWHM ≤ 100 keV Each peak within ± 20 keV of corresponding calibration peaks in initial energy calibration. Minimum 2,000 net counts. Efficiency within 95% - 105% of ICAL value.	Repeat ICV to check for error. If that fails, identify and correct problem and repeat ICV or ICAL and ICV, as appropriate.		
	CCV (Pulser check)	Pulser verification daily, prior to analysis of samples.	Gross counts within 5% of the average (20-point minimum). FWHM within 10-20 keV. Energy within ± 40 keV of the average (20-point minimum).	Recount and check control chart for trends. Determine cause, correct problem, and repeat CCV and all associated samples since last successful CCV.		
	CCV (Check source)	Monthly source check verification prior to analysis of samples.	FWHM ≤ 100 keV Each peak within ± 30 keV of corresponding calibration peaks in initial energy calibration. Minimum 2,000 net counts. Efficiency within 95% - 105% of ICAL value.	Recount and check control chart for trends. Determine cause, correct problem, and repeat CCV and all associated samples since last successful CCV.		

SAP Worksheet #24—Analytical Instrument Calibration (continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for CA	SOP Reference ¹
Alpha Spectrometer	BSC Measurement	Prior to initial use or after ICAL and monthly.	Use a statistical test to determine a change in the background count rate value.	Check control chart for trends and recount. Determine cause, correct problem, re-establish BSC. If background activity has changed, re-establish BSC and reanalyze all impacted samples since last acceptable BSC.	Analyst/Supervisor	GL-RAD-I-009
	ICC	Performed weekly, at minimum, and after counting high activity samples.	Blank ≤ 3 for blank subtracted (net) activity in all region of influence.	Check control chart for trends and recount. Determine cause and correct problem. If background activity has changed, re-establish BSC and reanalyze all infected samples.		
Scintillation Counter (Radon Emanation)	Initial Calibration - <u>Voltage Plateau</u> (ICALV)	Prior to initial use.	Plot the gross counts on the y-axis and the voltage on the x-axis and determine the "knee" of the plateau. The knee is determined by drawing straight lines along the rising slope and the plateau portions of the curve. The knee is the point where these two lines intersect. The operating voltage should be selected at 50 – 150 volts above the "knee."	Correct problem, then repeat ICAL.	Analyst/Supervisor	GL-RAD-I-004
	ICAL – Cell Constant	Prior to initial use.	Each counting cell is calibrated by spiking a 500-milliliter deionized water sample with known disintegrations per minute of ²²⁶ Ra activity. The sample is carried through the entire procedure. The procedure is performed 3 separate times to each cell. Calculate cell constant, average and standard deviation from the three runs. Standard deviation needs to be less than 10 % of the cell constant average.	Correct problem, then repeat ICAL.		
	CCV Daily Check	Daily or prior to use, after any instrument maintenance, or whenever a problem is suspected.	Compared to historical laboratory limits	Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.		

SAP Worksheet #24—Analytical Instrument Calibration (continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for CA	SOP Reference1
Gas Flow Proportional Counter	ICALV (separate plateaus determined for alpha and beta activity)	Prior to initial use and after loss of control.	Slope of the plateau less than 5% over a range of 100V.	Correct problem, then repeat ICALV.	Analyst/Supervisor	GL-RAD-I-016
	Initial Calibration - <u>Efficiency</u> (ICALE)	Prior to initial use, after loss of control, and upon incorporation of new or changed instrument settings.	Verify manufacturer's specifications for detector efficiency for both alpha and beta counting modes using electroplated sources.	Correct problem, then repeat ICALE.		
	ICAL – <u>Cross-talk Factors</u>	Prior to initial use, after loss of control, and upon incorporation of new or changed instrument settings.	Verify manufacturer's specifications for cross-talk in alpha and beta channels.	Correct problem, then repeat ICALCT.		
	ICAL – <u>Self-Absorption Curve</u>	Prior to initial use, after loss of control, and upon incorporation of new or changed instrument settings.	For each radionuclide of interest (or isotope with similar energy profile), establish mathematical function (curve) of detector efficiency vs. source mass loading. Best fit of data with coefficient of determination (r^2) \geq 0.9.	Correct problem, then repeat ICALSA.		
	Efficiency Calibration Verification (IECV)	After ICALE for alpha and beta and prior to analysis of samples.	Individual points within $\pm 30\%$ of true value, average of points within $\pm 10\%$ of ICAL value.	Correct problem and verify second source standard. Rerun IECV. If that fails, correct problem and repeat ICALE.		
	CCV	After a counting gas change and daily for short test-source counting intervals.	Within tolerance or control chart limits $\pm 3\%$ or 3σ of the mean.	Correct problem, rerun calibration verification. If that fails, then repeat ICALE. Reanalyze all samples since the last successful calibration verification.		

Notes:

The specifications in this table meet the requirements of Department of Defense (DoD) *Quality Systems Manual* (QSM) v.5.1.

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SAP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Gamma spectrometer	Liquid Nitrogen fill	Physical check	Physical check	Weekly	Acceptable background	<ul style="list-style-type: none"> Recalibrate Instrument maintenance Consult with Technical Director 	Analyst/Supervisor	GL-RAD-I-010
Alpha spectrometer	1. Vacuum Pump Oil replacement 2. Filter cleaning on the air intake of the instrument cabinet	1, 2. Physical check	1, 2. Physical check	1. Semi-annually 2. Quarterly	1, 2. Acceptable background and calibration efficiencies	<ul style="list-style-type: none"> Recalibrate Instrument maintenance Consult with Technical Director 	Analyst/Supervisor	GL-RAD-I-010
Gas Flow Proportional Counter	Sample Shelf Cleaning	Physical check	Physical check	Weekly	None applicable	None applicable	Analyst/Supervisor	GL-RAD-I-010
Liquid Scintillation Counter	Window cleaning on Radon Flask Counter	Physical check	Physical check	Weekly	None applicable	None applicable	Analyst/Supervisor	GL-RAD-I-007

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SAP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
<p>Sample Collection (Personnel/Organization): Field Team/CH2M</p> <p>Sample Packaging (Personnel/Organization): Field Team Leader/CH2M or qualified designee</p> <p>Coordination of Shipment (Personnel/Organization): Field Team Leader/CH2M</p> <p>Type of Shipment/Carrier: Overnight Carrier/ FedEx</p>
SAMPLE RECEIPT AND ANALYSIS
<p>Sample Receipt (Personnel/Organization): Sample Receipt Staff/GEL Laboratories, LLC</p> <p>Sample Custody and Storage (Personnel/Organization): Sample Receipt Staff/GEL Laboratories, LLC</p> <p>Sample Preparation (Personnel/Organization): Various chemists and technicians /GEL Laboratories, LLC</p> <p>Sample Determinative Analysis (Personnel/Organization): Various chemists and technicians/ GEL Laboratories, LLC</p>
SAMPLE ARCHIVING
<p>Field Sample Storage (No. of days from sample collection): 90 days from receipt</p>
SAMPLE DISPOSAL
<p>Personnel/Organization: Sample Disposal Staff/GEL Laboratories, LLC,</p> <p>Number of Days from Analysis: All laboratory samples and any remaining sample volume will be returned under chain-of-custody for archiving to:</p> <p>Aptim Federal Services Attn: Randall Kilpack/Aptim 200 Fischer Ave. Former Hunters Point Naval Shipyard San Francisco, CA 94124</p>

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SAP Worksheet #27—Sample Custody Requirements

Soil Sample Identification Procedures

Each surface and subsurface RBA sample will be given a unique ID number that is carried through the entire process from sample collection to data reporting (see **Worksheet #18**). The former TUs will be excavated and characterized in “batches” that will be given new unique identifiers at the time of excavation. Excavated material representing the backfill material from former TUs and excavated material representing the sidewalls and bottoms of former TUs will be given a unique ID number that is carried through the entire process of sample collection to data reporting (see **Worksheet #18**).

Samples will be assigned an alpha-numeric identifier that will be tied to the sampling location and sampling depth through a separate logbook that will be maintained in the field by the field sampling personnel. The field sampling personnel’s logbook will be kept in addition to the chain-of-custody.

Field Sample Custody Procedures

Field sample custody procedures include sample collection, packaging, shipment, and delivery to the laboratory. Custody of field samples will be maintained and custody transfer will be documented from the time of sample collection through receipt of samples at the analytical laboratory using chain-of-custody and custody seal procedures. These requirements will be fulfilled by the Sample Management Coordinator or qualified designee. Each sample will be considered to be in the sampler’s custody if one of the following occurs:

- The sample is in the person’s physical possession.
- The sample is in view of the person after that person has taken possession.
- The sample is secured so that no one can tamper with the sample.
- The sample is secured in an area that is restricted to authorized personnel.

Samples will be shipped directly from the field to each analytical laboratory. Samples will be packaged and shipped for offsite analysis in accordance with *SOP Packaging and Shipping Procedures for Low-Concentration Samples (Worksheet #21 and Attachment 2)*.

Chain-of-custody Procedures

The chain-of-custody record will document the transfer of sample custody from the time of sample collection to laboratory receipt and will accompany the samples from the field to the analytical laboratory. The requirements for sample labels, custody seals, and chains-of-custody are included in in the *SOP Chain-of-Custody (Attachment 2)*. A digital sample documentation/tracking program may be used during the execution of the work plan to provide additional confidence in sample recordkeeping and to add efficiencies to the process.

When custody of the samples is relinquished from one party to another, the individuals involved will sign, date, and record the time of transfer on the chain-of-custody record. The chain-of-custody records may consist of an original top copy and two carbonless copies, or the records may be in a pre-populated electronic format. When using the carbonless chain-of-custody format, the original and first copies will be transmitted to the primary analytical laboratory with the samples. The second copy will be retained in project files for the Field Team Leader, Project Chemist, and Database Manager. Field personnel will sign and date the chain-of-custody forms prior to sealing the cooler and shipping the samples. Field personnel will make a copy of the signed form and scan a copy of each chain-of-custody record to be saved electronically in the project files.

The chain-of-custody record will be completed by each field sampling team using waterproof ink. Corrections will be made with a single line-out, the error will be initialed and dated, and then the correct information will be entered. Empty fields on the chain-of-custody record will be crossed out with a single line or “Z’d” out, with the date and signature entered by the field sampling team. If samples are to be delivered to the laboratory by an

SAP Worksheet #27—Sample Custody Requirements (continued)

overnight carrier, the airbill number will be recorded, and the chain-of-custody records will be placed in a waterproof plastic bag and taped to the inside lid of the sample cooler prior to sealing with appropriate secure tape and custody seals. These requirements will be fulfilled by the field sampling personnel.

Custody seals

Custody seals will be placed on the outside of each sample cooler so that the seals must be broken to open. After field samples are placed into coolers, two or more custody seals will be placed on the outside of the cooler prior to shipment or transport. Each custody seal will be initialed and dated by the field sampling team, affixed to the cooler, and taped over using clear strapping tape.

Field Logbook

Field notes will be kept in bound, weatherproof logbooks. Notes will be taken with waterproof, nonerasable ink. Field staff completing separate tasks will keep separate logbooks, as necessary, according to the SOP *Preparing Field Logbooks* (**Worksheet #21** and **Attachment 2**).

Laboratory Sample Custody Procedures

Laboratory sample custody procedures include the receipt of samples, archiving, and disposal. Custody of samples will be maintained and custody transfer will be documented from the time of sample receipt through sample disposal by the analytical laboratory consistent with the analytical laboratory's SOP for maintaining sample integrity (SOP GL-LB-E-012).

The analytical laboratories will have established custody procedures, which include the following:

- Designation of a sample custodian
- Completion by the custodian of the chain-of-custody record, any sample tags, and laboratory request sheets, including documentation of sample condition upon receipt
- Laboratory sample tracking and documentation procedures
- Secure sample storage with the appropriate environment (e.g., refrigerated, dry), consistent with analytical method requirements
- Proper data logging and documentation procedures, including custody of original laboratory records

Upon arrival of the samples at the analytical laboratory, a sample custodian will take custody of the samples, assess the integrity of sample containers, and verify that the information on the sample labels matches the information on the associated chain-of-custody record. The laboratory will restrict access to the storage areas to authorized laboratory personnel only, to prevent unauthorized contact with samples, extracts, or documentation. The sample custodian will maintain security of the samples in accordance with the analytical laboratory SOP.

Soil and field QC water samples will be retained by the laboratory for 90 days after final sample results are reported. Laboratory samples and any remaining field sample volume will be returned under chain-of-custody to HPNS for archiving (**Worksheet #26**).

SAP Worksheet #28a—Laboratory QC Samples Soil Gamma Spectroscopy

Matrix: Soil

Analytical Group: Radiological (gamma spectroscopy)

Analytical Method/SOP Reference: USEPA Method 901.1/GL-RAD-A-013

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria
Method Blank	One per prep batch of 20 or fewer samples of similar matrix or one per day, whichever comes first	No analytes detected < reportable detection limit or less than 5% associated sample activity	Correct problem. If required, re-prepare and reanalyze method blank (MB) and all samples processed with the contaminated blank.	Analyst/ Supervisor	Bias/Contamination	Same as Method/SOP QC Acceptance Limits
Laboratory Control Sample		Recovery Limits: ¹³⁷ Cs: 75-125% ⁶⁰ Co: 75-125% ²⁴¹ Am: 75-125%	Identify problem; if not related to matrix interference, re-reanalyze LCS and all associated batch samples		Accuracy/Bias	
Laboratory Duplicate		RPD ≤25% and/or relative error ratio (RER) ≤1	Correct problem, then re-reanalyze all samples processed with the duplicate		Precision	

Notes:

DoD QSM v5.1 limits do not exist and the laboratory SOP limits will be used.

SAP Worksheet #28b—Laboratory QC Samples Soil Alpha Spectroscopy

Matrix: Soil

Analytical Group: Radiological (alpha spectroscopy)

Analytical Method/SOP Reference: USDOE Method HASL-300 A-01-R/ GL-RAD-A-011

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria
Method Blank	One per prep batch of 20 or fewer samples of similar matrix or one per day, whichever comes first	No analytes detected > MDC	Correct problem. If required, re-prepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst/ Supervisor	Bias/Contamination	Same as Method/SOP QC Acceptance Limits
Laboratory Control Sample		Recovery Limits: ²⁴¹ Am: 75-125% ²³⁸ Pu: 80-127% ^{239/240} Pu: 75-125% ²³⁸ U: 75-125% ²²⁶ Ra: 75-125% ²³² Th: 75 – 125%	Identify problem; if not related to matrix interference, re-reanalyze LCS and all associated batch samples		Accuracy/Bias	
Tracer		Barium-133 tracer: 15-125% Plutonium-242 tracer: 15–1250% Uranium-232 tracer: 15-125% Thorium-229 tracer: 15–125%	Truncate tracers above 100% recovery to eliminate low biased results. Re-prepare and reanalyze sample if carrier is low (indicating high biased results) if there is activity in the sample above the reporting limit. No reanalysis if matrix interference is nonconformance during sample preparation		Accuracy/Bias	

Notes:

DoD QSM v5.1 limits do not exist and the laboratory SOP limits will be used.

SAP Worksheet #28c—Laboratory QC Samples Soil Gas Flow Proportional Counting

Matrix: Soil

Analytical Group: Radiological (GFPC)

Analytical Method/SOP Reference: USEPA Method 905.0 mod/ GL-RAD-A-004

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria
Method Blank	One per prep batch of 20 or fewer samples of similar matrix or one per day, whichever comes first	No analytes detected > MDC	Correct problem. If required, re-prepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst/ Supervisor	Bias/Contamination	Same as Method/ SOP QC Acceptance Limits
Laboratory Control Sample		Recovery Limits: 75-125%	Identify problem; if not related to matrix interference, re-reanalyze LCS and all associated batch samples		Accuracy/Bias	
Laboratory Duplicate		RPD \leq 25% and/or RER \leq 1	Correct problem, then re-reanalyze all samples processed with the duplicate		Precision	
Carrier		Strontium and Yttrium carriers: 40-110%	Truncate Carriers above 100% recovery to eliminate low biased results. Reprepare and reanalyze sample if carrier is low (indicating high biased results) if there is activity in the sample above the reporting limit. No reanalysis if matrix interference is nonconformance during sample preparation		Accuracy/Bias	

Notes:

DoD QSM v5.1 limits do not exist and the laboratory SOP limits will be used.

SAP Worksheet #28d—Laboratory QC Samples Soil Radon Emanation and Scintillation Counting

Matrix: Soil

Analytical Group: Radiological (Radon Emanation)

Analytical Method/SOP Reference: USEPA Method 903.1 mod/ GL-RAD-A-008

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria
Method Blank	One per prep batch of 20 or fewer samples of similar matrix or one per day, whichever comes first	No analytes detected > MDC	Correct problem. If required, re-prepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst/ Supervisor	Bias/Contamination	Same as Method/ SOP QC Acceptance Limits
Laboratory Control Sample		Recovery Limits: 75-125%	Identify problem; if not related to matrix interference, re-reanalyze LCS and all associated batch samples		Accuracy/Bias	
Laboratory Duplicate		RPD \leq 25% and/or RER \leq 1	Correct problem, then re-reanalyze all samples processed with the duplicate		Precision	
Matrix Spike		Recovery Limits: 75-125%	Identify problem; if LCS recovery is acceptable, indicating possible matrix interference, no further CA necessary		Accuracy/Bias	

Notes:

DoD QSM v5.1 limits do not exist and the laboratory SOP limits will be used.

SAP Worksheet #29—Project Documents and Records

Document	Where Maintained
Final SAP, Work Plan, APP/SSHP, and Reports	Project file and NAVFAC Southwest Administrative Record
Field notes/logbooks	Project file
Field audits/reports	Project file
Chain-of-custody forms	Project file and analytical laboratory
Laboratory report: Laboratory raw data Corrective Action Report Laboratory equipment maintenance logs Sample preparation Run logs CLP-equivalent (Stage 4) analytical laboratory reports, including raw data	Analytical laboratory, project file, NAVFAC Southwest Administrative Record
Data validation reports	Data validator, project file, and NAVFAC Southwest Administrative Record Validated electronic data will be loaded into Naval Installation Restoration Information Solution (NIRIS), the Navy's centralized database

Notes:

Active project files will be maintained by the PM until project completion. Following project completion, hardcopy files will be archived at Iron Mountain. These files will be stored for a minimum of 10 years at the following location:

Iron Mountain Headquarters
 745 Atlantic Avenue
 Boston, Massachusetts 02111
 (800) 899-IRON

Documents submitted to the NAVFAC Southwest Administrative Record are located at:

Commanding Officer
 Naval Facilities Engineering Command, Southwest
 1220 Pacific Highway (NBSD Bldg. 3519)
 San Diego, CA 92132

Following response complete at the facility, hardcopy deliverables will be archived by the Navy at a Federal Records Center (FRC) (<http://www.archives.gov/frc/locations.html>) where they are maintained for 50 years.

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SAP Worksheet #30—Analytical Services

Matrix	Analytical Group	Sample Locations/ ID Number	Analytical Method	Data Package Turnaround Time	Laboratory/Organization (name and address, contact person and telephone number)	Backup Laboratory/ Organization ^a (name and address, contact person and telephone number)
Soil	Gamma Spectroscopy	See Worksheets #18 and #20	USEPA Method 901.1	28 calendar days for full deliverable	GEL Laboratories, LLC 2040 Savage Road Charleston, SC 29407 (843) 556-8171 POC: Valerie Davis	TBD
	Alpha Spectroscopy		USDOE Method HASL 300 A-01-R			
	GFPC		USEPA Method 905.0 mod			
	Radon Emanation		USEPA Method 903.1 mod			

Notes:

^a A backup laboratory has not been identified. If circumstances render the subcontracted laboratory unable to perform the analytical services, another laboratory will be determined at that time.

Samples will be analyzed by laboratories that are accredited by the DoD Environmental Laboratory Accreditation Program (ELAP) (**Attachment 4**).

GEL Laboratories DoD ELAP Certification Number 2567.01 (A2LA), Valid to June 30, 2019. Status of laboratory certifications/accreditations will be verified prior to fieldwork and before samples are delivered to the laboratory. Updates to laboratory accreditation to ensure the laboratory is qualified to perform the analysis will be made prior to sample testing.

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SAP Worksheet #31—Planned Project Assessments

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (title and organizational affiliation)	Person(s) Responsible for Responding to Assessment Findings (title and organizational affiliation)	Person(s) Responsible for Identifying and Implementing CA (title and organizational affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (title and organizational affiliation)
Operational Readiness Review (ORR)	Project startup	Internal	CH2M	Radiological STC CH2M	PM CH2M	PM CH2M	Radiological Lead CH2M
Field Sampling Technical Systems Audit (TSA)	At least one field TSA at the start of field activities	Internal	CH2M	Program Chemist (designee) CH2M	Field Team Leader CH2M	Field Team Leader CH2M	Radiological Lead CH2M
Data Review TSA	During field sampling and analysis through validation	Internal	CH2M	PM, Program Chemist CH2M	Field Team Leader (CH2M), Project Chemist, and Analytical Laboratory Manager	Project Chemist, Program Chemist (CH2M), and Analytical Laboratory Manager	Program Chemist CH2M
Quality Assurance/Quality Control	Project startup through completion of field investigation	Internal	CH2M	Quality Assessment Manager, CH2M Corporate Quality Assessment Manager, CH2M	PM, CH2M	PM, CH2M Quality Assessment Manager, CH2M	Quality Assessment Manager, CH2M

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SAP Worksheet #32—Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (name, title, organization)	Time Frame of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (name, title, organization)	Time Frame for Response
ORR	ORR Checklist	Kim Henderson PM CH2M	As soon as possible, within same day of finding	ORR Checklist with outstanding actions completed or addressed prior to project work.	Kim Henderson PM CH2M	1 business day
Field Sampling TSA	Audit form (See Attachment 5) showing results of field audit. If CAs are necessary and cannot be implemented during the audit, these deficiencies will be noted and their resolution will be documented in the CA Report.	TBD Field Team Leader CH2M	As soon as possible within same day of finding	Completed Audit Form indicating all CAs taken. Additional documentation will be attached as necessary. Audit form is issued by the STC.	Kevin Smallwood Field Team Leader CH2M	1 business day
		Kim Henderson PM CH2M	1 business day		Kim Henderson PM CH2M	1 business day
		Anita Dodson Program Chemist CH2M	1 business day		Anita Dodson Program Chemist CH2M	3 business days
		Danielle Janda/ George (Patrick) Brooks LRPM/BLTL Navy	1 business day if CA involving > 1 day delay is necessary		Danielle Janda/ George (Patrick) Brooks LRPM/BLTL Navy	Included with summary report
Data Review TSA	Memo or written audit report	Anita Dodson Program Chemist CH2M	1 business day	Letter or e-mail	Anita Dodson Program Chemist CH2M	3 business days

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SAP Worksheet #33—QA Management Reports

Type of Report	Frequency (daily, weekly, monthly, quarterly, annually)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
DQA <ul style="list-style-type: none"> • Provides an overview of sampling, decontamination, and data storage procedures • Identifies QC samples and summarizes associated analytical results • Summarizes the findings of the analytical data validation process • Provides an evaluation of data quality in accordance with the data quality indicator (DQIs) as defined in the SAP 	Once for all data per parcel	Approximately 60 days after field investigation is complete	Program Chemist, CH2M STC, CH2M Project Chemist, CH2M	Navy LRPM/BLTL
Laboratory System Audit Reports	During DoD ELAP assessment or renewal of DoD ELAP certification	To be determined by DoD ELAP if offsite lab audit/recertification is required	DoD ELAP Laboratory Evaluator	DoD ELAP POC (DoD ELAP) Laboratory Quality Assurance Managers
Field Sampling TSA Report	Once	Approximately 30 days after completion of audit	STC, CH2M	Navy LRPM/BLTL

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SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process

Data Review Input	Description	Responsible for Verification or Validation ^a	Step I/ IIa/IIb ^a	Internal/External ^b
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	Field Team Leader/CH2M	Step I	Internal
Chains-of-Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody will be initialed by the reviewer, a copy of the chains-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chains-of-custody will also be reviewed for adherence to the SAP by the project chemist.	Field Team Leader/CH2M Project Chemist/CH2M	Step I	Internal & External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the project chemist in the form of laboratory logins.	Project Chemist/CH2M	Step I	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the project chemist. Documentation will be incorporated into the case narrative which becomes part of the final hardcopy data package.	Project Chemist/CH2M	Step I	External
Electronic Data Deliverables	Electronic Data Deliverables (EDDs) will be compared against hardcopy laboratory results (10 percent check). Discrepancies will be resolved with the laboratory.	Project Chemist/CH2M	Step I	External
Case Narrative	Case narratives will be reviewed by the data validator during the data validation process. This is verification that they were generated and applicable to the data packages.	Data Validator/CH2M	Step I	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Respective Laboratory QAO	Step I	Internal
Laboratory Data	The data will be verified for completeness by the project chemist. In order to ensure completeness, EDDs will be compared to the SAP. This is a verification that all samples were included in the laboratory data and that correct analyte lists were reported.	Project Chemist/CH2M	Step I	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If CAs are required, a copy of the documented CA taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and CA forms will be reviewed internally to ensure that all appropriate CAs have been taken and that CA reports are attached. If CAs have not been taken, the site manager will be notified to ensure action is taken.	PM/CH2M Project Chemist/CH2M	Step I	Internal
Corrective Action Reports	Corrective action reports will be reviewed by the project chemist or PM and placed into the project file for archival at project closeout.	PM/CH2M Project Chemist/CH2M	Step I	External
Laboratory Methods	During the pre-validation check, ensure that the laboratory analyzed samples using the correct methods specified in the UFP-SAP. If methods other than those specified in the SAP were used, the reason will be determined and documented.	Project Chemist/CH2M	Step IIa	External
Target Compound List and Target Analyte List	During the pre-validation check, ensure that the laboratory reported all analytes from each analysis group in accordance with Worksheet #15 . If the target compound list is not correct, then it must be corrected prior to sending the data for validation. Once the checks are complete, the PM is notified via e-mail.	Project Chemist/CH2M	Step IIa	External
Reporting Limits	Ensure the laboratory met the project-designated QLs shown in Worksheet #15 . If QLs were not met, the reason will be determined and documented.	Project Chemist/CH2M	Step IIb	External
Field SOPs	Ensure that all field SOPs were followed.	Field Team Leader/CH2M	Step I	Internal
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	Respective Laboratory QAO	Step I	Internal

SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process (continued)

Data Review Input	Description	Responsible for Verification or Validation ^a	Step I/ IIa/IIb ^a	Internal/External ^b
Laboratory Data	A compliance check will be performed to compare the documented receipt conditions and analytical QC results in the data package to acceptance criteria this SAP and validation guidelines referenced in Worksheet #14 .	Data Validator/TBD	Step IIa	External
Raw Data	20 percent review of instrument outputs and recalculation checks of raw data to confirm identifications and laboratory calculations. For a recalculated result, the data validator attempts to re-create the reported numerical value. The laboratory is asked for clarification if a discrepancy is identified which cannot reasonably be attributed to rounding. In general, this is outside 5 percent difference.	Data Validator/TBD	Step IIa	External
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records.	Field Team Leader/CH2M	Step IIb	Internal
Documentation of Method QC Results	Establish that all required QC samples were run and met limits.	Data Validator/TBD	Step IIa	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run and met limits.	Project Chemist/CH2M	Step IIa	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP Certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	Project Chemist/CH2M	Step I	External
Analytical data for radiological parameters in all samples.	<p>Analytical methods and laboratory SOPs as presented in this SAP will be used to evaluate compliance against QA/QC criteria. Should adherence to QA/QC criteria yield deficiencies, data may be qualified. Data may be qualified if QA/QC exceedances have occurred and is summarized in Table 34_36-1. Guidance and qualifiers from MARLAP (USEPA et al., 2004), MARSSIM (USEPA et al., 2000), and USEPA National Functional Guidelines for Inorganic Superfund Data Review (ISM02.2) (USEPA, 2017) may also be applicable.</p> <p>Of the analytical data, 100 percent will be validated by a third-party data validation subcontractor, with 20 percent of the sample delivery groups subject to Stage 4 validation and 80 percent subject to Stage 2B validation.</p> <p>Stage 4 data validation follows the USEPA protocols and criteria set forth in the functional guidelines for inorganic and radiological data review (USEPA et al., 2000, 2004; USEPA, 2017). These guidelines apply to analytical data packages that include the raw data (e.g., spectra and chromatograms) and backup documentation for calibration standards, analysis run logs, laboratory control samples (LCSs), dilution factors, and other types of information. This additional information is used in the Stage 4 data validation process for checking calculations of quantified analytical data. Calculations are checked for QC samples (e.g., matrix spike [MS]/matrix spike duplicate [MSD] and LCS data) and routine field samples (including field duplicates, field and equipment rinsate blanks). To ensure that detection limit and data values are appropriate, an evaluation is made of instrument performance, method of calibration, and the original data for calibration standards.</p> <p>Under the Stage 2B data validation effort, the data values for primary and QC samples are generally assumed to be correctly reported by the laboratory. Data quality is assessed by comparing the QC parameters listed in the previous paragraph to the appropriate criteria (or limits) as specified in this SAP, by DoD-QSM v5.1 requirements, or by method-specific requirements (e.g., EPA, DOE). If calculations for quantitation are verified, it is done on a limited basis and may require raw data in addition to the standard data forms normally present in a data package.</p>	Data Validator/TBD	Step IIa and IIb	External

Notes:

^a Verification (Step I) is a completeness check that is performed before the data review process continues in order to determine whether the required information (complete data package) is available for further review. Validation (Step IIa) is a review that the data generated is in compliance with analytical methods, procedures, and contracts. Validation (Step IIb) is a comparison of generated data against measurement performance criteria in the SAP (both sampling and analytical). Should CH2M find discrepancies during the verification or validation procedures above, an e-mail documenting the issue will be circulated to the internal project team, and a Corrections to File Memo will be prepared identifying the issues and the CA. This Memo will be sent to the laboratory, or applicable party, and maintained in the project file.

^b Internal or external is in relation to the data generator.

SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process (continued)

Table 34_36-1. Data Validation Guidance for Data Qualification

Quality Control Check	Evaluation	Data Qualification	Samples Affected
Holding Time	Holding time exceeded for extraction, digestion, or analysis	J = positive results; Nondetects = use professional judgment – UJ or R	All analytes in sample
Sample Preservation	N/A	None required	
Temperature	N/A	None required	
ICAL (See Worksheet #24 for criteria)			
Energy	Energy difference outside criteria	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	Associated analytes in all samples in analytical batch
Efficiency	Efficiency difference outside criteria	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	
FWHM peak resolution	FWHM peak resolution outside criteria	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	
ICV	Observed peaks in ICV greater than 10% of ICAL value	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	Associated analytes in all samples in analytical batch
CCV (Daily Check)	Energy, efficiency, or FWHM outside criteria	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	Associated analytes in all samples in analytical batch
BSC	Background count rate of entire spectrum > 3σ of the average	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	All associated samples in analytical batch
ICC	Background count rate of entire spectrum > 3σ of the average	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	All associated samples in analytical batch
LCS	%R >UCL	Sample > MDC; qualify as estimated (J) Sample < MDC; None required	Associated analytes in all samples in preparation batch or analytical batch
	%R <LCL but ≥ 30%	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	
	%R <30%	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as unusable (R)	
Method Blank	Blank < MDC	None required	Associated analytes in all samples in preparation batch or analytical batch
	Blank > MDC	Sample < MDC; None required Sample > MDC by < 10x blank; qualify as estimated (J) Sample > 10x blank; None required	
Tracer Recovery (alpha spectroscopy only) Carrier Recovery (GFPC only)	%R >UCL	Sample > MDC; qualify as estimated (J) Sample < MDC; None required	Associated analytes in affected samples
	%R <LCL but ≥ 10%	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	
	%R <10%	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as unusable (R)	

SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process (continued)

Table 34_36-1. Data Validation Guidance for Data Qualification

Quality Control Check	Evaluation	Data Qualification	Samples Affected
Laboratory Control Sample Duplicates	Concentration of reported analytes are > 5x the MDC in either sample and RPD ≥ 25% and/or RER ≥ 1	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	Analytes in parent sample
	Concentration of reported analytes are < 5x the MDC in either sample and absolute difference > 3x MDC	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	
Matrix Spike ¹	%R >UCL	Sample > MDC; qualify as estimated (J) Sample < MDC; None required	Associated analytes in all samples in preparation batch or analytical batch
	%R <LCL but ≥ 30%	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	
	%R <30%	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as unusable (R)	
Field Duplicates	Concentration of reported analytes are > 5x the MDC in either sample and RPD ≥ 25% and/or RER ≥ 1	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	Analytes in parent sample and field duplicate
	Concentration of reported analytes are < 5x the MDC in either sample and absolute difference > 3x MDC	Sample > MDC; qualify as estimated (J) Sample < MDC; qualify as estimated (UJ)	

Notes:

- < = less than
- > = greater than

All QA/QC criteria are included in **Worksheets #12, #24, and #28** and will be used for validation criteria.

¹If activity of the sample > 5 times the spiking level.

- %R = percent recovery
- LCL = lower control limit
- UCL = upper control limit

SAP Worksheet #37—Usability Assessment

The DQO for the project include the following goals:

- To evaluate and document the validity of the obtained radiological data to support decisions
- To corroborate prior survey results if necessary
- To compare radiological data to RGs.
- To recommend additional remediation if necessary
- To compare radiological data to applicable natural background values.

Assessment of sampling and survey data consists of four separate and identifiable phases: data reduction, data verification, data validation, and DQA. These processes will be performed in accordance with MARLAP (USEPA et. Al, 2004) and other applicable guidance. Data reduction involves data transformation processes such as converting raw data into reportable quantities and units, using significant figures, and calculating measurement uncertainties. Verification and validation pertain to evaluation of survey and analytical data and are considered as two separate processes.

Data verification compares the survey and sampling data collection against the requirements of the project-specific Work Plan and SOPs. For example, the actual survey locations, scan speed, number and location of systematic static survey measurements, and the number and location of swipe samples will be compared with the planned survey activities. A verification report may be prepared depending on the size and complexity of the survey. The verification report identifies those requirements that were not met (called exceptions). Task-specific verification checklists will be developed in accordance with MARLAP Section 8.5 prior to field mobilization to ensure that requirements identified in the work planning documents are met. Data verification also involves reviewing data that was transcribed or transferred into the electronic data management systems. The data verification will be performed by the radiological STC and other senior staff with access to the original data, SOPs, and the Parcel G Work Plan.

At HPNS, the verification process will include the following:

- Appropriate selection of the survey instruments
- Appropriate survey methods for the ROCs
- Evaluation of data completeness
- Verification of instrument/detector calibration
- Daily response checks of the instrument/detector
- Assessment of survey method specifications, including scan speed, distance from the detector to surveyed surface, survey path, time that counts are collected, and adherence to operator response requirements, such as response to measurements exceeding the investigation level and documentation of adverse conditions
- Retrospective calculation of MDCs
- Adjustments of background count rate settings
- Checks on instrument system performance
- Swipes collected as required: labeling, analyses, and documentation
- Recorded measurement and sample locations per project requirements

SAP Worksheet #37—Usability Assessment (continued)

Validation is a systematic check on the set of survey or analytical data being used to meet the project requirements and is performed to address the usability of the data. The validation process begins with a review of the survey or analytical data package to identify its areas of strength and weakness. The validation process should determine the impact of not meeting the requirements of the Parcel G Work Plan and SOPs. Validation then evaluates the data to determine the absence of a required survey measurement and the uncertainty of the survey process. During validation, the technical reliability and the degree of confidence in the reported survey data are considered. The validator will note if data that do not meet the performance criteria (**Worksheet #28**). The products of the validation process are validated data and a statement on which data are acceptable and which data are sufficiently inconsistent that it should not be used in the decisions for which the survey data was collected.

The DQA is the last phase of the data collection process and consists of a scientific and statistical evaluation of project-wide knowledge to assess data usability. DQA considers all sampling, analytical, and data handling details, external QA assessments, and other historical project data to determine the usability of data for decision-making. To assess and document overall data quality and usability, the data quality assessor integrates the data validation report, field information, assessment reports, and historical project data, and compares the findings to the DQOs objectives defined in the Parcel G Work Plan and this SAP. The DQA process uses the combined findings of these multi-disciplinary assessments to determine data usability for the intended decisions, and to generate a DQA report documenting that usability and the causes of any deficiencies.

The DQA process varies depending on the survey objectives, and the level and depth of the verification. The process will evaluate and document the usability of the data by considering the project DQIs, which are precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS). The DQA process will determine whether the data will be suitable for the intended needs of the project. Every data type (e.g., sampling, field screening data, and laboratory analytical data) will be relevant to the usability assessment. Data usability will include the entry of analytical data validation flags, applied by the third-party analytical data validation subcontractor, to the project data, as well as an overall assessment of the analytical data and field QC samples.

The assessment will consider the relationship of each type of data to the entire data set, and the adequacy of the data to fulfill the project DQOs. The data will be assessed for correctness, completeness, and compliance to method- or project-specific QA/QC requirements, including the results of the independent analytical data validation process and contractual requirements. Analytical data validation will evaluate the data based on the PARCCS criteria defined in this SAP and other method-specific performance requirements. The overall assessment process will also evaluate data usability based on the intended use of the data. The intent of the DQA process will be to establish the PARCCS levels and usability of the final results with respect to the project DQOs. Upon completion of analytical data validation, each data point will be assessed as non-qualified, qualified as estimated (“J” or “UJ” qualified), or qualified as rejected (“R” qualified) based upon the acceptance criteria, and analytical data validation flags will be added to the project data. These parameters will be based on the analytical data quality and will encompass the DQIs established in this SAP. Qualification will be given according to each sample’s delivery group and will be based on the SAP and applicable laboratory and data validation SOPs. Both analytical and contractual compliance and completeness levels will be assessed for each analytical parameter. Finally, the overall usefulness of the data will be established as related to the project DQOs.

Data Quality Indicators

Quantifiable criteria, known as measurement performance criteria, are presented in **Worksheet #12**. The PARCCS criteria will be the qualitative and quantitative indicators of data quality. The PARCCS criteria are defined and discussed as follows.

SAP Worksheet #37—Usability Assessment (continued)

Precision

Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision will be measured by using laboratory duplicates and field duplicate samples. It will be expressed in terms of the RPD as follows:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

where:

- RPD = relative percent difference
- C_1 = concentration of sample or MS
- C_2 = concentration of duplicate or MSD

For the evaluation of precision between the native sample and its associated field duplicate, the sample results must be greater than 5 times the MDC in order for the RPD criteria (See **Worksheet #12**) to apply. When either the sample or field duplicate results are less than 5 times the MDC, then the RER must be less than 1 using the following equation:

$$RER = \frac{|S - D|}{2\sigma_s + 2\sigma_d}$$

where:

- RER = relative error ratio
- S = concentration of sample
- D = concentration of duplicate
- σ_s = uncertainty of sample result
- σ_d = uncertainty of duplicate result

If either the RPD or RER fail the criteria, the native sample and field duplicate results will be qualified as estimated (“J” flag). Other site-specific field duplicate and laboratory duplicate results will be evaluated for trends and if the exceedance is due to the sample matrix or field sample collection, as well as if resampling is warranted. This evaluation and any impact related to ROCs will be provided in the DQA.

Accuracy

Accuracy is the degree of agreement of an observed measurement (or an average of the same measurement type) with an accepted reference or true value. Accuracy of analytical determinations will be measured using laboratory QC analyses such as LCSs and surrogate spikes. Accuracy will be measured by evaluating the actual result against the known concentration added to a spiked sample and will be expressed as %R as shown below:

$$\%R = \frac{S - U}{C_{sa}} \times 100$$

where:

$\%R$ = Percent Recovery

- S = Measured concentration of spiked aliquot
- U = Measured concentration of unspiked aliquot
- C_{sa} = Concentration of spike added

SAP Worksheet #37—Usability Assessment (continued)

Representativeness

Representativeness is the reliability with which a measurement or measurement system reflects the true conditions under investigation. Representativeness is influenced by the number and location of the sampling points, sampling timing and frequency of monitoring efforts, and the field and laboratory procedures. The representativeness of data will be maintained by the use of established field and laboratory procedures and their consistent application.

Comparability

Comparability expresses the confidence with which one data set can be compared to another based on using USEPA-defined procedures, where available. If USEPA procedures are not available, the procedures have been defined or referenced in this SAP.

The comparability of data will be established through well documented methods and procedures, standard reference materials, QC samples, performance-evaluation study results, and by reporting each data in consistent units.

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions. Analytical data validation and DQA will determine which data will be valid and which data will be rejected. Percent completeness will be defined as follows:

$$\text{Percent Completeness} = \frac{V}{T} \times 100$$

where:

- V = Number of valid (not rejected) measurements over a given time
- T = Total number of planned measurements

The completeness goal for this project will be 90 percent for valid, usable data. If the completeness goal of the project is not achieved, a discussion on the limitations on the use of the project data will be included in the Usability Assessment section of the DQA.

Sensitivity

Sensitivity is the measure of a concentration at which an analytical method can positively identify and report analytical results. The sensitivity of an analytical method will be indicated by the project-required reporting limits, as compared to the RGs.

Detection and Quantitation Limits

The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95 percent probability of detection, given a detection criterion that ensures on a 5 percent probability of detection in an analyte-free sample. The MDCs are contractually specified minimum detection limits for specific analytical methods and sample matrices.

For this project, concentrations below the MDC will be reported as “U” to the MDC.

SAP Worksheet #37—Usability Assessment (continued)

Describe the evaluative procedures used to assess overall measurement error associated with the project:

The usability assessment process will consist of reviewing the analytical data validation reports for usable analytical data (i.e., no validation qualifications or estimated “J”/“UJ” qualifications) and rejected (“R” qualified) analytical data, as well as evaluating the field and analytical data for discrepancies or deviations. This assessment will evaluate the impact of the discrepancies or deviations on the usability of the data and assesses whether the necessary information has been provided for use in the decision-making process. The assessment will evaluate whether there were deviations in sampling activities (e.g., incorrect sample location, improper or malfunctioning sampling equipment, or incorrect analysis performed), chain-of-custody documentation, or holding times; compromised samples (i.e., damaged or lost samples) and the need to resample; or changes to SOPs or methods that could potentially affect data quality.

An evaluation of QC sample results will be performed to assess whether unacceptable QC results (e.g., blank contamination) affect data usability.

Other parameters to be evaluated during the usability assessment may include, but will not be limited to, the following:

- Matrix effects—matrix conditions that might have affected the performance of the extraction or analytical method
- Site conditions—unusual weather conditions or site conditions that might have affected the sampling plan
- Identifying critical and noncritical samples or target analytes
- Background or historical data
- Data restrictions—data that do not meet the project DQOs or were “R” qualified might be restricted, but usable, as qualitative values for limited decision-making purposes

Identify the personnel responsible for performing the usability assessment:

Project Chemist, CH2M, Mark Cichy

Data Validation Subcontractor, TBD

The project team will be consulted as appropriate to determine final usability of the collected data.

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented, so that they identify trends, relationships (correlations), and anomalies:

DQA/Data Usability Assessment will be reported in the Confirmation Survey Report.

The data will be evaluated for overall PARCCS criteria for each matrix, analytical group, and concentration level, and data use limitations will be discussed in the DQA/Data Usability Assessment Reports for data that do not meet the project DQOs or DQIs. The DQA/Data Usability Assessment reports will include a detailed discussion of the data usability evaluations with sufficient information to support the data usability conclusions, such as the following:

- a detailed description of the regulatory requirements and technical bases for assessment
- review of data reduction, verification and validation

SAP Worksheet #37—Usability Assessment (continued)

- assessment of trends and biases equilibrium of radionuclide decay chains
- analysis of environmental radioactivity
- variations of natural radionuclides
 - satisfaction of quality objectives
 - overall defensibility and usability
 - appropriate analysis to support usability.

The level of data verification, validation, and DQA performed on radiological samples is defined in **Worksheet #34-36**. Copies of surveys, sampling, and analytical data (and their supporting data) will be protected and maintained in project record files.

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USEPA. 2008. *Interim Ecological Screening Levels*. October.

USEPA. 2017. *USEPA National Functional Guidelines for Inorganic Superfund Data Review*. (ISM02.2). EPA-540-R-013-001. August.

Figures



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- Legend:**
-  Installation Boundary
 -  Parcel G

BASE MAP SOURCE:
 Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
 Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community
 Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,

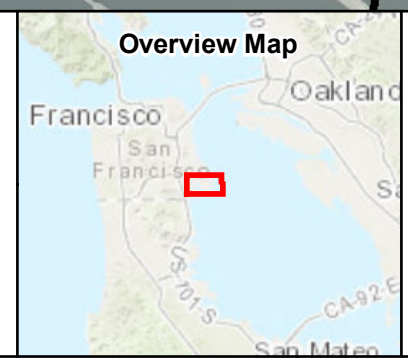
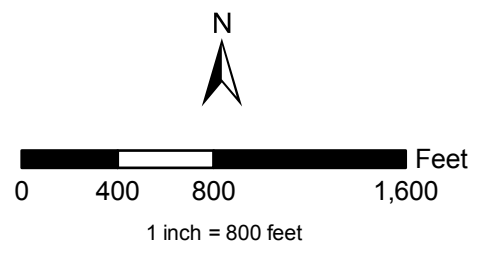


Figure 10-1
HPNS and Parcel G Location
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

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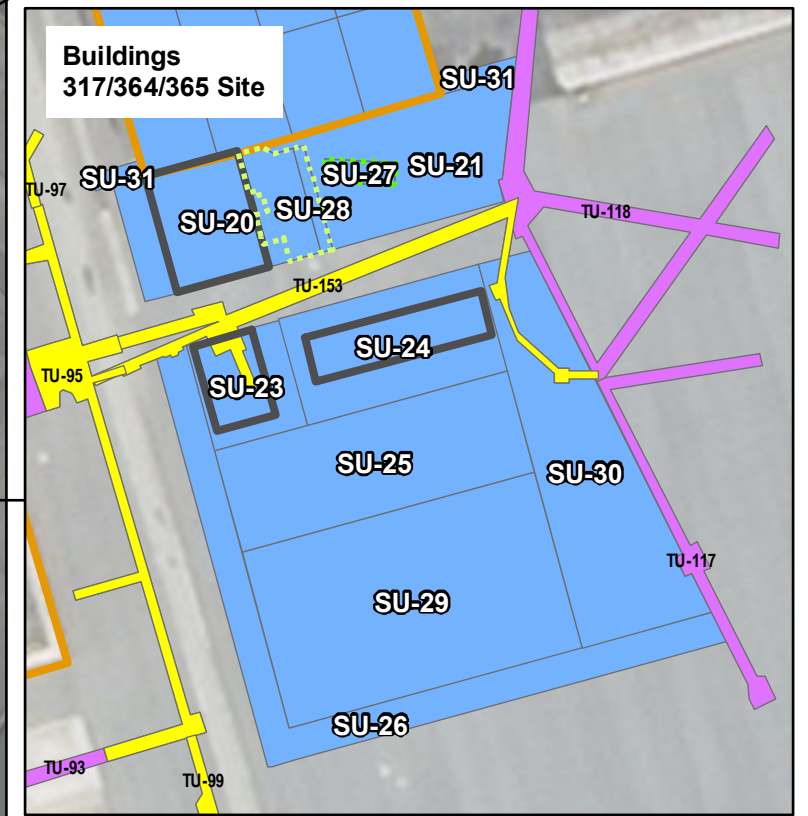
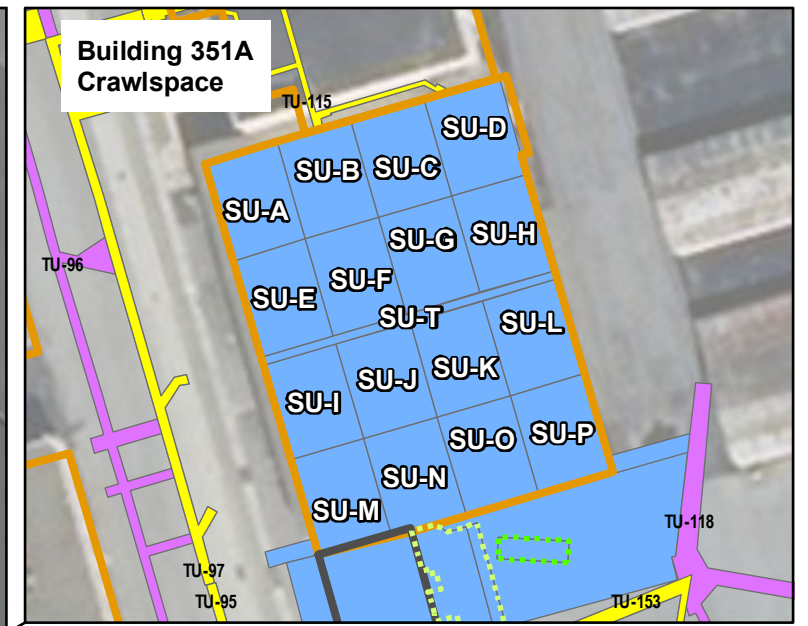
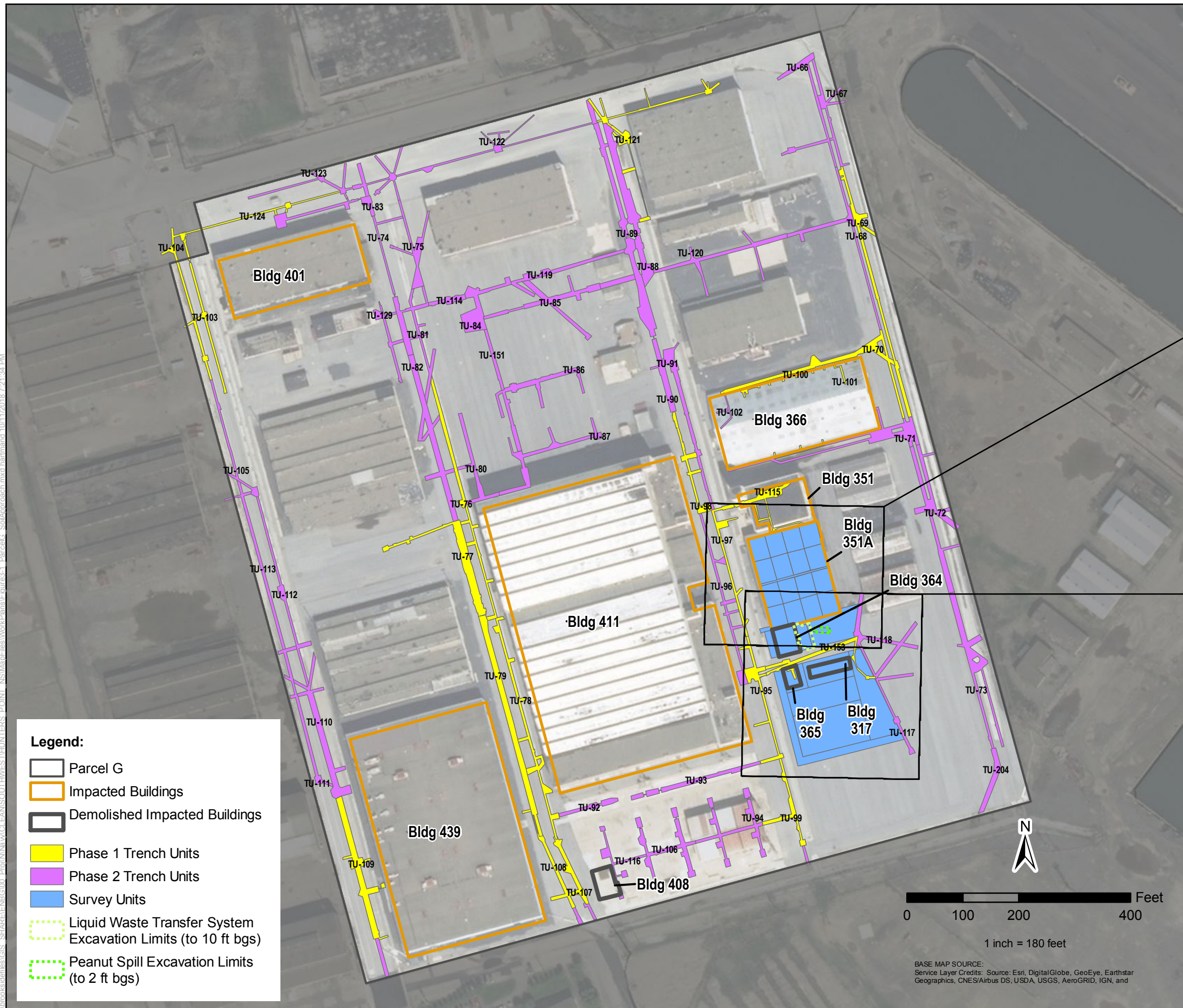
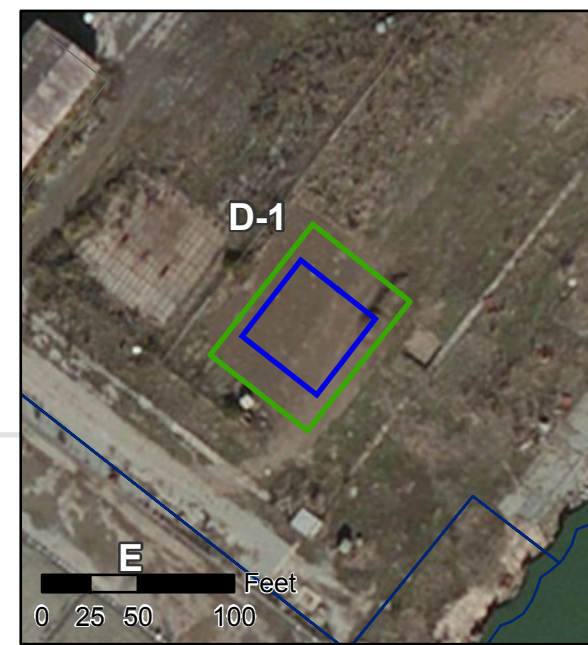
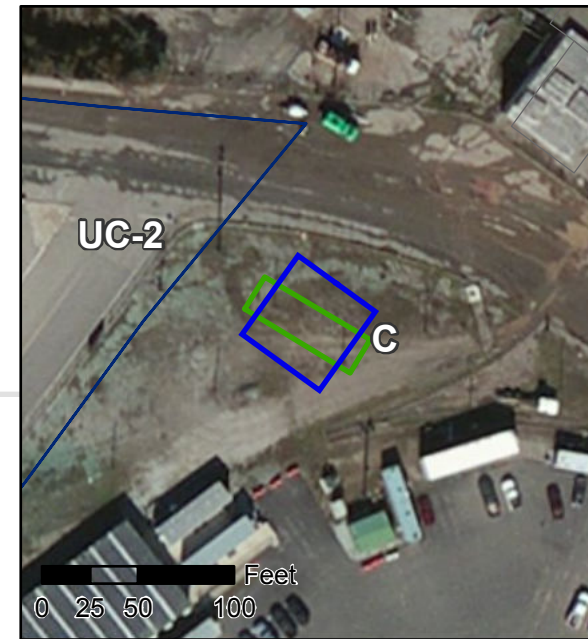


Figure 11-1
Soil Investigation Approach
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California



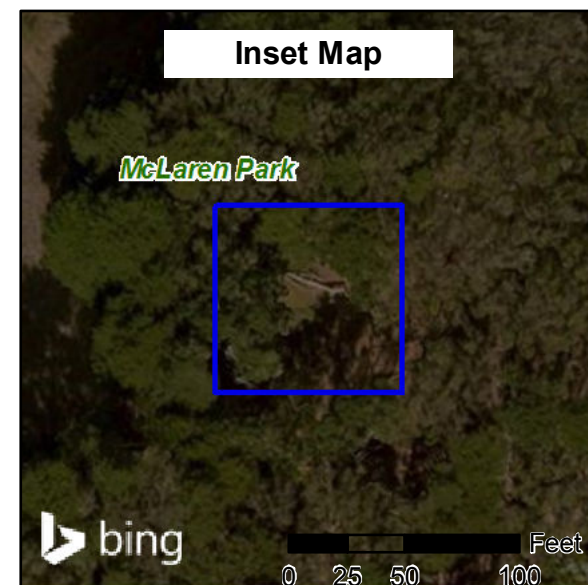
- Legend:**
- Reference Background Area
 - Historical Reference Background Area
 - Installation Boundary
 - Parcel Boundary
 - Current and Former Building Site



0 250 500 1,000 Feet

BASE MAP SOURCE:
 Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar
 Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the
 GIS User Community

Figure 11-2
HPNS Reference Background
Areas
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



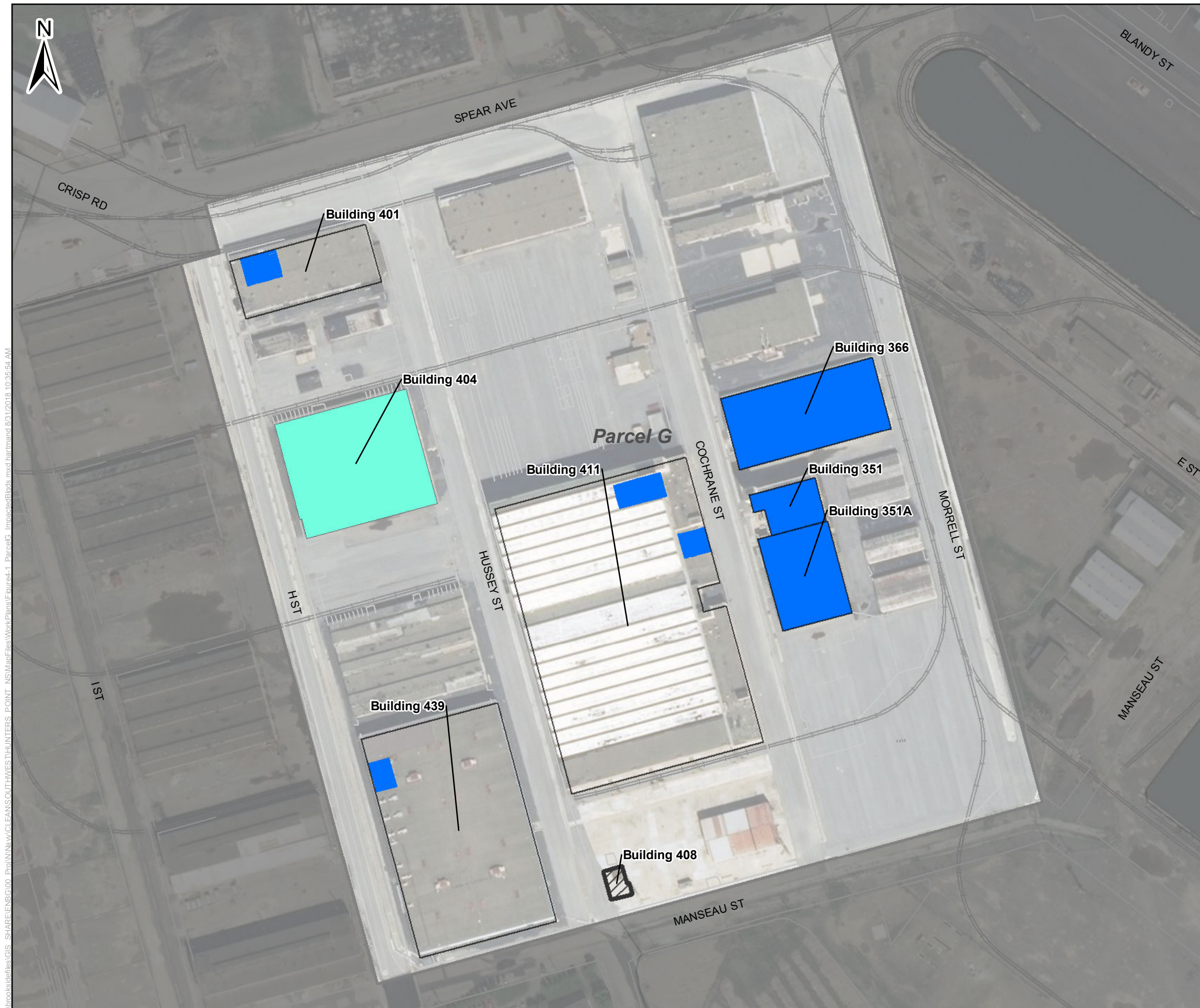
Legend:

- Reference Background Area*
- Park
- Installation Boundary

*NOTE:
The exact location of the RBA within McLaren Park may be adjusted based on consultation with the City of San Francisco.

BASE MAP SOURCE:
Service Layer Credits: © 2018 Microsoft Corporation Earthstar Geographics SIO
© 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS
Park Lands layer developed by the San Francisco Recreation and Parks Department (2016).

Figure 11-3
Offsite Reference Background Area,
McLaren Park
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



Legend

- Impacted Building Areas
- Background Reference Areas
- Impacted Building Extent
- Demolished Impacted Buildings
- Parcel G Boundary

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

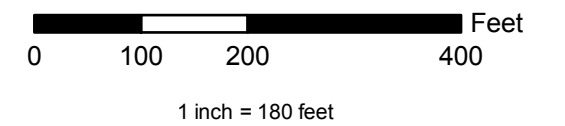
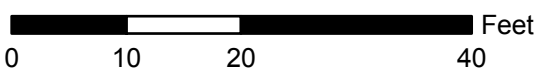
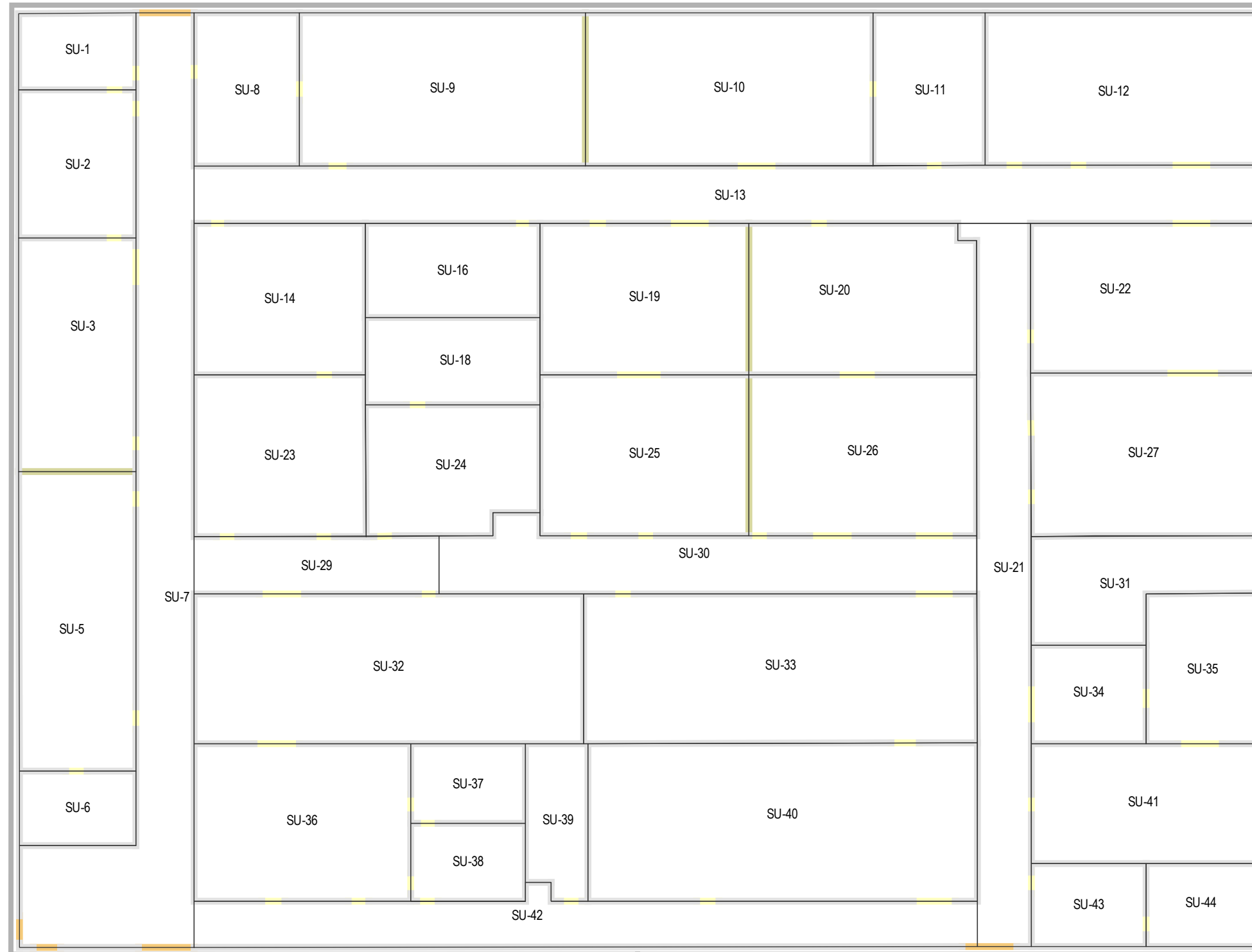


Figure 11-4
Impacted Buildings and
Background Locations
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

I:\books\del\GIS_SHARE\ENR\00_Proj\N\w\CLEANIS\OUT\WEST\HUNTERS_POINT_NS\MapFiles\Work\Plans\Figure4-1_ParcelG_ImpactedBuilds.mxd bartmand.8/31/2018 10:36:54 AM



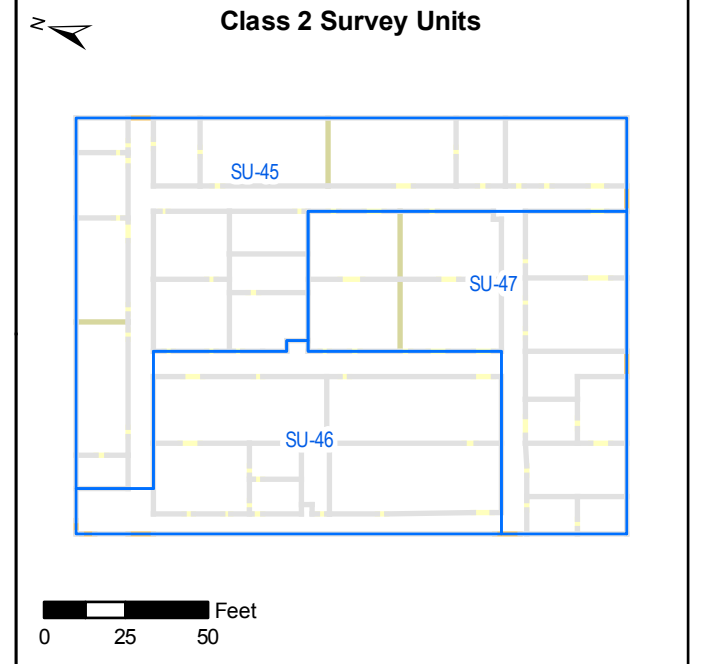
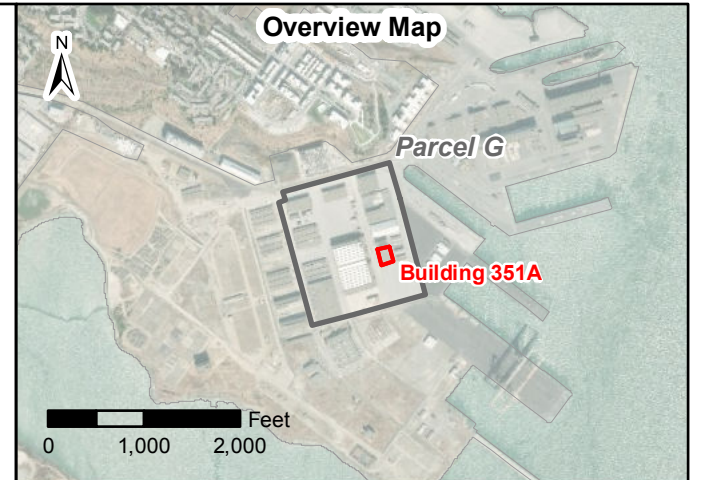
Class 1 Survey Units



Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, July 26, 2010, DCN: ECSD-5713-0072-0015.RI" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit and Floor Plan data are based on Figure 4-1 (2010).



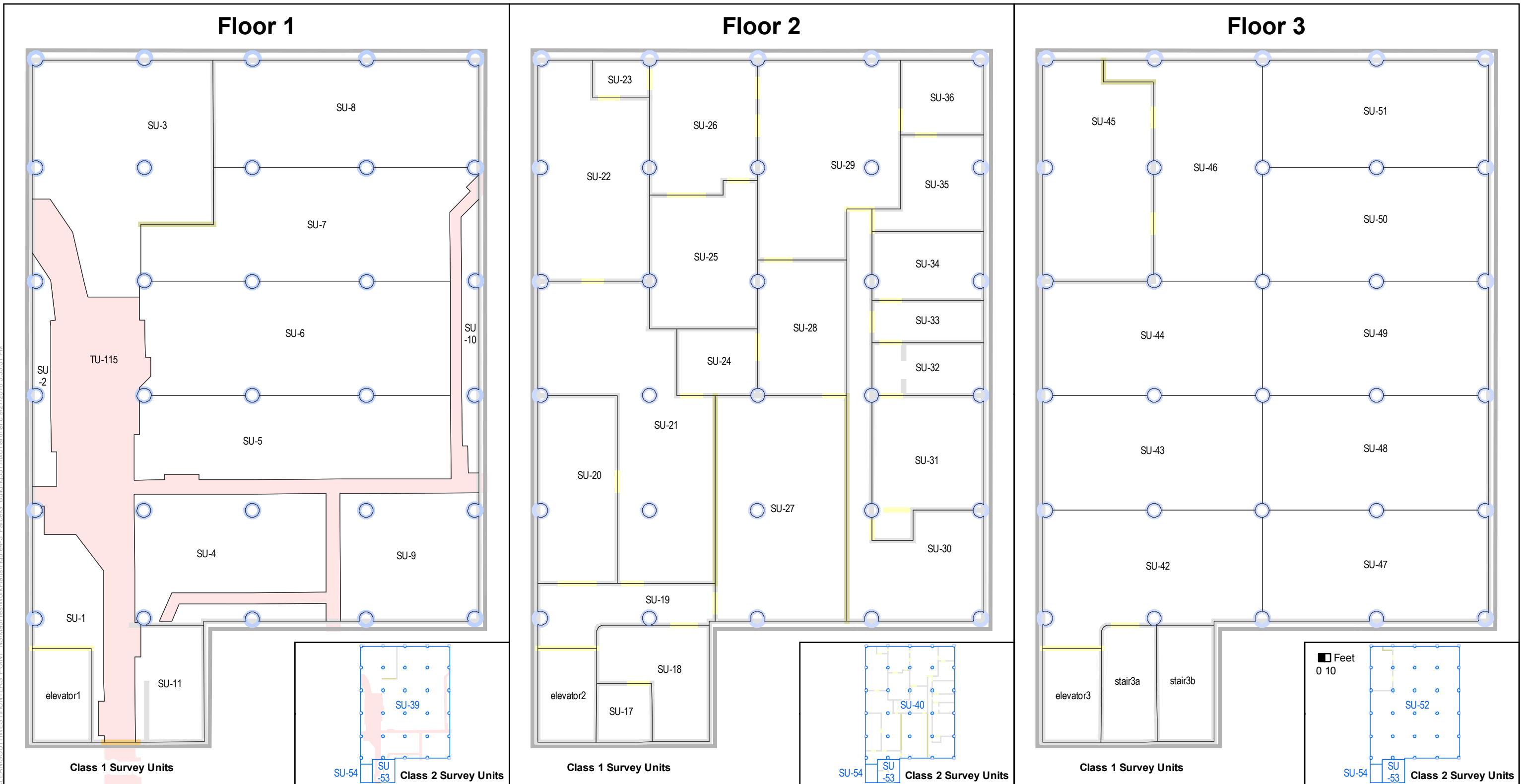
Legend

- Class 1 Survey Unit (Floor and Lower Wall)
- Class 2 Survey Unit (Ceiling and Upper Wall)
- Floor Plan**
- Interior Door
- Exterior Door
- Divider
- Wall
- Exterior Wall

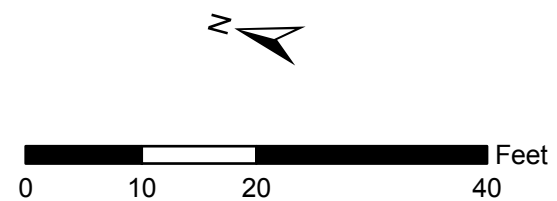
Figure 11-5
Building 351A Floor Plan
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

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- Legend**
- Class 1 Survey Unit (Floor and Lower Wall)
 - Class 2 Survey Unit (Ceiling and Upper Wall)
 - Trench Unit
 - Interior Door
 - Exterior Door
 - Divider
 - Wall
 - Column
 - Exterior Wall



Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, March 5, 2010, DCN: ECSD-5713-0072-0045.R1" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit and Floor Plan data are based on section 4 figures (2010). Trench Units from CH2M Phase 1 report. Dimensions are approximate.

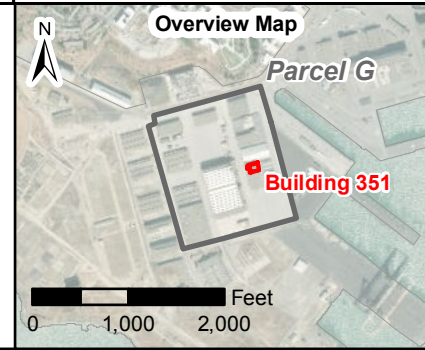
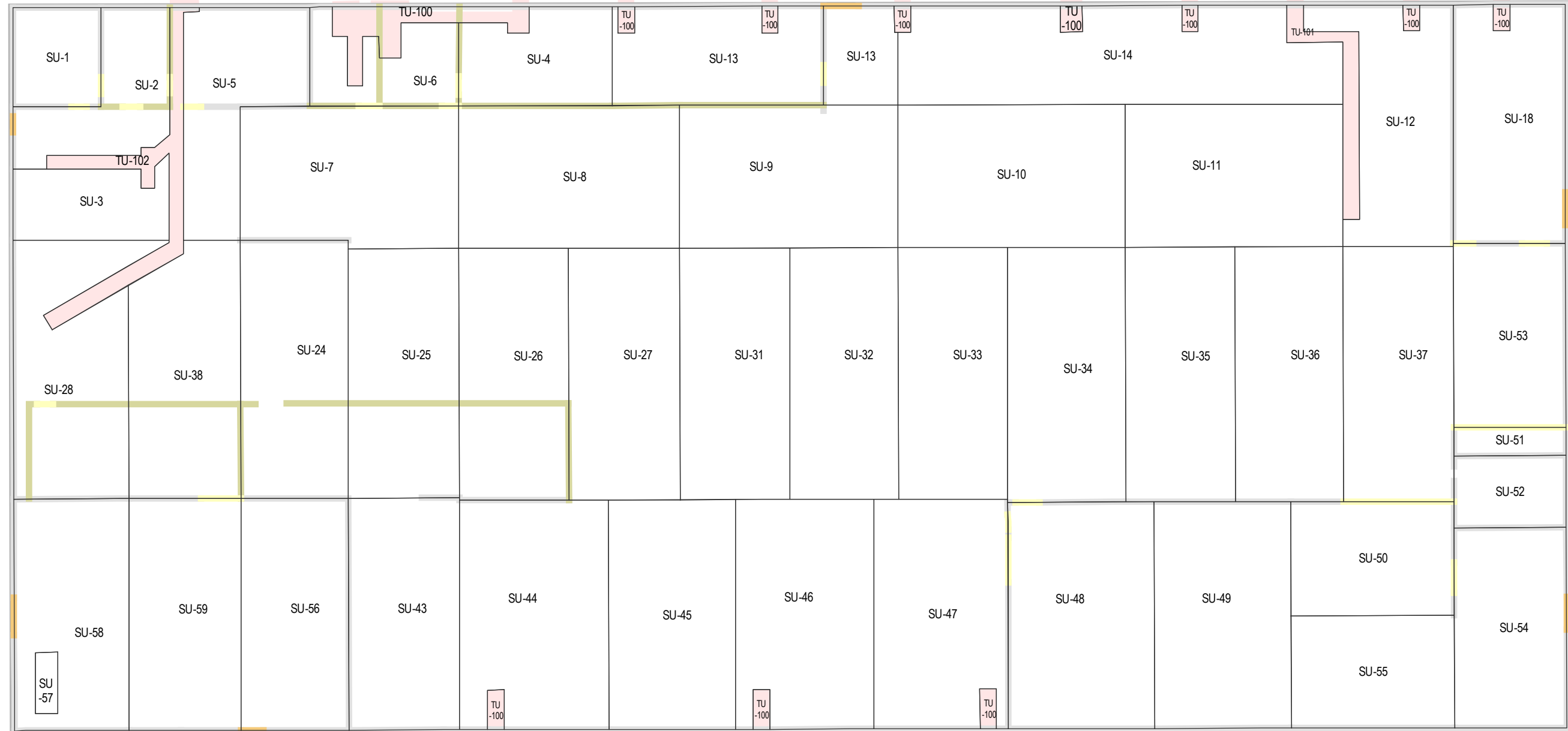


Figure 11-6
Building 351 Floor Plan
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

Class 1 Survey Units



Additional Survey Units (not drawn):

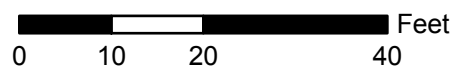
SU 69 consists of the building exterior surfaces, designated as Class 3.

SU 70 is a mezzanine level in the southwest corner of the building. If it can be safely accessed, it will be surveyed as a Class 1 SU.

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, December 30, 2009, DCN: ECSD-5713-0072-0043" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on figures 1-2 (2007), 2-7 (2008), and 4-2 (2008). Trench Units from CH2M Phase 1 report. Dimensions are approximate.



Legend

- | | | | |
|--|--|---------------|---------------|
| Class 1 Survey Unit (Floor and Lower Wall) | Class 2 Survey Unit (Ceiling and Upper Wall) | Floorplans | Divider |
| Trench Unit | Pitched Roof | Interior Door | Wall |
| | Truss | Exterior Door | Exterior Wall |
| | Upper Wall | | |

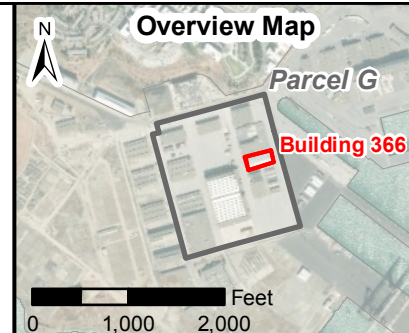
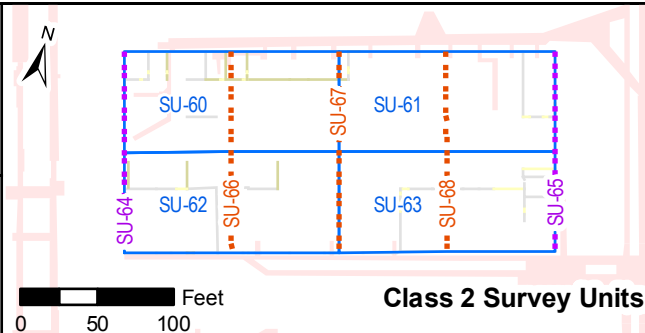
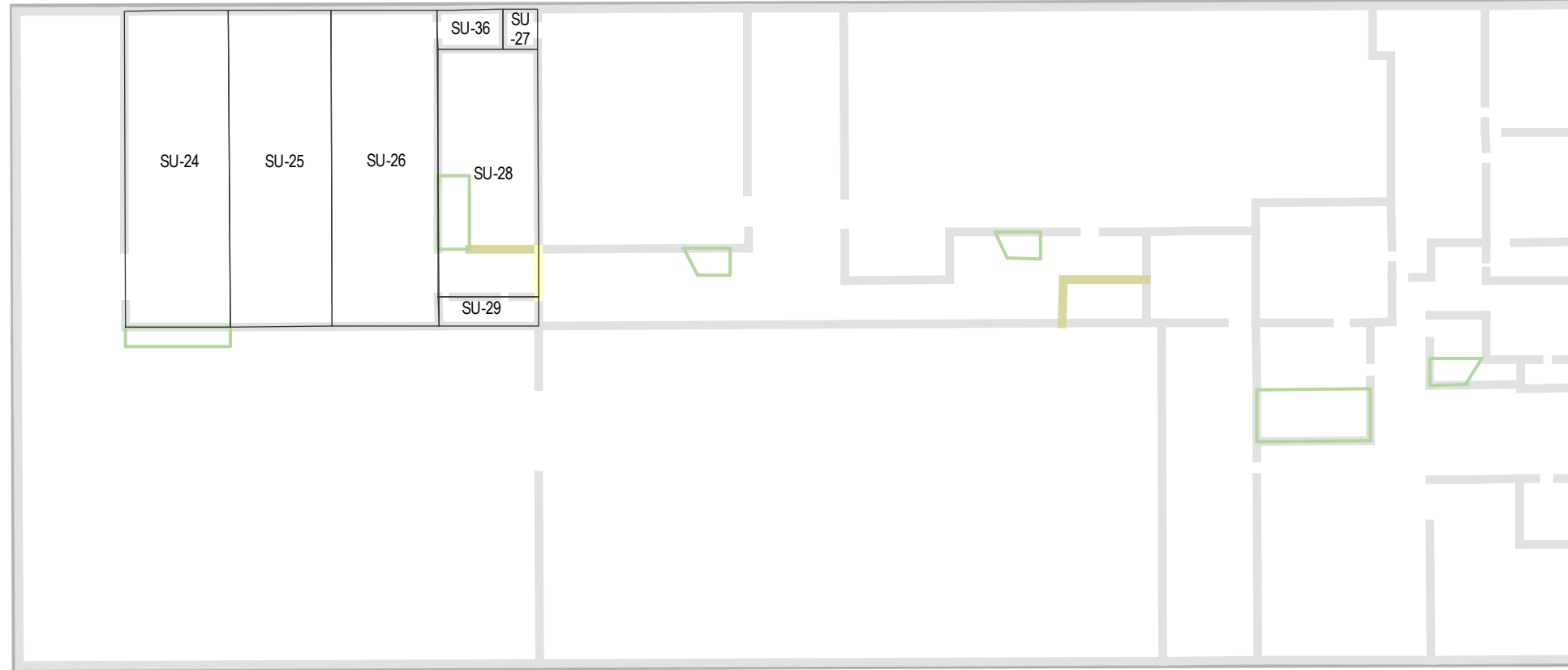
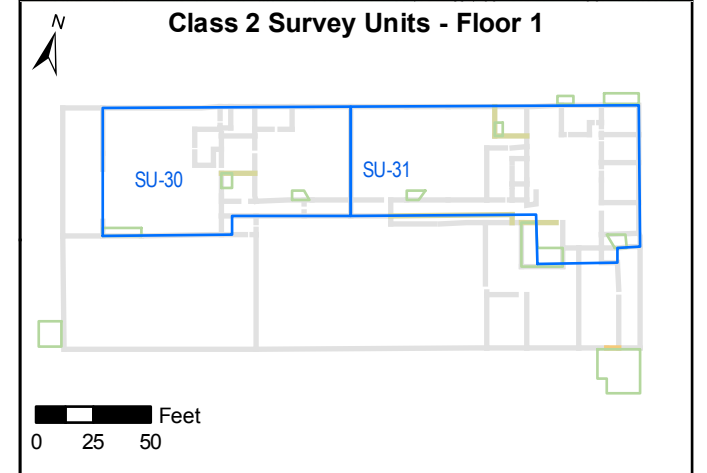
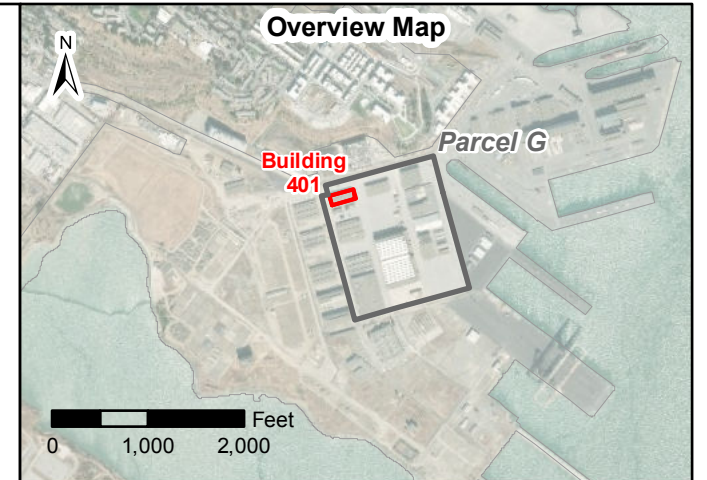


Figure 11-7
Building 366 Floor Plan
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

Class 1 Survey Units



Floor 2



0 5 10 20 Feet



Floor 1

Legend

- Class 1 Survey Unit (Floor and Lower Wall)
- Class 2 Survey Unit (Ceiling)
- Floorplans**
- Interior Door
- Exterior Door
- Divider
- Stairs
- Wall
- Exterior Wall

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

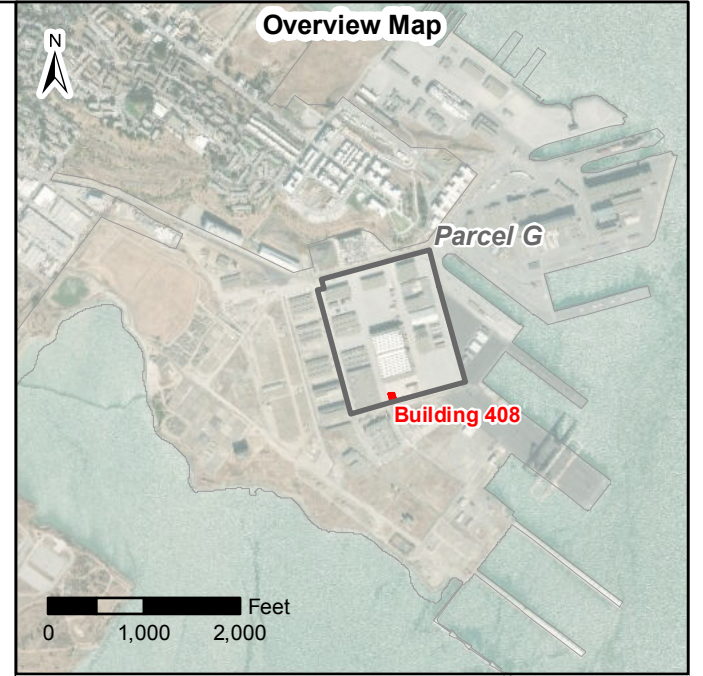
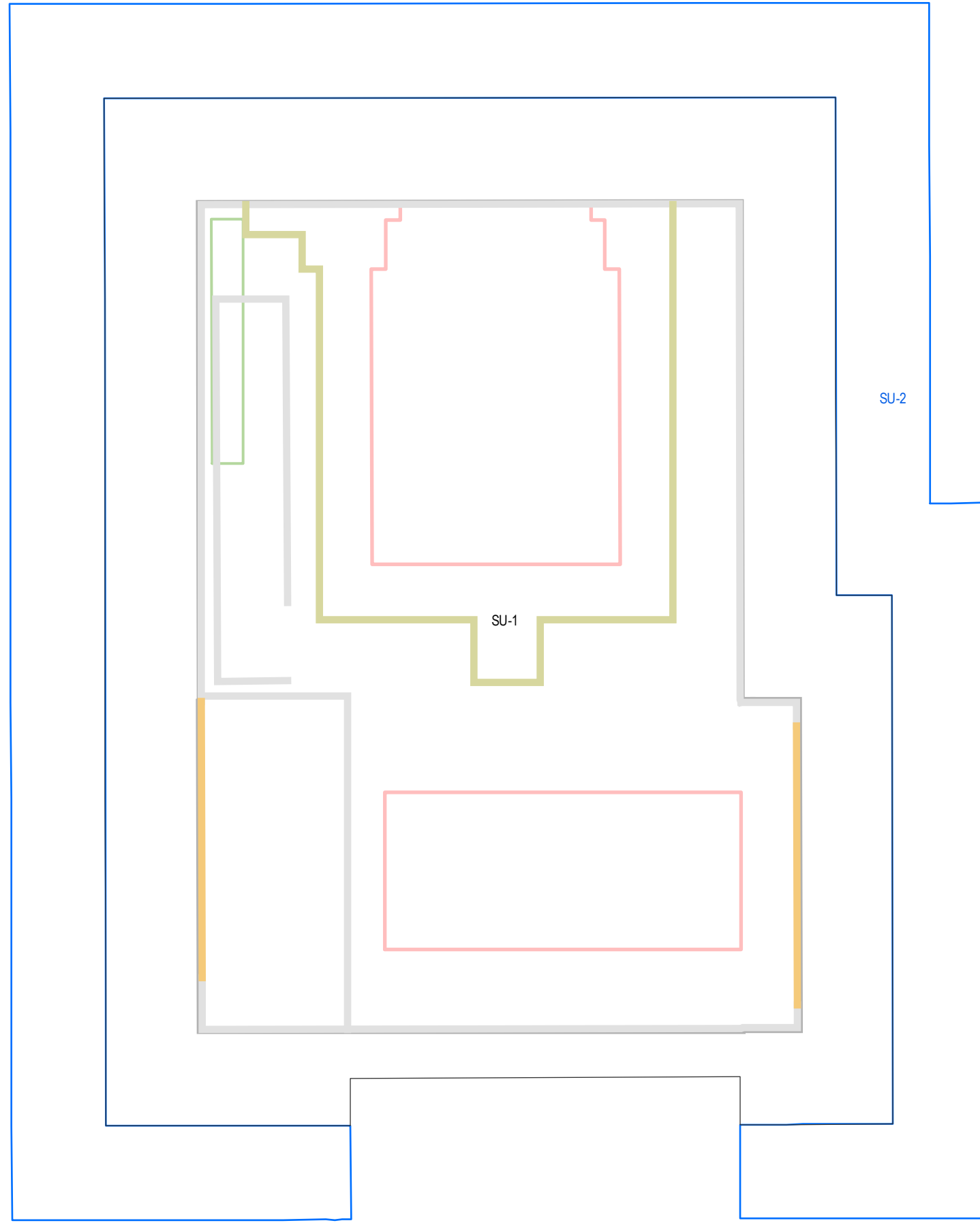
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, September 21, 2009, DCN: ECSD-5713-0072-0015.R1" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on section 4 figures (2009) and Floor Plans (2008). Dimensions are approximate.

Figure 11-8
Building 401 Floor Plan
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

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Legend

- Class 1 Survey Unit
- Class 2 Survey Unit
- Floorplans**
- Demolished Exterior Door Location
- Demolished Divider Location
- Demolished Wall Location
- Demolished Stairs Location
- Demolished Furnace Location
- Existing Concrete Floor

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, July 8, 2009, DCN: ECSD-S713-0072-0019.RI" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Floorplan data are based on Figure 1-1. Survey Unit data based on Figure 4-1 (2008). Dimensions are approximate.

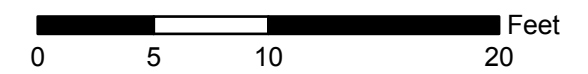
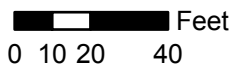


Figure 11-9
Building 408 Floor Plan
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

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Additional Survey Units (not drawn):

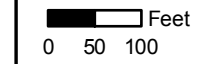
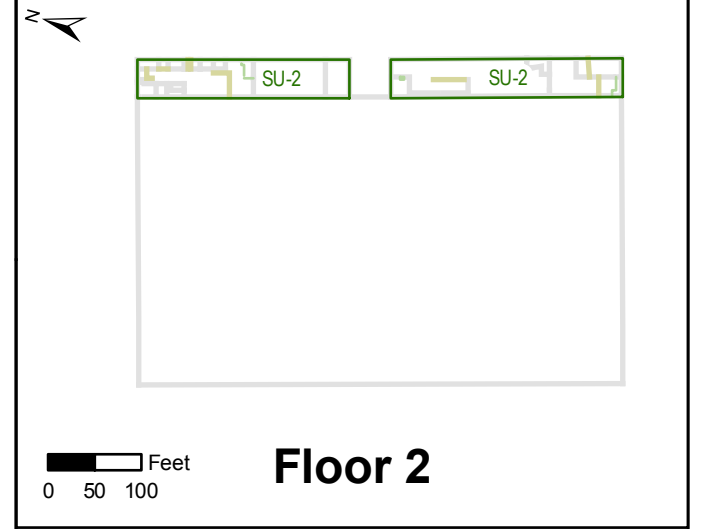
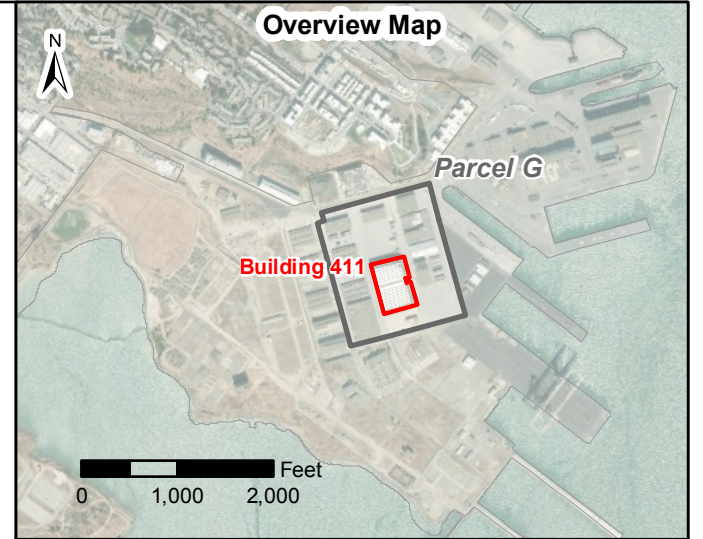
The third floor and mezzanine are no longer accessible because of concerns about structural stability; therefore, the Class 3 SU 1 that was previously surveyed is not included in this investigation. Access points to that area will be included with surveys of adjacent SUs.

Floor 1

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

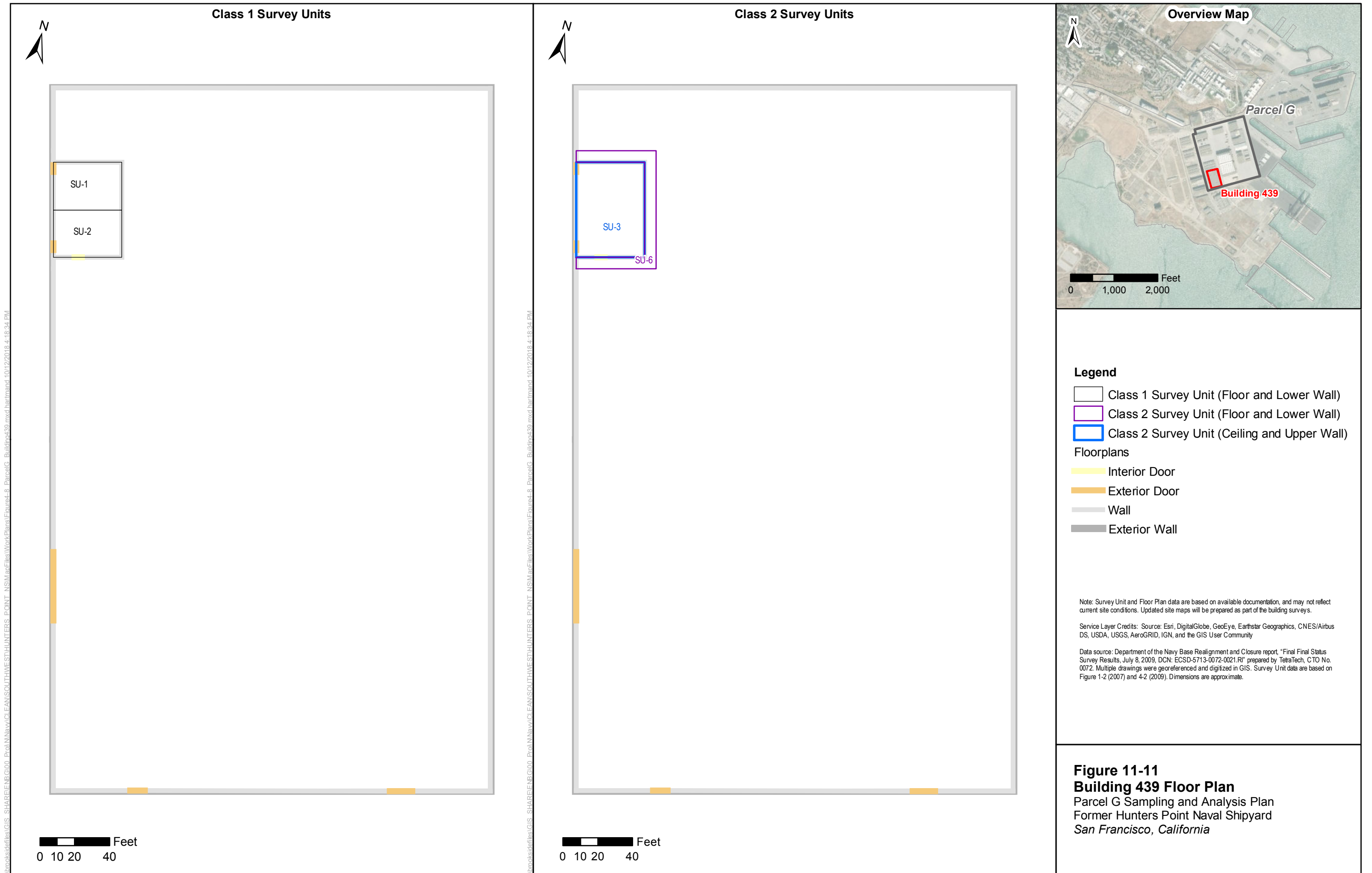
Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, July 6, 2010, DCN: ECSD-S713-0072-0081" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Floor 1 data are based on Figure 4-5 (2010). Dimensions are approximate.



Floor 2

- Legend**
- Class 1 Survey Unit (Floor)
 - Class 2 Survey Unit (Floor)
 - Class 3 Survey Unit (Floor)
- Floorplans**
- Interior Door
 - Exterior Door
 - Divider
 - Wall
 - Stairs
 - Exterior Wall

Figure 11-10
Building 411 Floor Plan
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Legend

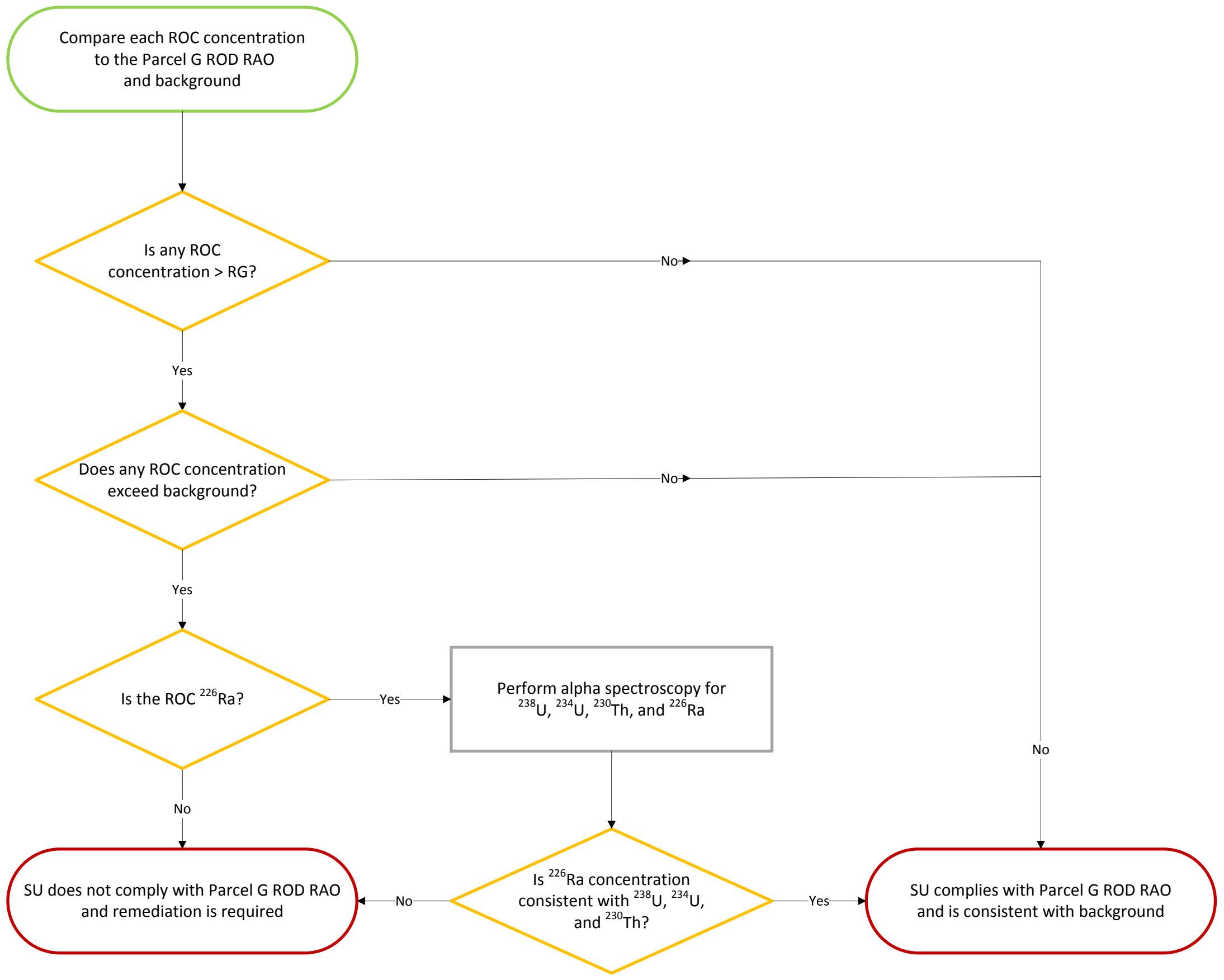
- Class 1 Survey Unit (Floor and Lower Wall)
- Class 2 Survey Unit (Floor and Lower Wall)
- Class 2 Survey Unit (Ceiling and Upper Wall)
- Floorplans**
- Interior Door
- Exterior Door
- Wall
- Exterior Wall

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

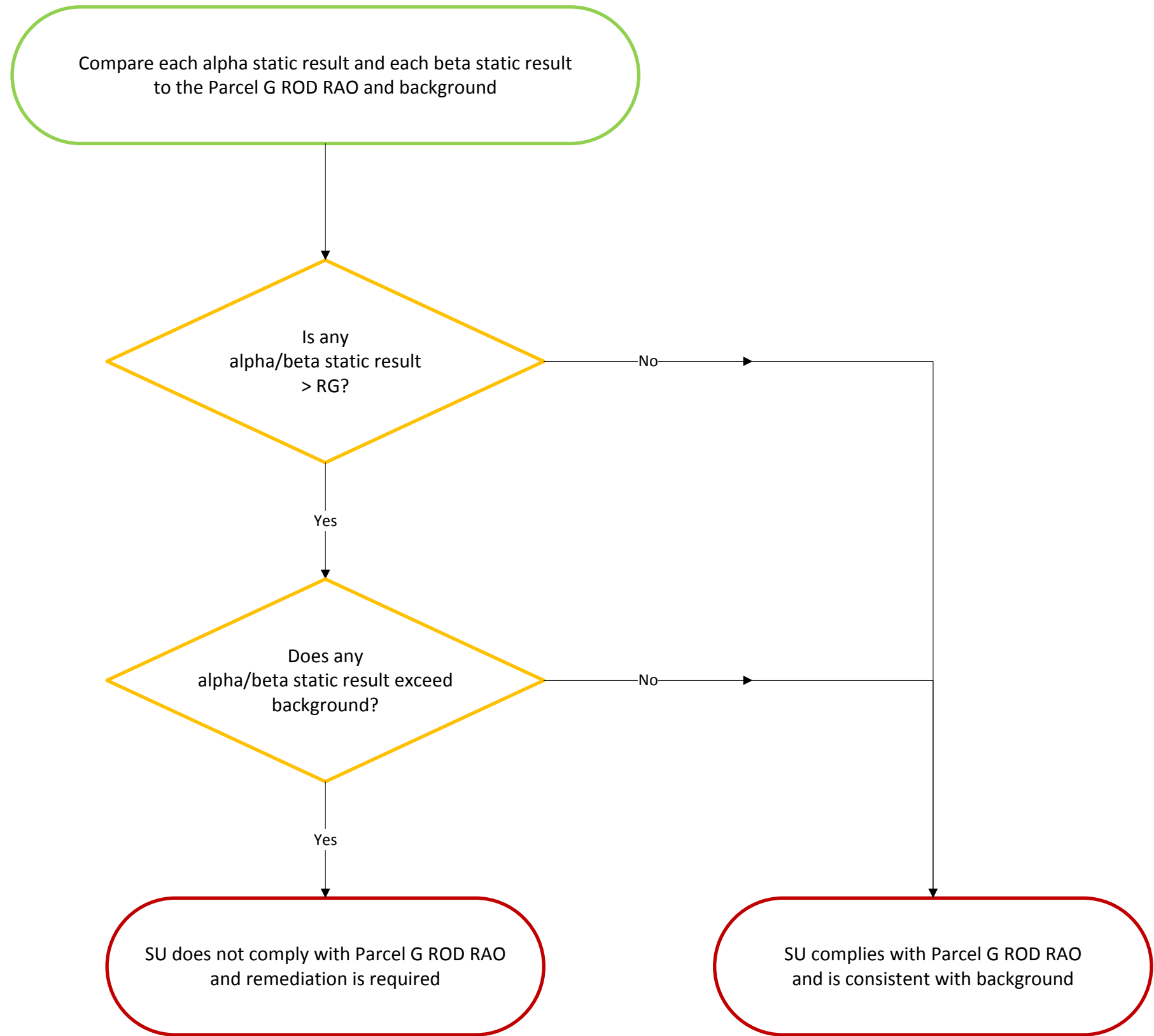
Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, July 8, 2009, DCN: ECSD-5713-0072-0021.RI" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on Figure 1-2 (2007) and 4-2 (2009). Dimensions are approximate.

Figure 11-11
Building 439 Floor Plan
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



- Acronyms:**
- Ra** = radium
 - RAO** = remedial action objective
 - RG** = remediation goal
 - ROC** = radionuclide of concern
 - ROD** = record of decision
 - SU** = survey unit
 - Th** = thorium
 - U** = uranium

Figure 11-12
Performance Criteria for Demonstrating Compliance with the Parcel G ROD – Soil
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



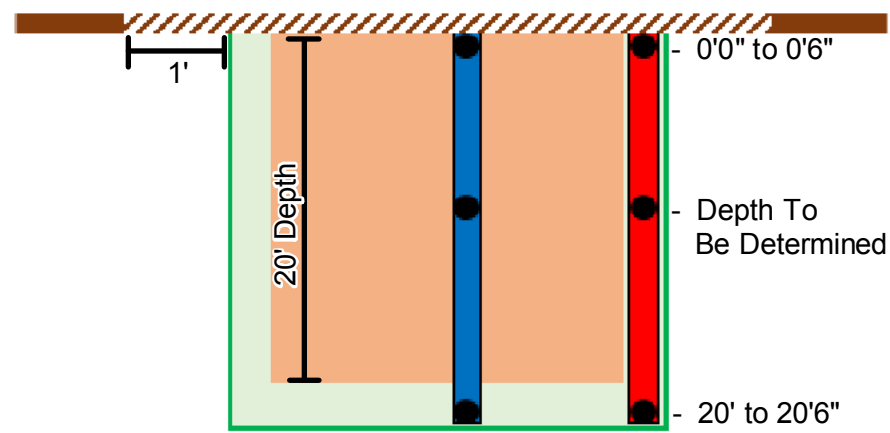
Acronyms:

- RAO** = remedial action objective
- RG** = remediation goal
- ROD** = record of decision
- SU** = survey unit

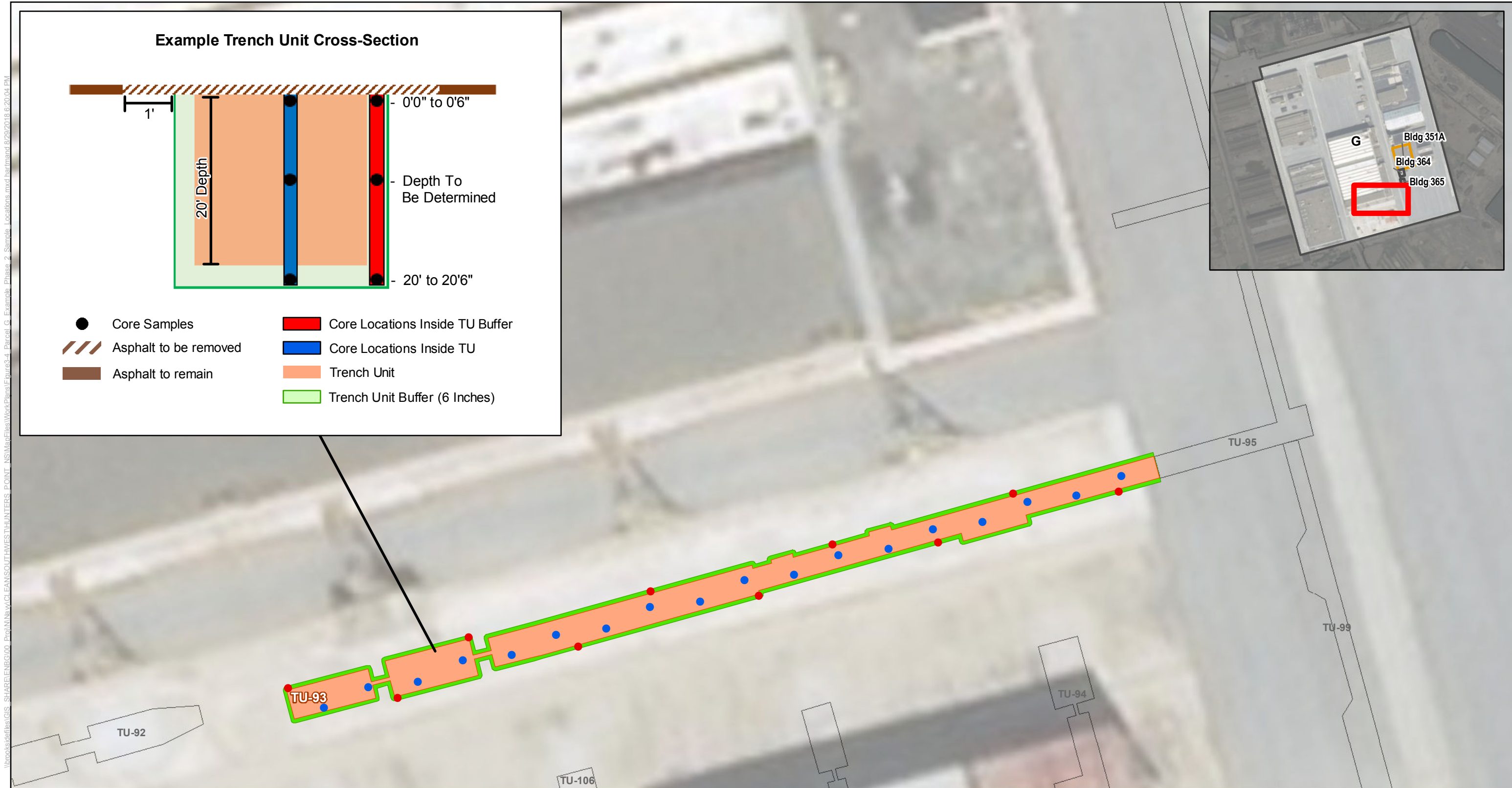
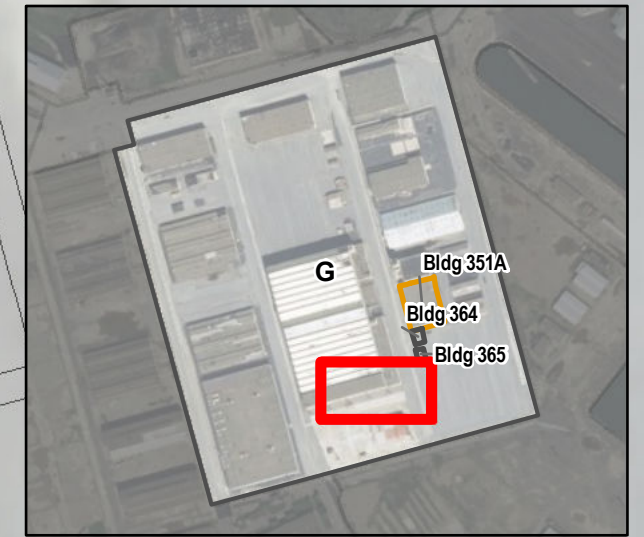
Figure 11-13
Performance Criteria for Demonstrating Compliance with the Parcel G ROD – Buildings
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

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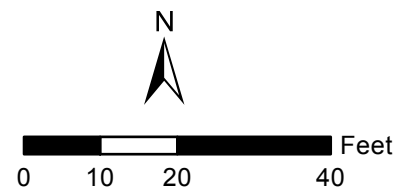
Example Trench Unit Cross-Section



- Core Samples
- ▨ Asphalt to be removed
- Asphalt to remain
- Core Locations Inside TU Buffer
- Core Locations Inside TU
- Trench Unit
- Trench Unit Buffer (6 Inches)



- Legend:**
- Core Locations Inside TU
 - Core Locations Inside TU Buffer
 - TU-93
 - TU-93 Buffer (6 Inches)
 - Trench Units



BASE MAP SOURCE:
 Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-2
Example Phase 2 Trench Unit
Soil Sample Locations
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-3
HPNS Reference Background Area RBA-1
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-4
HPNS Reference Background Area RBA-2
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-5
HPNS Reference Background Area RBA-3
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-6
HPNS Reference Background Area RBA-4
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California

McLaren Park



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Legend:

- Surface and Subsurface Sample Location
- Reference Background Area*
- Park

* NOTE: The exact location of the RBA within McLaren Park may be adjusted based on consultation with the City of San Francisco.

COORDINATE SYSTEM: NAD 1983 StatePlane California III FIPS 0403 Feet

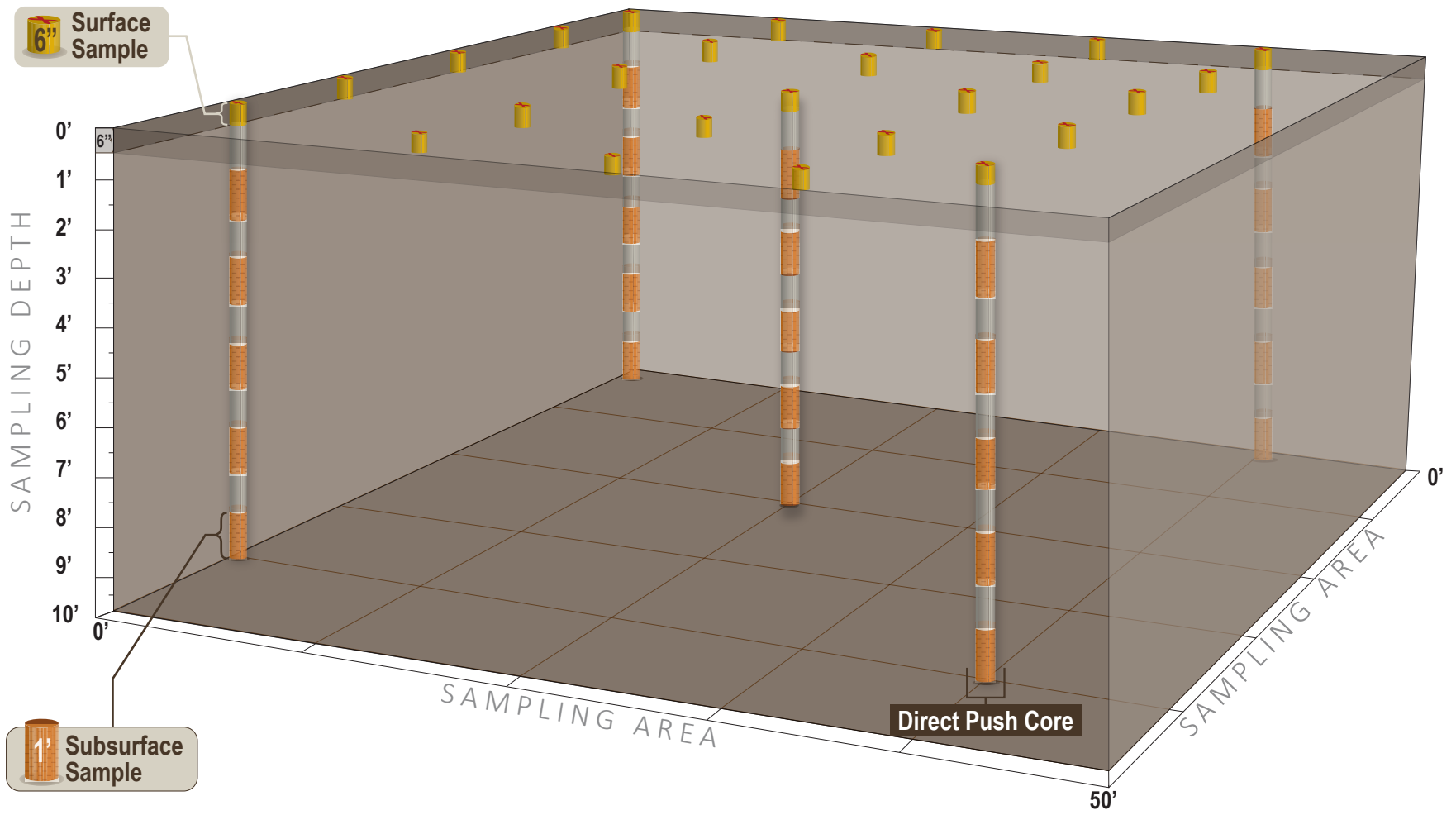
BASE MAP SOURCE: Service Layer Credits: © 2018 Microsoft Corporation © 2018 DigitalGlobe © CNES (2018) Distribution Airbus DS

Park Lands layer developed by the San Francisco Recreation and Parks Department (2016).

**Figure 17-7
McLaren Park Reference Background Area
RBA-McLaren**

Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Onsite RBA



Offsite RBA

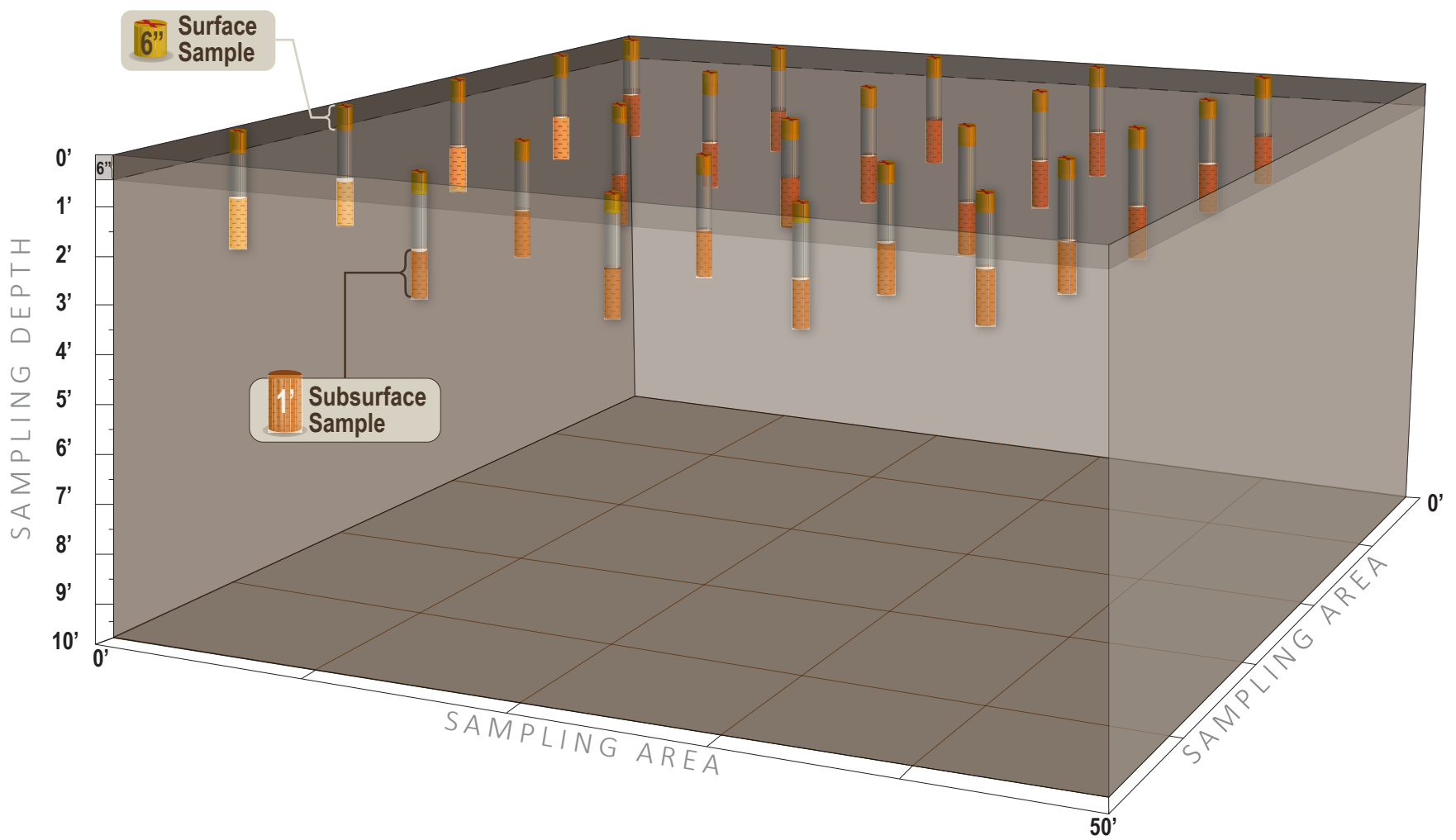
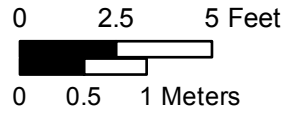
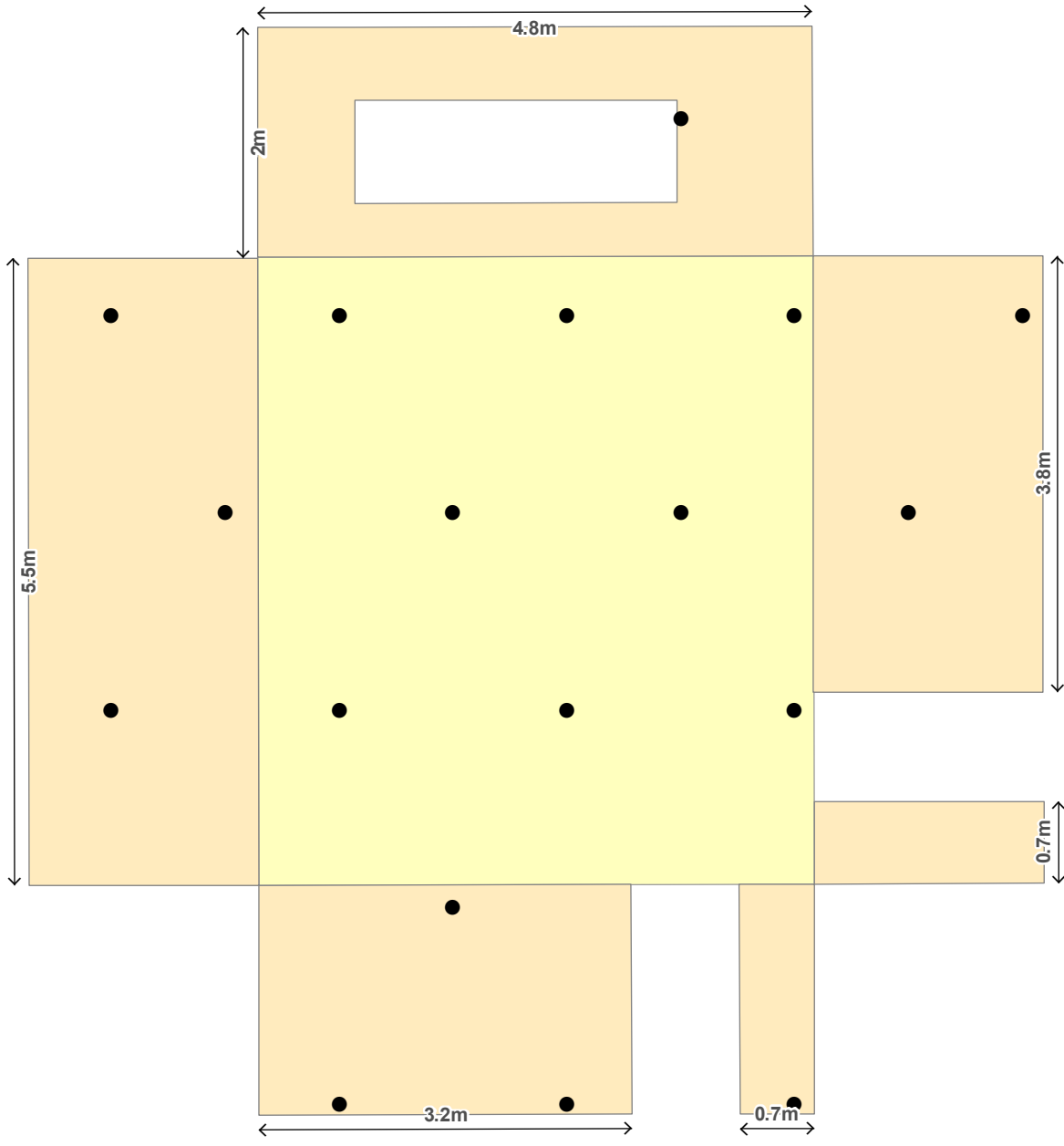


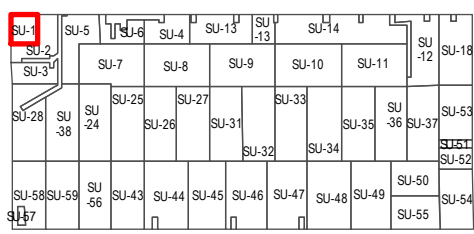
Figure 17-8
Example Surface and Subsurface Sample Locations
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, CA



Legend

- Systematic Static and Swipe Location
- Estimated Wall Area* = 35 m²
- Floor Area* = 26 m²

Total Area* = 61 m²
 *Areas are estimates, may not sum to total due to rounding



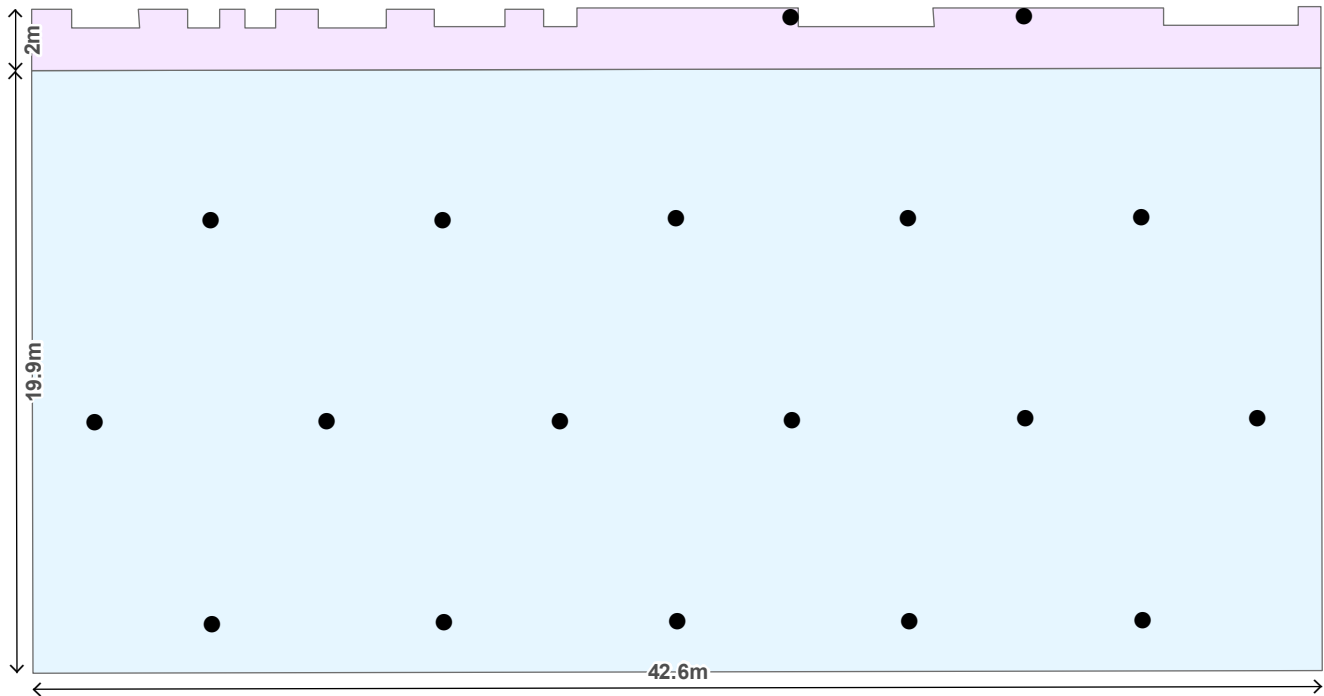
Class 1 Survey Units (Floors and Lower Walls)

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, December 30, 2009, DCN: ECSD-5713-0072-0043" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on figures 1-2 (2007) and 4-2 (2008). Trench Units from CH2M Phase 1 report. Dimensions are approximate.

Figure 17-9
Example Building Class 1
Survey Unit and Sample Locations
(Building 366 Survey Unit 1)
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

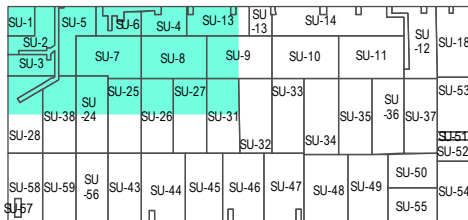
\brockside\files\GIS - SHARE\ENB\00 - Protin\Nav\CL EANSOUTH\HUNTERS POINT - NS\MapFiles\WorkPlans\Figure4-11 - ParcelG - Building366 - EXCIZ.mxd hartmand 9/28/2018 11:12:15 AM



Legend

- Systematic Static and Swipe Location
- Estimated Ceiling Area* = 850 m²
- Estimated Upper Wall Area* = 74 m²

Total Estimated Area* = 923 m²
 *Areas are estimates, may not sum to total due to rounding.



- Class 1 Survey Units (Floors and Lower Walls)
- Class 2 Survey Unit (Ceiling and Upper Walls): SU-60

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, December 30, 2009, DCN: ECSD-5713-0072-0043" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on figures 1-2 (2007), 2-7 (2008), and 4-2 (2008). Trench Units from CH2M Phase 1 report. Dimensions are approximate.

Figure 17-10
Example Building Class 2
Survey Unit and Sample Locations
(Building 366 Survey Unit 60)
 Parcel G Sampling and Analysis Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

Attachment 1
Project Scoping Meeting Minutes
and Responses to Comments

Hunters Point Naval Shipyard Scoping Meeting San Francisco, California

ATTENDEES:

Derek Robinson, Navy	Jeff Wong, CDPH
Pat Brooks, Navy	Tina Low, Water Board
Bill Franklin, Navy	Kellie Koenig, CH2M
Danielle Janda, Navy	Robert Kirkbright, CH2M
Lily Lee, EPA RPM	Adam Engel, CH2M
David Yogi, EPA	<i>On Phone:</i>
Jackie Lane, EPA	Matt Slack, RASO
Tamsen Drew, OCII (Office of Community Investment and Infrastructure)	Zach Edward, RASO
Amy Brownell, SFDPH	LCDR Soric, RASO
Scott Hay, Cabrera Services	Dr. Steve Doremus, RASO
Janet Naito, DTSC	Jana Dawson, Tech Law
Nina Bacey, DTSC	Mark Luckhardt, Five Point
Sheetal Singh, CDPH	Lindsay Land, EPA
	Carla Brazen

DATE: December 13, 2016

PROJECT: Navy CLEAN 9000, CTO-FZ12

Objectives

The objectives of the meeting were to introduce team members, discuss radiological data evaluation and community outreach activities, and gain feedback, input, and buy-in from stakeholders.

Introduction

A presentation and schedule were provided to all invitees prior to the meeting.

Derek Robinson from the BRAC PMO kicked off the meeting by thanking everyone for attending, and stated how important this project is for the Navy, BRAC, the City of San Francisco, Regulatory Agencies, and developers. He stated the urgency of this effort and the requirement to get it done right the first time. Lily Lee mentioned the EPA will be sending a letter outlining recommended actions. Derek also said that this venue is a good place for everyone to meet face to face. Pat Brooks and CH2M will be presenting the strategy and scope of the planned efforts which hopefully can draw to a close any unanswered questions

Introductions were made.

The Tiger Team points of contact were identified:

NAVY - Pat Brooks, Derek Robinson, Danielle Janda, Zachary Edwards, and Matthew Slack

DTSC - Janet Niato and Nina Bacey

EPA - John Chestnut and Lily Lee

CDPH - Sheetal Singh and Jeff Wong

Water Board – Tina Low

City of San Francisco - Tamsen Drew (OCII) and Amy Brownell (SFDPH)

Bob Kirkbright began the presentation with a brief discussion of the team CH2M has assembled, pointing out the challenge in finding experts for the team that have not been involved with Tetra Tech or its affiliates and subcontractors to avoid any possible perception of a conflict of interest. The assembled team consists of a consortium of experienced experts from CH2M and other recognized radiological companies to provide an independent third party analysis of the data. He mentioned CH2M has been in contact with Dr. Covello to consult on the outreach messaging efforts; Dr. Covello indicated he would be available after the New Year.

Pat Brooks explained this project is BRAC's number one priority, and they will be putting all their efforts toward facilitating its completion.

Scott Hay presented what has been accomplished so far, and explained the technical approach to the project.

Pat Brooks reiterated the challenges of balancing the aggressive schedule with the thorough analysis this project demands. He indicated a substantial amount of rework has taken place, including past efforts by RASO and Tetra Tech, using approaches that identified anomalous data. It was mentioned there were additional accusations after those efforts were completed. The CH2M team will perform an independent analysis that will include reviewing those efforts as well as performing additional analysis of the data.

Technical Approach

Scott Hay presented the phased approach and accomplishments to date.

Questions were raised about the database regarding how it was going to be examined. Scott Hay and Pat Brooks explained the first steps are to determine the completeness of the data set. Sample IDs can be used to break out survey units, and arrange them by parcel to form data subsets.

A discussion was had about why 2006 was determined as the starting point. The EPA expressed concerns that Tetra Tech was working at Hunters Point in the 1990s and their Health Physicists have identified anomalies in some of the pre 2006 data that they reviewed. Pat Brooks explained that 2006 was used as the cutoff because that was when the TCRA to remove sewer lines began, and everything before that was characterization and preliminary surveys, not used to determine final status. It was decided that any data that was used for decision making needs to be reviewed, and Derek Robinson and Pat Brooks agreed to look into the data that was used to determine work was complete. EPA, DTSC, and the project team agreed if the pre 2006 data was superseded by other work done after 2006, it does not need to be analyzed.

A discussion was held regarding scope. It was explained that during the initial phase, only soil data will be reviewed. In later phases of the project, buildings scans and gamma statics will be evaluated as well. Items such as lab EDDs and field notebooks will be requested as needed as potential issues are identified.

Lily Lee expressed they have been getting a lot of questions on parcels that have already been transferred. Scott Hay explained that we are including all locations where Tetra Tech has worked, and analyzing all of their data. Further concerns were expressed regarding the data that does not show any obvious anomalies. It is her opinion that since Tetra Tech has disclosed that data has been falsified, we cannot say that the data is reliable even though the statistical tests do not turn up any results. Scott Hay and Bob Kirkbright explained that our statistical tests will identify anomalies in the data, including running tests designed to identify instances where data may have been falsified. It was agreed that areas of highest potential risk should be the priority.

Sheetal Singh asked questions about what types of tests were going to be run, and how it is known whether they are effective. Scott Hay explained we will be using a test on the data sets where problems have already been identified, as well as the data set in its entirety. If these tests are able to identify the known problem areas, it will provide confidence in the analysis. Scott Hay went on to describe the statistical test and how the analysis was going to be approached in more detail, and explained that phase two will determine the amount and locations of confirmation sampling.

EPA raised questions of the amount of confirmation sampling, and what approach will be taken if data testing methods do not recommend sampling in places where allegations have pointed to. Scott Hay explained that confirmation sampling will be done to address specific issues, including allegations from former workers, if that is deemed appropriate. It was discussed that allegations of misconduct do not necessarily mean that there is a health risk. Danielle Janda stated that the Navy was fully committed to doing a resampling effort, with the extent to be determined. Scott stated the North Pier will probably be used as a test run analysis.

Pat Brooks mentioned this initial effort will examine static gamma readings, building scans, and soil data; only the soil data will be included in the initial analysis with the target completion in January 2017. Laboratory electronic data and gamma walk-over data has been requested from TetraTech. During the discussion it was noted that split sample results are not in NIRIS, so those would have to be obtained separately from the agency that conducted the analysis.

Community Outreach

Kellie Koenig provided a handout of the proposed format for the Draft Radiological Community Engagement Communications Plan, and presented the Community Involvement objectives, approach, tasks, and schedule. The following was discussed:

The group recommended adding the Water Board and Non-Regulatory City departments to the list of stakeholders. Key stakeholders will be included from all available lists including the 2014 CIP.

Tamsen Drew stated that the City recommends four languages, and with the known local population recommended public documents be provided in English, Spanish, written Chinese, Samoan, and Tagalog.

The communication efforts will include preparation of and frequently updating a FAQ sheet with answers generated through the Tiger Team.

EPA and City of San Francisco representatives expressed the community is very interested in being informed and involved throughout the duration of the project. The topic of fact sheets and the subjects of each one were discussed. It was suggested that a third fact sheet be added between sheet one and two in order to inform public about initial findings and explaining how the Navy is going to proceed. David Yogi of EPA expressed importance of keeping the community involved throughout the process, not just telling them what we did after it was complete.

Derek Robinson expressed his desire to present at the Mayor's Hunters Point Shipyard Citizen's Advisory Committee (CAC). Tamsen Drew stated that the CAC would be interested.

Additional Public Outreach discussion yielded the ideas that will be discussed further:

- Be proactive, not reactive.
- Get the community involved early in the process and bring them along the process to build trust.
- The possibility of EPA getting a third party technical advisor to help communicate technical aspect to the public. Agency grant availability information should be communicated to CBOs.
- Multiple feedback mechanisms for public communication are beneficial.

- Respond as quickly as possible to community concerns and give consistent responses; essential to building trust.
- Create a list of FAQs to facilitate fast and consistent responses to community questions.
- Go to reporters directly to get them involved, so they do not misinterpret what is going on. The Navy has specific reporters they have worked with in the past.
- Local “door to door” outreach has been successful in the past. Coordination with local churches and community groups has also been successful. A community liaison may help facilitate.
- Choose venues that facilitate the open exchange of information.
- Present Navy, EPA, State, City as a unit.
- Look into attending preexisting meetings
- Public stakeholders prefer information via Email.
- The District Supervisor expressed an interest to be involved.
- The community outreach team resolved to have a call twice per month for two months.

Tamsen Drew raised concern about CH2M’s past involvement at Hunters Point, and how the community may react to having a company with past history at the site doing the third party evaluation. Bob Kirkbright explained the differences in CH2M’s history and what occurred with Tetra Tech. It is recognized that a cohesive message is necessary to explain how the situations were vastly different, including the response by the companies; the CH2M team performing this review will include recognized senior experts from at least three other independent companies; and this effort will receive continuous independent scrutiny by the Federal, State, and Tiger Team members.

David Yogi of the EPA suggested that there are groups that will never change their distrust level and efforts are better spent on stakeholders who want to hear the facts and learn about current activities. He also brought up having a Technical Advisor, separate from CH2M and the Navy. Recommendations included Saul Bloom, and Kai Vetter. Pat Brooks commented that the Navy is working to involve a National Laboratory (such as Argonne National Laboratory), but it has not been contracted due to the time it takes to get them on board.

Bill Franklin discussed 3 key points:

- Need to identify the best forums and look for reasons to say “Yes” to outreach opportunities and venues to exchange information.
- Tiger Team to share public inquiries and answers to ROIs with the group to ensure a consistent message.
- Tiger Team participation in outreach and outreach planning meetings so that stakeholder interaction is productive and respectful.

Action Items

Determine if pre 2006 data was used for decision making – Pat Brooks

Provide library of compiled questions and answers on community outreach to share with team – Lily Lee

Plan twice a month Community outreach team check in meeting – Derek Robinson

Email copy of Draft Radiological Community Engagement Plan Communications Plan to RASO – Kellie Koenig

Responses to Comments

Draft Parcel G Removal Site Evaluation Sampling and Analysis Plan Former Hunters Point Naval Shipyard, San Francisco, California

The purpose of this document is to address comments on the Draft Parcel G Removal Site Evaluation Sampling and Analysis Plan, dated August 2018, for Former Hunters Point Naval Shipyard, San Francisco, California. The United States Environmental Protection Agency (USEPA), Department of Toxic Substances Control (DTSC), and California Department of Public Health (CDPH) comments received September 24, 2018 are listed below and responses to comments are provided in bold. The work plan will be updated to address these comments and a draft final version submitted for review.

USEPA Comments

General Comments

1. The SAP Worksheet #9, Project Scoping Session Participants Sheet, states that statistical tests will identify anomalies in the data, including running tests designed to identify instances where data may have been falsified; however, the SAP does not acknowledge that not all instances of falsification may be identified using the statistical tests. Therefore, the investigation must be designed to require that if any sample result from any of the Phase I TUs exceeds the remedial goals (RGs) specified in the Parcel G ROD, then all TUs will require excavation and analysis. Please revise the SAP to acknowledge that statistical tests may not identify all types/instances of falsification so that 100% excavation will be required if any sample from Phase I TUs exceeds RGs.

See response to USEPA General Comment 2 on the Parcel G work plan. The Executive Summary and Worksheets 9, 11, 14, and 17 have been updated accordingly.

2. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Step 1, State the Problem, does not describe how soil background values will be developed for all fill types for Ra-226 and other naturally occurring radioactive material (NORM)/fallout radionuclides. There is no proposal to separate results by fill type in the Work Plan and this would likely require a number of additional samples to generate background values for each soil type. Furthermore, SAP Worksheet #17, Sampling and Survey Design and Rationale, states that “additional sample locations at Bayview Park or other reference areas may be added as necessary to characterize different soil types and depositional areas,” but there are no criteria for this decision and insufficient details that explain how this would be done (e.g., how soil types will be determined, the number of required soil samples per soil type, how reference background areas would be expanded, etc.). Please revise the SAP to provide detailed criteria for evaluating whether background values will be calculated for different soil types, including the number of required samples and how reference background areas will be expanded to cover multiple fill types.

Because the HPNS soil that will be investigated as part of this SAP is mostly fill and has been homogenized, there is no current plan to collect background data/develop background data sets for individual soil types. However, because the background data may be used for other projects at HPNS, the soil lithology will be logged and once data is available and evaluated. If

there are significant differences in the analytical results by soil type, the SAP includes the flexibility for collecting additional samples if needed for further characterization.

3. The SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Step 3, Identify Inputs to the Objective, inputs include performing a gamma scan survey to identify biased soil sample locations; however, the SAP does not propose a scanning survey method to identify any potential remaining Sr-90 radiological objects. Please revise the SAP to discuss how Sr-90 radiological objects will be identified.

See response to USEPA Specific Comment 8 on the Parcel G work plan. The details on scanning are included in the Parcel G work plan and references to the work plan are provided in the SAP.

4. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements Step 5, Develop Decision Rules, is inconsistent with the Parcel G ROD. Step 5 states "If the building and soil investigation results demonstrate that site conditions are not compliant with the Parcel G RAO [remedial action objective] and exceed background levels, then the data will be evaluated to determine whether site conditions are protective of human health using USEPA's current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014a). A Removal Site Evaluation Report will be developed to include recommendations for further action." However, the ROD requires each sample result meet the RGs, therefore any reference to assessing risk must be applied within the context of meeting the RGs.

Please revise the SAP to require remediation of any location where one or more sample results exceed RGs.

See response to USEPA General Comment 2 on the Parcel G work plan. Worksheet 11 has been updated to reflect the response.

5. The number of surface samples is insufficient. Under the SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Step 5, Develop Decision Rules, the Background Evaluation subsection states that the statistical difference between data sets will be evaluated using the nonparametric Kruskal-Wallis (KW) test by comparing the calculated p-value against 0.05 significance level. However, background data sets only propose to collect five surface samples at each on-site location, which does not provide a sufficient data pool for estimating population parameters. The number of surface samples per on-site reference background area (RBA) location should be increased to provide sufficient data for statistical evaluation. In addition, the off-site RBA location should include sampling for subsurface soils. Please increase the number of surface samples at each on-site RBA and propose collecting subsurface samples at the off-site RBA.

See response to USEPA General Comments 12b and 12d on the Parcel G work plan. The number of samples has been increased accordingly throughout the SAP.

6. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements Step 5 – Develop Decision Rules does not state what investigative actions will be taken if the additional six inches of the trench sidewalls and floors has ROCs above RGs. Scanning and/or sampling of the trench sidewalls and floors should be conducted to investigate the location and extent of

any remaining contamination. Please revise the SAP to include this requirement and to include this approach in the data quality objectives in Worksheet #11.

See response to USEPA General Comment 4 on the Parcel G work plan. Text in the Executive Summary and Worksheets 11, 14, and 17 have been updated to include in situ investigation/remediation.

7. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements Step 6 – Specify the Performance Criteria proposes to analyze soil samples for U-238 if Ra-226 is detected to confirm estimates of the background contribution of Ra-226. Per previous EPA comments, all uranium and thorium isotopes should be analyzed and reported by alpha spectroscopy for background evaluations. Please revise the SAP to require alpha spectroscopy of all uranium and thorium isotopes for site samples with elevated Ra-226 results.

See response to USEPA General Comment 19 on the Parcel G work plan. Worksheet 11 has been updated accordingly.

8. Site samples should be analyzed for the same radionuclides as the RBA samples. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Step 6, Specify the Performance Criteria, states that all RBA samples will be analyzed by the respective method for the radionuclides listed in Worksheets #15a, #15b, #15c, and #15d, which include most primordial and decay chain radionuclides by gamma spectrometry and isotopic uranium, thorium, plutonium, and americium. Statistical tests will be conducted to compare soil data sets from surface gamma scan surveys, and surface and subsurface analytical concentrations against different identified soil types and against each RBA per sample depth. However, it is unclear how this data will be used in a background evaluation of site sample results since the SAP proposes to only analyze site samples for a limited number of radionuclides and to only perform alpha spectrometry analysis for U-238 if Ra-226 is detected in the gamma spectrometry analysis at concentrations greater than the RG. Per previous Regulatory Agency request, all site samples should be analyzed for the same radionuclides as the RBA samples. At a minimum, the requirement to analyze samples with Ra-226 concentrations above the RG for all uranium and thorium isotopes should be included in the SAP. Please revise the SAP accordingly.

See response to USEPA General Comment 19 on the Parcel G work plan. Worksheets 11 and 17 have been updated accordingly. Site samples will be analyzed for site-specific ROCs, as described in Worksheet 17.

9. SAP Worksheet #14, Summary of Project Tasks, does not discuss potential soil types, including those that are not native to the Bayview Hunters Point area, or how excavated soil will be segregated by soil type. Some fill has been determined to be granite from the Sierra, which has a very different radiological signature from local soil and rock. Also, the sand near the former theater is a unique fill type. While the backfill in the trenches is likely well mixed, the sidewall/floor unit (SFU) soil may not be, but there is no proposal to segregate this material by soil type during excavation. Also, use of the soil sorting system would preclude segregation by soil type. It may be possible to segregate SFU soil by soil type on a radiological screening yard (RSY) pad. Please revise the SAP to provide procedures for segregating SFU soil by soil type.

The lithology of excavated soil will be noted in the field; however, separation of excavated soil by soil type is not planned.

10. SAP Worksheet #15a, Reference Limits and Evaluation Soil Gamma Spectroscopy requires a Minimum Detectable Concentration (MDC) for cesium-137 (Cs-137) of 0.05 pCi/g, but the laboratory SOP provided quotes a Cs-137 detection limit of 0.1 pCi/g with a 500 gram dry sample. This can be remedied easily by using a counting geometry that would allow for twice the weight, increasing the count time by a factor of 4, or a combination of the two to reach the required detection limit of 0.05 pCi/g. Please revise the SAP to include the requirement that the contracted laboratory to meet the Worksheet #15 MDCs.

The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. However, the lab can achieve the lower MDCs specified in Worksheet 15a with larger aliquots and/or longer count times. A footnote was added for clarification.

11. SAP Worksheet #17, Sampling and Survey Design and Rationale is incomplete because it does not discuss whether soil samples collected from areas around Buildings 351, 364, and 365 identified in the Historical Radiological Assessment (HRA) as locations where Plutonium-239 (Pu-239) was used will be analyzed for Pu-239 as a requirement. Please revise the SAP to include a requirement to analyze all site soil samples for Pu-239 that are collected from trenches near or around all Parcel G buildings identified in the HRA as being associated with the use or disposal of Pu-239.

See CDPH Specific Comment 49 and the response on the Parcel G work plan. Worksheet 17 has been updated accordingly.

12. SAP Worksheet #17, Sampling and Survey Design and Rationale is incomplete because it does not require Plutonium-239 (Pu-239) analysis for all site soil samples collected from trench units near or around Buildings 351A, 364, and 365, which were identified in the Historical Radiological Assessment (HRA) as locations where Pu-239 was used and is a ROC. The SAP states Pu-239 analyses will only be conducted for soil samples with Cs-137 or Sr-90 detections at or above the respective RG. However, the SAP states Sr-90 analysis will only be performed for 10% of the samples, therefore this criterion is not appropriate for TUs near buildings that previously handled Pu-239. Please revise the SAP to include a requirement to analyze all site soil samples from trenches near or around all Parcel G buildings identified in the HRA as being associated with the use or disposal of Pu-239.

Pu-239 is only an ROC at the Former Buildings 317/364/365 Site; therefore, analysis for Pu-239 will be performed for 10 percent of systematic soil samples associated with the SUs at the former Buildings 317/364/365 Site. The 10 percent will be selected at random. Additional Pu-239 analyses will be performed on samples with Cs-137 or Sr-90 results at or above the RG. The text in Worksheet 17 has been updated for clarification.

13. SAP Worksheet #17, Sampling and Survey Design and Rationale, is inconsistent with Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, because Worksheet #17 does not propose segregating sidewall and floor unit soil on RSY pads. Please resolve this discrepancy.

The segregation of soil applies to both the soil sorter and RSY pads and the text in the Phase 1 Trench Unit sections in Worksheets 14 and 17 were updated for clarification. References to these worksheets are provided in Worksheet 11.

14. Previously submitted comments/concerns summary: The SAP gives details related to *Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard, San Francisco, California, June 15, 2018* (“Work Plan”). Therefore, many of the comments that EPA made on the draft Work Plan¹ also apply to the SAP. The draft SAP arrived for review at the same time that EPA submitted its comments on the Work Plan, so the Navy would not have had the opportunity to incorporate the Work Plan comments into the SAP. For convenience, this comment summarizes some examples of the Work Plan comments that are also relevant to the SAP. We appreciate that the Navy stated its intentions to incorporate regulatory comments already given for the Work Plan into the relevant corresponding aspects of the next version of the draft SAP.

- a. The SAP states that if site conditions are not compliant with the Parcel G ROD remedial action objectives (RAOs), then the data will be evaluated to determine whether site conditions are protective of human health using the EPA’s current guidance on Radiation Risk Assessment at CERCLA Sites rather than that exceedances will be excavated.

See response to USEPA General Comment 3 on the Parcel G work plan. Accordingly, the text has been revised throughout the SAP.

- b. The SAP Executive Summary and Worksheet #11 Decision Rules do not state that if contamination is identified in any of the initial 33 percent (%) of trench units/survey units (TUs/SUs), then all TUs/SUs in Parcel G will require excavation and investigation.

See response to USEPA General Comment 2 on the Parcel G work plan. Accordingly, the text has been revised throughout the SAP.

- c. The SAP does not include all the technical information requested for the proposed sample analyses, including a copy of all sampling and analytical standard operating procedures (SOPs) and as applicable, nuclide libraries used to quantitate results.

All analytical SOPs and nuclide libraries were checked and are included in Attachment 3.

- d. Analysis and reporting of all uranium and thorium isotopes by alpha spectroscopy for samples with elevated radium-226 (Ra-226) are not specified.

See response to USEPA General Comment 19 on the Parcel G work plan. Accordingly, the text has been revised throughout the SAP.

- e. A requirement to report count times, results, counting and total propagated uncertainty for all radiological results is not specified.

A footnote was added in Worksheet 14 to specify that reported radiological results will, at a minimum, include count times, results, counting uncertainty, and total propagated uncertainty.

- f. Only six locations are proposed for collection of core samples in Phase 2 trenches rather than at the number of locations as identified using the Multi-Agency Radiological Site

Survey and Investigation Manual (MARSSIM) formulas for performing a statistical analysis.

See response to USEPA General Comment 5 on the Parcel G work plan. The SAP has been updated to include 18 boring locations in Phase 2 TUs.

- g. The SAP does not state how large the SUs will be for Phase II, or how the size will be determined. Note that per MARSSIM guidance, Class 2 land areas should not exceed 10,000 square meters. EPA expects the survey units to be the same size as in previous work, i.e. the size of soil survey units will not exceed 1,000 square meters and the building survey unit sizes will not increase.

As stated in Worksheet 14, the size and boundaries of TUs/SUs will be based on previous plans and reports. The specific TU/SU sizes are detailed in the Parcel G work plan.

- h. The SAP discusses the soil sorting operations used to screen excavated soil but does not include an operations plan or include the specifics about which radiological properties will be monitored or how alarms will be set to segregate soils that will receive further radiological investigation/analysis.

The SAP only provides a summary of the soil sorting operations and refers to the Parcel G work plan text which contains a more detailed description. A contractor-specific Soil Sorting Operations Plan will be prepared and submitted for regulator review.

- i. The SAP does not provide the basis for the number of samples planned to be collected from TUs/SUs. It also does not propose incorporating the variance from newly collected data in MARSSIM equation 5-1 for updating the required number of samples to be collected from each survey unit as new data is collected as part of the Parcel G investigation. EPA comments recommend using MARSSIM procedures to calculate those.

See response to USEPA General Comment 5 on the Parcel G work plan.

- j. The SAP does not address the instrumentation and survey parameters for investigating the potential presence of radiological objects such as deck markers containing Strontium-90 (Sr-90) in soil.

See response to USEPA Specific Comment 8 on the Parcel G work plan.

- k. The SAP does not provide sufficient information to fully evaluate the sufficiency of the buildings investigation. It also does not propose updating the building release criteria using the EPA Building Preliminary Remediation Goal (BPRG) Calculator for radionuclides to ensure the limits remain protective of human health.

See response to USEPA General Comment 9 on the Parcel G work plan.

- l. The SAP does not explain the assignment of MARSSIM classifications to all building survey units.

Worksheet 17 was updated to explain the MARSSIM survey unit classifications for buildings.

- m. The SAP does not state how the number of static measurements was determined for building survey units and does not propose incorporating the variance from newly collected data in the MARSSIM equation 5-1 for updating the number of static measurements required to be collected from each survey unit as new data is collected as part of the Parcel G building investigation.

See response to USEPA General Comment 5 on the Parcel G work plan.

- n. The SAP does not state if wipe samples will be sent to the laboratory for destructive analysis to determine which radionuclide is contributing to the radiation if release limits are exceeded for gross alpha or gross beta.

Swipe or material samples may be sent to the offsite laboratory for further analysis and this was added to the SAP.

- o. The SAP proposes to evaluate background data for outliers using Dixon's and Rosner's statistical outlier tests, both of which assume the data are normally distributed. Population distributions are often not normally distributed; therefore, population distribution and careful evaluation of background data should be performed to fully justify removing any data points.

See response to USEPA Specific Comment 25 on the Parcel G work plan.

- p. The SAP does not propose analyzing and reporting all naturally occurring radionuclides in site samples that are also Radionuclides of Concern (ROCs) to determine if the uranium-238 (U-238) and thorium-232 (Th-232) decay chains are in secular equilibrium prior to conducting any outlier evaluations or comparison of ROCs to background levels of radionuclides.

See response to USEPA General Comment 19 on the Parcel G work plan. The SAP has been updated accordingly.

Please ensure that the SAP is revised to address these issues.

See responses to comments a through p above.

Specific Comments

1. SAP Worksheet #9, Project Scoping Session Participants Sheet, Pages 35, 36: Please include Dave Kappelman in this worksheet.

Dave Kappelman was not on the list of attendees for the December 7, 2016 meeting.

2. SAP Worksheet #14, Summary of Project Tasks, Page 59: The Data Management subsection does not provide sufficient data management requirements. The worksheet states that electronic

copies of original electronic data sets will be preserved on a nonmagnetic retrievable data storage device and further states additional details are provided in Worksheet #29 and the Parcel G Work Plan Appendix B SOPs. Worksheet #29 states that data will be maintained in project files and stored for a minimum of 7 years in accordance with the CLEAN 9000 contract requirement. However, given the nature of the planned future use of the site for residential re-development, please revise the SAP to propose retaining files for a longer period of time.

Worksheets 14 and 29 were updated to indicate that analytical data will be stored in NIRIS and will be included in final reports.

3. SAP Worksheet #14, Summary of Project Tasks, Page 59: The Data Management subsection states that project data will be documented in accordance with the Parcel G Work Plan Appendix B. The data management SOP in the Parcel G Work Plan Appendix B, SOP RP-114, Control of Radiation Protection Records, defines documentation requirements for "radiation protection records." Therefore, it appears the intent of this SOP is to govern worker protection records rather than environmental data. In addition, neither Worksheet #29 nor the Parcel G Work Plan specifies the location of the storage facility where these records will be maintained. Please revise the Parcel G Work Plan or SAP to include a SOP, or additional explanation for the requirements storing all project documents, to ensure the integrity and long-term retention of such records.

Worksheets 14 and 29 were updated for clarification on environmental data storage, including the locations for file storage.

4. SAP Worksheet #23, Analytical SOP References, Pages 93-94: This worksheet includes a listing of methods and SOPs, however some of the SOPs referenced in this worksheet are not included in Attachment 3, Laboratory SOPs. For example, SOP GL-RAD-A-013, The Determination of Gamma Isotopes, Revision 26, February 2017 is not included in Attachment 3. Please revise the SAP to include all analytical SOPs listed in Worksheet #23 and to ensure the nuclide libraries are included for all relevant methods.

All analytical SOPs and nuclide libraries were checked and are included in Attachment 3.

DTSC Comments

General Comments

1. Executive Summary, paragraph 2 refers to allegations. See DTSC draft Work Plan comment #9.

See response to USEPA Specific Comment 2 on the Parcel G work plan. The SAP has been updated accordingly.

2. Executive Summary, Soil Investigations -See DTSC draft Work Plan comment #6 regarding selection of trench and building soil survey units to be sampled.

See response to USEPA General Comment 13 on the Parcel G work plan. The SAP has been updated accordingly.

3. Executive Summary, Soil Investigations, paragraph 3 -See DTSC draft Work Plan comment #7 regarding the 6 inches of excavated soil along trench walls.

See response to USEPA General Comment 4 on the Parcel G work plan. The SAP has been updated accordingly.

4. Executive Summary, Soil Investigations, paragraph 4 -See DTSC draft Work Plan comment #8 regarding Phase II.

See response to USEPA General Comment 6 on the Parcel G work plan. The SAP has been updated accordingly.

5. Executive Summary, Data Evaluation, last paragraph -See DTSC draft Work Plan comments #4 and 5.

See response to USEPA General Comment 3 and CDPH General Comment 1 on the Parcel G work plan. The SAP has been updated accordingly.

6. SAP Worksheet #9 -Project Scoping Session participants Sheet -Generally information pertaining to community outreach is not included in an SAP. Suggest retitling Action Items to SAP Specific Action Items and delete bullet two through four.

Worksheet 9 was revised as suggested.

7. SAP Worksheet #10, Conceptual Site Model, par. 2 -See DTSC draft Work Plan comment #9

See response to USEPA Specific Comment 2 on the Parcel G work plan. The SAP has been updated accordingly.

8. SAP Worksheet #10, Conceptual Site Model, pg. 43, Current Status -Parcel UC- 2 should be added as a Parcel that has been transferred to San Francisco.

Worksheet 10 was revised as requested.

9. SAP Worksheet #11, Step 5 Develop Decision Rules, Bullet 2 and Step 6, Specify the Performance Criteria last bullet -See DTSC draft Work Plan comment #5

See response to CDPH General Comment 1 on the Parcel G work plan. The SAP has been updated accordingly.

10. SAP Worksheet #11, Step 5 and 6 -Reference Background Areas data evaluation process should be revised to reflect comments that will be provided by the U.S. EPA on the draft SAP.

Worksheet 11 has been revised to reflect the comments on the Parcel G work plan and SAP.

11. SAP Worksheet #11, Step #7, Develop the Plan for Obtaining Data -See DTSC draft Work Plan comment #8.

See response to USEPA General Comment 6 on the Parcel G work plan. The SAP has been updated accordingly.

12. SAP Worksheet #14, Phase 1 Trench Unit - This section indicates that excavated soil will "undergo radiological assay following either the automated soil sorting process or Radiological

Screening Yard (RSY) pad process." CDPH EMB has indicated that the automated soil sorting process must be approved by CDPH staff prior to initiation of this method. Most likely, the US EPA will also require the same. Therefore, please revise this Section as follows: "undergo radiological assay following either the automated soil sorting process (if approved by CDPH and US EPA) or Radiological Screening Yard (RSY) pad process."

The Soil Sorting Operations Plan will be submitted to the regulatory agencies for review and concurrence. See response to CDPH Specific Comment 12 on the Parcel G Work Plan.

13. SAP Worksheet #14, Phase 2 Trench Unit - See DTSC Work Plan comment #8

See response to USEPA General Comment 6 on the Parcel G work plan. The SAP has been updated accordingly.

14. SAP Worksheet #14, Phase 2 Trench Unit, paragraph 4 - See DTSC Work Plan comment #1. SAP Figures will need to be revised accordingly.

See response to USEPA General Comment 2 on the Parcel G work plan. The figures have been updated accordingly.

15. SAP Worksheet #14, Phase 2 Survey Unit - See DTSC Work Plan comment #1. SAP Figures will need to be revised accordingly.

See response to USEPA General Comment 2 on the Parcel G work plan. The figures have been updated accordingly.

16. SAP Worksheet #14, Site Restoration and Demobilization - If imported fill material is required to complete backfill requirements, DTSC's guidance, Information Advisory Clean Imported Fill Material must be used.

Worksheet 14 was revised as requested.

17. SAP Worksheet #17, Sampling and Survey Design and Rationale - See DTSC Work Plan comment #1. SAP Figures will need to be revised accordingly. Additionally, DTSC defers to CDPH and US EPA to provide comments on the technical aspects of this worksheet.

See response to USEPA General Comment 2 on the Parcel G work plan. The figures have been updated accordingly.

18. SAP Worksheets - DTSC defers to CDPH and US EPA to provide comments on all technical radiological worksheets provided in the SAP.

Comment noted.

CDPH Comments

General Comments

1. Please note that CDPH-EMB utilizes Section 30256 in Title 17 of the California Code of Regulations (17 CCR 30256) to render a decision to concur with a Radiological Unrestricted

Release Recommendation (RURR). As a result, CDPH-EMB requires a final status survey report that compares the distribution of data from the survey site with applicable reference area data and documents the remediation efforts. The final status survey should document and explain reasonable efforts that have been made to remediate the site.

See response to CDPH General Comment 1 on the Parcel G work plan. The SAP has been updated accordingly.

2. CDPH-EMB received the draft sampling and analysis plan (SAP) three days after submittal of our comments on the draft Parcel G Evaluation Work Plan (June, 2018) on August 14, 2018, because of this we understand that our comments on the Work Plan have not been reflected in the draft SAP. Therefore, to avoid repeating our previous comments, many of EMB's comments on the draft SAP refer to specific comments on the draft Work Plan. The comments submitted for the draft Parcel G Evaluation Work Plan are attached for reference purposes.

Comment noted, the SAP was updated per the Parcel G work plan comments and responses to comments.

Specific Comments

3. Executive Summary, page five, paragraph two, sentence four, "There have been various allegations of data manipulation or falsification committed by TtEC employees and their subcontractors during the TCRA." These allegations have been admitted to by Tetra Tech Inc., NJ; in a 10/11/2016 Nuclear Regulatory Commission Enforcement Action, EA-15-230; specifically that employees of Tetra Tech deliberately falsified soil sample records on several occasions at HPNS. Additionally, two Tetra Tech Radiological Supervisors, Justin Hubbard, and Stephen Rolfe, both supervisors for Tetra Tech at HPNS; pled guilty to falsifying soil samples in Federal Court and were incarcerated. Please correct the record in this, and in any similar references in this document (including, but not limited to, work sheets, attachments and appendices) to "allegations" by noting that both the Tetra Tech admission plea in the 10/11/2016 Nuclear Regulatory Commission Enforcement Action, EA-15-230 and the subsequent guilty pleas of the two individuals noted above.

See response to USEPA Specific Comment 2 on the Parcel G work plan. The Executive Summary has been updated accordingly.

4. Executive Summary, (Soil Investigations), page five, paragraph one, sentence one, "Soil investigations will be conducted in a phased approach at the following areas in Parcel G: ... " Please see EMB comment number 10.

See response to CDPH Specific Comment 10 on the Parcel G work plan. The SAP was updated accordingly.

5. Executive Summary, (Soil Investigations), page five, paragraph one, sentence two, "Phase 1 includes investigation of a targeted group of trench units (TUs) and survey units (SUs). Of the 63 former sanitary sewer and storm drain TUs, 21 were selected for the Phase 1 investigation." Please see EMB comment number 11.

See response to CDPH Specific Comment 11 on the Parcel G work plan. The SAP was updated accordingly.

6. Executive Summary, (Soil Investigations), page six, paragraph two, sentence two, "2) soil may be processed and scanned using soil segregation technology." Please see EMB comment number 12.

See response to USEPA Specific Comment 12 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

7. Executive Summary, (Soil Investigations), page six, paragraph two, sentence three, "Following excavation to the original TU boundaries, additional excavation of approximately 6 inches of the trench sidewalls and floors will be performed to provide ex situ scanning and sampling of the trench sidewalls and floors." Please see EMB comments numbers 13 and 14.

See responses to CDPH Specific Comments 13 on the Parcel G work plan. The SAP was updated accordingly.

8. Executive Summary, (Soil Investigations), page six, paragraph three, sentence five, "The data will be compared and evaluated to provide representative RBA data sets that will be used to evaluate site investigation data to support a final decision on whether residual radioactivity is found to exceed the RGs, thus requiring further remediation." Please see EMB comment number 7.

See response to CDPH Specific Comment 7 on the Parcel G work plan. The SAP was updated accordingly.

9. Executive Summary, (Building Investigations), page six, paragraph one, sentence one, "Building investigations will be performed at the following structures in Parcel G ... " Please see EMB comment number 8.

See response to CDPH Specific Comment 8 on the Parcel G work plan. The SAP was updated accordingly.

10. Executive Summary, (Data Evaluations), page seven, paragraph three, sentence one, "If the investigation results demonstrate that site conditions are not compliant with the Parcel G ROD RAO, then the data will be evaluated to determine whether site conditions are protective of human health using the United States Environmental Protection Agency's (USEPA's) current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014a)." Please see EMB comment number 19.

See response to CDPH General Comment 1 on the Parcel G work plan. The SAP was updated accordingly.

11. SAP Worksheet #10-(Conceptual Site Model), page 39, paragraph two, sentence one, "Following the investigation and removal actions, there were allegations that TtEC potentially manipulated and falsely represented data." Please see EMB Specific Comment number 3 of this memo.

See response to USEPA Specific Comment 2 on the Parcel G work plan. The SAP was updated accordingly.

12. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 1, (State the Problem), page 45, paragraph one, sentence one, "There have been various

allegations of data manipulation or falsification committed by a contractor during past sanitary sewer and storm drain removal actions and current and previous soil and building investigations in Parcel G." Please see EMB Specific Comment number 3 of this memo.

See response to USEPA Specific Comment 2 on the Parcel G work plan. The SAP was updated accordingly.

13. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 5, (Develop Decision Rules), page 45. bullet one. sentence two, *"The RACR will describe the results of the investigation, and will provide a demonstration that radioactivity levels meet the Parcel G RAO or represent background conditions."* Please replace the word, "or", with the word, "and".

See response to USEPA General Comment 2 on the Parcel G work plan. Worksheet 11 was updated accordingly.

14. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 5, (Develop Decision Rules), page 45, bullet one, sentence one, *"If the building and soil investigation results demonstrate that site conditions are not compliant with the Parcel G RAO and exceed background levels, then the data will be evaluated to determine whether site conditions are protective of human health using USEPA 's current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014a),* Please see EMB comment number 19.

See response to CDPH General Comment 1 on the Parcel G work plan. Worksheet 11 was updated accordingly.

15. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 6, (Specify the Performance Criteria). page 45. bullet one, inset one. sentence two, *"Analysis will be based on the site-specific ROCs (Worksheet #17). All soil samples at a minimum will be assayed by gamma spectroscopy for 137Cs and 226Ra with at least 10 percent of samples receiving gas flow proportional analysis for 90Sr. Additionally, if the laboratory results indicate concentrations of 137Cs above its RG (Worksheet #15a), the sample will be analyzed for 90Sr. If the laboratory results indicate the presence of concentrations of 137Cs or 90Sr at or above the respective RG (Worksheets #15a and #15c), additional analysis via alpha spectroscopy for 239Pu will be performed (Worksheet #15b).* Please see EMB comments numbers 48 and 49.

See responses to CDPH Specific Comments 48 and 49 on the Parcel G work plan. Worksheet 17 was updated accordingly.

16. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Develop the Plan for Obtaining Data), page 45, Soil Investigation, bullet one, inset one, sentence one, *"Phase 1 TUs/SUs - The radiological investigation will be conducted on a targeted group of 21 of the 63 TUs associated with former sanitary sewers and storm drains, and 14 of the 28 SUs associated with surface soil at building sites in Parcel G (see Figure 11-1). The Phase 1 TUs/SUs will be investigated using gamma scan surveys and soil sampling as described in Worksheets #14 and #17."* Please see EMB comment number 22.

See response to CDPH Specific Comment 22 on the Parcel G work plan. The SAP was updated accordingly.

17. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Develop the Plan for Obtaining Data), Soil Investigation, page 45, bullet one, inset two, sentence one, *"Phase 2 TUs/SUs - Additional soil sampling will be conducted on the remaining 42 TUs and 14 SUs in Parcel G (see Figure 11-1). The Phase 2 TUs/SUs will be investigated with soil sampling and scanning of soil cores as described in Worksheets #14 and #17.* Please see EMB comment number 25.

See response to CDPH Specific Comment 25 on the Parcel G work plan. The SAP was updated accordingly.

18. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Develop the Plan for Obtaining Data), Soil Investigation. page 45, bullet one, inset three, sentence one, *"The soil samples collected as part of the Phase 1 and Phase 2 investigations will be analyzed for the applicable ROCs by accredited offsite laboratories and the results will be evaluated as described in Step 6."* Please see EMB comment number 21.

See response to CDPH Specific Comment 21 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

19. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Develop the Plan for Obtaining Data), Soil RBA Investigation, page 45. inset one, bullet one, sentence one, *"Soil samples will be analyzed for the applicable ROCs along with NORM radionuclides and fallout radionuclides by accredited offsite laboratories (Worksheet #17)."* Please see EMB comment number 25.

See response to CDPH Specific Comment 12 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

20. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Building Investigation),page 45, inset one, sentence one, *"Building investigations will be conducted on floors, wall surfaces, and ceiling surfaces, and will consist of alpha and beta scan surveys, alpha-beta static measurements, and alpha-beta swipe samples as described in Worksheets #14 and #17.")."* Please see EMB comment number 15.

See response to CDPH Specific Comment 15 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

21. SAP Worksheet #12-(Field Quality Control Samples) - page 49, Soil Measurement Performance Criteria Table - Field QC Samples, Split Sample, Frequency, *"To be determined by the stakeholders on a case by case basis for each site."* Please retain all soil samples obtained for regulatory agency confirmation.

Worksheet 12 was updated to state that soil samples will be retained until the contractor for Parcel G soil work demobilizes from the site.

22. SAP Worksheet #13-Secondary Data Criteria and Limitations, page 51;(How Data Will be Used), *"To determine whether site conditions in soil and building surfaces are compliant with the Parcel G ROD RAO (Navy, 2009), analytical and building data will be compared to the RGs for Parcel G ROCs."* Please see EMB comment number 19.

See response to CDPH General Comment 1 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

23. SAP Worksheet #14-Summary of Project Tasks (Automated Soil Sorting System), page 56, paragraph one, sentence one, "Soil sorting systems are radiological monitoring and processing systems designed to perform real-time segregation of soil into two distinct bins based upon the soil's radiological properties" Please see EMB comment number 12.

See response to USEPA Specific Comment 12 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

24. SAP Worksheet #14-Summary of Project Tasks (Phase 2 Trench Unit), page 56, paragraph one, sentence two, "Subsurface soil samples will be collected as described in Worksheet #21 and Attachment 2)." Please see EMB comment number 25.

See response to CDPH Specific Comment 25 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

25. SAP Worksheet #15a-Reference Limits and Evaluation Soil Gamma Spectroscopy, (Laboratory-Specific Limits), MDC (pCi/g), page 63. The limits in this table of 0.05 and 0.1 pCi/g respectively for Cs-137 and Ra-226; appear to be less than the Method Scope, Applicability, And Detection Limit listed in Standard Operating Procedure, GL-RAD-A-013 Rev 26, (The Determination of Gamma Isotopes), Section 3.1, "A typical detection limit is 10 pCi/L or 0.1 pCi/g (based on Cs-137)": as well as the Method Scope, Applicability, And Detection Limit listed in Standard Operating Procedure, GL-RAD-A-008 Rev 15, GEL Laboratories, LLC (GEL). (Determination of Radium-226), Section 3.2, "Method Detection Limit (MDL): typical minimal detectable activity (MDA) for samples analyzed for Ra-226 is 1pCi/L or 1pCi/G." Please resolve these differences.

The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. However, the lab can achieve the lower MDCs specified in Worksheet 15a with larger aliquots and/or longer count times. A footnote was added for clarification.

26. SAP Worksheet #15b-Reference Limits and Evaluation Soil Alpha Spectroscopy, (Laboratory-Specific Limits), MDC (pCi/g), page 64. The limits in this table of 0.1 and 0.5 pCi/g respectively for Ra-226 and Pu-239/240; appear to be less than the Method Scope, Applicability, And Detection Limit listed in Standard Operating Procedure, GL-RAD-A-011 Rev 26, GEL Laboratories, LLC (GEL). (The Isotopic Determination of Americium, Curium, Plutonium and Uranium), Section 3.1. "Method Detection Limit (MDL) Typical minimum detectable activity (MDA) for samples analyzed for Am/Cm/Pu/U is 1 pCi/L or 1 pCi/g for all isotopes." Please resolve these differences for Pu-239/40.

The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. However, the lab can achieve the lower MDCs specified in Worksheet 15b with larger aliquots and/or longer count times. A footnote was added for clarification.

27. SAP Worksheet #15c-Reference Limits and Evaluation Soil Gas Flow Proportional Counting: (Laboratory-Specific Limits). MDC (pCi/g), page 65. The limits in this table for Sr-90, 0.15 pCi/g;

appear to be less than the Method Scope, Applicability, And Detection Limit listed in Standard Operating Procedure, GL-RAD-A-004 Rev 18, GEL Laboratories, LLC (GEL). (The Determination of Strontium 89/90 in Water, Soil, Milk, Filters, Vegetation, and Tissues), Section 3.1, "Method Detection Limit (MDL): Typical minimum detectable activity (MDA) for samples analyzed for Sr-89 and Sr-90 is 2 pCi/L or 2 pCi/g." Please resolve these differences.

The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. However, the lab can achieve the lower MDC specified in Worksheet 15c with larger aliquots and/or longer count times. A footnote was added for clarification.

28. SAP Worksheet #17-Sampling and Survey Design and Rationale (Soil Investigation), page 73 paragraph one, sentence two, "The radiological investigation design and rationale are based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012), with the ultimate requirement to demonstrate compliance with the Parcel G ROD RAO". Please see EMB comment number 19.

See response to CDPH General Comment 1 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

29. SAP Worksheet #17-Sampling and Survey Design and Rationale (Soil Investigation), page 73 paragraph three, sentence two, "Additionally, Phase 2 SU samples collected from the Former Building 317/364/365 Site will also have 10 percent of samples receiving alpha spectroscopy analysis for 239Pu. If the laboratory results indicate concentrations of 137Cs above its RG (Worksheet #15a), the sample will be analyzed for 90Sr (Worksheet #15c)." Please see EMB comments 48 and 49.

See response to CDPH Specific Comments 48 and 49 on the Parcel G work plan. Worksheet 17 was updated accordingly.

30. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 1 Trench Unit), page 73 paragraph one, sentence one. "Radiological investigations will be conducted on a targeted group of 21 of the 63 TUs associated with former sanitary sewer and storm drain lines (Figure 11-1 and Worksheet #18) to evaluate whether concentrations of ROCs are compliant with the RAO in the Parcel G ROD (Navy, 2009)." Please see EMB comments numbers 8 and 19.

See responses to CDPH Specific Comments 8 and CDPH General Comment 1 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

31. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 1 Trench Unit), page 74, paragraph two, bullet one sentence one, "If the automated soil sorting system process is used, 18 systematic soil samples will be collected from each ESU or SFU during assay with the soil sorting system". Please see EMB comment 12.

See response to USEPA Specific Comment 12 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

32. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 2 Trench Unit), page 74, paragraph two, sentence one, *"Within the backfill of each Phase 2 TU boundary, six systematic locations will be cored down to approximately 6 inches below the depth of the previous excavation"*. Please see EMB comment number 25.

See response to CDPH Specific Comment 25 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

33. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 2 Trench Unit), page 74, paragraph three, sentence one, *"An additional set of 18 systematic samples will be collected from 6 systematic locations representative of the trench sidewalls"*. Please see EMB comment number 25.

See response to CDPH Specific Comment 25 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

34. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 1 Survey Unit), page 75, paragraph one, sentence one, *"The Phase 1 SU investigation will be conducted on a targeted group of 14 of the 28 SUs associated with soil from building sites where only surface soil scanning and sampling were previously conducted (Figure 11-1)"*. Please see EMB comment number 8.

See response to CDPH Specific Comment 8 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

35. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 2 Survey Unit), page 75, paragraph one, sentence one, *"The Phase 2 SU investigation will be conducted on the remaining 14 of 28 SUs in Parcel G (Figure 11-1)." Please see EMB comment number 8.*

See response to CDPH Specific Comment 8 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

36. SAP Worksheet #17-Sampling and Survey Design and Rationale (Reference Background Area Investigation), page 76, paragraph two, sentence two, *"In order to simplify the sampling design, an approximately 20-foot by 20-foot square has been established within each of the four historical RBA footprints."* Please see EMB comment number 65.

See response to CDPH Specific Comment 65 on the Parcel G work plan. The SAP has been updated accordingly.

37. SAP Worksheet #17-Sampling and Survey Design and Rationale (Reference Background Area Investigation), page 76, paragraph two, sentence eight, *"Both surface gamma scan surveys and surface soil samples will be collected from RBA-Bayview to provide a more accurate surface soil data set to represent undisturbed surface soil areas."* Will subsurface soil samples be taken in the Bayview Park RBA? If so, how many subsurface soil samples will be obtained?

Twenty-five subsurface soil samples be collected from the RBA-McLaren location and the SAP was updated to reflect this.

38. SAP Worksheet #17-Sampling and Survey Design and Rationale (Building Investigation), page 77, paragraph one, sentence two, "The radiological investigation design and rationale is based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012), with the ultimate requirement being to demonstrate compliance with the Parcel G ROD RAO." Please see EMB comment number 19.

See response to CDPH General Comment 1 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

39. SAP Worksheet #17-Sampling and Survey Design and Rationale (Building Investigation), page 78, paragraph one, sentence three, "Parcel G buildings will be divided into identifiable SUs similar in area and nomenclature to the previous final status survey of each building." The following differences have been identified on comparing the building survey efforts proposed in the Parcel G work plan with the building final status survey reports (from years 2009 and 2010). Please provide justification for the deviation from the original work plan for each building and explain how the recommendations of the Historical Radiological Assessment (2004) are being met.

- a. Building 351A and Crawlspace: Survey units 045, 046, 047, R, S, and U are not being surveyed. Please explain.

For the Building 351A Crawl Space, former SU-R, SU-S, and SU-U overlapped SU-M, SU-N, and SU-O and will be investigated as SU-M, SU-N, and SU-O during the soil investigation and a footnote was added for clarification.

SUs 45, 46, and 47 in Building 351A will be surveyed as Class 2 SUs and the Class 2 SUs were added to the figure.

- b. Building 351: Survey Units 039, 040, 052, 053, 054 are not being surveyed. Please explain.

SUs 39, 40, 52, 53, and 54 in Building 351 will be surveyed as Class 2 SUs and the Class 2 SUs were added to the figure.

- c. Building 366: Survey Units 060 to 068 are not being surveyed. Please explain.

SUs 60 through 68 in Building 366 will be surveyed as Class 2 SUs and the Class 2 SUs were added to the figure.

- d. Building 401: Survey Units 001 to 022, 030, 031, and 032 to 035 are not being surveyed. Please explain.

SUs 1 to 22 and 30 to 35 in Building 401 will be surveyed as Class 1 or 2 SUs and are included and/or were added to the figure.

- e. Building 408: Survey Unit 002 is not being surveyed. Why does SU-001 have a different shape compared to the final status survey report (2009)? Please explain.

SU 2 will be surveyed as a Class 2 SU and was added to the figure.

- f. Building 411: Survey Unit-001, 002, 003, 004 are not being surveyed. Have the survey units SU-005 through SU-011 been redrawn? Will the second floor be surveyed? Please explain.

SUs 2 through 11 in Building 411 will be surveyed as Class 1 or 2 SUs and are included and/or were added to the figure. SUs 5 through 11 were not redrawn. The third floor and mezzanine are no longer accessible due to significant safety concerns and therefore SU 1 will not be surveyed. This explanation was added to the Parcel G work plan.

- g. Building 439: Survey Unit 003 is not being surveyed. Have the survey units SU-004 through SU-006 been redrawn? Please explain.

The original survey area consisted of two Class 1 SUs (SU 1 and SU 2) on the floors and lower walls of the enclosure, and a Class 2 SU (SU 3) on the enclosure upper walls and ceiling. After remediation was performed in a small area within SU 1, a new Class 1 SU (SU 4) was established within the remediated area, and two Class 2 SUs were established as buffer areas within the enclosure and in a 2-meter perimeter on the outside of the enclosure (SUs 5 and 6, respectively). Because of the overlap of the pre- and post-remediation SUs, the investigation at Building 439 will consist of Class 1 surveys in SUs 1 and 2, and Class 2 surveys in SUs 3 and 6 and the figure was updated to reflect this. The Class 1 survey in SU 1 will capture areas previously surveyed as SU 4 and 5.

40. Attachment B - Standard Operating Procedure (Locating and Clearing Underground Utilities), Services Available for Identifying and Marking Underground Utilities. None of the services that are available for identifying and marking underground utilities listed throughout this appendix are located in the State of California. Please correct.

The SOP was removed from the SAP and work plan. The work plan includes the utility locating process.

41. Attachment B - Standard Operating Procedure Decontamination of Personnel and Equipment Section F, (Heavy Equipment And Tools), page four, "Steam clean heavy equipment until no visible signs of dirt are observed." Is it in fact Navy's intent to steam clean heavy equipment and tools as they leave the radiologically controlled areas?

For radiologically controlled areas, equipment and materials will be surveyed and decontaminated based on the referenced SOP and procedures outlined in Section 6 of the Parcel G work plan. Steam cleaning may not be required if dry methods are successful in meeting the radiological release criteria.

Attachment 2

Field SOPs

Application and Description of Standard Operating Procedures

SOP Number	SOP Title	Application and Purpose
CH2M Document	Soil Sampling	Provides guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig-mounted equipment.
CH2M Document	Logging of Soil Borings	Provides guidance for obtaining accurate and consistent descriptions of soil characteristics during soil sampling operations.
CH2M Document	Decontamination of Equipment and Samples	Provides general guidelines for the decontamination of sampling equipment, and monitoring equipment used in potentially contaminated environments.
CH2M Document	Preparing Field Logbooks	Provides general guidelines for entering field data into logbooks during site investigation and remediation activities.
CH2M Document	Chain-of-Custody	Provides information on chain-of-custody procedures.
CH2M Document	Packaging and Shipping Procedures for Low-concentration Samples	Provides information on preparing, packaging, and shipping low activity radioactive samples for analysis.
RP-100	Radiation Protection Program	Describes the major elements of the Radiation Protection Program.
RP-102	Radiological Posting	Identifies the types of postings necessary and requirements to clearly identify radiological conditions in a specific area or location within an area for consistent posting and control of RCAs. It also specifies the requirements for access into and egress from RCAs.
RP-103	Radiation Work Permits Preparation and Use	Provides direction on the requirements of the application, preparation, approval, issuance, and use of general and specific Radiation Work Permits.
RP-104	Radiological Surveys	Specifies methods and requirements for radiological surveys, and the documentation required for the acquired survey data.
RP-105	Unrestricted Release Requirements	Describes the method of surveying equipment, materials, or vehicles for release for unrestricted use.
RP-106	Survey Documentation and Review	Provides the methodology for documenting radiological surveys and provides criteria for the review of these surveys.
RP-107	Measurement of Airborne Radioactivity	Provides the basis and methodology for the placement and use of air monitoring equipment, as well as the collection, analysis, and documentation of air samples.
RP-108	Count Rate Instruments	Provides the methods for setup, daily pre-operational check, and operation of portable count-rate survey instruments.
RP-109	Dose Rate Instruments	Provides the methods for performing source checks and operating portable gamma scintillation dose rate instruments, specifically, the Ludlum Model 12s uR and the Bicorn Model Micro Rem.
RP-111	Radioactive Materials Control and Waste Management Plan	Provides guidance and requirements for the control of radioactive materials, including the management of radioactive waste.
RP-112	Dosimetry Issue	Provides consistent methodology for the issuance of radiation monitoring dosimetry devices.

Application and Description of Standard Operating Procedures

SOP Number	SOP Title	Application and Purpose
RP-114	Control of Radiation Protection Records	Describes the requirements for controlling Radiation Protection Program records. It also establishes the requirements for review and temporary storage of these records.
RP-115	Radiation Worker Training	Provides consistent methodology for implementing Radiation Worker Training.
RP-130	Event Reporting and Notification for State of California	Provides a list of California regulatory contacts, a checklist for initiating emergency notifications, and general guidance for notification of incidents.
RP-132	Radiological Protective Clothing Selection, Monitoring, and Decontamination	Provides the guidance for selecting protective clothing, performing personnel surveys, and decontaminating personnel.

Note:

RCA = radiologically controlled area

Soil Sampling

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoop, coring device, hand auger, or other appropriate hand tool
- Split-spoon samplers
- Thin-walled sampling tubes
- Drilling rig or soil-coring rig
- Stainless-steel pan/bowl or disposable sealable bags
- Sample bottles

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP Decontamination of Drilling Rigs and Equipment. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. A decontaminated sampling tool will be used to collect the sample when the desired sampling depth has been reached. Soil for semivolatile organic and inorganic analyses is placed in the bowl and mixed; soil for volatile organic analysis is not mixed or composited but is placed directly into the appropriate sample bottles. A stainless-steel trowel or disposable plastic scoop is used to transfer the sample from the bowl to the container.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

More details are provided in the SOP Shallow Soil Sampling.

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight (“hammer”) dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless-steel tray or disposable sealable bag. The sample for semivolatile organic and inorganic analyses should be homogenized in the field by breaking the sample into small pieces and removing gravel. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

C. Thin-Walled Tube Sampling

Undisturbed fine grained samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) according to ASTM D 1587 (attached). Tubes will be 24- to 36 inches long and 3- to 4-inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends will be sealed with bees wax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample. Samples for geochemical analysis normally are not collected from thin-walled tube samples.

IV. Attachments

ASTM D 1586 Standard Penetration Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586.pdf)

ASTM D 1587 Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587.pdf)

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.



Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils¹

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in

parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,² NDA Drilling Safety Guide,³ drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 ASTM Standards:⁴

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
- D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
- D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- D 2488 Practice for Description and Identification of Soils

² Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, <http://www.osha.gov>.

³ Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, <http://www.nda4u.com>.

⁴ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

¹ This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

*A Summary of Changes section appears at the end of this standard.

(Visual-Manual Procedure)

- D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
- D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 4633 Test Method for Energy Measurement for Dynamic Penetrometers
- D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
- D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
- D 6026 Practice for Using Significant Digits in Geotechnical Data
- D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential
- D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
- D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
- D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N-value*, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m \pm 0.030 m) for each hammer blow.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N-value*, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N-value* should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

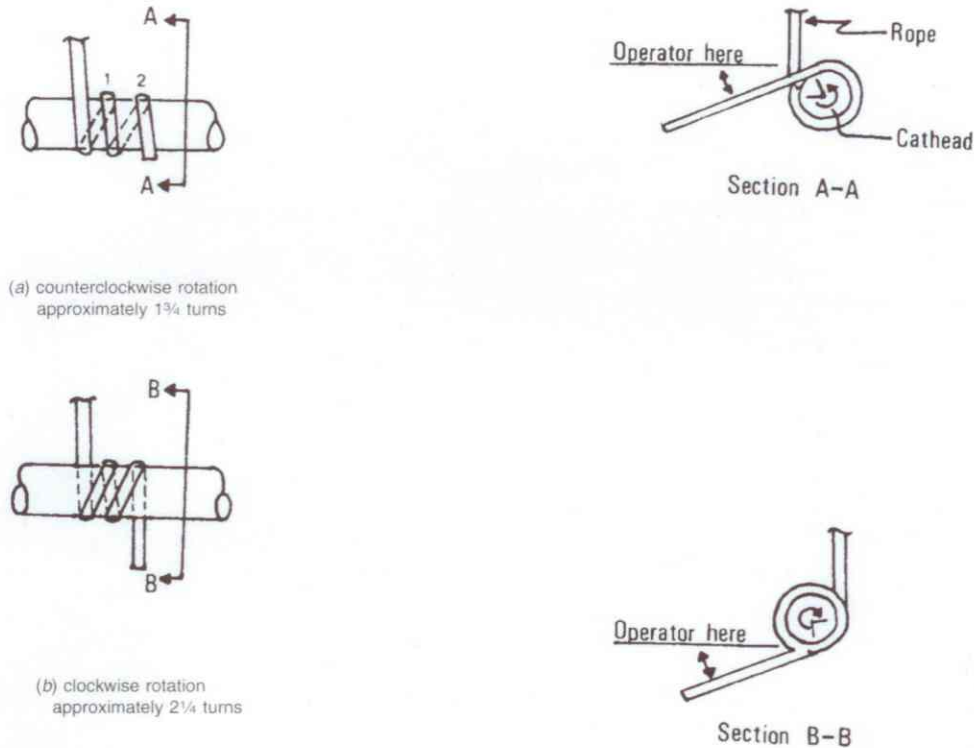


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

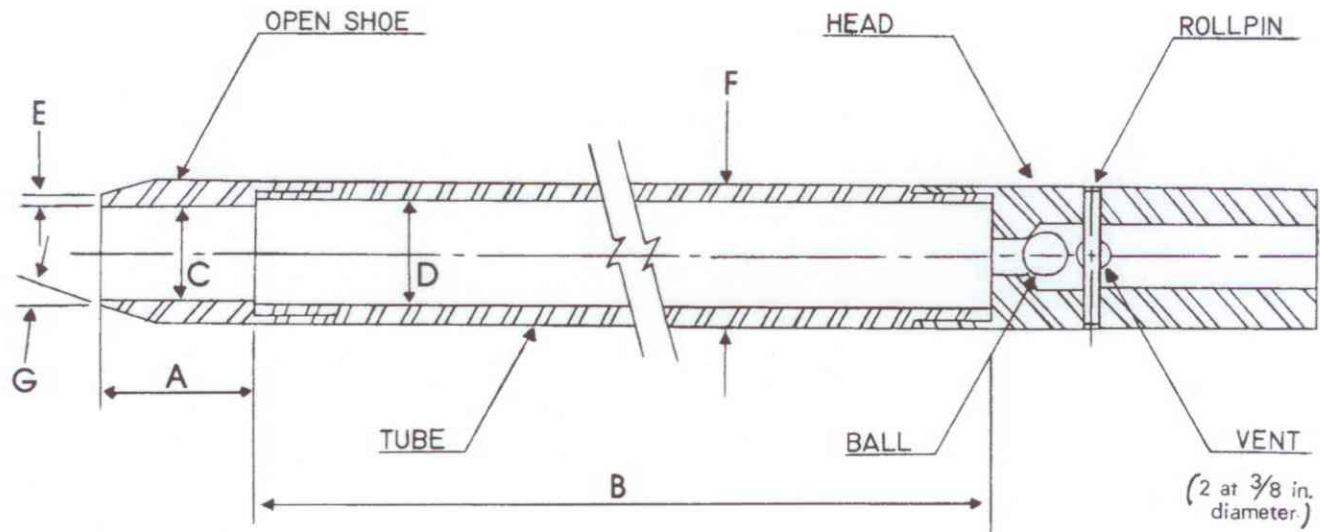
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall “A” rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm)).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



- A = 1.0 to 2.0 in. (25 to 50 mm)
- B = 18.0 to 30.0 in. (0.457 to 0.762 m)
- C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
- D = 1.50 ± 0.05 - 0.00 in. (38.1 ± 1.3 - 0.0 mm)
- E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
- F = 2.00 ± 0.05 - 0.00 in. (50.8 ± 1.3 - 0.0 mm)
- G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1/8-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1/2-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1/2 in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 Drive-Weight Assembly:

5.4.1 Hammer and Anvil—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbf (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 Hammer Drop System—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 Accessory Equipment—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

- 6.2.1 Open-hole rotary drilling method.
- 6.2.2 Continuous flight hollow-stem auger method.
- 6.2.3 Wash boring method.
- 6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

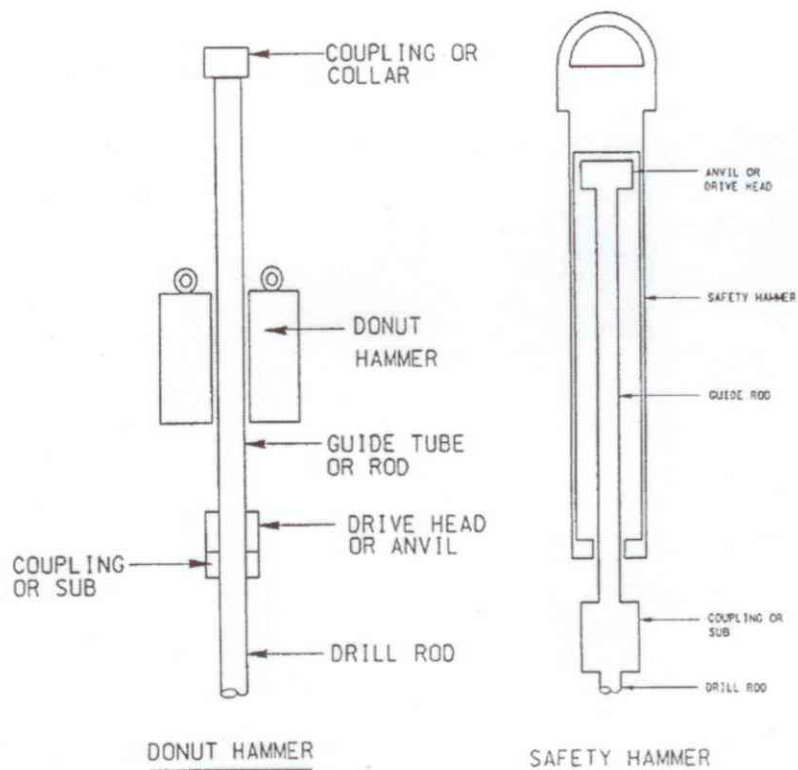


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare

the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

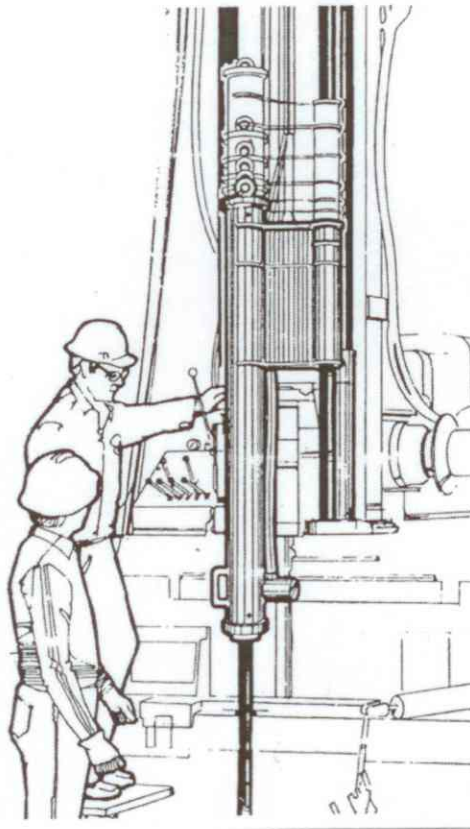


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (N) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the " N -value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) with limited unimpedance. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the N -value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, *N*₆₀). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

- 8.2.1 Name and location of job,
- 8.2.2 Names of crew,
- 8.2.3 Type and make of drilling machine,
- 8.2.4 Weather conditions,
- 8.2.5 Date and time of start and finish of borehole,
- 8.2.6 Boring number and location (station and coordinates, if available and applicable),
- 8.2.7 Surface elevation, if available,
- 8.2.8 Method of advancing and cleaning the borehole,
- 8.2.9 Method of keeping borehole open,
- 8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,
- 8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),
- 8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

- (1) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
- (2) Scope was completely revised.
- (3) Referenced Documents updated to include new standards.
- (4) Terminology: added section on Definitions.
- (5) Significance and Use: clarified use of the SPT test.
- (6) Apparatus: general editorial changes.
- (7) Sampling and Testing Procedure: general editorial changes.
- (8) Data Sheets/Forms: general editorial changes.
- (9) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

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Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes¹

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

^{ε1} NOTE—Editorial changes were made in June 2007.

1. Scope*

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.

NOTE 1—This practice does not apply to liners used within the samplers.

1.2 This Practice is limited to soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing gravel or larger size soil particles cemented or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (D 1586, D 3550, and D 6151). For information on appropriate use of other soil samplers refer to D 6169.

1.3 This practice is often used in conjunction with fluid rotary drilling (D 1452, D 5783) or hollow-stem augers (D 6151). Subsurface geotechnical explorations should be reported in accordance with practice (D 5434). This practice discusses some aspects of sample preservation after the sampling event. For information on preservation and transportation process of soil samples, consult Practice D 4220. This practice does not address environmental sampling; consult D 6169 and D 6232 for information on sampling for environmental investigations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information purposes only. The tubing tolerances presented in Table 1 are from sources available in North

America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 ASTM Standards:²

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 1452 Practice for Soil Investigation and Sampling by Auger Borings
- D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
- D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
- D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock

¹ This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved May 1, 2007. Published July 2007. Originally approved in 1958. Last previous edition approved in 2003 as D 1587 – 03.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard.

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TABLE 1 Dimensional Tolerances for Thin-Walled Tubes

Size Outside Diameter	Nominal Tube Diameters from Table 2 ^A Tolerances					
	2 in.	50.8 mm	3 in.	76.2 mm	5 in.	127 mm
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	± 0.007	± 0.179	± 0.010	± 0.254	± 0.015	± 0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

^A Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i , or D_o and Wall thickness, or D_i and Wall thickness.

- as Used in Engineering Design and Construction
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
- D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
- D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
- D 6232 Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities

3. Terminology

3.1 Definitions:

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *inside clearance ratio*, %, n —the ratio of the difference in the inside diameter of the tube, D_i , minus the inside diameter of the cutting edge, D_e , to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.2 *ovality*, n —the cross section of the tube that deviates from a perfect circle.

4. Summary of Practice

4.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

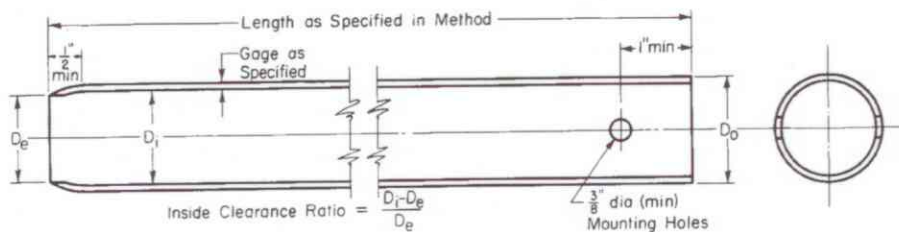
5. Significance and Use

5.1 This practice, or Practice D 3550 with thin wall shoe, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably



NOTE 1—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).

NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.

NOTE 3—Tube held with hardened screws or other suitable means.

NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for “undisturbed samples.” Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalent Conversions

in.	mm
3/8	9.53
1/2	12.7
1	25.4
2	50.8
3	76.2
4	101.6
5	127

FIG. 1 Thin-Walled Tube for Sampling

TABLE 2 Suitable Thin-Walled Steel Sample Tubes^A

Outside diameter (D_o):			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Inside clearance ratio, %			
	<1	<1	<1

^A The three diameters recommended in Table 2 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

6.3 *Thin-Walled Tubes*, should be manufactured to the dimensions as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having adequate strength for the type of soil to be sampled. Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here.

6.3.1 *Length of Tubes*—See Table 2 and 7.4.1.

6.3.2 *Tolerances*, shall be within the limits shown in Table 1.

6.3.3 *Inside Clearance Ratio*, should be not greater than 1 % unless specified otherwise for the type of soil to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled, except for sensitive soils or where local experience indicates otherwise. See 3.2.1 and Fig. 1 for definition of inside clearance ratio.

6.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is to be extruded less than 3 days. The type of coating to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. Galvanized tubes are often used when long term storage is required. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, zinc oxide, and others.

NOTE 3—Most coating materials are not resistant to scratching by soils that contain sands. Consideration should be given for prompt testing of the sample because chemical reactions between the metal and the soil sample can occur with time.

6.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube,

comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable check valve with the venting area to the outside equal to or greater than the area through the check valve. In some special cases, a check valve may not be required but venting is required to avoid sample compression. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 4—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1-ft (.03 m)

7.3.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.4 Advance the sampler without rotation by a continuous relatively rapid downward motion and record length of advancement to the nearest 1 in. (25 mm).

7.4.1 Determine the length of advance by the resistance and condition of the soil formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3-in. (75 mm) for sludge and end cuttings.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 2.

7.5 When the soil formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. The tube can be slowly rotated to shear the material at the end of the tube, and to relieve water and/or suction pressures and improve recovery. Where the soil formation is soft, a delay before withdraw of the sampler (typically 5 to 30 minutes) may improve sample recovery.

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube and measure the length of the soil

sample recovered to the nearest 0.25 in. (5 mm) in the tube. Seal the upper end of the tube. Remove at least 1 in. (25 mm) of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

8.1.1 Tubes sealed over the ends, as opposed to those sealed with expanding packers, should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Depending on the requirements of the investigation, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination and classification of the sample. Samples are extruded in special hydraulic jacks equipped with properly sized platens to extrude the core in a continuous smooth speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (D 4220). Bent or damaged tubes should be cut off before extruding.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Assure that the markings or labels are adequate to survive transportation and storage.

NOTE 6—Top end of the tube should be labeled “top”.

9. Field Log

9.1 Record the information that may be required for preparing field logs in general accordance to ASTM D 5434 “Guide

for Field Logging of Subsurface Explorations of Soil and Rock”. This guide is used for logging explorations by drilling and sampling. Some examples of the information required include;

9.1.1 Name and location of the project,

9.1.2 Boring number,

9.1.3 Log of the soil conditions,

9.1.4 Surface elevation or reference to a datum to the nearest foot (0.5 m) or better,

9.1.5 Location of the boring,

9.1.6 Method of making the borehole,

9.1.7 Name of the drilling foreman and company, and

9.1.8 Name of the drilling inspector(s).

9.1.9 Date and time of boring-start and finish,

9.1.10 Depth to groundwater level: date and time measured.

9.2 Recording the appropriate sampling information is required as follows:

9.2.1 Depth to top of sample to the nearest 0.1 ft. (.03 m) and number of sample,

9.2.2 Description of thin-walled tube sampler: size, type of metal, type of coating,

9.2.3 Method of sampler insertion: push or drive,

9.2.4 Method of drilling, size of hole, casing, and drilling fluid used,

9.2.5 Soil description in accordance with Practice D 2488,

9.2.6 Length of sampler advance (push), and

9.2.7 Recovery: length of sample obtained.

10. Keywords

10.1 geologic investigations; sampling; soil exploration; soil investigations; subsurface investigations; undisturbed

SUMMARY OF CHANGES

In accordance with committee D18 policy, this section identifies the location of changes to this standard since the last edition, 200, which may impact the use of this standard.

(1) Added parts of speech to terms.

(2) Corrected reference in Note 2 from D 5740 to D 3740.

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Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the soil boring log form (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for ASTM D1586 (attached), a standard soil boring log form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both sample jar labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, sonic). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A

partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil consistency of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual

procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch OD, and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch OD). A stiffer rod, such as an "N" rod (2-5/8-inch OD), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

Soil Boring Log Form with a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedures) (ASTM D2488.pdf)

ASTM 1586 Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP Decontamination of Drilling Rigs and Equipment.



PROJECT NUMBER _____	BORING NUMBER _____
SHEET _____ OF _____	
SOIL BORING LOG	

PROJECT _____ LOCATION _____

ELEVATION _____ DRILLING CONTRACTOR _____

DRILLING METHOD AND EQUIPMENT _____

WATER LEVELS _____ START _____ FINISH _____ LOGGER _____

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)			

Figure 1
**SOIL BORING LOG,
FORM D1586**



PROJECT NUMBER <i>DEN 22371.G5</i>	BORING NUMBER <i>BL-3</i>	SHEET <i>1</i> OF <i>3</i>
SOIL BORING LOG		

PROJECT *Howard Ave Landslide* LOCATION *Howard & 24th Ave, Centennial, CO*
 ELEVATION *513 1/2 Feet* DRILLING CONTRACTOR *Kendall Explorations, Aspen, Colorado*
 DRILLING METHOD AND EQUIPMENT *4"-inch H.S. Augers, Mobil B-61 rotary drill rig*
 WATER LEVELS *3.2 Feet, 8/5/89* START *August 4, 1989* FINISH *August 8, 1989* LOGGER *J.A. Michner*

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)			
0					Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
2.5						
4.0	1-S	1.5	2-3-4 (7)		POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
5.0						Driller notes very soft drilling
5	6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft; strong H ₂ S odor; many fine roots up to about 1/4 inch	4ft. dark grey, wet silty cuttings.
8.0						
10	10.0	3-ST	1.3		ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
11.5	4-S	1.3	2-2-2 (4)		SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730
15	15.0					Driller notes rough drilling action and chatter @ 13 ft
15.5	5-S	0.5	60/6"		SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
20	20.0					Driller notes smoother, firm drilling @ 19 ft
21.0	6-S	1.0	12-50/6"		LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ bot tip of 6-S, poss boulders or rock
23.0						Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
23.1	7-S	0	50/1"		NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM

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MAY 12, 2003

EXAMPLE

0715 ARRIVE ON SITE AT XYZ SITE.
 CH2M HILL STAFF:
 John Smith: FIELD TEAM LEADER
 Bob Builder: SITE SAFETY COORD.
 WEATHER: OVERCAST + COOL, 45°F
 CHANCE OF LATE SHOWERS
 SCOPE: • COLLECT GROUNDWATER
 SAMPLES FOR LTM WORK AT SITE 14
 • SUPERVISE SURVEY CREW

AT SITE 17

0725 BB ~~Calibrates~~ JS Calibrates

PID: 101 ppm / 100 ppm OK

PID Model #, SERIAL #

0730 BB Calibrates HORIBA METER

Model #, SERIAL #

→ List calibration Results

0738 Survey crew ARRIVES on site

→ List NAMES

0745 BB Holds H+S TALK on Slips,

Trips, Falls, Ticks + Air Monitoring

JS + SURVEY CREW ATTEND

No H+S ISSUES IDENTIFIED as
 CONCERNS. All work is in "Level D."

0755 JS conducts site-wide Air Monitoring

All readings = 0.0 ppm in

JS
5-12-03

MAY 12, 2003

EXAMPLE 48

SITE 14 LTM

BREATHING ZONE (BZ)

0805 Mobilize to well MW-22 to
 SAMPLE, SURVEYORS SETTING UP
 AT SITE 17

0815 PM (PAUL PAPER PUSHER) CALLS AND
 INFORMS JS TO COLLECT GWO SAMPLE
 AT WELL MW-44 TODAY FOR 24 hr
 TAT ANALYSIS OF VOC'S

0820 Purging MW-22

→ RECORD WATER QUALITY DATA

JS
5-12-03

0843 Collect SAMPLE AT MW-22 for
 total TAT Metals AND VOC'S. NO
 Dissolved Metals Needed PER PM

0905 JS + BB Mobilize to site 17 to
 show surveyors wells to survey.

0942 Mobilize to well MW-22 to
 collect SAMPLE ...

0950 CAN NOT ACCESS WELL MW-22
 due to BASE OPERATIONS; CONTACT
 PAUL PAPER PUSHER AND HE STATED
 HE WILL CHECK ON GAINING ACCESS
 WITH BASE CONTACT.

0955 Mobilize to well MW-19

JS
5-12-03



Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)¹

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific precautionary statements see Section 8.*

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which*

the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 ASTM Standards:

D 653 Terminology Relating to Soil, Rock, and Contained Fluids²

D 1452 Practice for Soil Investigation and Sampling by Auger Borings²

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils²

D 1587 Practice for Thin-Walled Tube Sampling of Soils²

D 2113 Practice for Diamond Core Drilling for Site Investigation²

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)²

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction³

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)²

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75- μ m) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

¹ This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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² Annual Book of ASTM Standards, Vol 04.08.

³ Annual Book of ASTM Standards, Vol 04.09.

*A Summary of Changes section appears at the end of this standard.

limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75- μ m) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425- μ m) sieve.

fine—passes a No. 40 (425- μ m) sieve and is retained on a No. 200 (75- μ m) sieve.

3.1.7 *silt*—soil passing a No. 200 (75- μ m) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

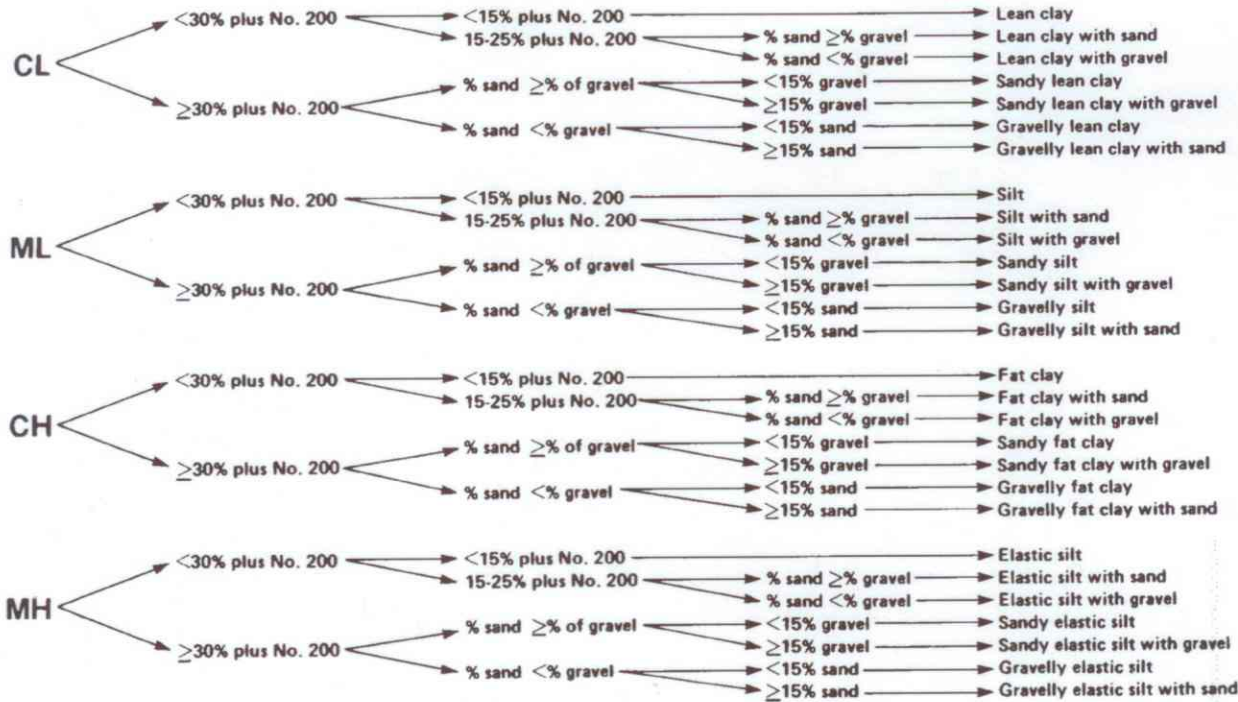
6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water

GROUP SYMBOL

GROUP NAME

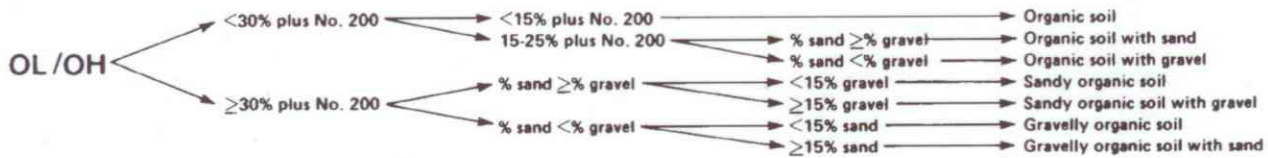


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

GROUP SYMBOL

GROUP NAME



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 N) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 N) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as

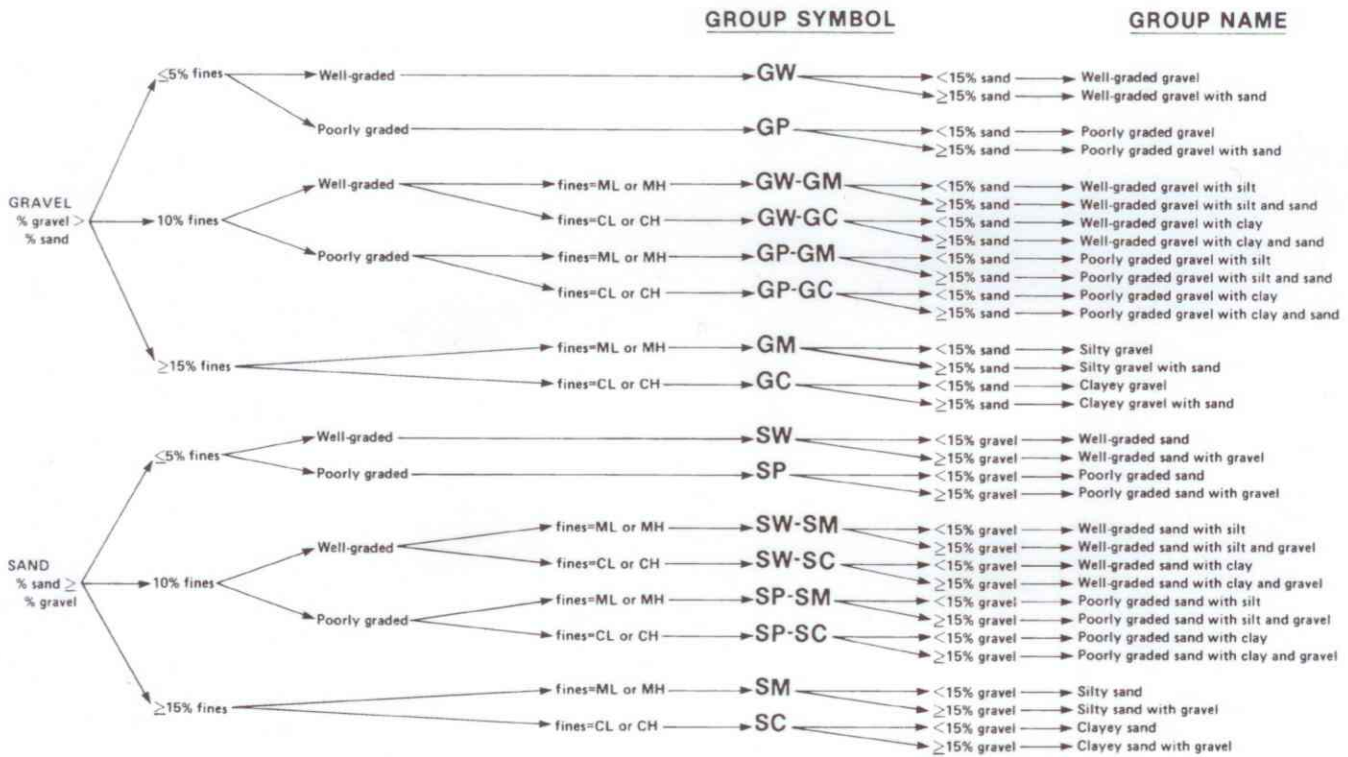
having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (¾ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the criteria in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

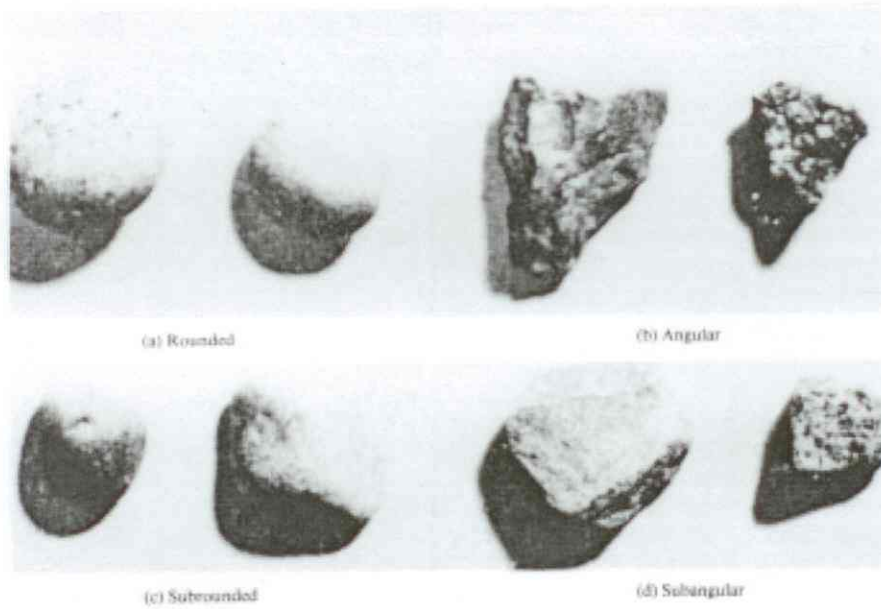


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

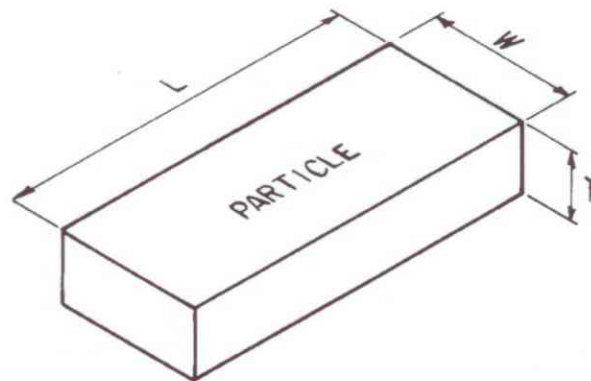
10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. “Hard” means particles do not crack, fracture, or crumble under a hammer blow.

PARTICLE SHAPE

W = WIDTH
T = THICKNESS
L = LENGTH



FLAT: $W/T > 3$
ELONGATED: $L/W > 3$
FLAT AND ELONGATED:
- meets both criteria

FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about 1/4 in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Dilatancy

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based

on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5%. The percentages of gravel, sand, and fines must add up to 100%.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5% of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100% for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50% or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50% fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 Dry Strength:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about 1/2 in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about 1/2 in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low,

medium, high, or very high in accordance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 Dilatancy:

14.3.1 From the specimen, select enough material to mold into a ball about 1/2 in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 Toughness:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1/8 in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 in. The thread will crumble at a diameter of 1/8 in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 Plasticity—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing Toughness

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 Identification of Inorganic Fine-Grained Soils:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.8 Identification of Organic Fine-Grained Soils:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words “with sand” or “with gravel” (whichever is more predominant) shall be added to the group name. For example: “lean clay with sand, CL” or “silt with gravel, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use “with sand.”

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words “sandy” or “gravelly” shall be added to the group name. Add the word “sandy” if there appears to be more sand than gravel. Add the word “gravelly” if there appears to be more gravel than sand. For example: “sandy lean clay, CL”, “gravelly fat clay, CH”, or “sandy silt, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use “sandy.”

15. Procedure for Identifying Coarse-Grained Soils
(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group

symbol plus the words “with clay” or “with silt” to indicate the plasticity characteristics of the fines. For example: “well-graded gravel with clay, GW-GC” or “poorly graded sand with silt, SP-SM” (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words “with gravel” or “with sand” shall be added to the group name. For example: “poorly graded gravel with sand, GP” or “clayey sand with gravel, SC” (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words “with cobbles” or “with cobbles and boulders” shall be added to the group name. For example: “silty gravel with cobbles, GM.”

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—Example: *Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
Gravel—fine, coarse
Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong
For intact samples:
18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only,

therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft³; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incorporated into a descriptive system for materials that are not

naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as “Sandy Lean Clay (CL)”; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; “Poorly Graded Sand with Silt (SP-SM)”; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; “Poorly Graded Gravel with Sand (GP).”

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; “Poorly Graded Gravel (GP)”; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard,

angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present.

The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supple-

mentary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:

Suffix:

s = sandy
g = gravelly

s = with sand
g = with gravel
c = with cobbles
b = with boulders

Group Symbol and Full Name

CL, Sandy lean clay
SP-SM, Poorly graded sand with silt and gravel
GP, poorly graded gravel with sand, cobbles, and boulders
ML, gravelly silt with sand and cobbles

Abbreviated

s(CL)
(SP-SM)g
(GP)scb
g(ML)sc

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993^{e1}) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

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Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils¹

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in

parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,² NDA Drilling Safety Guide,³ drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 ASTM Standards:⁴

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
- D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
- D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- D 2488 Practice for Description and Identification of Soils

² Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, <http://www.osha.gov>.

³ Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, <http://www.nda4u.com>.

⁴ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

¹ This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

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*A Summary of Changes section appears at the end of this standard.

(Visual-Manual Procedure)

- D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
- D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 4633 Test Method for Energy Measurement for Dynamic Penetrometers
- D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
- D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
- D 6026 Practice for Using Significant Digits in Geotechnical Data
- D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential
- D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
- D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
- D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N-value*, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m \pm 0.030 m) for each hammer blow.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N-value*, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N-value* should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

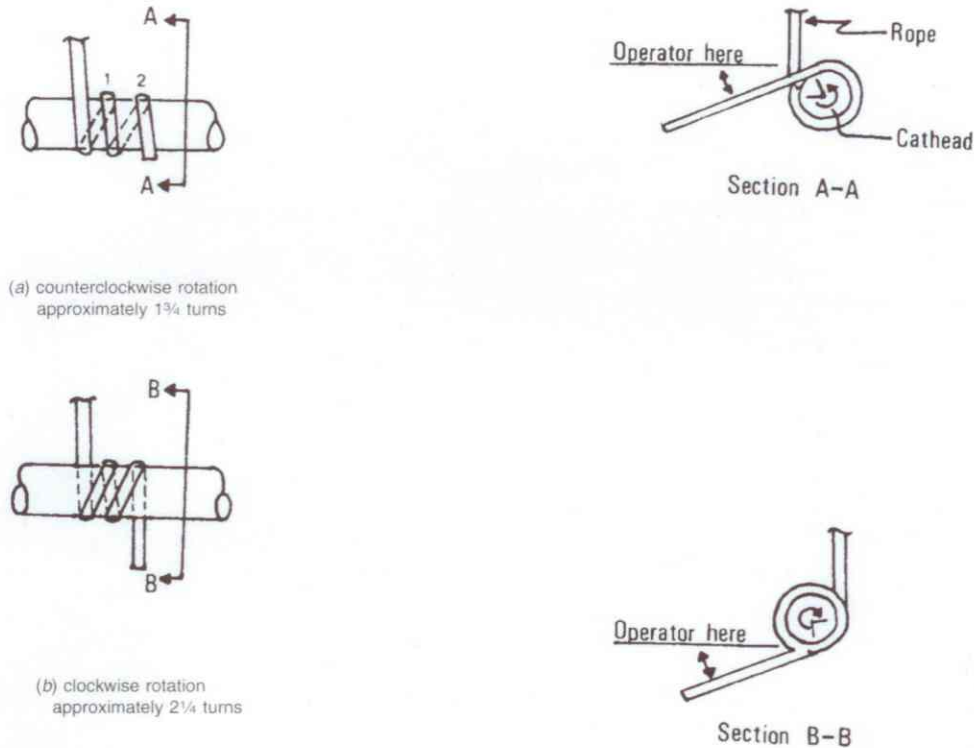


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

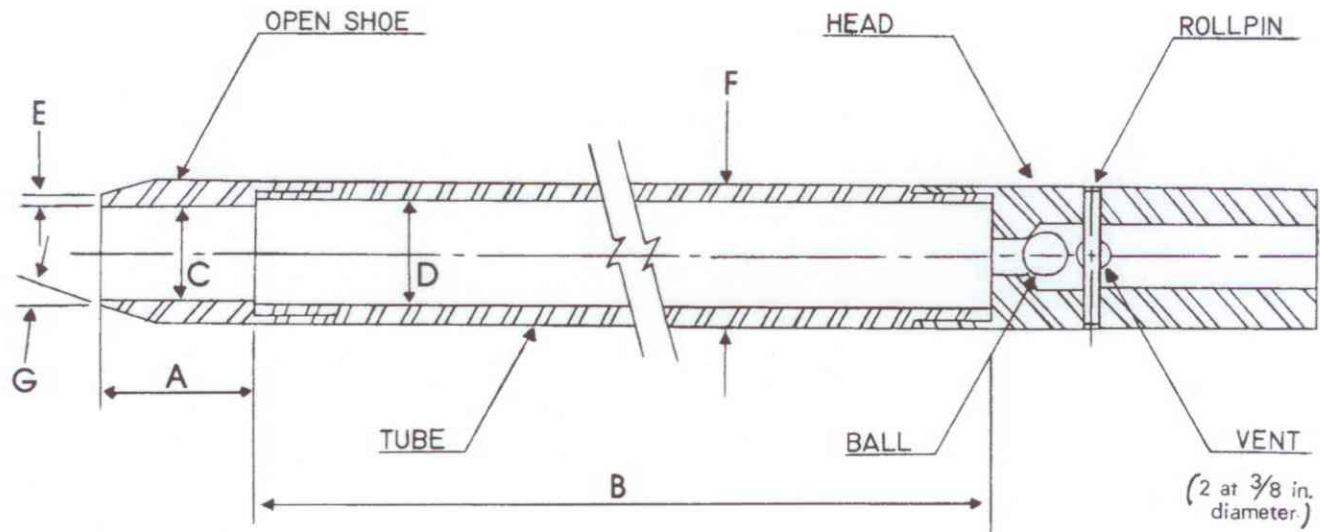
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall “A” rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm)).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



- A = 1.0 to 2.0 in. (25 to 50 mm)
- B = 18.0 to 30.0 in. (0.457 to 0.762 m)
- C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
- D = 1.50 ± 0.05 - 0.00 in. (38.1 ± 1.3 - 0.0 mm)
- E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
- F = 2.00 ± 0.05 - 0.00 in. (50.8 ± 1.3 - 0.0 mm)
- G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1/8-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1/2-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1/2 in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 Drive-Weight Assembly:

5.4.1 Hammer and Anvil—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbf (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 Hammer Drop System—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 Accessory Equipment—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

- 6.2.1 Open-hole rotary drilling method.
- 6.2.2 Continuous flight hollow-stem auger method.
- 6.2.3 Wash boring method.
- 6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

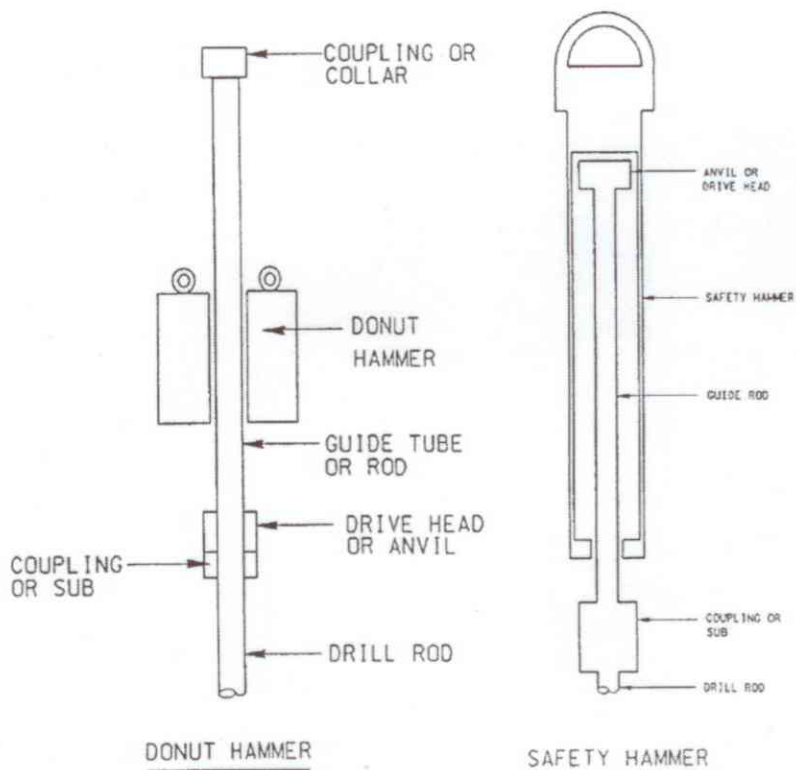


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare

the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

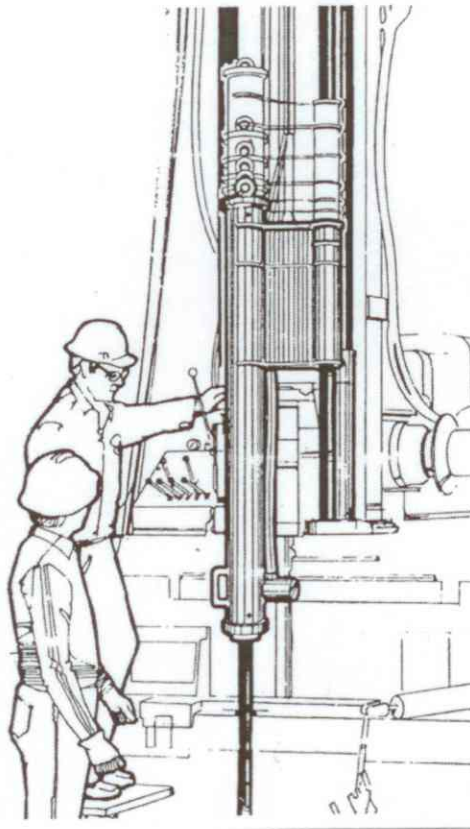


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (N) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the " N -value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) with limited unimpedance. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the N -value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, *N*60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

- 8.2.1 Name and location of job,
- 8.2.2 Names of crew,
- 8.2.3 Type and make of drilling machine,
- 8.2.4 Weather conditions,
- 8.2.5 Date and time of start and finish of borehole,
- 8.2.6 Boring number and location (station and coordinates, if available and applicable),
- 8.2.7 Surface elevation, if available,
- 8.2.8 Method of advancing and cleaning the borehole,
- 8.2.9 Method of keeping borehole open,
- 8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,
- 8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),
- 8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

DRILLERS BORING LOG

Project: _____ Project No: _____ Boring No: _____
 Location: _____ Sheet _____ of _____
 Date Started: _____ Date Completed: _____

Drill Crew: _____		Boring Location Station _____ Offset _____	
		Elevation _____	

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type _____
 Method Of Drilling: _____
 Auger _____ Size _____
 Wash _____ Water _____ Mud _____
 Hammer Type
 Auto _____ Manual _____
 Spill-Spoon Type
 Length _____ Liner Used _____
 Boring Size _____ Bit Used _____
 Casing Size _____ Length _____

Weather _____
 Non-Drilling Time (Hrs.)
 Boring Layout _____ Moving _____
 Hauling Water _____ Standby _____
 Water Level @ _____ Date _____ Time _____
 @ _____ Date _____ Time _____
 @ _____ Date _____ Time _____
 Cave-in Depth
 @ _____ Date _____ Time _____

FIG. 5 Example Data Sheet

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

- (1) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
- (2) Scope was completely revised.
- (3) Referenced Documents updated to include new standards.
- (4) Terminology: added section on Definitions.
- (5) Significance and Use: clarified use of the SPT test.
- (6) Apparatus: general editorial changes.
- (7) Sampling and Testing Procedure: general editorial changes.
- (8) Data Sheets/Forms: general editorial changes.
- (9) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

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**Table 1
EXAMPLE SOIL DESCRIPTIONS**

- POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size
- FAT CLAY (CH), dark gray, moist, stiff
- SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine
- WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max
- POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense
- ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica
- SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max
- INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick
- SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill
- SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation
- LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff
- WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

SF032/010.50

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

<u>Description</u>	<u>Criteria</u>
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

<u>Blows/Ft</u>	<u>Relative Density</u>	<u>Field Test</u>
0-4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb hammer
>50	Very dense	Penetrated only a few inches with ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

<u>Blows/Ft</u>	<u>Consistency</u>	<u>Pocket Penetrometer (TSF)</u>	<u>Torvane (TSF)</u>	<u>Field Test</u>
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized (“DI”) water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.
2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.
3. Remove disposable coveralls (“Tyveks”) and discard into DOT-approved 55-gallon drum.
4. Remove respirator (if worn).
5. Remove inner gloves and discard.
6. At the end of the work day, shower entire body, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Spread plastic on the ground to keep equipment from touching the ground
3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.
4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.
5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)
6. Rinse with 1 gallon of tap water. (deionized water may be substituted for tap water)
7. Rinse with 1 gallon of deionized water.
8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.
9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox[®] solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox[®] solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.
2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, Liquinox® solution (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for all of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and SESCO, Inc. Pages should be water resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Rite in the Rain[®] or Sanford Sharpie[®] permanent markers. Note: for sites where PFC is being analyzed for, Rite-in-the-Rain[®], Sanford Sharpie[®], or anything water-resistant or with Teflon[®] cannot be used in the field. All field book materials must be "fluorine free". Acceptable substitutes would be a sewn notebook without a plastic cover, or loose-leaf notebook paper.
2. On the inside cover of the log book the following information should be included:

- Company name and address
 - Log-holders name if log book was assigned specifically to that person
 - Activity or location
 - Project name
 - Project manager's name
 - Phone numbers of the company, supervisors, emergency response, etc.
3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."
 4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.
 5. Daily entries will be made chronologically.
 6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.
 7. Each page of the log book will have the date of the work and the note takers initials.
 8. The final page of each day's notes will include the note-takers signature as well as the date.
 9. Only information relevant to the subject project will be added to the log book.
 10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.
2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.
4. Weather: Record the weather conditions and any significant changes in the weather during the day.
5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified, and corrective actions or adjustments made to address concerns/problems, and other pertinent information.
6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.
7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.
8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.
9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.
10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.
11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.
12. Health and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.
13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.
14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.
15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements

for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).
17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:
 - Description of the general sampling area – site name, buildings and streets in the area, etc.
 - Station/Location identifier
 - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
 - Sample matrix and type
 - Sample date and time
 - Sample identifier
 - Draw a box around the sample ID so that it stands out in the field notes
 - Information on how the sample was collected – distinguish between “grab,” “composite,” and “discrete” samples
 - Number and type of sample containers collected
 - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
 - Parameters to be analyzed for, if appropriate
 - Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).
2. Use tables to record sampling information and field data from multiple samples.
3. Sketch sampling locations and other pertinent information.
4. Sketch well construction diagrams.

V. Attachments

Example field notes.

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term “chain-of-custody” refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When in situ measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

Sample Label

Samples, other than for in situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project – Name of project site.
- Sample Identification - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 05/21/17).

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name or initials of the sampler.
- Remarks - Any pertinent additional information.

The field team should always follow the sample ID system prepared by the Project Chemist and reviewed by the Project Manager.

Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.
- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include only the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.
- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.
- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample locations in photographs, an easily read sign with the appropriate sample location number should be included.
- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a

pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under "Relinquished by" entry.
- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used and enter the airbill number under "Remarks," in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

- A. Sample Label
- B. Chain of Custody Form
- C. Custody Seal

VII References

USEPA. User's Guide to the Contract Laboratory Program. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Attachment A
Example Sample Label



Quality Analytical Laboratories, Inc.
 2567 Fairlane Drive
 Montgomery, Alabama 36116
 PH. (334)271-2440

Client _____
 Sample No. _____
 Location _____
 Analysis _____
 Preservative **HCL** _____
 Date _____ By _____

CEIMIC CORPORATION

10 Dean Knauss Drive, Narragansett, R.I. 02882 • (401) 782-8900

SITE NAME	DATE
ANALYSIS	TIME
	PRESERVATIVE
SAMPLE TYPE	
<input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Other _____	
COLLECTED BY:	

Attachment B
Example Chain-of-Custody Record

CH2M HILL Project #		Purchase Order #		# O F C O N T A I N E R S	LAB TEST CODES										SHADED AREA— FOR LAB USE ONLY						
Project Name															Lab 1 #		Lab 2 #				
Company Name CH2M HILL Office															Quote #		Kit Request #				
Project Manager & Phone #					Report Copy to:		ANALYSES REQUESTED										Project #				
Requested Completion Date:		Sampling Requirements			Sample Disposal:					No. of Samples		Page of		Login		LIMS Ver					
		SDWA NPDES RCRA OTHER			Dispose		Return														
		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>														
Sampling		Type			Matrix			CLIENT SAMPLE ID (9 CHARACTERS)										REMARKS		LAB 1 ID	LAB 2 ID
Date Time		COMP	GRAB		WATER	SOIL	AIR														
Sampled By & Title				Date/Time		Relinquished By				Date/Time		QC Level: 1 2 3 Other: _____									
(Please sign and print name)						(Please sign and print name)															
Received By				Date/Time		Relinquished By				Date/Time		COC Rec		ICE							
(Please sign and print name)						(Please sign and print name)						Ana Req		TEMP							
Received By				Date/Time		Relinquished By				Date/Time		Cust Seal		Ph							
(Please sign and print name)						(Please sign and print name)															
Received By				Date/Time		Shipped Via				Shipping #											
(Please sign and print name)						UPS BUS Fed-Ex Hand Other _____															
Work Authorized By				Date/Time		Remarks															
(Please sign and print name)																					

Attachment C
Example Custody Seal



CUSTODY SEAL

Date _____

Signature _____

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated Jacobs HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- Strapping tape
- Contractor bags
- Absorbent pads or equivalent
- Resealable bags
- Bubble bags (for glass bottle ware)
- Bubble wrap (if needed)
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

- A. Prepare coolers for shipment:
 - Tape drains shut.
 - Place mailing label with laboratory address on top of coolers.
 - Fill bottom of coolers with absorbent pads or similar material.
 - Place a contractor bag inside the cooler.
- B. Affix appropriate adhesive sample labels to each container. Protect with clear packing tape.
- C. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks. Cross check CoC to ensure all samples are present.
- D. Seal each glass sample bottle within a separate bubble bag (VOCs grouped per sample location). Sample labels should be visible through the bag. Whenever possible, group samples per location for all analytes and place in resealable bags. Make sure to release as much air as practicable from the bag before sealing.
- E. Arrange sample bottles in coolers so that they do not touch.
- F. If ice is required to preserve the samples, cubes should be repackaged in resealable bags and placed on and around the containers.
- G. Fill remaining spaces with bubble wrap if needed.
- H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.
- J. Close lid and latch.
- K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear packing tape.
- L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with clear packing tape to avoid seals being able to be peeled from the cooler.
- M. Relinquish to Federal Express or to a courier arranged with the laboratory. Scan airbill receipt and CoC and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier. If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result, only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated Jacobs HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radiation Protection Program

NO.: RP-100

PAGE: 1 of 6

DATE: May 2013

APPROVED:

Technical Services Manager

5/31/13

Date

Corporate Certified Health Physicist

5/31/13

Date

1.0 PURPOSE

This administrative procedure describes the major elements of the Radiation Protection Program for Perma-Fix Environmental Services, Inc. (PESI). As applicable, this administrative procedure references sections in the Radiation Protection Plan and project procedures which describe the program in more detail.

2.0 APPLICABILITY

These program descriptions apply to personnel who plan, review, supervise, or perform work involving radiation protection activities during remediation.

3.0 REFERENCES

References are listed in the specific Project Procedures that comprise this Radiation Protection Program.

4.0 DEFINITIONS

Radiation Work Permit (RWP): A document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions that exist in the work area and the radiological requirements for the job.

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and byproduct material procured and used to support the operation or remediation.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

TITLE:	NO.: RP-100
Radiation Protection Program	PAGE: 2 of 6

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO advises project management on all aspects of Radiation Protection and Operational Health Physics. The RSO directs all radiological safety activities on the project. The RSO has the authority to suspend operations and / or restrict personnel access at the project as a result of nonconformance to this SSHP, or other applicable regulations, and when radiological conditions change beyond the scope of an HWP. The RSO is responsible for:

- Implementing and ensuring compliance with RPP's policies and procedures.
- Inspect work activities to ensure operations, including off-normal activities, are being conducted according to the facility or project requirements, applicable federal regulations, and industry accepted As-Low-As-Reasonably-Achievable (ALARA) principles.
- Reviewing and approving work plans, Radiation Work Permits, and RPP procedures.
- Trending radiation work performance of project personnel including contamination and radiation exposure control.
- Identifying, reviewing, and documenting nonconformance, their causes and corrective actions for incidents associated with radiation protection.
- Ensuring an effective ALARA Program including conducting onsite radiation safety and health briefings.
- Ensuring documentation of any RPP safety violation.
- Reviewing survey data.
- Conducting briefings concerning radiological work activities.
- Ensuring that radiological records are complete, clear and legible, meet the intended purpose, and are regularly transmitted to document control for archive.
- Ensuring Restricted Areas are correctly identified, posted and marked.
- Performing or coordinating regular internal audits of the RPP.

5.2 Radiation Protection Technicians (RPTs)

RPTs report directly to the RSO. RPTs are assigned by the RSO to provide support to each major field activity for implementation of RPP requirements. RPTs provide guidance in RPP matters to field personnel. RPTs have stop-work authority for radiological safety matters and activities that could result in an unsafe condition being present. RPTs are responsible for the following:

- Conducting routine and job-specific radiological surveys (i.e., radiation, contamination, and airborne radioactivity).
- Establishing radiological postings.
- Implementing the personal protective equipment (PPE) and respiratory protection programs for the purpose of keeping radiation exposures ALARA.

TITLE:	NO.: RP-100
Radiation Protection Program	PAGE: 3 of 6

- Maintaining and operating portable Health Physics survey instrumentation used in the performance of Radiation Protection (RP) activities.
- Performing unconditional release surveys of material from the restricted area.
- Performing transportation radiological surveys according to applicable U.S. Department of Transportation (DOT) regulations.
- Assisting the SSHO with IH&S monitoring and inspections to a level commensurate with training and experience.

5.3 Project Supervisors

All Project Supervisors are responsible for:

- Ensuring personnel under their direction comply with RPP requirements.
- Providing information on projected work activities to the RPP organization.
- Notifying RP personnel of any radiological problems encountered.
- Ensuring workers are prepared for tasks with tools, equipment and training to minimize time spent in radiological areas.

5.4 Project Radiation Workers

All Project Radiation Workers and individuals entering radiologically controlled areas are responsible for:

- Obeying promptly “stop-work” and “evacuate” orders from RP personnel and the SSHO.
- Obeying posted, oral and written radiological control instructions and procedures, including instructions on Radiation Work Permits and those in the SSHP.
- Immediately reporting lost dosimetry devices to RP personnel.
- Reporting medical radiation treatments to the RSO and supervisor.
- Keeping track of personal radiation exposure status to ensure that administrative dose limits are not exceeded.
- Notifying RP personnel of faulty or alarming radiation protection equipment, and unsafe radiological conditions.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

None

8.0 APPARATUS

None

9.0 RECORDS

None

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Radiation Protection Program	PAGE: 4 of 6

10.0 PROCEDURE

10.1 Radiation Protection Organization

1. The RPP Organization will provide appropriate personnel and resources to verify and maintain a radiologically safe working environment.
2. RPP staffing levels will be periodically reviewed to ensure that adequate staffing levels are maintained consistent with current and planned remediation activities.
3. The Project RPP Organization will have access to engineering and other personnel needed to support the Radiation Protection Program.
4. The development and control of RPP Project Procedures will be in accordance with the following guidelines:
 - Clearly defined scope, tasks, applicability, limiting conditions, precautions, consideration of special controls, reference to acceptance criteria and quality requirements.
 - Clearly understood text, using standard grammar, nomenclature and punctuation, concise instruction steps in a logical sequence, and references.
 - Review, approval, issuance, and control of changes and permanent revisions.

10.2 ALARA Program

All activities involving radiation and radioactive materials shall be conducted in such a manner that radiation exposure to workers and the general public are maintained As-Low-As-Reasonably-Achievable (ALARA), taking into account current technology and the economics of radiation exposure reduction in relationship to the benefits of health and safety. ALARA concepts are implemented throughout the entire RPP. ALARA-program requirements include:

1. Administrative controls and procedures endeavor to reduce individual and collective radiation exposures ALARA. Minimizing radiation exposure is accomplished by preliminary planning and scheduling, using proven and innovative engineering techniques and performing engineering reviews of proposed work plan changes.
2. Worker involvement and acceptance in minimizing radiation exposure is a key component of the ALARA Program. Workers are responsible to incorporate ALARA principles into work performance.
3. Work shall be planned in accordance with ALARA principles, involving input from discipline engineers, the project RPP staff and implementing supervisors.
4. An Embryo-Fetus Protection Program has been established for the Project and is specified in RPP-113, "Embryo-Fetus Protection"

10.3 Radiation Protection Audit Program

1. Internal / External Audits of the Radiation Protection Program should be performed, documented, and be of sufficient scope, depth, and frequency to

TITLE:	NO.: RP-100
Radiation Protection Program	PAGE: 5 of 6

identify and resolve actual or potential performance deficiencies before significant quality problems are encountered. Audit frequency and criteria is determined by the RSO and / or SSHO.

2. The RSO and / or SSHO shall perform an annual review of RPP content and implementation as specified in 10 CFR 20.1101(c).

10.4 External and Internal Dosimetry Program

Internal and external dosimetry and exposure control requirements are defined in the PESI Radiation Protection Plan and includes:

- A discussion of applicable regulatory limits for occupational workers and members of the public.
- ALARA goals.
- Monitoring requirements.
- Recordkeeping requirements.
- Reporting requirements for both normal operations and incidents.

10.5 Radiation Protection Instrumentation Program

All instrumentation used to measure radiation and radioactive material will be maintained in accordance with their respective technical manuals and operating procedures. This includes establishing criteria and requirements for the operation, calibration, response testing, maintenance, inventory and control of radiation protection instrumentation and equipment to comply with applicable regulations and conform with applicable ANSI standards. The Instrumentation Program is detailed by specific procedures including RP-108, RP-109, and RP-110.

10.6 Access Control Program

Access controls to radiological areas will be maintained at all times at the PESI. The administrative and physical measures used to control access to Restricted and/or Radiological Areas are established procedures RP-101, RP-102, and RP-103

10.7 Radiation Protection Surveillance Program

The Radiation Protection Surveillance Program provides for the conduct of radiological surveys in all areas controlled for the purpose of radiation and/or radioactivity. The Program encompasses both routine and non-routine surveys to be performed within the PESI. The specific requirements for conducting and documenting radiological surveys at the PESI are detailed in procedures RP-104, RP-105, RP-106, and RP-107

10.8 Radioactive Material Control Program

This Program provides guidance and requirements for control of radioactive materials. The Radioactive Material Control Program includes receipt, inventory, handling, and release of materials. It also provides for radioactive sealed source control, control of materials entering Restricted Areas and control of contaminated tools and equipment. The requirements of this program are established in RP-111

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Radiation Protection Program	PAGE: 6 of 6

10.9 Respiratory Protection Program

It is not expected that respirators will be widely used by PESI staff for radiation protection purposes at PESI. As such the Respiratory Protection Program will be administered by the SSHO in accordance with the PESI Site Safety and Health Plan. The SSHO will consult with the RSO when respiratory protection is required for radiological purposes.

10.10 Radiological Training

The Radiological Training is required for PESI employees and/or subcontractors who perform work near, or in areas controlled for the purpose of radiation and/or radioactive materials as defined in Section 8.1 of the PESI Radiation Protection Plan. There are two basic levels of training: General Employee Radiation Training for visitors and non-radiation workers, Radiation Worker Training for workers who access Restricted Areas.

10.11 Radiation Protection Records

Radiation Protection Records are routinely developed to document all aspects of the Radiation Protection Program. Records are generated using clear concise text using standard grammar and punctuation. Records are reviewed for adequacy and completeness and transmitted to the Document Control organization for long-term retention.



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Access Control

NO.: RP-101

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for controlling the access of personnel, equipment, and vehicles into radiological areas.

2.0 APPLICABILITY

This procedure applies to all Project personnel and visitors, equipment, and vehicles entering Restricted Areas.

3.0 REFERENCES

1. 10 CFR 19, "Notices, Instructions and Reports to Workers Inspection."
2. 10 CFR 20, "Standards for Protection Against Radiation."
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)
4. RPP-102, "Radiological Posting Requirements."
5. RPP-103, "Radiation Work Permits Preparation and Use."
6. 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response."

TITLE:	Access Control	NO.:	RP-101
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4.0 GENERAL

4.1 Discussion

Access controls are used to ensure the radiological safety of personnel entering into Restricted Areas. These controls include, but are not limited to Training, Dosimetry, Posting, Area Monitoring, and Radiation Work Permits (RWP).

4.2 Definitions

ALARA: Means as low as reasonably achievable.

GET: General Employee Training

GERT: General Employee Radiation Training

HAZWOPER: 40-Hour Hazardous Waste Operations and Emergency Response training in accordance with 29 CFR 1910.120

Radiation Worker: An individual who accesses any Restricted Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Restricted Areas. **RPT:** Radiation Protection Technician

Radiation Work Permit (RWP): A document or series of documents prepared by the Radiation Protection Group to inform workers of the radiological, industrial hygiene and other safety conditions which exist in the work area and task-related radiological and other safety requirements.

RSO: Radiation Safety Officer

SSHO: Site Safety and Health Officer

SRD: Self-Reading Dosimeter

Visitor: An individual who accesses the project site for purposes other than for assignment as a Project Worker (e.g., site visit, performance of an essential short-term task).

5.0 RESPONSIBILITIES

5.1 Site Safety & Health Officer (SSHO)

- The SSHO is responsible for ensuring that all activities performed within this procedure conform to the requirements of the PESI Site Safety & Health Plan (SSHP).
- Authorizing escorted visitor entries into Restricted Areas. This responsibility may be designated.
- Evaluating visitor entries to Restricted Areas to minimize or eliminate exposure risk to personnel who lack adequate training.

5.2 Radiation Safety Officer (RSO)

- Implementing this procedure.
- Approving RWPs to control access to Restricted Areas.
- Reviewing and approving training programs related to work in Restricted Areas.
- Implementing the requirements of the PESI Radiological Protection Program.
- Providing direction to the Project Personnel regarding radiological matters.

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- Authorizing escorted visitor entries into Restricted Areas. This responsibility may be designated.
- Evaluating visitor entries to Restricted Areas to minimize or eliminate exposure risk to personnel who lack adequate training.

5.3 Radiation Protection Technician (RPT)

- Identifying and posting Restricted Areas.
- Providing RWP briefings to individuals entering Restricted Areas.
- Conducting radiation and contamination surveys, and keeping legible records.
- Monitoring work activities to ensure compliance with the requirements of the Radiological Protection Program.

5.4 Project Supervisor

- Ensuring that personnel assigned to work in Restricted Areas or with radioactive material, attend required training and perform work in a radiologically sound and safe manner.
- Contacting the RSO or designee, to obtain approval to bring escorted visitors into Restricted Areas.
- Notifying the RSO or designee, in advance (when possible) of the need to bring any non-project owned equipment/ vehicles into the Restricted Area to arrange for baseline contamination surveys.

5.5 Project Personnel

- Attending designated training classes.
- Following directions from the RPT with regards to Safety and Health.
- Maintaining their personnel exposures ALARA.
- Limiting the amount of material taken into Restricted Areas to that necessary for task performance.
- Working in a manner so as to prevent spread of contamination and reduce airborne radiological emissions to the extent possible.

6.0 PREREQUISITES

6.1 Individuals requiring unescorted access into a Restricted Area shall submit the following documentation to the RSO **prior** to entry:

- Evidence of initial 40-Hour and 8-Hour Refresher OSHA HAZWOPER Training (if applicable)
- Current medical examination performed within the past 12 months.
- Evidence of successful completion of Site Orientation Training (GET/GERT) and Radiation Worker Training (RWT).

6.2 Individuals requiring unescorted access into a Restricted Area shall meet the requirements for Restricted Area access and have the following at a minimum:

- Thermoluminescence Dosimeter (TLD) or Self-Reading Dosimeter (SRD).
- Personal Protective Equipment (PPE) specified by posting and/or RWP.

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		PAGE:	4 of 8

6.3 Visitor access into Restricted Areas is limited to essential tasks which meet all of the following requirements:

- The task cannot be performed by appropriately trained Project Personnel
- The task is time critical in nature and would have a negative impact on safety & health or project operations if not performed.
- The task cannot be deferred until the Restricted Area is remediated or down posted.

7.0 PRECAUTIONS AND LIMITATIONS

- No unessential visitors shall be allowed access to the restricted areas.
- Visitors shall receive visitor specific site orientation training prior to accessing a restricted area. Training shall be documented.
- Personnel, equipment, and vehicle entry control shall be maintained for each radiological area.
- No radiological control(s) shall be installed in any area that would prevent the rapid evacuation of personnel in an emergency situation.
- Trained emergency response personnel (Fire Dept., Ambulance/EMT, Law Enforcement) responding to on-site emergencies are exempt from the requirements of this procedure.
- Any member of the public exposed to radiation and / or radioactive material shall not exceed 0.1 rem Total Effective Dose Equivalent per year.
- All visitors entering into a Restricted Area shall be escorted at all times by a qualified radiation worker. The RSO and SSHO or designee(s) shall approve these entries. The escort is responsible for visitor compliance with site protocols.
- Visitors may not enter a posted High Contamination Area, Radiation Area, High Radiation Area, or Airborne Radioactivity Area.
- Visitors shall not perform any work of an intrusive nature (i.e., digging, drilling, sampling, etc.) or an abrasive nature (i.e., welding, sanding, grinding, etc.) in Controlled Areas unless evaluated and approved by the RSO or designee.
- Visitors may only enter those areas where hazardous atmospheres do not exceed 50% of the Permissible Exposure Limit and where radiation exposures would not exceed the annual dose limit to a member of the public as specified in 10 CFR 20.
- The RSO shall ensure that risk of exposure to hazardous materials is minimized or eliminated prior to authorizing visitor entry into Restricted Areas. No work of an intrusive nature that may produce radioactive airborne particulates shall take place during visitor access to a restricted area.
- Visitors shall not be allowed to come into contact with tools, vehicles or materials that are contaminated above the release levels established in the SSHP.
- Project personnel who are required to escort individuals into a Restricted Area shall have successfully completed Radiation Worker Training (RWT), which includes training on the requirements of this procedure, and have a demonstrated knowledge of the site layout, site history, and emergency response protocols.

TITLE:	Access Control	NO.:	RP-101
		PAGE:	5 of 8

- Project personnel who are required to escort individuals into a Restricted Area shall ensure the visitors complete the “PESI Visitor Access Control Form” (see Attachment 1).
- RPTs shall perform exit frisking of visitors from Restricted Areas when frisking is required by RWP. Visitor access times and dates, PPE, controls and conditions shall be documented.

8.0 APPARATUS

None

9.0 RECORDS

- PESI Visitor Access Control Form
- RWP Access Registers are maintained under separate procedure.
- Quality Records generated under this procedure submitted to Document Control.

10.0 PROCEDURE

10.1 Restricted Areas

1. Enter the Restricted Area **ONLY** through the designated Access Control Point unless instructed otherwise by the RPT.
2. Inform the Access Control Point RPT of the nature of your work in the Restricted Area. Provide details as requested by the RPT.
3. Adhere to the requirements of Section 10.2 of this procedure if taking equipment or vehicles into the Restricted Area.
4. Review the applicable RWP and assemble and dress in the appropriate PPE.
5. Sign-in on the RWP Access Register. Signatures must be clear and legible, and must be accompanied by time of access.
6. Conduct all activities in a safe manner while working in the Restricted Area. Adhere to established safety and housekeeping protocols.
7. Exit the Restricted Area **ONLY** through the Access Control Point unless instructed otherwise by the RPT. Perform an exit frisk as required by RWP.
8. Sign-out on the appropriate RWP Access Register. Signatures must be clear and legible, and must be accompanied by time of egress.

10.2 Equipment and Vehicles Entering and Exiting Restricted Areas

1. Notify the RPT of any equipment / vehicles that need to be taken into a Restricted Area. Incoming surveys are performed on equipment and materials entering Restricted Areas. The purpose is to protect the client from financial liability associated with decontaminating equipment that arrived on the site with existing contamination. The decision regarding what must be surveyed will be made by the RSO. The degree of thoroughness of the survey and the requisite cleanliness of the equipment is at the discretion of the RSO.
2. Bring only the required equipment / supplies necessary for the task into the Restricted Area.

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3. When practicable, use contamination prevention methods such as wrapping or sleeving of equipment taken into a CA or ARA.
4. Remove as much packaging material as possible (i.e., plastic or cardboard) prior to entering a Restricted Area.
5. Notify the RPT of any equipment / vehicles that need to be removed from a Restricted Area.

10.3 Visitor Escorts

1. Discuss planned activities, work locations, and site hazards with the Visitor. Discuss any restrictions on where the Visitor may go and what the Visitor may do within the Restricted Areas. Define the obligations of the Visitor with respect to following instructions of the escort and of safety personnel.
2. Provide the Visitor with a copy of the PESI Visitor Access Control Form (Attachment 1).
3. Instruct the Visitor to review the form, complete the top portion, and sign.
4. Answer any questions the Visitor may have. RP personnel are available to answer questions as needed.
5. Sign the PESI Visitor Access Control Form acknowledging escort responsibilities.
6. Obtain RSO and SSHO signature permitting Restricted Area access.
7. Give completed form to RP Personnel.
8. RP Personnel should assign a personnel dosimeter to the Visitor or group of visitors (this is a TLD unless otherwise instructed by the RSO). Note Self-Reading Dosimeter (SRD) in/out readings, if used, on the RWP Access Register.
9. Review the appropriate RWP with the Visitor, and ensure the Visitor dons PPE and signs and records the time of entry onto the RWP Access Register.
10. Escort the Visitor into the Restricted Area observing all escort responsibilities.
11. Upon completion of activities, assist visitor with PPE removal, and RWP sign-out. An RPT will perform the exit frisking.
12. Escort the Visitor out of the Restricted Area.
13. Take the personnel dosimeter and give it to the RP personnel. RP Personnel shall notify the RSO immediately if SRD readings indicate a personnel exposure.

11.0 ATTACHMENT

Attachment 1 PESI Visitor Access Control Form (FRONT & BACK)

TITLE: Access Control	NO.: RP-101
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ATTACHMENT 1
PESI VISITOR ACCESS CONTROL FORM (FRONT)

Name _____ Representing _____

SSN ____ - ____ - _____ Mailing Address _____

Some work at the PESI involves exposure to hazardous environments, radiation or radioactive materials. In keeping with the provisions of the Code of Federal Regulations Title 10, Part 19, this is to inform you of the extent of the hazards to which you may be exposed.

Radiation and radioactive materials on this project site are confined within clearly posted and delineated areas. Other hazardous materials may be present in these areas. Signs in these areas are magenta or purple and yellow in color and contain the international symbol for radiation, a trefoil or **three-bladed design**.
(ESCORT: SHOW VISITOR AN EXAMPLE OF A RADIOLOGICAL POSTING).

During your visit, you will be provided with an escort. You must remain with your escort at all times. In the unlikely event of an incident involving radioactive or other hazardous materials, your escort will provide you with instructions. Comply with the instructions of your escort. If exit frisking is required by the RWP, Radiation Protection Personnel will perform the exit frisk.

Do not enter any areas posted “RADIATION AREA” “HIGH CONTAMINATION AREA” or “AIRBORNE RADIOACTIVITY AREA.”

Do not perform work of an intrusive nature (i.e., digging, drilling, sampling, etc.) or any abrasive work (i.e., welding, sanding, grinding, etc.) without specific written approval of the RSO.

Nuclear Regulatory Guide 8.13, “Instructions Concerning Pre-natal Radiation Exposure” is available for review upon request.

Address any questions you may have to your escort or to the person you are visiting. Questions may also be directed to the Safety & Health Department.

I have read and understand the above. I agree to comply with the terms of this form.

Visitor Signature

Date

I have reviewed the above with the visitor and agree to comply in full with PESI established radiological escort protocols including, but not limited to, those specific requirements specified on the back of this form.

Escort Signature

Date

Restricted Area Access Authorized:

RSO or designee Signature

Date

SSHO or designee Signature

Date

ALL SIGNATURES MUST BE PRESENT ON THIS FORM PRIOR TO RESTRICTED AREA ACCESS!

TITLE: Access Control	NO.: RP-101
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ATTACHMENT 1 (BACK OF FORM)
PESI VISITOR ACCESS CONTROL FORM

SSH0/RSO Requirements to Minimize or Eliminate Exposure Risks:

SSH0/RSO Remarks:

SSH0 Initials: _____ RSO Initials: _____



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radiological Postings

NO.: RP-102

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for posting requirements for various radiological hazard areas on PESI Projects.

2.0 APPLICABILITY

This procedure applies to all which require radiological postings.

3.0 REFERENCES

1. 10 CFR 19, "Notices, Instructions, and Reports to Workers; Inspection."
2. 10 CFR 20, "Standards for Protection Against Radiation."
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)

4.0 GENERAL

4.1 Discussion

Radiological postings are used to delineate areas containing radiological hazards and to inform personnel of hazards. In addition, supplemental or informational postings may be included which provide personnel with entry requirements or protective equipment requirements. Barriers may be used in conjunction with postings to ensure that personnel do not inadvertently enter into an area with a radiological hazard. Barriers at the PESI and the vicinity properties are normally composed of rope, tape, or fencing.

4.2 Definitions

Posting: A standardized sign or label which bears the standard trefoil radiation symbol in magenta or black on a yellow background and information concerning a specific radiological hazard.

TITLE: Radiological Posting Requirements	NO.: RPP-102
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5.0 RESPONSIBILITIES

5.1 Site Safety & Health Officer (SSHO)

- The SSHO is responsible for ensuring all activities performed within this procedure conform to the requirements of the SSHP.

5.2 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Reviewing pertinent survey data and making periodic tours to verify all areas within the PESI are properly posted.
- Authorizing the de-posting or down-posting of areas.
- Providing technical direction to the Radiation Protection Technicians (RPTs).

5.3 Radiation Protection Technician (RPT)

- Directing the placement of radiological postings and barriers.
- Performing periodic radiation / contamination surveys to ensure radiological conditions have not changed.

5.4 Project Supervisor

- Ensuring that personnel working in their particular area obey all radiological postings.

5.5 Project Personnel

- Obeying all radiological postings.
- Following directions from the RPT with regards to radiological postings.
- Maintaining their personnel exposures as low as reasonably achievable (ALARA).

6.0 PREREQUISITES

RPTs will be trained to assess and recognize the various radiological hazards present at the PESI.

7.0 PRECAUTIONS AND LIMITATIONS

- Barriers and other means shall be used as required to maintain control of areas requiring posting.
- At a minimum, all access / egress points to areas requiring radiological posting shall be conspicuously posted with the appropriate signs which includes area descriptions and specific requirements for entry.
- Appropriate signs should be placed approximately every 40 feet around the perimeter of a posted area. At least one sign should be placed on each side of an area's boundary, visible from any normal avenue of approach. These signs require only area identifiers (e.g., Restricted Area, Radioactive Materials Area, Radiation Area, etc.) in addition to the standard "Caution" or "Warning" and the tre-foil.
- An RPT with the appropriate field survey instrumentation may serve as the radiological posting in situations where the task is of a short duration or at the discretion of the RSO.
- No radiological control(s) shall be installed in any area that would prevent the rapid evacuation of personnel in an emergency situation.

TITLE: Radiological Posting Requirements	NO.: RPP-102
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- Trained emergency response personnel (Fire Dept, Ambulance / EMT, Law Enforcement) responding to on-site emergencies are exempt from the requirements of this procedure.
- Postings should be as clear and concise as possible to prevent confusion on the part of personnel desiring to enter an area.
- Postings should not be hung from ladders, electrical wire, switches, vehicles, or any other item that could be damaged, moved, or could cause injury to personnel.
- If more than one level of radiological posting is required in an area, posting for each unique condition shall be identified starting with the highest hazard potential. However, it is not required to post areas with area identifiers that are superseded by postings identifying a higher hazard potential (e.g., posting a Contamination Area as a Radioactive Materials Area, etc.).
- Radiological postings shall not be moved or altered without approval from the RSO or the RPT covering the work.

8.0 APPARATUS

- Yellow and magenta barrier supplies (e.g., rad-rope, rad-tape, rad-ribbon, etc.)
- Signs and inserts as required
- Radioactive Material Labels or tags
- Stands or Stanchions

9.0 RECORDS

All surveys performed for radiological posting placement will be forwarded to project document control.

10.0 PROCEDURE

10.1 Controlled Areas

All access points to areas meeting the definition of a Controlled Area shall be posted with the words “CONTROLLED AREA,” or “US GOVERNMENT PROPERTY” plus any additional verbiage deemed appropriate by Project Management.

10.2 Restricted Areas

All access points to areas meeting the definition of a Restricted Area shall be posted with the words “RESTRICTED AREA.”

10.3 Contamination Areas

All access points to areas meeting the definition of a Contamination Area shall be posted with the words “CAUTION, CONTAMINATION AREA,” and with the words “RESTRICTED AREA,” as well as any special instructions deemed necessary by the RSO.

10.4 High Contamination Areas

All access points to areas meeting the definition of a Contamination Area shall be posted with the words “CAUTION, HIGH CONTAMINATION AREA,” and with the words “RESTRICTED AREA,” as well as any special instructions deemed necessary by the RSO.

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10.5 Radiation Areas

All access points to areas meeting the definition of a Radiation Area shall be posted with the words “CAUTION, RADIATION AREA” as well as any special instructions deemed necessary by the RSO.

10.6 High Radiation Areas

All access points to areas meeting the definition of a High Radiation Area shall be posted with the words “DANGER, HIGH RADIATION AREA” as well as any special instructions deemed necessary by the RSO.

10.7 Radioactive Materials Areas

All access points to areas meeting the definition of a Radioactive Materials Area shall be posted with the words “CAUTION, RADIOACTIVE MATERIALS AREA” as well as any special instructions deemed necessary by the RSO.

10.8 Airborne Radioactivity Area

All access points to areas meeting the definition of an Airborne Radioactivity Area shall be posted with the words “CAUTION, AIRBORNE RADIOACTIVITY AREA” as well as any special instructions deemed necessary by the RSO.

10.9 Posting / De-Posting / Down-Posting

Posting, De-posting, and Down-posting activities should be noted in the appropriate technician logbook with reference to applicable survey number(s).

11.0 ATTACHMENTS

None



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: **Radiation Work Permits
Preparation and Use**

NO.: RP-103

PAGE: 1 of 7

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure describes the conditions under which a Radiation Work Permit (RWP) is required on PESI Projects. This procedure establishes consistent methodology and responsibilities for developing, utilizing and terminating an RWP. The procedure also describes the functions of the RWP (a sample is given in Attachment 1).

2.0 APPLICABILITY

This procedure applies to RWP requests, preparation, use, and termination. All personnel working on a task for which a RWP is required are required to comply with its conditions.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Section 30255, "Notices, Instructions and Reports to Workers, Inspections, and Investigations."
2. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
3. RP-101, "Access Control."

4.0 DEFINITIONS

Airborne Radioactivity Area: Means any area where the measured concentrations of airborne radioactivity above natural background exceed, or are likely to exceed, 25% of the Derived Air Concentration (DAC) values identified in Section 6.0 of the Radiation Protection Plan; and as listed in 10 CFR 20, Appendix B, Table I, Column 3

Contamination Area (CA): Means any area accessible to personnel with loose surface contamination values in excess of the values specified in the United States Army Corps of Engineers (USACE) Radiation Protection Manual, "Acceptable Surface Contamination Levels," (also refer to Table 1 of the Radiation Protection Plan; and procedure RPP-104, "Radiological Surveys,") or any additional area specified by the Radiation Safety Officer (RSO). The

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Contamination Area posting requirement is more restrictive than the Radioactive Material Area posting requirement. Any area posted as a Contamination Area shall also be considered to be a Radioactive Materials Area.

Radiation Work Permit (RWP): Means a document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions which exist in the work area and the radiological requirements for the job.

Radiation Area (RA): Means any area, accessible to personnel, where the whole body dose rate exceeds 5 mrem/hr but less than 100 mrem/hr at 30 cm from the source.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

High Radiation Area (HRA): Means any area accessible to personnel where the whole body dose rate exceeds 100 mrem/hr at 30 cm (12 inches) from the radiation source.

Radioactive Materials Area (RMA): Any area or room where quantities of radioactive materials in excess of 10 times the 10 CFR 20, Appendix C quantities are used or stored, or any area designated by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: Means any area to which access is limited by Project Management for the purpose of protecting individuals against exposure to radiation and radioactive materials.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Approving all protective measures incorporated into the RWP with regards to Radiological Safety.

5.2 Radiation Protection Technician (RPT)

- Conducting radiation and contamination surveys and keeping legible records.
- Preparing RWPs to control access to and activities in radiological areas.
- Monitoring worker compliance with RWP requirements.

5.3 Project Personnel

- Reviewing the correct RWP for the task to be performed.
- Accurately and legibly completing required information on the RWP Access Register.
- Observing radiological postings.
- Obeying oral and written radiological and industrial hygiene control instructions and procedures, including instructions on RWPs.
- Maintaining an awareness of radiological and industrial hygiene conditions in the work area.

6.0 PREREQUISITES

1. A RWP shall be required for the following:
 - All tasks requiring entries into Radiological Areas.

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- As specified by the RSO or their designees.
2. Prior to use of an RWP, the RSO or designee shall:
 - Define an access location appropriate for the RWP.
 - Review the inventory at the applicable Access Control Points and shall verify that Personal Protection Equipment (PPE), instruments and other safety-related equipment necessary to support the requirements of the RWP are available.
 3. Prior to entry, all personnel working under an RWP must:
 - Satisfy medical and training requirements as established in the Access Control procedure.
 - Be adequately briefed by the Radiation Protection Group regarding:
 - Work to be performed and the associated RWP requirements.
 - Safety procedures to be followed for its completion.

7.0 PRECAUTIONS AND LIMITATIONS

- Personnel shall not deviate from the requirements, precautions, or other instructions on the RWP without authorization from the RSO or designees.
- A copy of the RWP shall be posted at the work site. The original shall remain at a central location (Safety and Health office). Associated support documents containing environmental conditions (soil activities, contamination surveys, etc.) shall be maintained by the RSO and are available upon request.
- An RWP is not required when responding to emergency situations where serious consequences could result if time were taken to prepare the RWP.

8.0 APPARATUS

None

9.0 RECORDS

- Hazardous Work Permit (RWP)
- Hazardous Work Permit Access Register

10.0 PROCEDURE

10.1 Active RWP Use

1. The RP group will activate the RWP upon review and signature by the RSO.
2. A copy of active RWPs will be maintained at applicable Access Control Points.
3. The RSO or designee shall review the inventory and shall verify that PPE, instruments and other safety-related equipment necessary to support the requirements of the RWP are available at the applicable Access Control Points. Inventory reviews shall also be performed, as necessary, during the course of work on the RWP.
4. All workers who will be working on tasks supported by an RWP will be provided an initial briefing on the RWP by a Safety and Health representative:

- Upon their entry on the RWP.
 - Upon initial entry following revision of a RWP.
 - When significant changes occur in the work area.
5. The purpose of the briefing is to ensure:
- All Safety and Health conditions, requirements, special precautions, are fully understood by the workers.
 - Ensure that all anticipated tools, materials, and equipment are assembled for the work.
 - Ensure that work party members have been issued any radiological monitoring or protective devices specified for the work.
6. All personnel will read and verify that they understand and agree to comply with the terms of the RWP by signing in on the RWP Access Register (Attachment 2).
7. While working under an RWP, personnel are responsible to know and understand:
- The tasks that fall under the RWP.
 - Procedural controls and precautions taken to:
 - Reduce spread of contamination.
 - Reduce airborne emissions of radionuclides.
 - Reduce dose to workers and the public as low as reasonably achievable (ALARA).
 - Requirements to apply the sound radiological and safe work practices taught in indoctrination and continuing training.
8. The RSO or the attending RPT have stop work authority for all phases of work under an RWP. Stop work authority can be implemented when personnel safety is jeopardized due to:
- A change in the radiological (or other hazard) environment occurs, requiring additional controls and / or precautions.
 - If poor work practices are employed.
 - If RWP, ALARA, or procedural controls and / or precautions are violated.
9. Personnel shall sign in / out on the RWP Access Register for each entry into and egress from an area including when exiting the area for short break periods and when transferring to work on a different RWP.
10. Upon completion of work or at the end of the shift the Work Party Supervisor shall ensure that:
- Access Control Point and Work Area conditions are satisfactory. This includes housekeeping, safe storage of equipment, ensuring any required contamination control measures are implemented, and accurate completion of RWP Access Registers.

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- All radiological and Industrial Hygiene monitoring and protection devices that were issued have been returned to the Safety and Health (S&H) Group.

10.2 Termination of RWP

1. If the work was not or cannot be completed within the duration period of the RWP, an extension of the RWP should be requested.
2. An RWP is considered “terminated upon:
 - Signature by the RSO, or designee(s) in the appropriate section on the **original** RWP.
 - If the duration period for the RWP is been exceeded and the RWP was not extended.
3. Upon Completion of an RWP task, the Work Party Supervisor shall ensure that:
 - Access Control Point and Work Area conditions are satisfactory. This includes housekeeping, safe storage of equipment, ensuring any required contamination control measures are implemented, and accurate completion of RWP Access Registers.
 - All radiological and Industrial Hygiene monitoring and protection devices that were issued have been returned to the RP Group.
4. Upon completion of the job, the RWP copy and RWP Access register shall be returned to the RP Group for disposition.
5. Completed RWP forms (originals) and RWP Access Registers are quality records. These documents shall be maintained by the RP Group until transmitted to Project Records.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 Radiation Work Permit (Typical)

Attachment 2 Radiation Work Permit Access Register (Typical)

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Attachment 1 (Typical)

PESI RADIATION WORK PERMIT (RWP)		NO. <table border="1" style="display: inline-table; border-collapse: collapse;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px; text-align: center;">-</td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>			-		
		-					
		Revision Number <table border="1" style="display: inline-table; border-collapse: collapse;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>					
WORK DESCRIPTION:	WORK LOCATION(S):						
	Start Date /Time:						
	Est. Completion Date:						
	Requested by:						
	Request Date:						
HAZARDOUS CONDITIONS							
IS A RADIOLOGICAL / ALARA REVIEW REQUIRED ? No <input type="checkbox"/> Yes <input type="checkbox"/>							
I.H. LIMITS:	RADIOLOGICAL LIMITS	CURRENT CONDITIONS					
O₂:	Exposure Rate:	<i>IH/Rad conditions are evaluated by Safety & Health personnel, as necessary, during job coverage. The adjacent IH/Rad limits are the maximum allowed by this RWP.</i>					
LeL:	Alpha Contamination:						
Org. Vapors:							
DUST:	General Area Airborne:						
H₂S:	Limiting Isotope / DAC Value:						
REQUIRED PERSONAL PROTECTIVE CLOTHING & EQUIPMENT (PPE)							
HEAD / EYES	FEET / LEGS	BODY					
<input type="checkbox"/> Hard Hat <input type="checkbox"/> Safety Glasses <input type="checkbox"/> Monogoggles <input type="checkbox"/> Face Shield	<input type="checkbox"/> Sturdy Work Shoes <input type="checkbox"/> Disposable Shoe Covers <input type="checkbox"/> Rubber Over Shoes / Boots <input type="checkbox"/> Other (Specify):	<input type="checkbox"/> Cotton Coveralls <input type="checkbox"/> Tyvek Coveralls (Regular) <input type="checkbox"/> Tyvek Coveralls (Coated) <input type="checkbox"/> Other (Specify)					
RESPIRATORY	HANDS	MISCELLANEOUS					
<input type="checkbox"/> Full Face (Negative Pressure) * <input type="checkbox"/> Powered Air Purifying* <i>* Specify Cartridge or Canister Type Below</i> <input type="checkbox"/> Other (specify)	<input type="checkbox"/> Cotton / Work Gloves <input type="checkbox"/> Nitrile Surgeons Gloves <input type="checkbox"/> Rubber Gloves <input type="checkbox"/> Other (Specify):	<input type="checkbox"/> Tape Gloves & Boots to Coveralls <input type="checkbox"/> Fall Protection <input type="checkbox"/> Hearing Protection <input type="checkbox"/> Other (Specify)					
ADDITIONAL REQUIREMENTS / SPECIAL INSTRUCTIONS / MONITORING REQUIREMENTS							
Additional Requirements	Special Instructions	Dosimetry	Indiv.	Group			
<input type="checkbox"/> "Buddy System" in Effect <input type="checkbox"/> S&H Tech Job Coverage (Intermittent / Continuous) <input type="checkbox"/> Confined Space Entry Permit <input type="checkbox"/> HotWork Permit <input type="checkbox"/> Lockout-Tagout Permit <input type="checkbox"/> Excavation Permit <input type="checkbox"/> Review MSDS <input type="checkbox"/> Emergency Response Equipment <input type="checkbox"/> Communication Method (Radio / Voice) <input type="checkbox"/> Portable Eyewash Station <input type="checkbox"/> Pre-Entry Monitoring <input type="checkbox"/> S&H Tech Notification Prior to Work (Daily / Each Entry) <input type="checkbox"/> Personnel Frisking Required (Whole-Body / Hand & Feet) <input type="checkbox"/> _____ <input type="checkbox"/> _____ <input type="checkbox"/> _____		TLD Badge					
		Extremity TLD					
		Other (Specify):					
		Air Monitoring	Indiv.	Group			
		Lapel-Breathing Zone					
		Low Volume					
		Dust					
		PID / FID					
		4 Gas					
		Expiration Date/Time:					
		This permit will be reviewed for revision as conditions change and at 1-year from date of implementation.					
APPROVALS	DATE	TERMINATION	DATE				
RSO		RSO or SSHO					
SSHO		Reason:					

Attachment 2 (Typical)

PESI RWP ACCESS REGISTER

RWP # ___ - ___

WORK LOCATION: _____

DATE: ___ / ___ / ___

Sheet: ___ of ___

ENTRANT BADGE NUMBER (1)	ENTRANT SIGNATURE (2)	TIME IN (3)	TIME OUT	TIME IN	TIME OUT	TIME IN	TIME OUT	TIME IN	TIME OUT	TIME IN	TIME OUT	TOTAL HOURS (RP USE)

- Notes:**
- (1) If no badge number assigned, print name (Last, FI, MI)
 - (2) Entrant signature acknowledges understanding of and agreement to comply with RWP requirements, including required personnel monitoring. Entrants are to immediately report any frisker alarms or indications of personnel contamination to RP Personnel. **Escorts shall initial after entrant signature for visitors.**
 - (3) Use Military Time (24 Hour) for ALL entry/exit times (ex. 7:15 AM = 0715 or 3:25 PM =1525). Log each entry/exit, including break periods.

REGISTER REVIEW / DATA ENTRY: _____



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radiological Surveys

NO.: RP-104

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure establishes consistent methodology for performing radiation and contamination surveys at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This procedure is applicable to all personnel trained and qualified to perform radiation and contamination surveys at PESI.

3.0 REFERENCES

1. 10 CFR 20, "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)"
3. RP-101, "Access Control."
4. RP-105, "Unrestricted Release of Requirements."
5. RP-106, "Survey Documentation and Review"

4.0 GENERAL

4.1 Discussion

Radiological surveys are performed to detect and assess radiological conditions, which may be encountered at PESI.

4.2 Definitions

Contact Dose Rate: A radiation dose rate as measured at contact or within 1/2 inch of the surface being measured.

CPM: Counts per minute

Dose Rate: The quantity of absorbed dose delivered per unit of time.

DPM: Disintegrations per minute

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General Area Dose Rate (GA Dose Rate): The highest radiation dose rate accessible to any portion of the whole body measured at a distance of 30 cm (12 inches) from a significant radiation source or combination of sources.

LAW: Large area Wipe (i.e., Masslinn)

MDA: Minimum Detectable Activity

Survey: An evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of ionizing radiation under a specific set of conditions.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Ensuring appropriate radiation surveys are performed to measure and document radiation levels.
- Ensuring all completed surveys are adequately reviewed.
- Providing technical direction to the RPTs.

5.2 Radiation Protection Technician (RPT)

- Conducting and documenting radiation surveys.
- Performing all necessary pre / post use operability checks.
- Creating neat, legible, and concise records.

6.0 PREREQUISITES

- Prior to performing a radiation survey, personnel should review previous survey data and familiarize themselves with possible radiological hazards.

7.0 PRECAUTIONS AND LIMITATIONS

- Personal Protective Equipment (PPE) should be appropriate for the level of contamination expected and shall be in compliance with Site Safety & Health Plan (SSHP), Radiation Work Permits (RWPs), or other work specific controlling documents. At a minimum, gloves or tweezers should be used when handling swipes.
- Direct probe surveys may be used to demonstrate compliance with removable limits given in Attachment 1 (Acceptable Surface Contamination Levels), and discussed in RPP-105, "Unrestricted Release of Requirements." When instrumentation is used in this manner it should be capable of achieving the removable minimum detectable count (MDC) requirements.
- Surface contamination limits are contained in Attachment 1.
- Instruments used in surveys should be capable of achieving a Minimum Detectable Activity (MDA) that is less than the applicable release limits.
- In high background areas it may not be possible to achieve the required survey MDAs for beta / gamma instruments.

8.0 APPARATUS

- Radiation and contamination survey instruments

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- Smears
- Masslinn
- Personal Protection Equipment

9.0 RECORDS

Survey documentation to be completed per RPP-106, "Survey Documentation and Review."

10.0 PROCEDURE

10.1 General Instructions

1. Select the survey instrument based on the anticipated hazards and dose rates as determined by a review of previous survey data and ongoing work activities.
2. Perform pre-operational and response checks in accordance with the operating procedures for the instrument.
3. Remove any defective instrument from service.
4. Obtain survey forms and any other material required to document survey results.
5. Contamination Surveys are normally done for alpha emitting constituents. In certain circumstances the RSO can dictate that a survey be performed for both alpha and beta emitting constituents.

10.2 Routine Survey Frequencies

1. The RSO shall specify areas for routine monitoring surveys and the frequency of such surveys. The RSO should maintain a routine survey frequency schedule. The schedule is NOT considered a record, and does not need to be retained.
2. The following areas should be considered for a routine survey on a DAILY basis:
 - Access Control Points.
 - Designated eating, drinking, and smoking areas within Restricted Areas.
 - Radiological Counting Labs and sample prep areas.
 - Any other area specified by the RSO.
3. The following areas should be considered for a routine survey on a WEEKLY basis:
 - High Traffic areas on the PESI Site.
 - Operating high-efficiency particulate air (HEPA) exhaust areas.
 - Highly occupied areas within the radioactive Materials Area that could be a source of personnel contamination or an intake of radioactive materials (e.g., the boot change area, equipment floorboards, and workshops).
4. The following areas and equipment should be considered for a routine survey on a MONTHLY basis:
 - Occupied offices.
 - Storage areas.

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- Occupied areas within the radioactive Materials Area that could be a source of personnel contamination or an intake of radioactive materials (e.g., equipment storage areas).
5. The following should be done on an as-needed basis:
- Incoming Surveys

The RSO can direct that incoming surveys be performed on equipment and materials arriving onto the site. The purpose of an incoming survey is to protect the client from financial liability associated with decontaminating equipment that arrived on the site with existing contamination. The degree of thoroughness of the survey and the requisite cleanliness of the equipment is at the discretion of the RSO.
 - Surveys of Materials Vehicles, and Personnel leaving Restricted Areas

All materials, vehicles, and personnel shall perform surveys upon leaving Restricted Areas that have a potential for spread of contamination. The RSO or designee can direct that additional surveys be performed as needed to monitor for spread of contamination.
 - Direct Total Contamination Surveys
 1. All items being surveyed should appear to be clean prior to being surveyed. To the extent possible, all interior and exterior surfaces should be free from oil and visible dirt. The RSO may dictate the required degree of cleanliness, based on the purpose of the survey and the history of the item being surveyed.
 2. Obtain proper instrumentation for the survey. Ensure that the instruments are currently calibrated and have been performance checked prior to the survey.
 3. Determine and record the background count in the area to be surveyed. Ensure that the background is representative of the measurement to be taken. Calculate and record the MDA on the appropriate survey form. Verify the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. In no case shall the background count time be less than the sample count time.
 4. Perform a scanning survey of the item. Concentrate survey measurements on areas most likely to be contaminated. The fraction of the total area scanned is subjective, based on technician experience, an item's use history, and RSO guidance. Typically, the scan frequency is a minimum of 10% of accessible surface areas.
 5. Obtain static measurements at locations with the highest potential for contamination. The number of survey points selected is subjective, based on technician experience, an item's use history, and RSO guidance. The count time should be consistent with the MDA calculation. A typical count times is one minute for digital scalers and until the meter reading stabilizes for analog ratemeters.

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6. Record and identify all locations surveyed on the appropriate survey form(s). The use of diagrams or sketches is recommended.
 - **Beta-Gamma Probe** - In high background areas it may not be possible to achieve the required survey MDAs. This should be noted on the survey cover sheet, and should be brought to the attention of the RSO.
 - **Alpha Probe** - The performance check background may be used in place of background count in the area to be surveyed. A good practice is to check the probe for light leaks or for faulty cables if positive results begin appearing.
7. All measurements shall be reported in units of “dpm” unless otherwise directed by the RSO. Examples include “dpm/100 cm²,” and “dpm/probe.”
8. Direct non-smearable hot spots may be averaged over 1 square meter to determine compliance with release levels. If the entire item is less than 1 square meter in area, the entire surface area may be averaged. Bolt on parts of a vehicle should not be considered separate items.
 - The method for determining an average activity is to mark a 1 square meter area on the piece to be surveyed that is roughly centered on the hot spot. Take 1 measurement at the highest activity point of the hot spot. Take 4 (or more) other measurements within the square meter at locations representative of the whole square meter. Record count-rate of each individual measurement. Calculate the activity of all measurements being averaged, including those that are less than the MDA and those with a calculated activity less than zero. Calculate the average of all measurements and record on the survey form.
9. Complete the appropriate survey form.

10.3 Removable Contamination

With RSO approval, removable contamination surveys may be disregarded, provided that direct survey measurements and instrument MDAs are below site removable contamination limits for release.

1. All items being surveyed shall be clean prior to being surveyed. All interior and exterior surfaces should be free from oil and visible dirt. The RSO may dictate the required degree of cleanliness, based on the purpose of the survey and the history of the item being surveyed.
2. Wipe each location of interest with moderate pressure area using a standard 1 ¾-inch swipe. The area wiped should be approximately 100 cm². Larger areas may be wiped. It can be inferred that if the wipe meets the required limit for 100 cm² when it was actually taken from a larger area, the object will pass the 100 cm² criteria. No special documentation is required if the wiped area exceeds 100 cm². If the object is smaller than 100 cm², the area of the entire object should be wiped.
3. Large area wipes (LAW), also commonly referred to by the trade name “Masslinn” may be used to supplement smear surveys for removable

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contamination. The use of LAWs should be documented on the survey form with the notation “LAW,” or equivalent.

4. Ensure each used swipe (i.e., smear or large area wipe) is handled, stored, and transferred in such a fashion as to prevent to loss of sampled material or cross-contamination with other personnel and other swipe samples.
5. Record the location of each wipe on the appropriate survey form. It is preferable to record the location by circling the sequential number location on a survey map where the wipe was taken.

10.4 Analyzing Swipes

1. Smear samples should be counted using available scintillation or gas-flow proportional laboratory counters, when practicable. Field instruments may be used for smear counting at the discretion of the RSO.
2. LAW samples may be counted using field instruments. The use of laboratory counters is inappropriate.
3. Determine and record the background count-rate. Calculate and record the MDA on the appropriate survey form. Verify the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. In no case shall the background count time be less than the sample count time.
4. Remove each swipe from the paper backing, as needed. The use of tweezers is recommended.
5. Place the swipe in the counter and close.
6. Count for the designated counting time.
7. Record the gross result under cpm in the appropriate column (either alpha or beta-gamma) of the survey form.
8. Calculate and record the activity. Removable contamination survey results shall be reported in units of “dpm” unless otherwise directed by the RSO. Examples include “dpm/100 cm²” and “dpm/LAW.”

10.5 Gamma Surveys

1. Routine gamma surveys may be used to detect the gradual buildup of gamma emitting contaminated materials in soils. This may occur at heavy equipment, heavy traffic, or egress points from contaminated areas. Normal uncontaminated trash should be gamma surveyed prior to leaving the site.
2. Obtain proper instrumentation for the survey. Ensure that the instruments are currently calibrated and have been performance checked prior to the survey.
3. Perform the survey with the appropriate detector using techniques specified by the RSO.
4. Complete the appropriate survey form.

10.6 Gamma Dose Rate Surveys

- Obtain proper instrumentation. Ensure that the instrument is currently calibrated and has been performance checked prior to the survey.

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- When entering areas with known radiation levels, select the appropriate scale.
 - Observe the meters as you enter the area. If necessary, change scales to maintain on-scale reading.
- Perform gamma dose rate surveys as follows:
 - Monitor dose rates from the lower thighs to head level, recording the highest level as General Area Dose Rate.
 - Monitor dose rates 30 cm (12 inches) from a significant radiation source recording the highest level as General Area Dose Rate.
 - Additional measurements are necessary to determine Transport Index for shipping per procedure PP-8-810, “Conveyance Survey.”
 - If dose rate sources are predominantly from overhead, then denote on survey.
 - Perform contact gamma dose rate measurements with the detector within ½-inch of the surface to be surveyed.
 - Additional measurement locations should be clearly identified in survey documentation.
 - Record all survey results on the appropriate survey form.

11.0 CALCULATIONS

11.1 Sample Activity

$$DPM = \frac{\left(\frac{TotalSampleCounts}{SampleCountTime} \right) - \left(\frac{TotalBkgCounts}{BkgCountTime} \right)}{(E)(A)}$$

where:

E = Instrument Efficiency
 A = Area correction factor, if applicable

11.2 Minimum Detectable Activity (MDA)

The following MDA equation is to be used for a background count time equal to the sample count time:

$$MDA = \frac{\left(3 + 4.65\sqrt{B} \right)}{(E)(A)(T_s)}$$

where:

T_s = Sample count time
 E = Instrument efficiency

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- A* = Area correction factor, if applicable
B = Background cpm

The following equation is to be used for a background count time equal to 5 or more times the sample count time:

$$MDA = \left(\frac{(3 + 3.29\sqrt{B})}{(E)(A)(T_s)} \right)$$

12.0 DOCUMENTATION

- Survey forms shall be completed in entirety. This includes attaching printouts, diagrams, or other supporting documentation, appending sequential page and survey tracking numbers, a review for completeness and accuracy, and appending the appropriate signatures of personnel performing the survey and / or analyzing samples.
- Once complete, the survey package shall be submitted to the RSO or designee, for final review and approval signature.
- Survey documentation shall be maintained according to established RP document control and retention requirements.

13.0 ATTACHMENT

Attachment 1 Acceptable Surface Contamination Levels

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Attachment 1

Acceptable Surface Contamination Levels

NUCLIDE^a	AVERAGE^{b c} dpm/100 cm²	MAXIMUM^{b d} dpm/100 cm²	REMOVABLE^{b e} dpm/100 cm²
U-nat, U-235, U-238 and associated decay products	5,000	15,000	1,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	15,000	1,000

Notes:

- ^a Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.
- ^b As used in this table, dpm means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
- ^c Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each object.
- ^d The maximum contaminated level applies to an area of not more than 100 cm².
- ^e The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

*Source:USCG / USEPA EM 385-1-80 Table 6-4 Acceptable Surface Contamination Levels, 1985.

Note: The acceptable surface contamination levels for Th-nat will be used unless subsequent sampling indicate the presence Ra-226, Ra-228, Th-230, Pa-231, or Ac-227 in concentrations greater than that of the parent nuclide. The RSO will determine if contamination limits should be modified for a specific activity or location based on available data.



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Unrestricted Release Requirements

NO.: RP-105

PAGE: 1 of 5

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This project procedure describes the method of surveying equipment, materials, or vehicles for release for unrestricted use at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This project procedure applies to all site personnel responsible for the unrestricted release of equipment and materials used in a Restricted Area. This procedure is not used for vehicles that are transporting radioactive materials. Vehicles conveying radioactive materials also must follow USDOT Regulation 49 CFR Part 173.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)"
3. NRC Regulatory Guide 1.86.
4. RP-104, "Radiological Surveys"

4.0 DEFINITIONS

CPM: Counts per minute

DPM: Disintegrations per minute

Equipment and Material: Equipment and material refers to any item used in a Restricted Area to support work activities (i.e., hand tools, heavy equipment, plastic, etc.).

LAW: Large Area Wipe (i.e., Masslinn)

Unrestricted Release: Release of equipment and / or material to the general public.

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5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Ensuring adequate staffing, facilities, and equipment are available to perform the survey tasks assigned to Radiation Protection personnel.
- Approving purchase or acquisition of equipment necessary to perform surveys.
- Ensuring that surveys take place in appropriately posted areas.
- Reviewing results of survey data as required to determine acceptability for release of items.
- Dispositioning materials that cannot be released based on survey results.
- Investigating and initiating corrective actions for the improper release of radiologically contaminated material.

5.2 Radiation Protection Technician (RPT)

- Identify equipment and material to be surveyed for unrestricted release.
- Performing and documenting contamination surveys.
- Posting, securing and controlling radioactive material that cannot be released.
- Releasing material in accordance with this and implementing procedures.

5.3 Project Personnel

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.

6.0 EQUIPMENT AND MATERIAL

- Alpha Detector
- Beta-Gamma Detector
- Portable Ratemeter / Scaler
- Scintillation or Gas-Flow Proportional Lab Alpha / Beta Counter
- Survey forms
- Cloth smears
- Masslinn™ type cloths

7.0 INSTRUCTIONS

7.1 General Instructions

Prior to conducting any surveys, ensure that all survey instrumentation has been response checked, is in operating within control limits and has not been removed from service.

- Response checks shall be performed daily.
- Background measurements are to be taken prior to use at the point of use. The background count time shall be greater than or equal to the sample count time.

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- Verify that the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. Refer to RPP-104, “Radiological Surveys,” for the MDA calculation.
- Survey results are converted from counts per minute (cpm) to disintegrations per minute (dpm). A sample “cpm to dpm” calculation is attached for review and use at the end of this procedure.

7.2 Release of Items for Unrestricted Use

1. Surveys for both total and removable contamination shall be made in accordance with Section 7.3 (below) on all equipment, materials or vehicles which have either been in a Restricted Area or which may be potentially contaminated.
2. With RSO approval, removable contamination surveys may be disregarded, provided that direct survey measurements and instrument MDAs are below site removable contamination limits for release.
3. RP personnel will determine which items located outside a Restricted Area may be potentially contaminated based on their use, site history, or previous survey data. The potential for these objects to have become contaminated by airborne radioactive materials must be considered. This could include items that are used to support site activities, such as office equipment, cleaning devices, furniture, trailers, etc., even though direct contact may not have occurred.
4. Items which have a potential for internal contamination of inaccessible surfaces shall be evaluated by the RSO or designee prior to release.
5. All items to be released shall be surveyed in such a manner as to fully demonstrate that accessible surfaces comply with the surface contamination release criteria specified in RP-104, “Radiological Surveys.”
6. Items that do not meet release criteria shall be decontaminated until release criteria is met or shall be disposed of as radiological waste.
7. Air intakes / filters on motorized equipment should be surveyed as an indicator of potential internal contamination. Notify the RSO or designee if air intake / filter surfaces indicate the presence of contamination. Contaminated air filters shall be removed and disposed of as radiological waste.
8. To the extent practicable, visible dirt and mud or other material shall be removed from surfaces prior to survey.
9. The RSO or designee, shall review all survey data prior to the release from the Controlled Area.

7.3 Direct Surveys Scans and Static Measurements

1. Surfaces shall be dry and cleaned, to the extent practicable prior to performing direct alpha measurements.
2. The RSO may authorize the short-term relocation or staging of equipment / vehicles for direct measurements in any portion of the Controlled Area. This is provided that the item has been verified to be clean of removable

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	PAGE: 4 of 5

- contamination prior to removal from a Restricted Area and fixed contamination producing general area dose rates greater than 0.2 mrem/hr is not anticipated.
3. Alpha detectors should be placed within ¼-inch of the surface to be surveyed. Beta detectors should be placed within ½-inch of the surface to be surveyed. Use caution to not contaminate or damage the detector surface.
 4. Perform a scanning survey of the item. Concentrate survey measurements on areas most likely to be contaminated. The fraction of the total area scanned is subjective, based on technician experience, an item's use history, and RSO guidance. Typically, the scan frequency is a minimum of 10% of accessible surface areas.
 5. Obtain static measurements at locations with the highest potential for contamination. The number of survey points selected is subjective, based on technician experience, an item's use history, and RSO guidance.
 6. Static measurement count times shall be appropriate for desired MDAs. Typical count times are one minute for digital scalers and until the meter reading stabilizes for analog ratemeters.
 7. Record and identify all locations surveyed on the appropriate survey form(s). The use of diagrams or sketches is recommended.
 8. All measurements shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100 cm²" and "dpm/probe."

7.4 Removable Contamination Surveys

1. "Cloth" smears shall be used for smear surveys.
2. A notation (e.g., smear number, date, time, location, etc.) should be made on the smear envelopes to ensure proper smear tracking. Smears may also be numbered using a pen or marker prior to use.
3. Using moderate pressure, swipe an area of 100 cm² (4-inch square area or equivalent) of the surface at the selected location. Smear surveys should be performed at the same location that direct surveys were performed.
4. Large Area Wipes (LAW), also commonly referred to by the trade name "Masslinn," may be used to supplement smear surveys for removable contamination. The use of LAWs should be documented on the survey form with the notation "LAW" or equivalent.
5. Ensure each used swipe (i.e., smear or large area wipe) is handled, stored, and transferred in such a fashion as to prevent to loss of sampled material or cross-contamination with other personnel and other swipe samples.
6. Smear samples should be counted using available scintillation or gas-flow proportional laboratory counters, when practicable. Field instruments may be used for smear counting at the discretion of the RSO.
7. LAW samples may be counted using field instruments. The use of laboratory counters is inappropriate.
8. Removable contamination survey results shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100cm²" and "dpm/LAW."

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9. Ensure all results are documented on the appropriate survey form. Lab printouts may be attached and referenced on the survey form.

8.0 CALCULATIONS

MDA and Sample Activity formulas are located in RPP-104, "Radiological Surveys."

9.0 DOCUMENTATION

- Survey forms shall be completed in entirety. This includes attaching printouts, diagrams, or other supporting documentation, appending sequential page and survey tracking numbers, a review for completeness and accuracy, and appending the appropriate signatures of personnel performing the survey and / or analyzing samples.
- Once complete, the survey package shall be submitted to the RSO or designee, for final review and approval signature.
- Survey documentation shall be maintained according to established RP document control and retention requirements.

10.0 ATTACHMENT

None



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Survey Documentation and Review

NO.: RP-106

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure establishes consistent methodology for documenting radiological surveys and provides criteria for the review of these surveys.

2.0 APPLICABILITY

This procedure is applicable to all radiological surveys excluding air samples.

3.0 REFERENCES

1. 10 CFR 20, "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)"
3. RP-104, "Radiological Surveys."

4.0 GENERAL

4.1 Discussion

The results of surveys will be documented on survey forms or in designated logs as approved by the Radiation Safety Officer (RSO). Survey data will contain enough detail to provide personnel with adequate information concerning radiological conditions existing in the area surveyed.

The RSO or designee will review completed survey documentation to ensure appropriate, adequate and complete information is recorded. The individual reviewing the survey will ensure that the recorded results are legible, in accordance with Radiological Protection Program (RPP) implementing procedures, consistent with anticipated levels, and will determine the reason for any variances.

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4.2 Definitions

Airborne Radioactivity Area (ARA): Means any area where the measured concentrations of airborne radioactivity above natural background exceed, or are likely to exceed, 25% of the Derived Air Concentration (DAC) values listed in 10 CFR 20, Appendix B, Table I, Column 3.

Contamination Area (CA): Means any area accessible to personnel with loose surface contamination values in excess of the values specified in RP-104 , “Radiological Surveys, or any additional area specified by the Radiation Safety Officer (RSO). The Contamination Area posting requirement is more restrictive than the Radioactive Material Area posting requirement. Any area posted as a Contamination Area shall also be considered to be a Radioactive Materials Area.

Contact Dose Rate: A radiation dose rate as measured at contact or within 1/2 inch of the surface being measured.

General Area Dose Rate (GA Dose Rate): The highest radiation dose rate accessible to any portion of the whole body measured at a distance of 30 cm (12 inches) from a significant radiation source or combination of sources.

Radiation Work Permit (RWP): Means a document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions, which exist in the work area and the radiological requirements for the job.

Radiation Area (RA): Means any area, accessible to personnel, where the whole body dose rate can exceed 5 mrem in 1 hour at 30 cm from the source.

Radioactive Material: Material activated or contaminated by the operation or remediation activities and by-product material procured and used to support the operations.

Radioactive Materials Area (RMA): Any area or room where quantities of radioactive materials in excess of 10 times the 10 CFR 20, Appendix C quantities are used or stored, or any area designated by the RSO which does not exceed the site Contamination Area criteria.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- The Radiation Safety Officer (RSO) or designee is responsible for reviewing radiological surveys performed by Radiation Protection Technicians (RPT).

5.2 Radiation Protection Technician (RPT)

- RPTs are responsible for documenting surveys in a legible manner on approved forms.

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	PAGE: 3 of 7

6.0 PREREQUISITES

- Surveys for radiation and contamination have been performed in accordance with RP-104 “Radiological Surveys”.

7.0 PRECAUTIONS AND LIMITATIONS

- Surveys for airborne radioactivity will be documented in accordance with RP-107, “Measurement of Airborne Radioactivity.”

8.0 APPARATUS

Survey Forms

9.0 RECORDS

- PESI Survey Form (Attachment 1)
- PESI Survey Log Number Form (Attachment 2)
- Radiation Protection Technician (RPT) Logbooks

10.0 PROCEDURE

The methods outlined in this procedure are intended to assure the clear and concise transfer of survey information. Variations or deviations from the protocols in this procedure are permitted if the clear transfer of information is maintained.

10.1 Documentation

10.1.1 General

1. Record all information on survey forms in a neat and legible manner.
2. Document all surveys on a form with approved project heading. Technician logbooks may be used for documenting surveys (e.g., daily routines, material transfers, minor posting changes, etc.) as authorized by the RSO and providing instrument serial numbers are documented with survey data.
3. When recording information on survey forms, check all appropriate boxes and circle all appropriate answers.
4. Use a survey form with pre-drawn diagrams when available. If not, draw a diagram or picture of the object surveyed. Should a diagram not be appropriate, use a lined survey form.
5. Assign the next sequential survey number to the survey from the survey number logbook.
6. Complete the following information for all surveys:
 - Date and time of survey
 - Location of survey
 - Instrument type and serial numbers and associated supporting information (i.e., detector efficiencies, calibration dates, background values, etc.)
 - HWP number, if applicable
 - Reason for survey

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- Name and signature of surveyor
7. Indicate Radiological Hazard Area boundaries on the survey form using x's and -'s (-x-x or **).
 8. Note the posted Radiological Hazard using common designator such as
 - Contamination Area = CA
 - Radiation Area = RA
 - Radioactive Material Area = RMA
 - Airborne Radioactivity = ARA
 9. The use of Greek alphabet and other nuclear industry standard nomenclature (e.g., “k” = 1000) is acceptable when documenting surveys.

10.1.2 Survey Log Number Book:

1. Survey log number book is to be used to assign a unique sequential number to each survey form package. This number provides the ability to track individual surveys as well as ensuring the submittal of a complete documentation package for archiving.
2. Unless otherwise directed by the RSO, survey numbers will be assigned with the following format:

NFSSyyRS.xxxx

“NFSS” corresponds to “Niagara Falls Storage Site,” yy is the last two digits in the year, “RS” refers to “Radiological Survey,” and xxxx refers to the sequential survey number.

3. As surveys are generated, the RPT will take the next sequential number on the form and fill in the remaining boxes with a brief description of the reason for the survey as well as the date and RPT’s initials.

10.1.3 Radiation Surveys

1. Indicate GA dose rates by underlining the radiation level on the Survey Form at the appropriate location (Example: 25 uR/hr).
2. Indicate CONTACT dose rates by recording the radiation level with an asterisk on the Survey Form at the appropriate location (Example: * 25 ur/hr). If there are corresponding 30 cm and GA readings, document them as follows:

* CONTACT / @ 30 cm / GA

3. Use a legend to inform the reviewer of any other notation utilized or if deviating from standard protocol.

10.1.4 Contamination Surveys

1. Indicate survey locations by placing sequential numbers within a circle on the Survey Sheet. The Survey Sheet has corresponding direct and transferable columns for both alpha and beta / gamma activity.
2. Use a legend to inform the reviewer of any other notation utilized or if deviating from standard protocol.
3. The use of the letter “k” to indicate units of a thousand is acceptable.

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10.2 Technician Review and Evaluation

- 10.2.1 After completing the surveys, evaluate the results against previous surveys or anticipated results.
- 10.2.2 Verify that radiological boundaries and postings are correct in accordance with RPP-102, "Radiological Posting Requirements."
- 10.2.3 Take any immediate actions required based on survey results.
- 10.2.4 Ensure all relevant supporting documentation (e.g., count room print-outs, etc.) are attached to the survey package and that the package is properly paginated.
- 10.2.5 Submit documentation to the RSO or designee for supervisory review.

10.3 Supervisory Review

- 10.3.1 Ensure that the survey form is complete and legible.
- 10.3.2 Ensure that all required information has been completed.
- 10.3.3 Ensure that any changes, single line cross-outs, or deletions are initialed and dated at time performed.
- 10.3.4 Verify that results are consistent with those anticipated.
- 10.3.5 If results are not consistent, ensure that appropriate actions have been taken to explain the results or re-examine the area.
- 10.3.6 Sign-off in the appropriate review section of the survey form and submit package to RP Document Control for retention / transmittal to Project Files.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 PESI Survey Form (Typical)

Attachment 2 PESI Survey Log Number Form (Typical)



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Measurement of Airborne Radioactivity

NO.: RP-107

PAGE: 1 of 12

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure establishes the basis and methodology for the placement and use of air monitoring equipment, as well as the collection, analysis, and documentation of air samples. Radiological air sampling and analysis is performed to monitor concentrations of radionuclides in the air for purposes of tracking internal radiation exposure to occupational radiation workers, determining appropriate respiratory protection devices, establishing radiological posting boundaries, verifying effluent airborne radioactivity concentrations, and providing information on radiological conditions in the work area.

2.0 APPLICABILITY

This procedure applies to all radiological air monitoring activities performed in support of Perma-Fix Environmental Services (PESI) activities.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
2. Perma-Fix Environmental Services (PESI), "Radiation Protection Plan (RPP)"
3. Rock, R.L., *Sampling Mine Atmospheres for Potential Alpha Energy Due to the Presence of Radon-220 (Thoron) Daughters*, Informational Report No. 1015, United States Department of the Interior, Mining Enforcement and Safety Administration, 1975.
4. Kusnetz, H.L., *Radon Daughters in Mine Atmospheres, A Field Method for Determining Concentrations*, Am. Ind. Hyg. Assoc. Quat., Vol. 17, No. 87, 1956.
5. ANSI N13.1, *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities*.
6. *Regulatory Guide 8.25, Air Sampling in the Workplace*.
7. 29 CFR 1910.1096, *United States Occupational Health & Safety, Ionizing Radiation*.

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Measurement of Airborne Radioactivity	PAGE: 2 of 12

4.0 DEFINITIONS

Airborne Radioactivity: Radioactive material in any chemical or physical form that is dissolved, misted, suspended, or otherwise entrained in air.

Ambient Air: Air in the volume of interest, such as room atmosphere, as distinct from a specific stream or volume of air that may have different properties.

Annual Limit on Intake (ALI): The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent (CEDE) of 5 rems or a committed dose equivalent (CDE) of 50 rems to any organ or tissue.

Breathing Zone (BZ): A uniform description of the volume of air around the worker's upper body and head which may be drawn into the lungs during the course of breathing.

Committed Dose Equivalent (CDE): The dose equivalent to tissues or organs of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed Effective Dose Equivalent (CEDE): The sum of committed dose equivalents (CDEs) to various tissues in the body, each multiplied by the appropriate weighting factors found in 10 CFR 20.

Derived Air Concentration (DAC): The concentration of a given radioactive nuclide in air which, if breathed by the reference man for a working year of 2000 hours under conditions of light work (1.2 m³ of air per hour), would result in an intake of one (1) ALI.

DAC-hour (DAC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide in hours. A facility may take 2000 DAC-hr to represent 1 ALI.

Grab Sample: A single sample of ambient air collected over a short time.

Maximum Permissible Concentration (MPC): That concentration of radionuclides in air or water that will result in the Maximum Permissible Body Burden or Organ Burden and result in a whole body or organ receiving the annual dose limit if breathed in by a worker for 2000 hours.

Monitoring: The measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation.

MPC-hour (MPC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the MPC for each radionuclide) and the time of exposure to that radionuclide in hours.

Occupational Dose: An individual's ionizing radiation dose (external and internal) received as a result of that individual's work assignment.

Protection Factor: The degree of protection given by a respirator. The protection factor is used to estimate radioactive material concentrations inhaled by the wearer and is expressed as the ratio

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Measurement of Airborne Radioactivity	PAGE: 3 of 12

of ambient concentration of airborne radioactive materials to the concentration that can be maintained inside the respirator during use.

Representative: Sampling in such a manner that the sample closely approximates both the amount of activity and the physical and chemical properties of the material (e.g., particle size and solubility in the case of aerosol to which workers are exposed). Air sampling performed within the Breathing Zone (BZ) is considered representative of the airborne radioactive material concentration inhaled by the worker.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Manages the implementation of this procedure.
- Ensures technicians performing activities under this procedure are competent and have sufficient experience to perform assigned tasks.

5.2 Radiation Protection Technician (RPT)

- Initiates, collects, submits, counts, and documents air samples according to the requirements of this procedure, and the SSHP.
- Ensures he / she has sufficient experience and / or knowledge to perform assigned duties under this procedure.

6.0 PRECAUTIONS AND LIMITATIONS

- Running air samplers for extended periods may cause excessive dust loading of the filter media. The frequency of filter change-out should be increased if excessive dust loading is observed.
- Air samplers shall not be used in combustible / explosive atmospheres.
- Air sampling and sample counting equipment shall not be operated beyond their respective calibration periods.
- Air samples shall be taken in such a manner as to not contaminate the filter with materials that were not airborne during the sample interval or by re-suspension of loose contamination from surfaces near the sampling head.
- Sampler exhaust may cause the re-suspension of loose surface contamination if the sampler is positioned improperly.
- Consider higher volume air samplers when covering short duration tasks.
- The decision to provide individual monitoring devices to workers is influenced by the expected levels of intake, likely variations in dose among workers, and the complexity of measurement and interpretation of results.

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7.0 ACTION STEPS

7.1 Air Monitoring Methods

1. Utilize the following monitoring methods to implement the radiological air monitoring program:
 - General Area (GA) Air Monitoring
 - Breathing Zone (BZ) Air Monitoring
 - Passive Radon Monitoring
 - Particulate Radon Grab Samples
 - Perimeter Monitoring, frequently referred to as Air Environmental (AE)
2. Air sampling equipment should be placed so as to:
 - Not directly contact a contaminated (transferable) surface.
 - Minimize interference with the performance of work.
 - Be easily accessible for changing filters and servicing.
 - Be downstream of potential release points.
 - Minimize the influence of supply airflow.
3. An airflow study of any indoor area to be monitored should be performed prior to placement of the sampler (other than BZ samplers). Additional studies should be performed after changes in the work area setup, ventilation systems, or seasons, if seasonal changes may affect airflow patterns.
4. Perform BZ air sampling in occupied areas where, under typical conditions, a worker is likely to be exposed to an air concentration of 10 % or more of the DAC.

7.2 General Area (GA) Air Sampling

1. GA samples are typically taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. GA sampling shall be performed with instrumentation operating at volumes capable of meeting the Minimum Detectable Concentration (MDC) values established in the Technical Basis Document for Dosimetry and Air Sampling.
3. GA samples should be collected:
 - During work activities as a supplement to Breathing Zone (BZ) sampling as deemed appropriate.
 - At site boundaries to confirm effluent air discharge concentrations. These are the Air Environmental (AE) type samples.
 - At discharge points to determine the worst case airborne radiological conditions.
4. Document airflow studies, if performed in the appropriate project logbook or as directed by the RSO.

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5. Select a calibrated low / high volume sampler with the appropriate glass fiber air filter and place the sample head into position. The fuzzy side of the filter should face outwards.
6. Turn the sampler ON. At a minimum, document the following information on the air filter envelope or log sheet:
 - Sampling station identifier (as determined by the RSO)
 - Sampler model
 - Serial number
 - Date / time on
 - Flow rate
 - On by (individual starting sampler)
7. When air monitoring is complete, observe the sampler flow rate and turn the sampler off. At a minimum, document the following information on the air filter envelope or logsheet:
 - Date / time off
 - Flow rate
 - Off by (individual terminating sample)
8. Remove and / or replace the sample head and filter using caution to prevent cross-contamination.
9. Store the filter in a protective container to minimize the loss of collected material.
10. Submit sample to counting lab for analysis.

7.3 Breathing Zone (BZ)

1. Specific instructions on the use and calibration of Lapel Samplers are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Collect BZ samples during entries into posted airborne radioactivity areas and during activities which have a reasonable potential of producing airborne radioactivity (e.g., excavating contaminated soils, surface destructive activities on surfaces with fixed contamination) as determined by the RSO.
3. Position the sampler on the individual representative of the worst-case exposure for the group if a single lapel sampler is used for multiple members of a work group. Base this selection on operating experience and consultation with the RSO. A single lapel sampler should be used for a group of no more than four workers spending greater than one hour in the work area under the same RWP.
4. Ensure the sample head is positioned as close to the breathing zone as practical without interfering with the work or the worker.
5. Operate lapel samplers according to the appropriate instrument use procedure. At a minimum, document the following information on the air filter envelope or log sheet:
 - Wearer's name(s)
 - Applicable Hazardous Work Permit (HWP) number

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Measurement of Airborne Radioactivity	PAGE: 6 of 12

- Sampler model / serial numbers
 - Date / time On
 - Flow rate (sampler must be running)
 - On by (individual starting sampler)
6. Upon exit from the work area, note the flow rate, turn the sampler OFF and detach from the worker / object. Note that sampling may be suspended / restarted during the workday to facilitate break periods. Accurate volume tracking is crucial during these periods of non-operation.
 7. Perform necessary post-operation sampler checks according to the specific instrument use procedure.
 8. Carefully, remove the air filter from the sample head and place in air filter envelope. Complete the pre-printed air filter envelope or sample log sheet:
 - Date / time off
 - Flow rate
 - Off by (individual stopping sampler)
 9. Submit sample to Counting Room for analysis.

7.4 Radon and Thoron Progeny

1. High volume or low volume grab samplers such as HV-1, LV-1, or RAS-1 (typically in the 35-75 lpm range) should be used for collecting radon and thoron samples.
2. Radon and thoron samples should be collected:
 - During work activities as deemed appropriate by the RSO or designee.
 - At restricted area boundaries as deemed appropriate by the RSO or designee.
 - Each frequently occupied work location should have its own samplers.
 - Airflow patterns should be considered in placing samplers so that the sampler is likely to be in the airflow downstream of the source.
 - A simultaneous background sample shall be taken upwind of all activities when radon and thoron sampling is performed. This sample is critically important.
 - When collecting a radon and thoron breathing zone sample, the sampler should be located in the breathing zone for the worker. Preferably it should be held immediately downwind of the worker and moved around with the worker.
3. Select a calibrated high volume sampler with a 47 mm filter and place the sample head into position. The preferred filter is a membrane filter such as the F&J Specialty Products, Inc. model number A020A047A or equivalent. Alternatively, a glass fiber filter such as the F&J Specialty Products, Inc. model number AE-47 or equivalent can be used

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4. Turn the sampler ON and complete the required information on the air filter envelope to include:
 - RWP number, if appropriate
 - Sampler model and serial number
 - On date, time, and flow rate
 - On by (site worker initials)
 - Sample location
5. Collect a sample for exactly 5 minutes, with no more than a 5-second uncertainty. Exercise caution when handling sample head so as not to cross-contaminate the air filter.
6. Remove air filter from sample head and place in air filter envelope. Complete the required information on the air filter envelope including:
 - Off date, time, and flow rate
 - Site worker stopping the sampler
7. Submit the sample to the counting room within 30 minutes after collection. Samples must be counted between 40 and 90 minutes, or they will be void.
8. Analyze the sample in accordance with Sections 8.1 or 8.2, whichever is appropriate.
9. Alternate industry-accepted methods for Radon-Thoron monitoring may be used at the discretion of the RSO with concurrence from the Project Certified Health Physicist.

7.5 Perimeter Environmental Air (AE) Sampling

1. Perimeter samples are taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Perimeter samples are collected to verify compliance with off-site release criteria.
3. Samples are collected at locations designated by the RSO. The air sampling locations should be established at the most likely downwind perimeter boundary, as determined by evaluation of local meteorological data, and / or the nearest perimeter boundary from active work areas.
4. Perimeter samplers should be operated 24 hours a day 7 days a week if possible.
5. Filters from continuously operating perimeter air samplers are normally changed out weekly. Filter change-out of perimeter air samplers will be performed at a frequency long enough to ensure acceptable counting statistics and short enough to maintain consistent sampler flow rates.
6. Perimeter sampler operation shall be verified on a daily basis around locations when airborne generating activities are in progress. This requirement may be relaxed by the RSO for samplers with data logging capability.

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7. Document daily verification (i.e., flow rate) and notify the RSO of any discrepancies. Replace filter and investigate pump operation if daily flow rates vary by greater than 20%.
8. Any sampler that is out of service due to malfunction for more than 1 hour and any invalid samples should be brought to the attention of the RSO.
9. Samples are to be collected in accordance with Section 7.2, Steps 5-10.

7.6 Passive Radon Monitoring

1. Passive radon monitoring methods include the use of either alpha track-etch detectors or electrets.
2. Detectors should be placed for a length of time, so that the minimum detectable concentration is 0.1 pCi/l or less, following manufacturer guidelines. The length of placement is generally 1 month or greater. Locations selected should be representative of the breathing zone, when practical. A simultaneous background sample should always be taken at a location unaffected by site activities. This sample is critically important.
3. Open the bag containing the detector and place the detector in a protective container to allow for air circulation. Follow manufacturer guidelines to activate the detector, as necessary.
4. Record in the logbook:
 - Sample location
 - Date and time of placement
 - Serial number of the detector
 - Initials of the worker placing the detectors
5. Ship the detector to the manufacturers processing center to read the results.

8.0 ANALYSIS OF AIR SAMPLES

General Area (GA), Breathing Zone (BZ), and Perimeter Air (PA) samples should be submitted to a counting room or off-site laboratory for gross alpha/beta analysis. Samples may be sent to an outside laboratory for isotopic analysis as necessary per the RSO.

8.1 Analysis for Radon and Thoron Progeny from a 5-Minute Low Volume Grab Sample

- 8.1.1 Count the sample twice for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The first count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of sample collection. The second count should start at least 5 hours after the end of the count, but not greater than 17 hours after the end of the first count. Count the sample for 5 minutes each time.

NOTE: It is not recommended that a gas flow proportional counter be used for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

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- 8.1.2 Calculate the thoron progeny (TDC) in working levels from the delayed (second) count as follows:

$$TDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Th}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Th} = Working level factor from Graph 1 (Attachment 1).

- 8.1.3 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{\left(\frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF} - TDC \times 16.5 \right)}{F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

TDC = Thoron Progeny determined from second count.

8.2 Alternate Method for the Analysis of Radon Progeny from a 5-Minute Low Volume Grab Sample

This section only applies to the determination of radon and not the determination of thoron.

- 8.2.1 Count the sample once for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of the count. Count the sample for 5 minutes.

NOTE: It is not recommended to use a gas flow proportional counter for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

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8.2.2 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

9.0 REPORTS

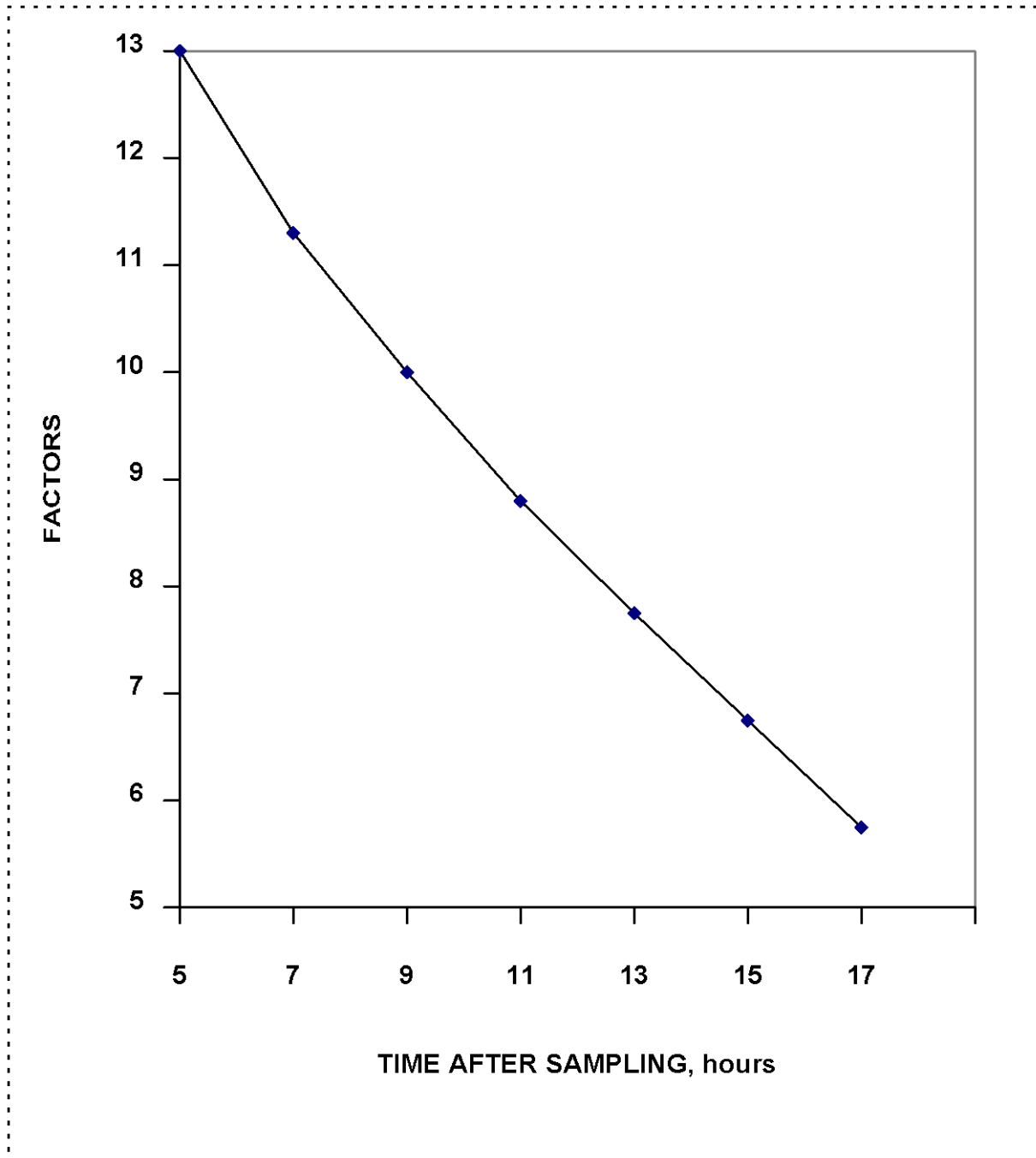
Maintain air monitoring instrument data, sampling data, and analysis results as a quality record.

10.0 ATTACHMENTS

Attachment 1 Graph 1, Thoron Working Level Factors

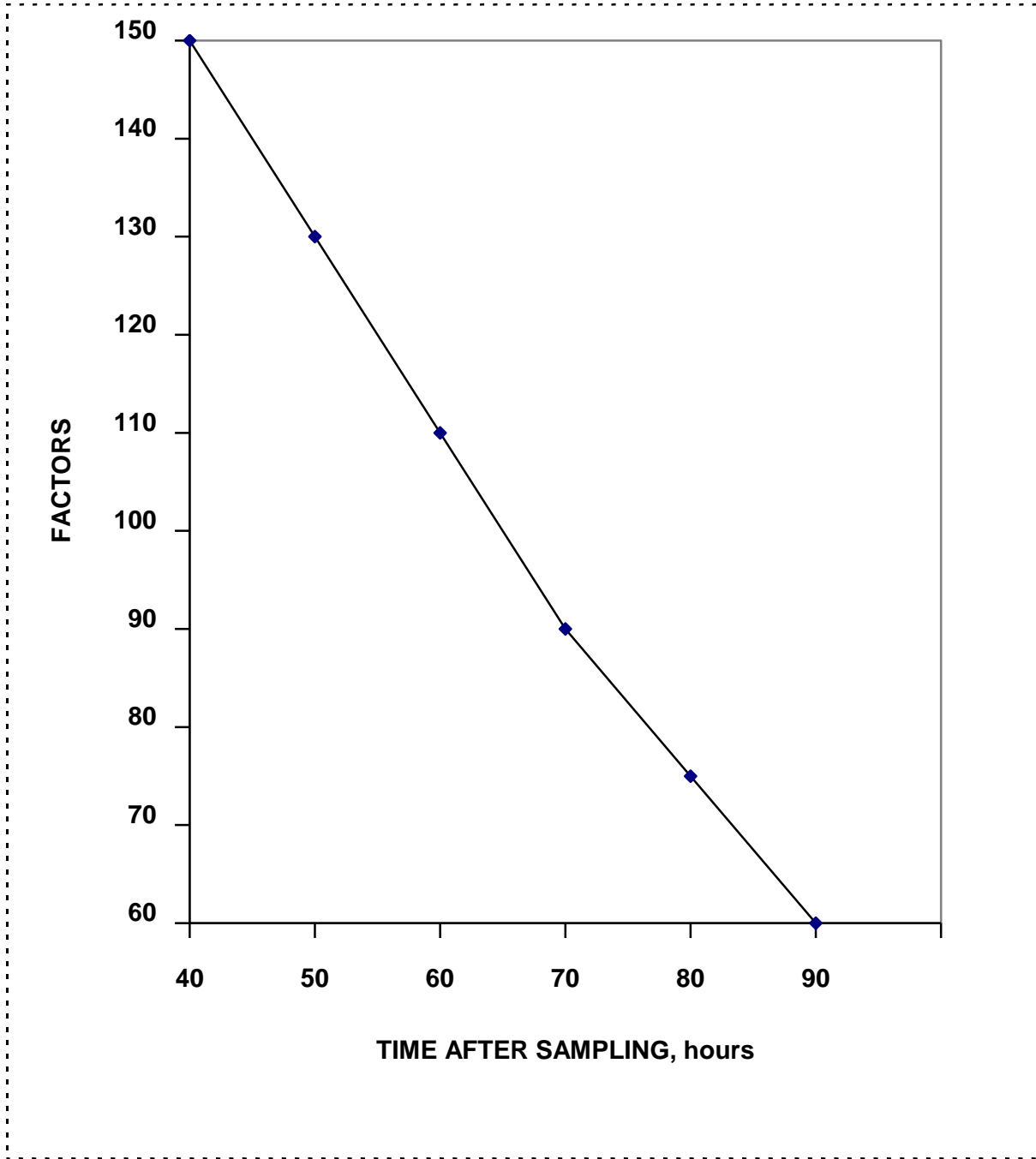
Attachment 2 Graph 2, Radon Working Level Factors

ATTACHMENT 1
GRAPH 1, THORON WORKING LEVEL FACTORS



Time factors versus time after sampling for thoron daughter samples.

ATTACHMENT 2
GRAPH 2, RADON WORKING LEVEL FACTORS



Time factors versus time after sampling for radon daughter samples.



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Count Rate Instruments

NO.: RP-108

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure specifies the methods for set-up, daily pre-operational check, and operation of portable count-rate survey instruments. These instruments are used for the detection of radioactivity on personnel, on or within material surfaces, and in the environment. This procedure does not include associated instrument calibrations or cover the operation of exposure rate instruments.

2.0 APPLICABILITY

This procedure specifically addresses those meter-probe combinations that report values in units of counts or counts per minute (cpm) such as Ludlum Measurements models 2221 and 2241 Scaler-Ratemeters; and the Ludlum Model 177 Alarming Ratemeter or equivalent. These meters are mated to probes including the Ludlum Model 44-10, 44-20, and 44-62 NaI Detectors, the Ludlum Model 43-5 Alpha Scintillation Detector, and the Ludlum Model 44-9 Pancake Geiger-Mueller detectors or equivalent. Additional equivalent meters and probes may be used under this procedure without revision as approved by the RSO.

3.0 REFERENCES

1. ANSI N323A-1997, Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments.
2. Instrument Technical Manuals.
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)
4. RP-104, Radiological Surveys

4.0 DEFINITIONS

cpm: counts per minute

DFSCL: Daily Field Source Check Logsheet.

dpm: disintegrations per minute

HV: High Voltage

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MDA: Minimum Detectable Activity

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Reviewing and approving changes to this procedure and ensuring compliance with applicable regulations.
- Ensuring an adequate inventory of Radiation Protection instruments are available to support remediation activities.
- Overseeing the issue, control, and accountability of Radiation Protection instrumentation per the requirements of this procedure.
- Ensuring transmittal of all issue, control and accountability records to the appropriate document control authority when applicable.

5.2 Radiation Protection Technician (RPT)

- Maintaining instrument documentation and records as required by this procedure.
- Maintaining adequate instrument and equipment availability.
- Verifying current calibration and response test dates prior to issue or use of instruments.
- Promptly returning instruments to their proper location when work is complete.
- Ensuring that instruments are properly surveyed for contamination and decontaminated as necessary after use.

6.0 PREREQUISITES

- Only personnel with appropriate documented training shall issue or use RP instrumentation.
- Instruments and detectors shall be inspected for mechanical damage, and response tested prior to issue.
- Any instrument to be used shall have a current calibration label affixed to the instrument.

7.0 PRECAUTIONS AND LIMITATIONS

- Portable count rate survey instrumentations are susceptible to damage from physical and environmental stresses.
- QA/QC requirements established by an approved survey plan (e.g., Master Final Status Survey Plan) supercede the requirements of this procedure.

8.0 APPARATUS

- Appropriate survey instruments

9.0 RECORDS

- Portable Instrument Set-Up Sheet
- Daily Field Source Check Logsheet

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10.0 PROCEDURE

10.1 General

1. Ensure the meter-probe combination selected is within their acceptable calibration periods. The swapping of probes between meters is permitted, but not encouraged. The following precautions and limitations must be observed and the following action steps must be taken:
 - If the meter-probe combination is calibrated as a set, Probe swapping is not permitted, without specific RSO approval.
 - The HIGH VOLTAGE (HV) and THRESHOLD settings for the meter-probe combination shall be identical. Note that the Ludlum 177 and 2241 do not have user adjustable settings for HV and THRESHOLD.
 - An initial set-up must be performed for each meter-probe combination prior to field use.
 - A source with known pedigree must be counted to verify the efficiency is within 10% of the calibrated efficiency, as applicable.
2. The RP Group will coordinate the calibration of boxes and probes on a minimum annual basis and after major repair operations. Battery and / or cable change-outs do not require re-calibration. Calibration procedures are outside of the scope of this instruction.
3. Pre-operational checks are required daily prior to use. Post-operational checks are performed as specified in work plans or procedures. Instruments used in the performance of daily activities do not normally require a post-operational check..
4. Instruments that fail operational checks or malfunction during use should be tagged or labeled “Out-of-Service” or “Do Not Use” and segregated from operational instruments. If possible, describe the problem on the tag / label and add initials and date.
5. Instruments leaving RP Group control (i.e., repair, calibration, excess, etc.) shall be surveyed for unconditional release according to the contamination criteria established in Table 1 of the Site RPP. The repair / calibration center may request a copy of the survey accompany any shipments of RP instruments.
6. Ensure meters with a “WINDOW” or “WIN” setting are set to “OUT.”
7. Instruments may be operated in the FAST response mode if necessary. This setting is recommended if the audible response cannot be heard. SLOW response shall be used when performing instrument set-up and operational checks.
8. Ludlum NaI crystals are located in the end of the probe opposite of the cable connection. Use this end for surveys.
9. Calibration stickers are attached to the instruments and detectors. Illegible stickers should be replaced prior to instrument use.
10. Instrument set-up and subsequent operational checks should be performed in the same location, with consistent temperature and background radiation levels.

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11. Source positioning devices (i.e., jigs) may be used to ensure a reproducible geometry between instrument checks. Source geometry must be consistent between initial instrument set-up and subsequent operational checks.
12. Instruments that do not have scaler capability should be set-up and checked by replacing 1-minute timed counts with static count rate measurements. Each static measurement should last until the meter reading fully stabilizes.

10.2 Instrument Set-Up

1. Inspect the meter-probe combination for physical damage or defect.
2. Complete Section A of the Portable Instrument Set-Up Sheet (Attachment 1).
3. Perform 10 1-minute source counts alternating with 10 1-minute background counts. Remove / replace the source and reposition the probe after each count. During alternating background counts, ensure that the source is sufficiently shielded so as not to impact background values.

NOTE: Counts (Source and Background) performed with a Ludlum 43-5, or other large surface area probe, should be alternated between the Heel, Center, and Toe Positions, if the source surface is smaller than the active surface area of the probe. Instrument response can vary greatly across the probe surface.

4. Document each count on the Portable Instrument Set-Up Sheet.
5. Calculate and record the net count value by subtracting the corresponding background count from each source count.

NOTE: Determining Sigma (Standard Deviation) values is useful when specific plans or activities require higher data quality objectives and / or when the development of control charts is necessary.

6. Calculate and record the following values from the obtained background counts:
 - Avg. Value (Sum of values / # of counts)
 - Sigma Value (Standard Deviation of all counts)
 - 20% Value (Avg. Value * 0.20)
7. Calculate and record the +/- 20% Values and the +/- 1,2, and 3 Sigma values using the AVG. VALUE as a reference point.
8. Repeat the previous two steps for determining NET COUNT acceptable ranges. The 3 Sigma value must be less than the +/- 20% value.
9. Obtain a blank Daily Field Source Check Logsheet (DFSCCL) (Attachment 2) and transfer the instrument, source, and acceptable range data, as applicable, from the Portable Instrument Set-Up Sheet.
10. Place the DFSCCL in the designated use location and forward the completed Portable Instrument Set-Up Sheet and submit to the RSO, or designee for review.
11. Ensure sources are stored properly after use in the designated source storage location.

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10.3 Operational Check

1. Obtain the selected meter-probe combination and corresponding DFSC (Attachment 2).
2. Record the date and time on the DFSC.
3. Perform and document the following checks on the DFSC, as applicable:
 - Perform a physical inspection. Observe for instrument damage. Alpha probes should be checked for light leaks by inverting the probe face towards a light source and observing instrument response. If the instrument fails to respond at all or over-responds this may be an indication of a light leak and should be investigated further, prior to proceeding.
 - Perform a battery check. Instrument Models differ in method. Some meters have a visible battery range on the meter face. The Ludlum Model 2241 has a battery indicator in the digital display that lights if the batteries require replacement. The Ludlum Model 2221 has a BAT button that brings up the battery level in the digital display. Ensure this value is at least 5.0v. Change batteries and retest as necessary.
 - Verify and adjust the HV, when possible, to match the initial set-up data. Minute differences in HV (+/- 5v) are acceptable without adjustment.
 - Perform an audio response check..
4. Perform and record a 1-minute background count. Report any abnormal background responses to the RSO, prior to instrument use. Normally acceptable background levels < 5 cpm for alpha probes, and < 300 cpm for Pancake G-M probes. Acceptable background levels for NaI probes are variable due to crystal size and based on technician experience.
5. Perform and record a 1-minute source gross count using the same source and geometry applied during initial set-up.
6. Calculate and record the net count value.
7. Compare the net count value to the acceptable range. If the instrument response is outside the acceptable range, the process may be repeated a maximum of 1 additional time before placing the instrument out-of-service.
8. If the instrument fails the pre-operational checks, mark FAIL, initial the DFSC, and place the instrument out-of-service. Deliver completed DFSC to the RSO or designee, and explain the failed condition(s).
9. If all checks pass, mark PASS, initial the DFSC, and return form to designated in-use storage location. This may be a binder, folder, or cabinet. The instrument is now ready for use.
10. If the instrument will be used for routine personnel exit monitoring ensure the alarm threshold is set to alarm and actuates at a level below the site removable contamination limits identified in Table 6-1 of the Site Safety & Health Plan (SSHP). Make adjustments as necessary.

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11. Ensure sources are stored properly after use in the designated source storage location.

10.4 Operations

1. Operate instrument in a manner that minimizes the potential for cross-contamination and physical damage.
2. Evaluate the surface or area to be surveyed for potential scanning interferences. For example, thin layers of water or soil can prevent the detection of alpha contamination. Another example is the use of a NaI probe to qualify soil contamination. The presence of standing water can have a significant impact on instrument response. Initiate necessary corrective actions prior to survey or note conditions during survey reporting.
3. Most instruments will operate in temperatures between 10 and 120 degrees Fahrenheit. However, anytime the temperature is outside of the 32 degree (freezing) or 100 degrees ranges, observe the following precautions:
 - Use particular caution with NaI crystals that may shatter under extreme temperature changes. If the temperature difference is greater than 30 degrees between storage and usage locations, wrap the probe tightly in a cloth towel or other insulator and allow warming or cooling over at least one hour prior to use.
 - Periodically check the instrument against a known source of radiation or contamination. If the instrument appears to be responding incorrectly contact the RSO or designee for guidance.
 - Contact the RSO for guidance anytime work is planned outside of the 10 to 120 degree range.
4. Protect instruments to the extent possible from exposure to moisture (i.e., rain, snow, etc.) during use. Instruments shall be stored in a safe manner when not in use.
5. Minimum Detectable Activities (MDA) for each survey should be determined by evaluating field background levels, not background values obtained during operational checks. Calculate MDA using the formula provided in PP-8-805, "Radiological Surveys."
6. Determining activity in disintegrations per minute (dpm) should be performed using the instrument efficiency obtained during calibration. Efficiencies are normally not established for NaI probes, and therefore should not be used for quantifying activity concentrations. The use of NaI probes for activity quantification shall be evaluated by the RSO prior to performance.
7. Observe the following when performing survey scans and static measurements:
 - Alpha probes should be held within ¼-inch of the surface being surveyed. Probe speed should not exceed 1 probe width per second.
 - Beta probes should be held within ½-inch of the surface being surveyed. Survey speed should not exceed one probe width per second.

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- NaI probes should be held as close as possible to the surface being surveyed without contaminating the probe housing. Note that the crystal is located in the probe end opposite the cable connection. Use appropriate sleeving or wrapping in wet or dirty environments.
 - The scan speed for performing Gamma Walkover Surveys is approximately 0.5 m/sec. Move the detector side to side using a 1-meter path length. Each side-side swing should take 2 seconds to traverse the 1-meter path. Advance the probe forward as you go at a rate of approximately 0.5 m/sec. Use the audio function. When increased counts are detected, slow down and locate the source as would be done in a normal survey. Walk parallel paths to ensure that 100% of the area is surveyed. Ensure that the survey extends to the boundaries of the survey unit. Pay particular attention to low lying areas, ditches, and points of possible contamination.
 - Static measurements should be performed in any location where scans indicated the presence of activity. This is due to the fact that instrument MDAs are normally based on a 1-minute static measurement.
 - All static measurements should be at least 1 minute, if the instrument has a scaler function. If the instrument is a ratemeter only, static measurements should last until the meter reading has fully stabilized.
8. Perform a post-operational check after use if directed by work plan, procedure, or the RSO.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 Portable Instrument Set-Up Sheet (Typical)

Attachment 2 Daily Field Source Check Logsheets (Typical)

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Attachment 1
Portable Instrument Set-Up Sheet (Typical)

PORTABLE INSTRUMENT SET-UP SHEET

Set-Up Location: _____

INSTRUMENT DATA		COUNT (n)	Source Counts	Source Count Time (min)	Source CPM	Background Counts	Background Count Time (min)	Background CPM	NET CPM
	INSTRUMENT	DETECTOR	1						
	MODEL								
	SERIAL #		2						
	CAL DUE								
	HV		3						
	THRESHOLD								
SOURCE DATA			4						
	ISOTOPE		5						
	SERIAL #		6						
				7					
	ACTIVITY (uCi)		8						
	ACTIVITY (dpm)		9						
				10					
REMARKS			CALCULATED VALUES			ACCEPTABLE RANGES			
			Background (CPM)		Net CPM	Background (CPM)		Net CPM	
			Average		+ 20 %				
					+ 3 Sigma				
			+/- Sigma		+ 2 Sigma				
					+ 1 Sigma				
					- 1 Sigma				
					- 2 Sigma				
		- 3 Sigma							
		- 20 %							
Performed By:			Date / Time:		Reviewed By:		Date / Time:		

TITLE:

Portable Count Rate Survey Instruments

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**Attachment 2
Daily Field Source Check Logsheet (Typical)**

DAILY FIELD SOURCE CHECK LOG

MONTH / YEAR: _____

INSTRUMENT DATA		Date/Time	Physical	Battery	High Voltage	Audio	Background CPM {A}	Source CPM {B}	Net CPM {C}	PASS or FAIL	Tech. Initials
	INSTRUMENT	DETECTOR									
MODEL											
SERIAL #											
CAL DUE											
SOURCE DATA											
ISOTOPE											
SERIAL #											
ACTIVITY dpm											
INSTRUMENT RANGES											
	Background	Net CPM									
	+ 20 %										
	+ 3 Sigma										
	+ 2 Sigma										
	+ 1 Sigma										
	- 1 Sigma										
	- 2 Sigma										
	- 3 Sigma										
	- 20 %										
NET CPM CALCULATION											
		{B} - {A} = {C}									
Remarks:						Reviewed by:					



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Dose Rate Instruments

NO.: RP-109

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure specifies the methods for performing source checks and operating portable Gamma scintillation dose rate instruments, specifically, the Ludlum Model 12s uR and the Bicon Model Micro Rem. These instruments are used for the evaluation of exposure rates from radioactive materials and determining environmental radiation levels.

2.0 APPLICABILITY

This procedure addresses those instruments that measure dose rate from a scintillation detector and have displays that read in uR/hr, uRem/hr and/or mRem/hr such as Ludlum 12s, Bicon Micro Rem, or Eberline RO-2. Equivalent instruments that operate in a similar fashion to those identified in this section may be operated under this Project Procedure with RSO approval.

3.0 REFERENCES

1. ANSI N323-1978, Radiation Protection Instrument Test and Calibration.
2. Instrument Technical Manuals.
3. Perma-Fix Environmental Services (PESI) RPP

4.0 DEFINITIONS

None

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Reviewing and approving changes to this procedure and ensuring compliance with applicable regulations.
- Ensuring an adequate inventory of Radiation Protection instruments are available to support remediation activities.
- Overseeing the issue, control and accountability of Radiation Protection instrumentation per the requirements of this procedure.

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- Ensuring transmittal of all issue, control and accountability records to the appropriate document control authority when applicable.

5.2 Radiation Protection Technician (RPT)

- Maintaining instrument documentation and records as required by this procedure.
- Maintaining adequate instrument and equipment availability.
- Verifying current calibration and response test dates prior to issue or use of instruments.
- Promptly returning instruments to their proper location when work is complete.
- Ensuring that instruments are properly surveyed for contamination and decontaminated as necessary, after use.

6.0 PREREQUISITES

- Only personnel with documented training shall issue or use RP instrumentation.
- Instruments and detectors shall be inspected for mechanical damage, and response tested prior to issue.
- Any instrument to be used shall have a current calibration label affixed to the instrument.

7.0 PRECAUTIONS AND LIMITATIONS

- Portable count rate survey instrumentations are susceptible to damage from physical and environmental stresses.

8.0 APPARATUS

- Survey instrument
- Tech source
- Source positioning device (jig)

9.0 RECORDS

- Daily Field Source Check Log – Exposure Rate Instruments (Attachment 1)
- Exposure Rate Instrument Set-Up Sheet (Attachment 2)

10.0 PROCEDURE

10.1 General

1. Ensure the instrument selected is within their acceptable calibration periods. This is indicated on an attached calibration sticker. Illegible stickers should be replaced prior to instrument use.
2. The RP Group will coordinate instrument calibration on a minimum annual basis and after major repair operations. Battery change-outs do not require re-calibration. Calibration procedures are outside of the scope of this instruction.
3. Pre-operational source checks are required daily, or prior to each intermittent use, whichever is less frequent. Post-operational source checks are performed as specified in work plans or procedures. Instruments used in the performance of daily activities do not normally require a post-operational source check.

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4. Instrument set-up and subsequent operational checks should be performed in the same location, with consistent temperature and radiation background levels.
5. Use a gamma check source with an activity sufficient to produce contact exposure rates at least ten times higher than background. Cs-137 is typically since it emits 662 keV gamma rays which are representative of the mid-range of gamma energies encountered at NFSS. Alternate sources may be used with RSO approval.
6. Source positioning devices (i.e., jigs) should be used to ensure a reproducible geometry between instrument checks. Source geometry must be consistent between initial instrument set-up and subsequent operational checks.
7. The Ludlum 12s may be operated in the FAST response mode. Switch to SLOW response for obtaining precise readings.
8. Internal scintillation crystals are orientated towards the front of the instrument. Meter cases have visible indicators showing optimum locations to obtain measurements (i.e. effective detector center).
9. Allow instrument readings to maximize prior to recording instrument reading. This may take up to twenty seconds. Note that the needle may not rest on a single value, but may fluctuate slightly between two points on the scale. If this is the case, an average reading should be obtained by summing these two end points and dividing by two.
10. Instruments should be allowed to warm-up for at least one minute prior to obtaining readings.
11. Report any abnormal instrument readings (e.g., unstable analog meter fluctuations), or background inconsistencies to the RSO, prior to continuing instrument use.
12. Instruments that fail operational checks or malfunction during use should be tagged or labeled "Out-of-Service," or "Do Not Use," and segregated from operational instruments. If possible, describe the problem on the tag / label and add initials and date.
13. Instruments leaving RPP Group control (i.e., repair, calibration, excess, etc.) shall be surveyed for unconditional release. The repair / calibration center may request a copy of the survey to accompany shipments of RP instruments.

10.2 Instrument Source Check

1. Obtain the selected instrument.
2. Obtain the corresponding Daily Field Source Check Log – Exposure Rate Instruments form, Attachment 1. This form will be referred to as the "Source Check Log." Initiate a new Source Check Log, if necessary.
3. Perform a physical inspection of the instrument. Place particular emphasis on the following items:
 - Instrument case is not visibly damaged beyond minor scrapes and scratches.
 - Analog display is not cracked or otherwise damaged.

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- Switches and buttons are functional.
 - Audio, if present, is functional.
 - Calibration labels are legible and instrument is within calibration period.
4. Note results of physical inspection on the Source Check Log.
 5. Verify the battery level is within the acceptable range on the analog display. Replace batteries and re-verify, as necessary.
 6. Note battery check results on the Source Check Log.
 7. Verify the high voltage (HV) level is within the acceptable range on the analog display, if present. Place the instrument out-of-service if the HV is outside the acceptable range.
 8. Note the HV check results on the Source Check Log.
 9. If acceptable background ranges have not been established, perform the following:
 - Obtain a blank NFSS Exposure Rate Instrument Set-Up Sheet, Attachment 2. This form will be referred to as the “Set-Up Sheet.”
 - Record the basic source and instrument information at the top of the form.
 - Using the instrument and the source jig (without source), obtain and record ten background readings. The instrument should be removed from the source jig and repositioned after each reading is obtained. Make sure the location where readings are obtained has stable background levels and is the location used for subsequent source checks.
 - Calculate and record the average background value and +/- 20% values on both the set-up and source check logsheets.
 10. Obtain and record an average background reading on the source check log.
 11. Compare the average background reading to the acceptable range. If background response is outside this range, report the condition to the RSO for evaluation, otherwise continue with source check process.
 12. Obtain the source to be used for instrument source checks.
 13. If acceptable source check ranges have not been established, perform the following:
 - Obtain the Set-Up Sheet used to determine acceptable background ranges for the instrument.
 - Using the instrument and the source jig (with source), obtain and record ten contact source readings. The instrument and source should be removed from the source jig and repositioned after each reading is obtained. Make sure the location where readings are obtained is the same location where previous background readings were obtained.
 - Calculate and record the average source value and +/- 20% values on both the set-up and source check logsheets.

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14. Load the source and instrument onto the source jig.
15. Obtain and record the “CONTACT” reading.
16. Verify the contact reading is within the acceptable range (+/- 20%).
17. If the contact source reading falls outside the acceptable range, tag the instrument out of service and notify the RSO, otherwise continue.
18. Complete the source check log including technician initials. The instrument is now ready for use.
19. Ensure sources and forms are stored properly after use in the designated storage location. Forms are retained in RP Instrument logbooks of field files during instrument use (i.e. calibration) cycle. Records are then reviewed by the RSO, or designee for completeness and forward to Project Records for retention.

10.3 Operations

1. Verify that required source checks have been performed prior to initial instrument use.
2. Operate instrument in a manner that minimizes the potential for cross-contamination and physical damage.
3. Limit readings taken while the instrument is positioned sideways to minimize the effects of “geotropism” on the analog needle.
4. Obtain readings by positioning the instrument as close to the detector’s “effective center” as possible. The detector effective center is represented on the instrument housing a cross inside a circle on the Bicon Micro Rem, and a small circular depression on the Ludlum 12s. Overall optimum readings are collected from the front of the instrument housing.
5. Most instruments will operate in temperatures between 10 and 120 degrees Fahrenheit. However, anytime the temperature is outside of the 32 degree (freezing) or 100 degree ranges, observe the following precautions:
 - Be observant of instrument response to background. If the instrument begins to show a decreased response to expected background levels contact the RSO, or designee for guidance.
 - If practicable, perform a period response check of the instrument against a known source of radiation. If the instrument appears to be responding incorrectly contact the RSO or designee for guidance.
 - Contact the RSO for guidance anytime work is planned outside of the 10 to 120 degree range.
6. Protect instruments, to the extent possible, from exposure to moisture (i.e. rain, snow, etc.) during use. Instruments shall be stored in a safe manner when not in use.
7. Perform a post-operational source check after use, if directed by work plan, procedure, or the RSO.

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11.0 ATTACHMENTS

Attached forms are examples and may be modified by the RSO, as needed, without revision to this procedure.

Attachment 1 Daily Field Source Check Log – Exposure Rate Instruments (Typical)

Attachment 2 Exposure Rate Instrument Set-Up Sheet (Typical)

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Attachment 1

Daily Field Source Check Log – Exposure Rate Instruments (Typical)

FMSS DAILY FIELD SOURCE CHECK LOG
- EXPOSURE RATE INSTRUMENTS

MONTH / YEAR: _____

INSTRUMENT DATA		Date/Time	Physical	Battery	High Voltage	Audio	Background	Contact Source	PASS or FAIL	Tech. Initials
INSTRUMENT										
MODEL										
SERIAL#										
CAL DUE										
HV										
SOURCE DATA										
ISOTOPE										
SERIAL #										
ACTIVITY uCi										
INSTRUMENT RANGES										
	Background	Contact Source								
+ 20 %										
- 20 %										
Units (Circle One)										
uR	urem	mR	mrem	R	rem					
Remarks:						Reviewed by:				

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Attachment 2




Exposure Rate Instrument Set-Up Sheet (Typical)

FMSS EXPOSURE RATE INSTRUMENT SET-UP SHEET

Set-Up Location: _____

INSTRUMENT DATA		READING (n)	Background Rate	Contact Source Rate	CALCULATED AVERAGE AND RANGES		
INSTRUMENT		1			Background		Contact Source
MODEL		2				Average + 20%	
SERIAL #		3				Average	
CAL DUE DATE		4					
HV		5				Average - 20%	
SOURCE DATA		6			Units (Circle One)		
ISOTOPE		7			uR urem mR mrem R rem		
SERIAL #		8			REMARKS		
		9					
ACTIVITY (uCi)		10					
Performed By:		Date/Time:		Reviewed By:		Date/Time:	

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		PERMA-FIX ENVIRONMENTAL SERVICES	
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	DATE: March 2017		
APPROVED:			
		03/03/17	
_____ Technical Services Manager		Date	
		03/03/17	
_____ Corporate Certified Health Physicist		Date	

1.0 PURPOSE

This procedure provides guidance and requirements for the control of radioactive materials including the management of radioactive waste. The Radioactive Materials Control and Waste Management Program applies to the receipt, inventory, storage and handling of radioactive materials; the release of materials from Restricted Areas; the control of radioactive sealed sources; the control of materials and contaminated tools and equipment entering and/or leaving Restricted Areas; and the management of waste including transportation and disposal.

2.0 APPLICABILITY

This procedure applies to all PESI Project personnel and all decommissioning projects that involve radioactive materials. This procedure does not apply to the monitoring of liquid and gaseous effluents, radiological environmental monitoring, or final termination surveys of the reactor or facilities.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Radiation."
2. Title 22, California Code of Regulations, Division 4.5; Environmental Health Standards for the Management of Hazardous Waste
3. California Executive Order D-62-02 regarding disposal of decommissioned materials.
4. 10 Code of Federal Regulations (CFR) 20; Standards for Protection Against Radiation, and Transfer and Disposal and Manifests
5. 49 CFR, Subchapter C "Transportation – Hazardous materials Regulations"

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6. 40 CFR, Subchapter I "Solid Wastes"
7. 40 CFR Part 260-273 "Hazardous Waste Management System"
7. USNRC Circular 81-07, "Control of Radioactively Contaminated Materials."
8. USNRC IE Information Notice No. 80-22, "Breakdowns in Contamination Control Programs."
9. ANSI N13.2-1969, "USA Standard Guide for Administrative Practices in Radiation Monitoring (A Guide for Management)."
10. RP -102, "Radiological Posting Requirements."
11. RP -104, "Radiological Surveys."
12. RP- 105, "Unrestricted Release Requirements."
13. RP -114, "Control of Radiation Protection Records."

4.0 GENERAL

4.1 Discussion

Radioactive material controls are established to provide positive control of radioactive material, prevent inadvertent release of radioactive material to uncontrolled areas, ensure personnel are not unknowingly exposed to radiation from lost or misplaced radioactive material, and to minimize the amount of radioactive waste material generated during PESI activities.

4.2 Definitions

Aggregate Material: Items or materials that by their physical nature do not lend themselves to being effectively surveyed using portable instrumentation and require bulk or composite survey techniques or representative sampling and analysis.

Conditional Release of Material: Items or materials that do not meet unconditional release criteria and that are released under the control of Radiation Protection personnel.

Contamination Area (CA): Means any area with loose surface contamination values in excess of the applicable values specified in RP-104 Acceptable Surface Contamination Levels that is accessible to personnel, or any additional area specified by the RSO. The Contamination Area posting is defined as more restrictive than Radioactive Material Areas, hence all Contamination Area postings are considered to be Radioactive Material postings.

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Minimum Detectable Activity (MDA): The smallest amount or concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal. MDA depends upon the type of instrument, the counting geometry, and the radionuclide to be detected. MDA has the same meaning as Lower Limit of Detection (LLD). (ANSI N13.3, 1989).

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and by-product material procured and used to support the operation or remediation.

Radioactive Material Area: Any area or room where quantities of radioactive materials in excess of ten times the 10 CFR 20 Appendix C quantities are used or stored, or any area designated a RMA by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

Unconditional Release of Material: Release of equipment or material to the general public. The equipment and / or material are deemed to meet site release criteria for both total and removable contamination.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO is responsible for:

- Ensuring adequate staffing, facilities and equipment are available to perform the radioactive material control functions assigned to Radiation Protection personnel.
- Investigating and initiating corrective actions for the improper handling of radioactive material.
- Approving purchase or acquisition of radioactive sources.
- Ensuring a source inventory and leak testing program is established.
- Authorizing the establishment of radioactive material and sealed source storage locations.
- Packaging and transferring radioactive material to appropriate authorities.
- Administering receipt / release survey programs of radioactive material.
- Administering radioactive source inventory and leak testing.
- Ensuring correct posting of radiological area.
- Reviewing results of sample analysis and survey data as required to determine acceptability for release of items.
- Ensuring packages for transport and disposal meet applicable regulations for integrity and dose limits.

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5.2 Certified Waste Shipper

The certified (as required by 49 CFR 172, Subpart H) waste shipper is responsible for:

- Identifying proper packaging and posting requirements for all offsite transport of radioactive and/or mixed wastes.
- Reviewing results of conveyance package radiation surveys and performing inspections of conveyance packages prior to approving packages to leave a site.
- Maintaining records of all waste shipments.
- Assisting the RSO in proper characterization, classification and sampling of any potentially radioactive or mixed waste
- Selecting the treatment, storage and disposal facility (TSDF) to be used for processing, treatment, and/or disposal of radioactive or mixed waste
- Preparing profiles and shipping paperwork for disposal of radioactive or mixed wastes generated
- Directing and performing inspections, marking, labeling and placarding of radioactive or mixed waste prior to shipment
- Selecting the proper packages to use for radioactive or mixed waste
- Maintaining an inventory of radioactive and mixed waste onsite and shipped off the project.
- Ensuring periodic inspections as required by regulation are performed and documented

5.3 Radiation Protection Technicians (RPTs)

The RPT is responsible for:

- Performing and documenting radiation and contamination surveys, inspections and leak tests.
- Posting, securing, and controlling radioactive material and source storage areas.
- Safely opening packages of radioactive material.
- Identifying radioactive material.
- Releasing material in accordance with this and implementing procedures.
- Notifying the RSO or designee on arrival of radioactive material.
- Performing pre-transportation surveys of radioactive materials packaging and conveyance vehicles.

5.4 Project Personnel

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Project personnel are responsible for:

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.
- Obtaining RSO authorization prior to accepting receipt of radioactive material at the project. This includes, but is not limited to items such as sealed sources, liquid standards, and contaminated equipment from other sites, and waste generated outside normal project remediation activities. This is to ensure that required receipt surveys are scheduled, appropriate ALARA considerations are implemented, and that the source term is evaluated for possible effects to the project waste stream criteria.
- Complying with direction from RP personnel regarding the proper methods for receipt, handling, decontamination, packaging, storage, transport and disposal of radioactive material.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

Packages of radioactive material or sources shall NOT be opened until the required receipt survey is performed by RP personnel.

Packages of radioactive waste shall not leave a site until approval to do so is granted by the Certified Waste Shipper.

8.0 RECORDS

- Receipt radiological surveys
- Radiological release surveys
- Radiological transportation surveys
- Source Inventory which includes Leak Test Results
- Transportation records including manifests, transportation checklists, and a transportation log

Records generated shall be transmitted to Project Document Control for filing according to procedure RPP-114.

9.0 PROCEDURE

9.1 Receipt of Radioactive Material

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1. Obtain RSO authorization prior to accepting receipt of radioactive material at the project.
 - Radioactive materials which may be received include, but are not limited to, items such as sealed sources, liquid standards, contaminated equipment from other sites, waste generated outside normal project remediation activities and shipments of radioactive materials from vicinity properties to the PESI for storage and / or transportation and disposal. This is to ensure that required receipt surveys are scheduled, appropriate ALARA considerations are implemented, and that the source term is evaluated for possible effects to the project waste stream criteria.
 - Refer to 10 CFR 71.4 and Appendix A to 10 CFR 71 for definition and limits for “Type A Quantities” of radioactive materials.
 - The RSO may direct receipt surveys to be performed on any incoming radioactive material shipment.
2. If an expected package exceeds Type A quantities, the package requestor shall make arrangements with RP and the carrier to receive or pick-up the shipment when the carrier makes notification of package availability.
3. RP personnel perform receipt inspections and surveys of incoming radioactive material shipments which exceed a Type A quantity (refer to 10 CFR 71.4 and Appendix A of 10 CFR 71) as follows:
 - The inspection and survey shall be performed within three hours of receipt. If received after normal work hours, the survey is required with three hours from the beginning of the next business day.
 - Don latex gloves, at a minimum, when performing incoming inspections and surveys.
 - Inspect the package for leaks or apparent damage.
 - Ensure the contents match the packing slip or shipping papers.
 - Perform a radiation survey of the package exterior.
 - Perform a removable contamination survey of the package interior and exterior.
4. RP Personnel shall store the package in a secure, radiologically posted area, notify the RSO or designee if any the following conditions are observed during receipt of a radioactive material shipment:
 - Contents do not match packing slip or shipping papers
 - The contents of the package do not contain the isotopes or quantities of material as ordered or expected.
 - Package is leaking or sufficiently damaged to compromise package contents.
 - The receipt survey results exceed any of the following limits:
 - Radiation (mrem/hr) – 200 @ Contact or 10 @ 1 meter from the package
 - Removable Contamination (dpm/100cm²) – 2200 Beta-Gamma, 220 Alpha

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9.2 Identification of Radioactive Material

1. Radioactive material exceeding limits specified in 10 CFR 20, Appendix C shall be identified and labeled by Radiation Protection personnel:
 - On receipt of packages containing radioactive material or sources.
 - During removal of items or material from contaminated systems or areas, or from radioactive materials areas.
 - In the course of performing area and job specific surveys.
 - In the course of surveying items for release.
2. Items that meet or exceed the contamination limits established in the PESI RPP should be labeled radioactive material.
3. Use the following guidance, as a minimum, when labeling radioactive material:
 - Labels shall only be placed or removed by Radiation Protection personnel.
 - Unique features (e.g., yellow plastic bags, yellow and magenta tags, purple paint, etc.) should be used to clearly identify the physical and radiological parameters of the material.
 - Labeling shall state "CAUTION - RADIOACTIVE MATERIAL."
4. Exceptions to labeling requirements for radioactive material are as follows:
 - The item or material is under the direct control of personnel who are aware of the contents and the associated radiological hazards.
 - The material is radiation protection equipment (e.g., respirators, instruments, etc.).
 - The material consists of radiological samples being analyzed or sampling equipment controlled by Radiation Protection personnel.
 - The material is packaged and labeled in accordance with DOT regulations while awaiting transport.
 - The material is contained in permanently installed equipment and / or potentially contaminated systems.
 - The material consists of permanently installed equipment or components, including check sources installed in radiation monitoring equipment, which have manufacturer supplied check source labels affixed. Radiation level posting requirements shall remain applicable.
 - The material consists of laundered protective clothing:
 - a. In controlled use, inside the Restricted Area; or
 - b. Stored in designated laundry containers.
 - The material consists of check sources or sealed sources and source storage containers identified as radioactive material with identifiable labels affixed to the source.

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- The material is stored or in-use in a posted Contamination Area or Airborne Radioactivity Area. All items in these areas are considered potentially radioactive/contaminated until properly dispositioned by RP personnel.
 - The material consists of contaminated items (e.g., hand tools) impractical to label, that are marked with magenta paint.
5. Project personnel should notify Radiation Protection of any items or containers with lost or damaged radioactive material labels.
 6. Material requiring labeling as radioactive material which is found uncontrolled and outside a Restricted Area shall be brought to the immediate attention of RP Personnel.

9.3 Storage of Radioactive Material

1. Radioactive Material Storage Areas shall be posted in accordance with RP -102, "Radiological Posting Requirements."
2. Radiation Protection personnel should consider the following when specifying radiological requirements for Radioactive Material Storage Areas:
 - Changes to radiation levels in an area as a result of material storage.
 - External environmental conditions are such that significant container degradation does not occur during storage.
 - Material is adequately packaged and controlled to minimize the potential for loss of radioactive material control
3. Unsealed radioactive materials e.g. soil, debris, liquids will be posted and controlled in accordance with RP-102, Radiological Posting Requirements.
4. Soil, debris, and materials will be staged in appropriate containers/bags or covered with tarps as necessary to prevent migration outside of radiological boundaries.
5. Liquids will be stored in appropriate containers (e.g. drums, totes, etc.)
6. All storage containers will be labeled with pertinent information including description and radiological data.
7. PPE requirements for handling radioactive materials are established in the applicable RWP and procedure RP-132, *Selection and Use of Radiological PPE*.

9.4 Special Considerations for Control of Accountable Radioactive Sources

1. The RSO, or designee shall serve as the Source Custodian and shall be responsible for the following:
 - Ensuring that all accountable radioactive sources are stored in their designated storage location when not in use.
 - Maintaining a source inventory that includes accountable source identification, isotopic content, activity, assay date, designated storage location, and date and results of most recent semi-annual leak test.

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2. Any individual planning to procure a radioactive source for the project shall request approval from the RSO in writing. This request shall include a justification for bringing additional sources onto the project and shall include all necessary source information to update the source inventory.
3. Licensed sources under the control of a licensee (e.g., radiography sources, soil density gauges, etc.) are not maintained in the project accountable source inventory. Project personnel requesting such vendor services shall ensure that the RSO receives evidence of the following prior to source mobilization to the project:
 - Source license including isotope and source activity
 - Semi-annual leak testing performed by the licensee
4. Source Custodian, or designee shall ensure that a leak test is performed and documented for any accountable source in inventory under any the following conditions:
 - Upon source receipt in inventory
 - Semi-annually
 - Prior to transfer to a new permanent storage location
 - Prior to disposal
 - If source integrity is compromised
5. A source leak test consists of a physical source inventory, a visual inspection for source integrity and a contamination survey capable of detecting the presence of 0.005 microcuries (200 Bq) of removable radioactivity.
6. If direct contact with the source is impractical (i.e., inaccessible, unsafe from an ALARA standpoint, or could potentially compromise source integrity) the source container or storage location may be surveyed as representative of the leak test.
7. All accountable sealed radioactive sources or their individual storage containers shall bear a durable label or tag which includes the following minimum information:
 - Source Identification
 - Radionuclide(s)
 - Source Activity
 - Assay Date
 - Source Custodian Name and Contact Number
8. The RSO shall establish designated locations for the storage of accountable radioactive sources using the following guidance:
 - Sources should be stored in a lockable location
 - Sources should be stored to minimize exposure to fire or combustible materials
 - Sources should be stored in such a manner to minimize radiation exposure to personnel routinely present in the area.

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9.5 Movement of Radioactive Material

1. Radioactive material or contaminated material shall be properly contained before moving to minimize radiation levels and prevent spread of contamination.
2. Obtain direction from the Project Transportation Specialist and / or the RSO prior to transporting radioactive materials across public highways or railroads regulated by the Department of Transportation. Transport shall be performed in accordance with this procedure and all applicable local, state, and federal regulations.

9.6 Control of Tools, Equipment and Material

1. All items to be released from radiological controls shall be surveyed by RP personnel.
2. The RSO may authorize the establishment of “Hot Tool” storage areas for reusable contaminated tools, components, equipment and material. If labeling of these items (e.g., hand tools) is impractical, magenta paint may be used to identify the item as radioactive material.
3. Project Management should ensure that adequate supplies of clean and “hot” tools are available project personnel. This maximizes worker effectiveness in radiological areas, minimizes survey and decontamination efforts, and reduces radioactive waste generated.
4. Radioactive waste receptacles will be established and maintained for the disposal of items.

9.7 Release of Items from Radioactive Material Controls

1. RP personnel shall perform surveys to release items from radioactive material controls, with the following exception:
 - Hand-carried items (e.g., pens, paper, flashlights, logbooks, clipboards, safety glasses, dosimetry, badges, etc.) under a single individual’s control and that are not expected to have come into contact with potentially contaminated surfaces may be monitored by that individual during the personnel frisking process.
2. RP personnel will survey items designated for unrestricted release according to RPP-105, “Unrestricted Release of Equipment.”
3. RP personnel shall ensure the labeling is appropriate and direct Project personnel as how to best disposition the item (i.e., decontamination, packaging, storage, or disposal as radioactive waste) if an item is contaminated and cannot be released for unrestricted use.
4. RP personnel shall ensure that any labeling or marking identifying the item as radioactive material is removed or thoroughly defaced if the release survey indicates that the item may be released for unrestricted use.

9.8 Transportation and Disposal of Radioactive Waste

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1. Characterization sampling and analysis of waste for radioactive and hazardous constituents shall be performed to ensure waste meets the selected waste facility's Waste Acceptance Criteria.
2. Waste which is considered "decommissioned waste" (waste with residual radioactivity distinguishable from background regardless if it meets alternative requirements for unrestricted release) shall not be disposed of in a Class III California land fill or in a California unclassified waste management unit in accordance with California Executive Order D-62-02.
3. Packaging of waste shall be commensurate with the radionuclide(s) activity and the physical form of the waste in accordance with 49 CFR 178.350 (if applicable).
4. Labeling and placarding of waste packages shall be performed in accordance with 49 CFR 178.350 (if applicable).
5. Radiation surveys shall be performed on waste packaging and/or conveyance vehicles. These surveys shall include dose rates as required by 49 CFR 173 and offsite transportation shall not be permitted if applicable dose limits are exceeded.
6. A transportation inspection shall be performed and documented on the "Transportation Checklist Form" (**Attachment 1**) prior to waste shipments leaving a site.
7. Proper shipping paperwork shall be completed and shall accompany all transports of radioactive waste.
8. Emergency response guidance and contact information shall be provided to all conveyors of radioactive waste (refer to **Attachment 2**).
9. Records of waste disposal shall be maintained sufficient to meet the requirements of CDPH 5314 (to support eventual license termination). Information required includes inventory of waste, dates of transfer, and recipient information. These records should be maintained even if license termination is not the immediate goal of a project.

10.0 ATTACHMENTS

1. Transportation Checklist Form
2. Emergency Response Instructions

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Attachment 1
Transportation Checklist Form



TRANSPORT VEHICLE INSPECTION CHECKLIST

Shipment No.		Carrier DOT Hazmat Registration No. / Exp. Date					
Carrier Name:		Tractor No.			Trailer No.		
Drivers Name:		State:		License No.		Exp. Date	
	ITEM	STATUS		STATUS		CRITERIA	
		Pre Load		Post Load			
		SAT	UNSAT	SAT	UN SAT		
1	Operator's License					Driver possesses a valid commercial driver's license (with a tank vehicle or hazardous materials endorsement) to operate the vehicle	
2	Windshield, Side Glass and Mirrors					No cracked or broken glass that would affect the vision of the driver. Mirror(s) in place and usable	
3	Wipers					Wipers operate and are in good condition	
4	Horn					Air/electric horn(s) work	
5	Suspension					Visually check for loose, broken, or damaged spring leaves, "U" bolts, shackles. Pads, torque arms, and locking pins	
6	Brake Lines					Brake lines and connectors do not have cracks, crimps, restrictions, or evidence of damage or audible air leaks	
7	Brake Pots, Cams					Brake pots are in good physical condition and mechanical linkages are intact and in good condition	
8	Exhaust System					No loose or broken brackets and no evidence of leaks which would affect driving/sleeping compartment	
9	Fuel System					No visible damage affecting fuel tank integrity, no visible leaks, no loose or broken mounting brackets, no evidence of damage to vents, and fuel cap is securely in place	
10	Structure, Welds					No visible significant cracks in major welds	
11	Frame					No cracked, loose, sagging, or broken frame	
12	Trailer Floor					No holes or projecting nails. Capable of bearing weight of load and fork truck (if used)	
13	Trailer Walls					No holes, severe dents or buckling	
14	Trailer End Gate					Can be closed and secured properly	
15	Rims					Rims are not bent or cracked and stud nuts are in place	
16	Tires					Tires appear properly inflated, tread depths appear greater than minimum (tread depth at least 1/8" on front and 1/16" on all others) and show no evidence of cuts or damage affecting the ply cord	
17	Hubs					No visible oil leakage from seals	
18	Head Lights					Both low beams working	
19	Running Lights					All affixed running lights operable	
20	Turn Signals					Front and back working	
21	Brake Lights					Must work on tractor and trailer	
22	Liner					Insure liner is properly installed	
23	Cleanliness					No amount of material from the site on external surfaces of the conveyance.	
PRE-LOAD INSPECTION		(Printed Name, below)				(Signature, below)	
INSPECTION DATE:							
POST-LOAD INSPECTION		(Printed Name, below)				(Signature, below)	
INSPECTION DATE:							
Comments:							
REVIEWED BY:		(Printed Name, below)				(Signature, below)	
REVIEW DATE:							

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Attachment 2
Emergency Response Instructions



EMERGENCY RESPONSE INSTRUCTIONS

Manifest No.: _____

EMERGENCY PHONE NUMBER:

MATERIAL DESCRIPTION:

IMMEDIATE ACTIONS:

RENDER FIRST AID TO INJURED PERSONS

SECURE THE IMMEDIATE AREA

REPORT THE EMERGENCY

FIRST AID:

Use First Aid according to the nature of the injury

Do not delay care and transport of a seriously injured person

Advise medical personnel that injured persons who may have contacted spilled material may be contaminated with low level radioactive material

SECURE THE IMMEDIATE AREA:

Keep unnecessary people at least 160 feet away in all directions and upwind of shipment

Fight small fires with portable extinguisher, *if safe to do so*

Isolate the area and deny entry to unnecessary personnel

REPORT THE EMERGENCY:

Contact the applicable Emergency Phone Number listed at the top of this page.



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Dosimetry Issue

NO.: RP-112

PAGE: 1 of 4

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure provides consistent methodology for the issuance of radiation monitoring dosimetry devices at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This procedure applies to all Safety and Health personnel issuing dosimetry devices.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 “Standards for Protection Against Radiation.”

4.0 GENERAL

4.1 Discussion

This procedure describes the requirements for the issuance of standard dosimetry devices to visitors and radiation workers accessing restricted areas of the remediation project.

The Thermoluminescent Dosimeter (TLD) normally provides the dose of record, while the Self-Reading Dosimeter (SRD) provides a means of deep dose tracking prior to TLD processing, as well as verifying the reasonableness of the results

4.2 Definitions

Radiation Worker: An individual who accesses any Radiological Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Radiological Areas.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

TITLE:	Dosimetry Issue	NO.: RP-112
		PAGE: 2 of 4

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

Self-Reading Dosimeter (SRD): A radiation monitoring device (either electrostatic or electronic) that can be read by the wearer at any time and indicates total accumulated dose.

Thermoluminescent Dosimeter (TLD): An integrating detector where radiation energy is absorbed (trapped) and can be read out later by thermal excitation of the detector (ANSI N13.15-1985).

Visitor: An individual who accesses the project site for purposes other than working (e.g., tour the site or meet with an individual).

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- The RSO is responsible for implementing this procedure.

5.2 Radiation Protection Technicians (RPTs)

- RPTs are responsible for the performance of this procedure.

5.3 Project Personnel

- Provide the RP Dosimetry Group with required personal information to track and report radiation exposures (e.g., Social Security/ID Number, Address, Date of Birth, Exposure History from Other Sites, etc.)
- Complying with Radiation Protection Program (RPP) requirements, including dosimetry care & use requirements identified in Attachment 1.

6.0 PREREQUISITES

Individuals who are planning to visit other radiologically monitored facilities while being monitored at PESI shall notify RSO prior to going to the other monitored facility(s).

7.0 PRECAUTIONS AND LIMITATIONS

- The NRC Form-4 for individuals with current year recorded or estimated exposures from other site(s) shall be reviewed by the RSO prior to issuance of dosimetry. The purpose of this review is to ensure that individuals would not exceed the quarterly exposure limit of 1.25 rem, or the annual exposure limit of 5 rem Total Effective Dose Equivalent.
- Any individual entering a Restricted Area, or performing work under a Radiation Work Permit shall wear dosimetry.
- TLDs will be changed out on a quarterly basis.
- Employee personal information shall be accessible only to personnel authorized by the RSO, SSHO, or Project Manager.

8.0 APPARATUS

- Self-Reading Dosimeters
- Thermoluminescent Dosimeters

TITLE: Dosimetry Issue	NO.: RP-112
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9.0 RECORDS

- Occupational External Radiation Exposure History (NRC Form-4)
- TLD Issue Form (e.g., TLD Processor Chain-of-Custody)
- TLD Use & Care Acknowledgement

10.0 PROCEDURE

10.1 Dosimetry Issuance for Visitors

- Dosimetry is issued to escorted visitors accessing Restricted Areas, and as required by the RSO.

10.2 Dosimetry Issuance for Radiation Workers

1. Ensure that Radiation Worker Training has been successfully completed by the worker prior to dosimetry issue.
2. Ensure the individual has completed an NRC Form 4 "Occupational Radiation Exposure History."
3. Ensure the individual has completed the "TLD Use & Care Acknowledgement" form.
4. Ensure the worker understands the administrative dose limit and the fraction remaining (available dose) for the current year.
5. Review all other paperwork for completeness and legibility.
6. Issue a TLD to the individual by recording the pertinent information on the TLD Issue Form.

11.0 ATTACHMENTS

Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachment(s).

Attachment 1 Dosimetry Care & Use Acknowledgement Form

TITLE: Dosimetry Issue	NO.: RP-112
	PAGE: 4 of 4

Attachment 1

DOSIMETRY CARE & USE ACKNOWLEDGEMENT

1. Use **only** dosimetry specifically issued to you.
2. Verify that you are wearing the appropriate dosimetry **prior** to entering Restricted Areas.
3. Unless otherwise directed by the RSO, Dosimetry **shall** be worn facing out, and attached to clothing/lanyard on the front of the upper torso. **Do not** attach dosimetry to waist belt loops, safety glasses, or hard hats.
4. Dosimetry **shall** be stored in the designated location during non-work periods.
5. Dosimetry **shall** not be worn off-site or to another radiological facility unless specifically authorized by RSO.
6. If dosimetry is misplaced or damaged, **perform** the following:
 - a. Place work in a safe condition and exit the radiological area;
 - b. Report the lost dosimeter to RP Personnel;
 - c. RP shall initiate a Radiological Occurrence Report (ROR); and
 - d. Obtain RSO authorization to issue replacement dosimetry.
7. **Do not** tamper with or expose dosimetry to excessive heat, security x-rays, or medical radiation sources. Report instances of tampering or unnecessary exposure to the RSO immediately.

Dosimetry is used to monitor your exposure as required by Federal Law and Company Policy. Failure to comply with these or other Radiation Protection Program requirements implemented for your safety, and for the protection of the public and environment may result in revocation of RadWorker Training credentials and Restricted Area access privileges.

I have read and understood the information presented and will comply with Radiation Protection Program requirements as established in the FMSS Site Safety & Health Plan.

Signature

Date



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Control of Radiation Protection Records

NO.: RP-114

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This project procedure defines the requirements for controlling Radiation Protection Program records. It also establishes the requirements for review and temporary storage of these records at PESI Sites prior to transmittal to Document Control.

2.0 APPLICABILITY

The requirements of this procedure are applicable to records generated by the Radiation Protection Group, and apply to all documents considered to be records.

3.0 REFERENCES

1. 10 CFR 20 "Standards for Protection Against Radiation."
2. PESI, "Radiation Protection Plan (RPP)"

4.0 DEFINITIONS

Non-record: Non-record material includes those classes of documentary or other material that shall be disposed of without archival authority. Examples are copies of records transmitted to Document Control, paper copies of e-mail, and informal notes.

Records: For the purpose of this procedure, records shall be interpreted as radiation protection records. A record is considered to have been "generated" when it has been completed, signed (or initialed) by the generator, and completed required reviews. Examples of records are all survey forms and original Radiation Work Permits (RWP).

Retention Period: The period of time that a record may be retained by the Radiation Protection Group, prior to transmittal to Document Control.

TITLE: Control of Radiation Protection Records	NO.: RP-114
	PAGE: 2 of 3

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementing this procedure, and performing oversight activities to ensure compliance with the requirements of this document.
- Establishing an RP Record Retention Schedule.
- Ensuring adequate storage space and personnel are available to perform Records Management activities.

5.2 Radiation Protection Records Coordinator (RC)

- Acts as the departmental contact for records.
- Ensures that records are adequately controlled according to this procedure.
- Ensures that records are transmitted to Document Control in a timely fashion, as defined by this procedure.

5.3 Radiation Protection Technicians (RPT)

- Complying with the requirement for this procedure.
- Protecting records in their possession from loss or damage.

6.0 PROCEDURE

6.1 Radiation Protection Group Functions

6.1.1 All personnel assigned to the group shall control records in accordance with applicable requirements of this procedure beginning when a record is first generated.

6.1.2 Records shall be prepared in accordance with Project Procedures. Preparation of these documents shall conform to the following:

Document content, including signatures, shall be:

- Legible and reproducible
- Appropriate for the particular activity performed
- Complete per the applicable requirements
- Traceable to the activity or item to which it applies

6.1.3 If records are damaged (i.e., torn, lost, illegible, or incomplete), action shall be taken and documented to ensure that re-created records are as complete and accurate as possible. Re-created records shall be identified as copies and be signed and dated by the generator.

6.2 Records Coordinator (RC)

6.2.1 The Radiation Protection RC shall:

- Ensure that all records received for transmittal are included on the Record Retention Schedule. The RSO should be notified if any record is not on the schedule.
- Review the records for acceptability by ensuring the content of the record complies with this procedure. The RC shall review each record ensuring that the record is legible, complete, signed and dated, and that the record contains sufficient information to fulfill the intended purpose of the record.

TITLE: Control of Radiation Protection Records	NO.: RP-114
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NOTE: The RC is not responsible for the technical adequacy or correctness of the record.

- Coordinate appropriate corrective action with the RSO when the condition of the records is not acceptable.
- Transmit records according to Document Control
- Prepare a document transmittal form, attach the completed form to the documentation package, and forward the records to Document Control.
- Retain a copy of the returned document transmittal form, which documents transmittal to Document Control.
- Maintain a Records Retention Schedule, approved by the RSO and provide a copy to Document Control.

6.3 Control of Records



- 6.3.1 Records shall be controlled and properly maintained from the time the record is generated until it is transmitted to Document Control
- 6.3.2 Records shall be stored in a controlled environment that protects the records from damage (i.e., winds, floods, fires, high and low temperatures and humidity and infestation of insects, mold, or rodents).
- 6.3.3 Each record shall be reviewed by the RSO to ensure that:
- The record contains sufficient information to fulfill the intended purpose of the document.
 - The content of the record is accurate and complete.
- 6.3.4 Records monitoring transmittal to Document Control shall be stored in a 1-hour fire-rated container, if possible.
- 6.3.5 Storage facilities or cabinets with confidential information should be locked when unattended. Storage facilities for other document should be locked when unattended as is practicable.
- 6.3.6 Records that are in the process of being generated may be controlled by electronic storage, provided there is data back-up available.
- 6.3.7 Following transmittal, Document Control shall review the documentation to ensure that it is complete as indicated on the transmittal form, sign and date the transmittal form signifying receipt of the record package, and return a copy of the signed and dated form to Radiation Protection RC.

7.0 ATTACHMENTS

None



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radiation Worker Training	NO.: RP-115
	PAGE: 1 of 6
	DATE: May 2014
APPROVED:	
 _____ Technical Services Manager	<u>5/31/14</u> Date
 _____ Corporate Certified Health Physicist	<u>5/31/14</u> Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for implementing Radiation Worker Training (RWT) at Perma-Fix Environmental Services, Inc. (PESI) Sites.

2.0 APPLICABILITY

RWT is applicable to ALL PESI employees and subcontractors who perform work within Restricted Areas.

3.0 REFERENCES

- 10 CFR 19, "Notices, Instructions and Reports to Workers: Inspections and Investigations."
- 10 CFR 20, "Standards for Protection against Radiation."

4.0 GENERAL

4.1 Discussion

Successful completion of the RWT will qualify employees for unescorted access into Restricted Areas, provided other access requirements are met as specified in procedure RP-101, "Access Control".

Qualified individuals with a demonstrated knowledge of radiological concepts should provide RWT instruction. The RSO approves RWT Instructors.

4.2 Definitions

Controlled Area: An area under the control of PESI management area to which access is limited by Project Management.

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Practical Factors: The “performance-based” portion of RWT that focuses on demonstration and evaluation of safe radiation worker practices. Particular emphasis is given to the donning and doffing of protective clothing and self-monitoring for radioactive contamination.

Radiation Worker: An individual who accesses any Restricted Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Restricted Areas as specified this procedure.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

The RSO is responsible for implementation of this procedure and approval of course content and materials.

6.0 PREREQUISITES

Prior to obtaining RWT qualification, individuals shall have submitted evidence of completion of other medical / training requirements established in the PESI Site Safety & Health Plan.

7.0 PRECAUTIONS AND LIMITATIONS

- RWT shall be required on a bi annual basis. Active site personnel may be granted up to a 90-day extension beyond the RWT anniversary date, with RSO approval.
- Individuals must have documented evidence of completing both academic and Practical Factors objectives before being allowed to work unsupervised in a Restricted Area.
- Personnel may be allowed to challenge the academic examination portion of this training by passing the examination.
- Bi-Annual re-qualification of the Practical Factors portion of RWT may be by observation of actual work practices.
- A minimum passing score on the RWT exam and Practical Factors is 80%.
- Trained emergency response personnel (Fire Department, Ambulance/EMT, Law Enforcement) responding to on-site emergencies are exempt from this training.
- The RSO may waive the classroom portion of RWT provided the individual is able to show documented proof of successful completion of an equivalent level of training from another facility during the previous 12-month period.
- RP technicians are exempt from this training.

8.0 APPARATUS

None

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9.0 RECORDS

The Site Safety & Health Group shall maintain a copy of the RWT certificate or attendance roster in each employee file.

10.0 PROCEDURE

10.1 RWT Classroom Training

- A. At a minimum, the following topics shall be discussed during RWT:
 - Fundamental of Radioactivity
 - Prenatal Exposure Risks
 - Shaw Group Radiation Protection Plan
 - Site Specific Radiological Hazards / contaminants
 - ALARA Concepts
 - Radiological Postings / Barriers
 - Emergency Response / Evacuation Routes
- B. Provide the trainees with a copy of the course materials and all pertinent training forms.
- C. Present the course material including overhead slides.
- D. Lecture on the associated concepts.
- E. Answer any questions the trainees may have.
- F. Review the material with the trainees prior to administering the exam.
- G. Administer the RWT exam.
- H. The proctor will grade the test and review incorrect answers with the trainee.
- I. Submit the completed exam to RP Document Control.

10.2 RWT Practical Factors Training

- A. At a minimum, the following topics shall be discussed as part of Practical Factors training:
 - Proper PPE donning and doffing procedures
 - Use of RWP
 - Recognition of postings
 - Utilization of ALARA concepts (time, distance, shielding)
 - Use of frisking equipment and proper frisking techniques
- B. Develop a mock-up area from which trainees may be evaluated. Include the following:
 - RWP
 - Radiological postings
 - Ropes / barriers
 - Radiological hazards
 - Whole body frisking instrument
 - In-use work areas may be used, with RSO approval, and provided that airborne generating activities are not underway.

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- C. Introduce the practical training by relating it back to the academics the trainees have just completed.
- D. Explain what will be expected of each trainee.
- E. Demonstrate how to perform the tasks, talk about good practices while doing so.
- F. Allow the participants to practice as you coach.
- G. Proceed to the Mock-Up area and begin Practical Factors evaluation.
- H. Complete a Practical Factors Evaluation Form.
- I. Review evaluation results with the trainee and forward form to RP Document Control.

11.0 ATTACHMENTS

None



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: RADIOLOGICAL PROTECTIVE CLOTHING SELECTION, MONITORING, AND DECONTAMINATION	NO.: RP-132 <hr/> PAGE: 1 of 9 <hr/> DATE: March 2017
APPROVED: <div style="display: flex; justify-content: space-between; align-items: flex-end; margin-top: 20px;"> <div style="text-align: center;">  <hr style="width: 100%;"/> Technical Services Manager </div> <div style="text-align: center;"> 03/10/17 <hr style="width: 100%;"/> Date </div> </div> <div style="display: flex; justify-content: space-between; align-items: flex-end; margin-top: 20px;"> <div style="text-align: center;">  <hr style="width: 100%;"/> Corporate Certified Health Physicist </div> <div style="text-align: center;"> 0310/17 <hr style="width: 100%;"/> Date </div> </div>	

1.0 PURPOSE

This procedure provides the guidance for selecting protective clothing, performing personnel surveys, and decontaminating personnel.

2.0 APPLICABILITY

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors while performing activities in areas with known or suspected radioactive contamination.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Radiation."
2. Title 22, California Code of Regulations, Division 4.5; Environmental Health Standards for the Management of Hazardous Waste
3. California Executive Order D-62-02 regarding disposal of decommissioned materials.
4. 10 Code of Federal Regulations (CFR) 20; Standards for Protection Against Radiation, and Transfer and Disposal and Manifests
8. USNRC IE Information Notice No. 80-22, "Breakdowns in Contamination Control Programs."
9. ANSI N13.2-1969, "USA Standard Guide for Administrative Practices in Radiation Monitoring (A Guide for Management)."
10. RP -102, "Radiological Posting Requirements."
11. RP -103, "Radiation Work Permits."

4.0 GENERAL

4.1 Discussion

Radioactive material controls are established to provide positive control of radioactive material, prevent inadvertent release of radioactive material to uncontrolled areas, ensure personnel are not unknowingly exposed to radiation from lost or misplaced radioactive material, and to minimize the amount of radioactive waste material generated during PESI activities.

4.2 Definitions

Contamination Area (CA): Means any area with loose surface contamination values in excess of the applicable values specified in RP-104 Acceptable Surface Contamination Levels that is accessible to personnel, or any additional area specified by the RSO. The Contamination Area posting is defined as more restrictive than Radioactive Material Areas, hence all Contamination Area postings are considered to be Radioactive Material postings.

Minimum Detectable Activity (MDA): The smallest amount or concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal. MDA depends upon the type of instrument, the counting geometry, and the radionuclide to be detected. MDA has the same meaning as Lower Limit of Detection (LLD). (ANSI N13.3, 1989).

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and by-product material procured and used to support the operation or remediation.

Radioactive Material Area: Any area or room where quantities of radioactive materials in excess of ten times the 10 CFR 20 Appendix C quantities are used or stored, or any area designated a RMA by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO is responsible for:

- Identifying the radiological personal protective equipment (PPE) and, when appropriate, ensuring that the radioactive work permit lists the proper radiological PPE.
- Providing guidance and direction for decontamination of personnel.
- Notifying the corporate RSO of any personnel contamination event.

- Reviewing the Personnel Contamination Report and verifying all information is accurate.
- Requesting support from the qualified medical personnel regarding management of personnel who have been exposed to radiological contamination, when appropriate.
- Determining reimbursements and disposition of personal property that cannot be decontaminated.

5.3 Radiation Protection Technicians (RPTs)

The RPT is responsible for:

- Ensuring that workers don and doff the correct PPE properly, and performing decontamination of personnel under the guidance and direction of the RSO.
- Performing and documenting radiation and contamination surveys.
- Posting, securing, and controlling radioactive material and source storage areas.

5.4 Project Personnel

Project personnel are responsible for:

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.
- Complying with direction from RP personnel regarding the proper methods for donning and doffing of PPE.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

PPE should be fully inspected prior to use.

8.0 RECORDS

- Personnel Contamination Reports
- Radiological surveys

Records generated shall be transmitted to Project Document Control for filing according to procedure RPP-114.

9.0 PROCEDURE

The following factors should be considered when selecting PPE:

- The levels and types of radiological material present, or expected, in the work area
- The presence of chemical hazards
- The base in which the contamination is carried (dry, wet, oily)
- The work to be performed, or work in progress
 - The location of the contamination (e.g., floor, walls, overhead, air handling systems, sewer systems)
- The physical configuration of the work area
- The environmental conditions, such as heat and humidity
- The exposure situation (vapor, pressured splash, liquid splash, intermittent liquid contact, and continuous liquid contact)
- The toxicity of the radioactive materials and/or chemical(s) (i.e., ability to permeate the skin, and systemic toxicity)
- The physical properties of the contaminant (vapor pressure, molecular weight, and polarity)
- The functional requirements of the task (dexterity, thermal protection, fire protection, and mechanical durability requirements)

Table 9-1 provides guidance for the selection of PPE when radiological hazards are present or suspected.

**TABLE 9-1
GUIDE FOR THE SELECTION OF RADIOLOGICAL PROTECTIVE CLOTHING**

Removable Contamination Levels	Clothing for Access Only No Work *	Clothing for Work or Access During Work *
General contamination levels < 1,000 dpm/100 cm ²	Level D PPE	Level D PPE
General contamination levels > 1,000 dpm/100 cm ² , but ≤ 10,000 dpm/100 cm ²	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**
General contamination levels > 10,000 dpm/ 100 cm ² , but ≤ 100,000 dpm/100 cm ²	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (or hood) Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**
General contamination levels > 100,000 dpm/100 cm ² See Note ***	Glove liners Gloves (2 pairs) Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**	Glove liners Gloves (2 pairs) Booties (2 pairs), cloth or PVC Tyvek (2 pairs) Cap Hood Rubber shoe covers**

The guidelines for PPE selection specified in Table 9-1 may be modified under certain circumstances, such as the following:

- Wet areas – Where splashing water or spray is present, use rain suits in addition to the protective clothing listed in Table 9-1. A second set of coveralls may not be necessary when a rain suit is worn.
- Standing water – In addition to the clothing requirements for wet areas, use hip boots or waders for deep standing water areas.
- Face shields – Consider for use when there is significant beta radiation, or a likelihood of water splashing and respirators are not required.
- High temperature areas – Consult with the RSO and Site Health and Safety Specialist (SHSS) prior to working in high temperature areas.

9.1 DONNING PROTECTIVE CLOTHING

- Select the appropriate PPE.
- Inspect coveralls, cotton glove liners, gloves, shoe covers, and hoods for rips, tears, and holes, or other indications of damage. If damaged, do not wear the damaged PPE and remove the PPE from service.
- Do not wear PPE that does not fit properly.
- Place dosimetry, if worn, in the upper body area on the interior of the breast tab with the window of the dosimeter facing out. When coveralls that do not have a breast tab or pocket are worn, dosimetry should be attached per the direction of the RSOR or designee. The dosimeter shall not be worn inside clothing or placed in pockets if exposure of bare skin to beta radiation is expected.
- If a respirator is specified in the Radiation Work Permit (RWP), then ensure that the individual using the respirator has been medically cleared for respirator use and is respirator qualified.; and a respirator fit test has been performed.
- Don the respirator.
- Don the hood, if required, allowing it to overlap the rubber around the lens of the face piece and fall over the shoulder.
- If required, tape the hood to the respirator and to the coveralls.
- Ensure that any required hood is slack enough around the shoulders to allow for full head movement.
- Don rubber gloves.
- Tape the innermost pair of rubber gloves to the coverall sleeves.
- Leather work gloves may be substituted for outer rubber gloves on some jobs as specified in the corresponding radiation work permit.
- If specified on the RWP, don additional PPE as required.

9.2 DOFFING OF PROTECTIVE CLOTHING

Before stepping out of the contamination area or airborne radioactivity area to the step-off pad, the worker should:

- Remove exposed tape and place it in the appropriate container.
- Remove rubber overshoes and place them in the appropriate container.
- Remove the outer pair of gloves and place them in the appropriate container.
- Remove the hood, from front to rear, and place it in the appropriate container.
- Remove coveralls, inside out, touching the inside only and place them in the appropriate container.
- Remove the respirator, as applicable, by bending forward at the waist slightly, pulling the respirator away from the face, and then rolling the straps/headbands to remove the respirator, and place it in the appropriate container.
- Take down the barrier closure, as applicable.
- Remove any tape or fastener from the inner shoe cover and place it in the appropriate container.
- Remove a shoe cover and place it in the appropriate container while simultaneously stepping onto the clean step-off pad with the shoe whose shoe cover was just removed. Repeat this process with the other shoe.
- Remove the cloth glove liners and place them in the appropriate container.
- Replace the barrier closure, as applicable.
- Have the Radiological Control Technician (RCT) commence whole body frisking.
- Monitor the dosimeter.

The sequence for the removal of primary and supplemental dosimetry is dependent upon where the dosimetry was worn and the potential for contamination. The sequence for removal of respiratory protection devices may be altered if it is determined that the potential for inhalation of airborne contamination or the spread of surface contamination is reduced by keeping respiratory protection devices on until all protective garments have been removed.

The sequence for protective clothing removal may vary from that described above, under the following circumstances:

- At the discretion of the RCT providing job coverage.
- As designated in the assigned RWP.
- Depending on radiological and hazardous material conditions encountered during the work evolution.

It is important to be aware that pushing clothing or trash into an already full collection container to compress the contents is forbidden as the act can result in the potential for airborne radioactivity.

9.3 MONITORING

During exit surveys, the following procedures should be followed.

- Use the portable instrument staged for the area of concern, which should have both a visual and an audible response.

- Ensure that the instrument is set on slow response, if available, and operating with an audible response.
- Verify that the instrument is operational on the lowest scale and that the area background count rate is acceptable.
- Hold the detector with the window approximately 1/4 inch from the surface being monitored.
- Move the detector over the surface being monitored at a rate not to exceed 2 inches per second. It should take at least 3 minutes to perform a whole body frisk.
- If an increase in the audible response is noted, then cease moving the detector and allow the meter 5 to 10 seconds to stabilize.
- Pause (approximately 5 seconds) at the nose and mouth area to check for indications of inhalation/ingestion of radioactive material.
- Pay particular attention to hands, feet (shoes), elbows, knees, or other areas with a high potential for contamination.
- If no contamination can be detected, as indicated by an alarm or by an audible or visual response distinguishable from background, then exit the area.
- If an audible or visual response distinguishable from background is noted, then the RCT will further investigate to verify if contamination is present.
- If personnel are found to be contaminated, proceed to the procedures outlined in Section 9.3.1.

9.3.1 CONTAMINATED PERSONNEL

When dealing with contaminated personnel, the following procedures should be followed.

1. Notify the RSOR of any individual with known or suspected contamination.
2. If the contamination is on a personal article of clothing, then perform the following:
 - Survey the inside surface that was against the skin.
 - Verify that no contamination was transferred to the skin.
3. If the contamination is on the skin, determine if the contamination is in the form of a hot particle.
4. If the contamination is a hot particle, then:
 - Quickly evaluate the particle size, radiation type, and visible characteristics.
 - Attempt to collect and retain the particle for subsequent evaluation.
 - Decontaminate the individual in accordance with Section 9.3.2.
5. If the contamination is not a particle, then:
 - Evaluate the contamination levels.
 - Decontaminate the individual in accordance with Section 9.
6. Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

9.3.2 PERSONNEL DECONTAMINATION

The steps to follow for personnel decontamination are presented below.

1. Perform personnel decontamination in a manner that prevents the spread of contamination to other body parts, or the ingestion or inhalation of radioactive material.
2. Take appropriate precautions to minimize the spread of contamination when proceeding from the control point or step-off pad to the decontamination area.
3. Refrain from releasing personnel if detectable skin contamination is present, unless authorized by the RSOR.
4. Perform skin decontamination as follows:
 - Exercise care to avoid damaging the skin.
 - Discontinue the decontamination and notify the RSOR if skin irritation becomes apparent.
 - Record results after each decontamination attempt.
 - indicate the method of decontamination used.
 - Decontaminate ears, eyes and mouth using damp swabs, water, or saline solution rinses that are performed by the individual. Perform further decontamination under the direction of qualified medical personnel.
 - Decontaminate nasal passages by having the individual repeatedly blow the nose. Perform supplemental nasal irrigations under the direction of qualified medical personnel, as required.
 - Use decontamination processes or materials other than those listed in Table 9-2, only under the specific direction of qualified medical personnel.
 - Report incidents of individual contamination immediately to the RSOR.
 - Note the final survey results and time of the survey.
 - Record the area of the skin contaminated in square centimeters (cm^2) on the Personnel Contamination Report (Attachment 1).
 - Assume the measured activity is distributed over the probe area (the area of a typical pancake probe is 15.5 cm^2) for contamination distributed over an area greater than or equal to the area of the probe.
 - Determine the actual area of the activity if the area of contamination is less than the area of the probe but greater than 1 cm^2 ,
 - Assume an area of 1 cm^2 if the contamination area is less than or equal to 1 cm^2 .
 - Obtain the information needed to complete the Personnel Contamination Report (Attachment 1) when skin decontamination has been successfully completed.
 - Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

Table 9-2 Decontamination Techniques

TABLE 4-2 PERSONNEL DECONTAMINATION METHODS METHOD	EFFECTIVE FOR	INSTRUCTIONS
Masking Tape	Dry contamination, hot particles	Apply tape to skin by lightly patting. Remove carefully.
Waterless Hand Cleaner	All skin contamination	Apply to affected area and allow it to melt onto the skin. Remove with cotton or soft disposable towel.
Soap and Tepid Water	All skin contamination except tritium	Wash area with soap and lukewarm water. Repeat until further attempts do not reduce the level. A cloth or surgical hand brush may be used with moderate pressure.
Soap and Cool Water	Tritium contamination	Wash area with soap and cool water. Repeat until further attempts do not reduce the level. A cloth may be used with moderate pressure.
Carbonated Water	All skin contamination	Apply to affected area with cotton or soft disposable towel and wipe with dry towel.
Cornmeal Detergent Paste	All skin contamination	Mix cornmeal and powder detergent in equal parts with enough water to form a paste. Rub onto affected area for 5 minutes. Remove with cotton or disposable towel.

**Attachment 1
Personnel Contamination Event Report (Front)**

Name: _____ Site Badge#.: _____ RWP No.: _____

Employer: _____ Date: _____ Time: _____ Location of Incident: _____

Description of Work Being Performed: _____

Description of Circumstances and the Suspected Cause: _____

Skin Contamination Survey Summary

Body Location *	Initial Levels dpm/100cm ²	1st Decon Method	Attempt Results dpm/100cm ²	2ND Decon Method	Attempt Results dpm/100cm ²	3rd Decon Method	Attempt Results dpm/100cm ²
A							
B							
C							
D							

* Indicate location on back of form

Nasal Swab Activity: Swab 1 _____ dpm/100 cm² Swab 2 _____ dpm/100 cm²

Clothing Contamination Survey Summary

Item	Initial Levels dpm/100 cm ²	Decon Method	Final Results dpm/100 cm ²	Released to employee (Y/N)

Bioassay Intake?

Scheduled / N/A
N

Skin Dose

Calculated / NA

ROR Follow-up

Initiated / NA

Potential for

Yes / N

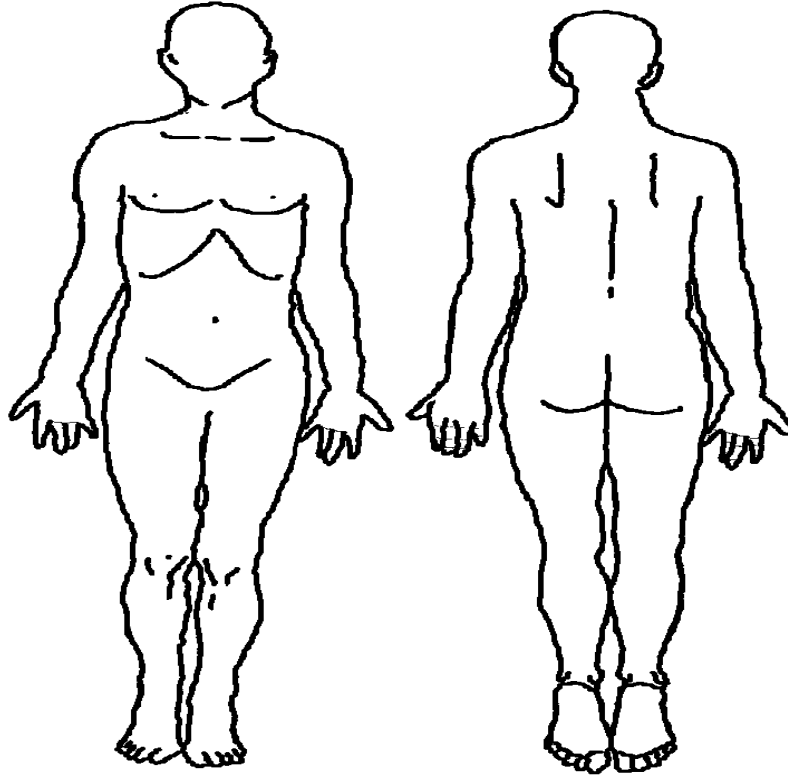
SRSO
Date

Date

RP Technician

**Attachment 1 (Back of Form)
Personnel Contamination Event Report**

Comments and additional detail (identify by letter and include estimated area in square cm):



RP SURVEY INSTRUMENT(S) INFORMATION

Instrument Model	Serial Number	Cal. Due Date

Attachment 3 Laboratory SOPs



***Final Parcel G Removal Site Evaluation Sampling and Analysis Plan
Attachment 3 - Laboratory SOPs
Former Hunters Point Naval Shipyard
San Francisco, California***

**NOTIFICATION: THIS ATTACHMENT CONTAINS SENSITIVE BUT UNCLASSIFIED
INFORMATION WHICH IS PROTECTED BY THE FREEDOM OF INFORMATION ACT**

***FOIA Exemption 4 (5 USC 552(b)(4)). Trade secrets and commercial or financial
information received from a person which is privileged or confidential.***

TO REQUEST A COPY OF THE DOCUMENT

PLEASE CONTACT

**Department of the Navy
Freedom of Information Act Office**

<http://www.secnav.navy.mil/foia/Pages/default.aspx>

Distribute to U. S. Government Agencies Only

Attachment 4 Laboratory Certifications



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

GEL LABORATORIES, LLC
2040 Savage Road
Charleston, SC 29414
Robert L. Pullano Phone: (843) 556-8171
rlp@gel.com

ENVIRONMENTAL

Valid To: June 30, 2019

Certificate Number: 2567.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2009 TNI Environmental Testing Laboratory Standard, the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.1 of the DoD Quality Systems Manual for Environmental Laboratories), accreditation is granted to this laboratory to perform the following radiochemical tests in various matrices, including soils, drinking water, wastewater, groundwater, fiber air filters, vegetation, animal tissues, milk and construction debris:

<u>Test(s)</u>	<u>Preparation SOP(s)</u>	<u>Analytical SOP(s)</u>
<u>Alpha Spectrometry:</u> Alpha: Am-241, Am-243, Cf-252, Cm-242, Cm-243/244, Cm-245/246, Np-237, Po-208, Po-209, Po-210, Pu-236, Pu-238, Pu-239/240, Pu-241, Pu-242, Pu-244, Ra-224, Ra-226, Th-228, Th-229, Th-230, Th-232, U-232, U-233/234, U-235/236, U-238	GL-RAD-A-011, GL-RAD-A-016, GL-RAD-A-032, GL-RAD-A-035, GL-RAD-A-036, GL-RAD-A-038, GL-RAD-A-046	GL-RAD-I-009, GL-RAD-I-015
<u>Radon Emanation:</u> Ra-226	GL-RAD-A-008, GL-RAD-A-028	GL-RAD-I-007
<u>Gamma Spectrometry:</u> Gamma: 46 to 1836 keV, I-129, I-131, Ni-59	GL-RAD-A-006, GL-RAD-A-013, GL-RAD-A-022	GL-RAD-I-001
<u>Kinetic Phosphorescence Analyzer:</u> Total Uranium	GL-RAD-A-023	GL-RAD-B-018

<u>Test(s)</u>	<u>Preparation SOP(s)</u>	<u>Analytical SOP(s)</u>
<p><u>Gas Flow Proportional Counting:</u> Alpha: Total Radium</p> <p>48 Hour Gross Alpha</p> <p>Gross Alpha/Gross Beta</p> <p>Beta: Cl-36, I-131, Pb-210, Ra-228, Sr-89, Sr-90</p>	<p>GL-RAD-A-010, GL-RAD-A-044</p> <p>GL-RAD-A-047</p> <p>GL-RAD-A-001, GL-RAD-A-001B, GL-RAD-A-001C, GL-RAD-A-001D</p> <p>GL-RAD-A-004, GL-RAD-A-009, GL-RAD-A-017, GL-RAD-A-018, GL-RAD-A-029, GL-RAD-A-030, GL-RAD-A-033, GL-RAD-A-054, GL-RAD-A-058</p>	<p>GL-RAD-I-006, GL-RAD-I-015, GL-RAD-I-016, GL-RAD-I-021</p>
<p><u>Liquid Scintillation Spectrometry:</u> Gross Alpha/Gross Beta</p> <p>Alpha: Rn-222</p> <p>Beta: C-14, Ca-45, Fe-55, H-3, Ni-63, P-32, Pm-147, Pu-241, S-35, Se-79, Tc-99</p> <p>Pyrolysis Preparation C-14, H-3 (Special Matrices)</p>	<p>GL-RAD-A-056</p> <p>GL-RAD-A-007</p> <p>GL-RAD-A-002, GL-RAD-A-003, GL-RAD-A-005, GL-RAD-A-019, GL-RAD-A-020, GL-RAD-A-022, GL-RAD-A-031, GL-RAD-A-035, GL-RAD-A-040, GL-RAD-A-048, GL-RAD-A-049, GL-RAD-A-050, GL-RAD-A-059 GL-RAD-A-067</p>	<p>GL-RAD-I-004, GL-RAD-I-014, GL-RAD-I-017</p>
<p><u>ICP-MS:</u> Uranium Isotopes, Tc-99</p>	<p>GL-RAD-A-005, GL-RAD-A-055</p>	<p>GL-RAD-B-034</p>



Additionally, In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2009 TNI Environmental Testing Laboratory Standard, the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.1 of the DoD Quality Systems Manual for Environmental Laboratories), accreditation is granted to this laboratory to perform recognized EPA, Standard Methods for the Examination of Water and Wastewater, ASTM, California and Connecticut test methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

Atomic Absorption/ICP-AES Spectrometry, ICP/MS, Gas Chromatography, Gas Chromatography/Mass Spectrometry, Gravimetry, High Performance Liquid Chromatography, Ion Chromatography, Methylene Blue Active Substances, Misc.-Electronic Probes (pH, O₂), Oxygen Demand, Hazardous Waste Characteristics Tests, Spectrophotometry (Visible), Spectrophotometry (Automated), IR Spectrometry, Titrimetry, Total Organic Carbon, Total Organic Halide, Turbidity, Liquid Chromatography/Mass Spectrometer/Mass Spectrometer and Various Radiochemistry Techniques

<u>Parameter/Analyte</u>	<u>Potable Water</u>	<u>Aqueous Film Forming Foams (AFF)</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
<u>Per-and Polyfluoroalkyl Substances (PFAS)</u>				
Fluorotelomer sulfonate 4:2 (4:2 FTS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Fluorotelomer sulfonate 6:2 (6:2 FTS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Fluorotelomer sulfonate 8:2 (8:2 FTS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorobutanesulfonate (PFBS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorobutyric acid (PFBA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15



<u>Parameter/Analyte</u>	<u>Potable Water</u>	<u>Aqueous Film Forming Foams (AFFF)</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Perfluorodecanesulfonate (PFDS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorodecanoic acid (PFDA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorododecanoic acid (PFDoA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoroheptanesulfonate (PFHpS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoroheptanoic acid (PFHpA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorohexanesulfonate (PFHxS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorohexanoic acid (PFHxA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorononane sulfonate (PFNS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15



<u>Parameter/Analyte</u>	<u>Potable Water</u>	<u>Aqueous Film Forming Foams (AFF)</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Perfluorononanoic acid (PFNA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorooctanesulfonamide (PFOSA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorooctanoic acid (PFOA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoropentanoic acid (PFPeA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorotetradecanoic acid (PFTeDA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorotridecanoic acid (PFTrDA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoroundecanoic acid (PFUdA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoropentanesulfonate (PFPeS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15



<u>Parameter/Analyte</u>	<u>Potable Water</u>	<u>Aqueous Film Forming Foams (AFFF)</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Perfluorooctanesulfonic acid (PFOS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
N-ethyl perfluorooctanesulfonamidoacetic acid (N-EtFOSAA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
N-methyl perfluorooctanesulfonamidoacetic acid (N-MeFOSAA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Propanoic acid (PFPrOPrA) – GenX	EPA 537	EPA 537 Mod*	EPA 537 Mod*	-----

* Non DoD work

<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
<u>Metals</u>		
Aluminum	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Antimony	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B ²
Arsenic	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Barium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Beryllium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Bismuth	EPA 200.8/6020 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Boron	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Cadmium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Calcium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Chromium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Cobalt	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Copper	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Hafnium	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Iron	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Lead	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Lithium	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Magnesium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Manganese	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Mercury	EPA 245.1/245.2 EPA 7470/7470A EPA 1631E	EPA 7470/7470A EPA 7471A/7471B
Molybdenum	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Nickel	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Phosphorous	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Potassium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Rhenium	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Rhodium	EPA 200.8 EPA 6020A/6020B	EPA 6020/6020A/6020B



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Selenium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Silicon ¹	EPA 200.7 EPA 6010B/6010C/6010D	EPA 6010B/6010C/6010D
Silica as SiO ₂	EPA 200.7 EPA 6010B/6010C/6010D	EPA 6010B/6010C/6010D
Silver	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B ²
Sodium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Strontium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Sulfur	EPA 200.7 EPA 6010B/6010C/6010D	EPA 6010B/6010C/6010D
Tantalum	EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Thallium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Thorium	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Tin	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B ²
Titanium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Tungsten	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Uranium	EPA 200.8 EPA 6020/6020A/6020B ASTM D5174-02/97 DOE U-02	EPA 6020/6020A/6020B DOE U-02
Isotopic Uranium	EPA 200.8 EPA 6020A/6020B	EPA 6020A/6020B
Vanadium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Zinc	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Zirconium	EPA 200.8 EPA 6020A/6020B	EPA 6020A/6020B
<u>General Chemistry</u>		
Acidity	EPA 305.1 SM 2310B	-----
Adsorbable Organic Halogens (AOX)	EPA 1650	-----



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Alkalinity	EPA 310.1 SM 2320B	-----
Ammenable Cyanide	EPA 9012A/9012B EPA 335.1 SM 4500-CN ⁻ G	EPA 9012A/9012B
Ammonia Nitrogen (and distillation)	EPA 350.1 SM 4500NH ₃ B/H	EPA 350.1 Modified
Biochemical Oxygen Demand (BOD)	EPA 405.1 SM 5210 B	-----
Bromide	EPA 300.0 EPA 9056A	EPA 9056A ³
Carbon Dioxide (Total and Free by calculation)	SM 4500-CO ₂ D	-----
Carbonaceous BOD (CBOD)	EPA 405.1 SM 5210B	-----
Chemical Oxygen Demand (COD)	EPA 410.4 SM 5220D	-----
Chloride	EPA 300.0 EPA 9056A	EPA 9056A ³
Chlorine (residual)	EPA 330.5 SM 4500-Cl G	-----
Chromium VI	EPA 7196A SM 3500-Cr B	EPA 7196A
Color	EPA 110.2 SM 2120B	-----
Corrosivity toward Steel	-----	EPA 1110/1110A
Cyanide	EPA 335.4 EPA 9012A/9012B SM4500-CN ⁻ E/G	EPA 9012A/9012B
Density	-----	ASTM D5057
Extractable Organic Halides (EOX)	-----	EPA 9023
Fluoride	EPA 300.0 EPA 9056A	EPA 9056A ³
Ignitability	EPA 1020A/1020B	EPA 1020A/1020B
Iodide	EPA 300.0 EPA 9056A	EPA 9056A
Hardness (by calculation/titration)	EPA 130.2 EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B SM 2340B/C	EPA 6010B/6010C/6010D EPA 6020A/6020B
Kjeldahl Nitrogen (TKN)	EPA 351.2 SM 4500N _{org} D	EPA 351.2 Modified
MBAS/Surfactants	EPA 425.1 SM 5540C	-----
Nitrate (as N)	EPA 300.0 EPA 9056A SM4500-NO ₃ -F	EPA 9056A ³
Nitrate-nitrite (as N)	EPA 300.0, 353.2 EPA 9056A SM 4500 NO ₃ -F	EPA 9056A ³



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Nitrite (as N)	EPA 300.0 EPA 9056A	EPA 9056A ³
Oil & Grease	EPA 1664A	EPA 1664A ²
Organic Nitrogen	EPA 350.1 EPA 351.2 TKN – Ammonia	-----
Orthophosphate (as P)	EPA 300.0 EPA 9056A	EPA 9056A ³
Oxygen, Dissolved	SM 4500O G	-----
Paint Filter Liquids Test	-----	EPA 9095B
Perchlorate	EPA 314.0 EPA 6850	EPA 314.0 Modified EPA 6850
pH	EPA 150.1 EPA 9040B/9040C EPA 9041A SM 4500-H ⁺ B	EPA 9040B/9040C EPA 9045C/9045D
Reactive Cyanide	Sec 7.3.3 SW846	Sec 7.3.3 SW846
Reactive Sulfide	Sec 7.3.4 SW846	Sec 7.3.4 SW846
Residue- Filterable (TDS)	EPA 160.1 SM 2540C	-----
Residue- Nonfilterable (TSS)	EPA 160.2 SM 2540D	-----
Residue- Total	EPA 160.3 SM 2540B	-----
Residue- Total, fixed, and volatile	SM 2540G	-----
Residue- Volatile	EPA 160.4 SM 2540E	-----
Salinity	SM 2520B	-----
Specific conductance	EPA 120.1 EPA 9050A/120.1 SM 2510B	-----
Sulfate	EPA 300.0 EPA 9056A	EPA 9056A ³
Sulfite	SM 4500-SO ₃ ²⁻ B	-----
Sulfide	EPA 376.2 EPA 9030B EPA 9034 SM 4500 S ²⁻ D	EPA 9030B EPA 9034
Total Nitrate-Nitrite	EPA 353.2 SM 4500-NO ₃ ⁻ F	-----
Total Organic Carbon (TOC)	EPA 9060/9060A SM 5310B/415.1	EPA 9060/9060A ²
Total Organic Halides (TOX)	EPA 9020B	EPA 9020B ²
Total Petroleum Hydrocarbons	EPA 1664A	EPA 1664A
Total Phenolics	EPA 420.4 EPA 9066	EPA 9066
Total Phosphorous	EPA 365.4 SM 4500-P H	EPA 365.4 Modified
Turbidity	EPA 180.1 SM 2130B	-----



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
<u>Organic Analytes</u>		
1,2-Dibromo-3-chloropropane (DBCP)	EPA 504.1 EPA 624.1 EPA 8011 EPA 8260B/8260C	EPA 8260B/8260C
1,2 Dibromoethane (EDB)	EPA 504.1 EPA 624.1 EPA 8011 EPA 8260B/8260C	EPA 8260B/8260C
1,2,3-Trichloropropane	EPA 504.1 EPA 624.1 EPA 8011 EPA 8260B/8260C	EPA 8260B/8260C
<u>Purgeable Organics (Volatiles)</u>		
1,1,1,2-Tetrachloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1,1-Trichloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1,2,2-Tetrachloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1,2-Trichloro-1,2,2-trifluoroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1,2-Trichloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1-Dichloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1-Dichloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1-Dichloropropene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,2,3-Trichlorobenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,2,3-Trichloropropane	EPA 504.1 EPA 624.1 EPA 8011 EPA 8260B/8260C	EPA 8260B/8260C
1,2,4-Trichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,2,4-Trimethylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8060C
1,2-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,2-Dichloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
1,2-Dichloropropane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,3,5-Trimethylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,3-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,3-Dichloropropane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,4-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,4-Dioxane	EPA 522 EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D/	EPA 8260B/8260C EPA 8270C/8270D
1-Chlorohexane	EPA 8260B	EPA 8260B
2,2-Dichloropropane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Butanone (Methyl Ethyl Ketone)	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
2-Chloroethyl vinyl ether	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Chlorotoluene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Hexanone	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Nitropropane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Pentanone	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
4-Chlorotoluene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
4-Isopropyltoluene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
4-Methyl-2-pentanone	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Acetone	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Acetonitrile	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Acrolein (propanol)	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Acrylonitrile	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Allyl Chloride	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Benzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Benzyl chloride	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bis(2-chloro-1 methyl-ethyl) ether	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Bromobenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bromochloromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bromodichloromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bromoform	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bromomethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Carbon disulfide	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Carbon tetrachloride	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chlorobenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chloroform	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chloromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chloroprene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
cis-1,2-Dichloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
cis-1,3-Dichloropropene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
cis-1,4-Dichloro-2-butene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Cyclohexane	EPA 8260B/8260C	EPA 8260B/8260C
Cyclohexanone	EPA 8260B/8260C	EPA 8260B/8260C
Cyclohexene	EPA 8260B	EPA 8260B
Dibromochloromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Dibromomethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Dichlorodifluoromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Diethyl ether	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Ethyl Acetate	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
Ethyl Benzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Ethyl methacrylate	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Ethyl tert-butyl ether	EPA 8260B	EPA 8260B
Hexachlorobutadiene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Hexane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Iodomethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Isobutyl alcohol	EPA 624.1 EPA 8015B/8015C EPA 8260B/8260C	EPA 8260B/8260C
Isopropyl alcohol	EPA 8260B	EPA 8260B
Isopropylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Isopropyl ether	EPA 8260B	EPA 8260B
m+p-Xylene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Methacrylonitrile	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Methyl acetate	EPA 8260B/8260C	EPA 8260B/8260C
Methyl methacrylate	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Methyl tert-amyl ether (TAME)	EPA 8260B	EPA 8260B
Methyl tert-butyl ether (MTBE)	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Methylcyclohexane	EPA 8260B/8260C	EPA 8260B/8260C
Methylene chloride	EPA 624.1 EPA 8260B/8260C	EPA 8260C
Naphthalene	EPA 624.1 EPA 625.1 EPA 8310 EPA 8260B/8260C EPA 8270C/8270D ⁴	EPA 8310 EPA 8260B/8260C EPA 8270C/8270D ⁴
n-Butyl alcohol	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
n-Butylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
n-Propylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
o-Xylene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Pentachloroethane	EPA 624.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Propionitrile	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Sec-Butylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Styrene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
tert-Butyl Alcohol	EPA 8260B/8260C	EPA 8260B/8260C
tert-Butylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Tetrachloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Tetrahydrofuran	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Toluene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
trans-1,2-Dichloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
trans-1,3-Dichloropropene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
trans-1,4-Dichloro-2-butene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Trichloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Trichlorofluoromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Trihalomethanes	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Vinyl acetate	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Vinyl chloride	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Xylenes, total	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
<u>Semivolatile Compounds</u>		
1,2,4,5-Tetrachlorobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
1,2,4-Trichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,2-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,2-Diphenylhydrazine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
1,3,5-Trinitrobenzene	EPA 625.1 EPA 8330A/8330B ⁵ EPA 8270C/8270D	EPA 8330A/8330B ⁵ EPA 8270C/8270D
1,3-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,3-Dinitrobenzene	EPA 625.1 EPA 8330A/8330B ⁵ EPA 8270C/8270D	EPA 8330A/8330B ⁵ EPA 8270C/8270D
1,4-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,4-Dioxane	EPA 522 EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,4-Dinitrobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
1,4-Naphthoquinone	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
1,4-Phenylenediamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
1-Methylnaphthalene	EPA 625.1 EPA 8270C/8270D ⁴	EPA 8270C/8270D ⁴
1-Naphthylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,2-Dichlorobenzil	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,3,4,6-Tetrachlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,3-Dichloroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4,5-Trichlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4,6-Trichlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4-Dichlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4-Dimethylphenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4-Dinitrophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4-Dinitrotoluene	EPA 625.1 EPA 8330A/8330B ⁵ EPA 8270C/8270D	EPA 8330A/8330B ⁵ EPA 8270C/8270D
2,6-Dichlorophenol	EPA 625.1/8270C/8270D	EPA 8270C/8270D



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
2,6-Dinitrotoluene	EPA 625.1 EPA 8330A/8330B ⁵ EPA 8270C/8270D	EPA 8330A/8330B ⁵ EPA 8270C/8270D
2-Acetylaminofluorene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Butoxyethanol	EPA 8270C/8270D	EPA 8270C/8070D
2-Chloronaphthalene	EPA 625.1 EPA 8270C/8270D ⁴	EPA 8270C/8270D ⁴
2-Chlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Ethoxyethanol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Methyl-4,6-Dinitrophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Methylnaphthalene	EPA 625.1 EPA 8270C/8270D ⁴	EPA 8270C/8270D
2-Methylphenol (o-cresol)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Naphthylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Nitroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Nitrophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Picoline (2-Methylpyridine)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
3,3'-Dichlorobenzidine	EPA 625.1 EPA 8270C/8270D ⁴	EPA 8270C/8270D
3,3'-Dimethylbenzidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
3/4-Methylphenols(m/p cresols)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
3-Methylcholanthrene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
3-Nitroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4,4-Dichlorodiphenyl sulfone	EPA 8270C/8270D	EPA 8270C/8270D
4-Aminobiphenyl	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Bromophenyl phenyl ether	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Chloro-3-methylphenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Chloroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Chlorophenyl phenyl ether	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Nitroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Nitrophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
5-Nitro-o-toluidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
7,12-Dimethylbenz(a)anthracene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Acenaphthene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Acenaphthylene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Acetophenone	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
alpha, alpha-Dimethylphenethylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
alpha-Terpineol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Aniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Anthracene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Aramite	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Atrazine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Benzaldehyde	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Benzidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Benzo (a) anthracene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Benzo (a) pyrene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Benzo (b) fluoranthene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Benzo (ghi) perylene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Benzo (k) fluoranthene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Benzoic acid	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Benzyl alcohol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Biphenyl	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Bis(2-chloroethoxy) methane	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Bis(2-chloroethyl) ether	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Bis(2-chloro-1 methyl-ethyl) ether	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Bis(2-ethylhexyl) phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Butyl benzyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Caprolactam	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Carbazole	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Chlorobenzilate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Chrysene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
cis-Diallate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Diallate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dibenzo (a,e) pyrene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dibenzo (a,h) anthracene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Dibenzofuran	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Diethyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dimethoate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dimethyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Di-n-butyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Di-n-octyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dinoseb	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Diphenylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Disulfoton	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Ethyl methacrylate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Ethyl methanesulfonate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Famphur	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Fluoranthene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Fluorene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Hexachlorobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Hexachlorobutadiene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Hexachlorocyclopentadiene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Hexachloroethane	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Hexachlorophene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Hydroxymethyl phthalimide	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Indeno (1,2,3-cd) pyrene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Isodrin	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Isophorone	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Isosafrole	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Kepone	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Methapyrilene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Methyl methacrylate	EPA 8270C/8270D	EPA 8270C/8270D
Methyl methanesulfonate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Methyl parathion	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Methylene bis(2-chloroaniline)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Naphthalene	EPA 624.1 EPA 625.1 EPA 8310 EPA 8260B/8260C EPA 8270C/8270D ⁴	EPA 8310 EPA 8260B/8260C EPA 8270C/8270D ⁴
Nitrobenzene	EPA 625.1 EPA 8330A EPA 8270C/8270D	EPA 8330A EPA 8270C/8270D



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Nitroquinoline-1-oxide	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Decane	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodiethylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodimethylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodimethylethylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodi-n-butylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodi-n-propylamine	EPA 625.1 EPA 8270C/8270D ⁴	EPA 8270C/8270D
n-Nitrosodiphenylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosomorpholine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosopiperidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosopyrrolidine	EPA 625.1 EPA 8270C/8270D ⁴	EPA 8270C/8270D
n-Octadecane	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
o,o,o-Triethyl phosphorothioate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
o-Toluidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Parathion, ethyl	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
p-Dimethylaminoazobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pentachlorobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pentachloroethane	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Pentachloronitrobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pentachlorophenol	EPA 625.1 EPA 8151A EPA 8270C/8270D	EPA 8151A EPA 8270C/8270D
Phenacetin	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Phenanthrene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Phenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Phorate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pronamide (Kerb)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pyrene	EPA 625.1 EPA 8310 EPA 8270C/8270D ⁴	EPA 8310 EPA 8270C/8270D ⁴
Pyridine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Safrole	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Sulfotepp	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Thionazin (Zinophos)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
trans-Diallate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Tributyl Phosphate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
<u>Pesticides & PCBs</u>		
2,4'-DDD	EPA 8081A/8081B	EPA 8081A/8081B
2,4'-DDE	EPA 8081A/8081B	EPA 8081A/8081B
2,4'-DDT	EPA 8081A/8081B	EPA 8081A/8081B
4,4'-DDT	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
4,4'-DDD	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
4,4'-DDE	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Aldrin	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
alpha-BHC	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
beta-BHC	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Chlordane (N.O.S)	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
cis-Chlordane (alpha-Chlordane)	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
cis-Nonachlor	EPA 8081A/8081B	EPA 8081A/8081B
delta-BHC	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Dieldrin	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endosulfan sulfate	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endosulfan I	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endosulfan II	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Endrin	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endrin aldehyde	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endrin ketone	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
gamma-BHC	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Heptachlor	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Heptachlor epoxide	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Hexachlorobenzene	EPA 8081A/8081B	EPA 8081A/8081B
Methoxychlor	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Mirex	EPA 8081A/8081B	EPA 8081A/8081B
Oxychlorane	EPA 8081A/8081B	EPA 8081A/8081B
Toxaphene	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
trans-Chlordane	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
trans-Nonachlor	EPA 8081A/8081B	EPA 8081A/8081B
PCB-1016 (Aroclor)	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1221	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1232	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1242	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1248	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1254	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1260	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1262	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1268	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
Total Aroclors	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
<u>FID Compounds</u>		
1,1,1-Trichloroethane	EPA 8015C/8015D	EPA 8015C/8015D
2-Butanone (Methyl Ethyl Ketone)	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
4-Methyl-2-Pentanone	EPA 8015C/8015D	EPA 8015C/8015D
Acetone	EPA 8015C/8015D	EPA 8015C/8015D
Benzene	EPA 8015C/8015D	EPA 8015C/8015D



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Chloroform	EPA 8015C/8015D	EPA 8015C/8015D
Diesel Range Organics (DRO)	EPA 8015C/8015D	EPA 8015C/8015D
Diethylene glycol	EPA 8015C/8015D	EPA 8015C/8015D
Ethanol	EPA 8015C/8015D	EPA 8015C/8015D
Ethyl acetate	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
Ethylbenzene	EPA 8015C/8015D	EPA 8015C/8015D
Ethylene glycol	EPA 8015C/8015D	EPA 8015C/8015D
Gas Range Organics (GRO)	EPA 8015C/8015D	EPA 8015C/8015D
Kerosene	EPA 8015C/8015D	EPA 8015C/8015D
Isobutyl alcohol	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
Isopropyl alcohol (2-Propanol)	EPA 8015C/8015D	EPA 8015C/8015D
m, p-Xylenes	EPA 8015C/8015D	EPA 8015C/8015D
Methanol	EPA 8015C/8015D	EPA 8015C/8015D
Methylene chloride	EPA 8015C/8015D	EPA 8015C/8015D
n-Butyl alcohol	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
o-Xylene	EPA 8015C/8015D	EPA 8015C/8015D
Propylene glycol	EPA 8015C/8015D	EPA 8015C/8015D
Toluene	EPA 8015C/8015D	EPA 8015C/8015D
Triethylene glycol	EPA 8015C/8015D	EPA 8015C/8015D
Volatile Petroleum Products	NWTPH-Gx(WDOE)	NWTPH-Gx(WDOE)
Semi-Volatile Petroleum Products	NWTPH-Dx(WDOE)	NWTPH-Dx(WDOE)
C8-C10 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C10-C12 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C12-C16 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C16-C21 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C21-C34 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
Alaska GRO	AK-101 (GRO)	AK-101 (GRO)
Alaska DRO	AK-102 (DRO)	AK-102 (DRO)
Alaska RRO	AK-103 (RRO)	AK-103 (RRO)
EPH Aliphatic C9-C18	MADEP EPH	MADEP EPH
EPH Aliphatic C19-C36	MADEP EPH	MADEP EPH
EPH Aromatic C11-C22 Unadjusted	MADEP EPH	MADEP EPH
<u>Nitrosamines, Nitroaromatics</u>	8330A is by either LC/MS/MS or HPLC 8330B is by LC/MS/MS	
1,3,5-Trinitrobenzene	EPA 625.1 EPA 8330A/8330B ⁵ EPA 8270C/8270D	EPA 8330A/8330B ⁵ EPA 8270C/8270D
1,3-Dinitrobenzene	EPA 625.1 EPA 8330A/8330B ⁵ EPA 8270C/8270D	EPA 8330A/8330B ⁵ EPA 8270C/8270D
2,4,6-Trinitrotoluene	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
2,4-Dinitrotoluene	EPA 625.1 EPA 8330A/8330B ⁵ EPA 8270C/8270D	EPA 8330A/8330B ⁵ EPA 8270C/8270D



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
2,6-Dinitrotoluene	EPA 625.1 EPA 8330A/8330B ⁵ EPA 8270C/8270D	EPA 8330A/8330B ⁵ EPA 8270C/8270D
2-Amino-4,6-Dinitrotoluene	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
2-Nitrotoluene	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
<u>Nitrosamines, Nitroaromatics</u>	8330B is by LC/MS/MS. 8330A is by either LC/MS/MS or HPLC	
3,5-Dinitroaniline	EPA 8330B ⁵	EPA 8330B ⁵
3-Nitrotoluene	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
4-Amino-2,6-Dinitrotoluene	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
4-Nitrotoluene	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
Nitrobenzene	EPA 625.1 EPA 8330A/8330B ⁵ EPA 8270C/8270D	EPA 8330A/8330B ⁵ EPA 8270C/8270D
Nitroglycerin	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
Pentaerythritoltetranitrate (PETN)	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
Tetryl (methyl-2,4,6-trinitrophenylnitramine)	EPA 8330A/8330B ⁵	EPA 8330A/8330B ⁵
<u>Dissolved Gases by FID</u>		
Ethane	RSK 175	-----
Ethene	RSK 175	-----
Methane	RSK 175	-----
<u>Herbicides</u>		
2,4-D	EPA 8151A	EPA 8151A
2,4-DB	EPA 8151A	EPA 8151A
Dalapon	EPA 8151A	EPA 8151A
Dicamba	EPA 8151A	EPA 8151A
Dichloroprop	EPA 8151A	EPA 8151A
Dinoseb	EPA 625.1 EPA 8151A EPA 8270C/8270D	EPA 8151A EPA 8270C/8270D
MCPA	EPA 8151A	EPA 8151A
MCPP	EPA 8151A	EPA 8151A
2,4,5-T	EPA 8151A	EPA 8151A
2,4,5-TP (Silvex)	EPA 8151A	EPA 8151A
Pentachlorophenol	EPA 8151A	EPA 8151A
<u>Radiochemistry</u>		
Barium 133	DOE 4.5.2.3	DOE 4.5.2.3
Cesium 134	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Cesium 137	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Cobalt-60	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Gamma Emitters	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Gross Alpha	EPA 900.0 EPA 9310	EPA 9310
Gross Beta	EPA 900.0 EPA 9310	EPA 9310
Radioactive Iodine	EPA 901.1 EPA 902.0 DOE 4.5.2.3	DOE 4.5.2.3
Radium-226	EPA 903.0/903.1 DOE Ra-04	DOE Ra-04
Radium-228	EPA 904.0 EPA 9320 DOE 4.5.2.3	EPA 9320 DOE 4.5.2.3
Total Alpha Radium	EPA 903.0 EPA 9315	EPA 9315
Radon-222	SM 7500 Rn-B	-----
Strontium-89	EPA 905.0 DOE Sr-01	DOE Sr-01
Strontium-90	EPA 905.0 DOE Sr-02	DOE Sr-02
Thorium	EMSL-LV	EMSL-LV
Tritium	EPA 906.0	EPA 906.0 Modified
Uranium	EPA 200.8 EPA 6020/6020A ASTM D5174-02/97 DOE U-02	EPA 6020/6020A DOE U-02
Zinc-65	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
<u>Preparatory and Clean-up Methods</u>		
Toxicity Characteristic Leaching Procedure (Inorganics, Extractable Organics, Volatile Organics)	EPA 1311	EPA 1311
Synthetic Precipitation Leaching Procedure	EPA 1312	EPA 1312
Waste Extraction Test (W.E.T.)	CCR Ch. 11, Article 5, Appendix II	CCR Ch. 11, Article 5, Appendix II
Anion Preparation	EPA 9056A ³	EPA 9056A ³
Cyanide Distillation	EPA 9010B/9010C SM 4500CN ³ C	EPA 9010B/9010C ³
Sulfide Distillation	EPA 9030B	EPA 9030B
Metals Digestion	EPA 200.2 EPA 3005A EPA 3010A	EPA 3050B
Alkaline Digestion for Hex Chromium	-----	EPA 3060A
Bomb Preparation for Solid Waste	-----	EPA 5050
Mercury Preparation	EPA 245.1/245.2 EPA 7470/7470A	EPA 7471A/7471B



<u>Parameter/Analyte</u>	<u>Nonpotable Water</u>	<u>Solid Hazardous Waste (Liquids and Solids)</u>
Separatory Funnel Liquid-Liquid Extraction	EPA 3510C	-----
Solid Phase Extraction	EPA 3535A	EPA 3535A (Liquid)
Automated Soxhlet Extraction	-----	EPA 3541
Ultrasonic Extraction	-----	EPA 3550C
Waste Dilution	-----	EPA 3580A
Waste Dilution for Volatile Organics	-----	EPA 3585
Purge and Trap for Volatile Organics	EPA 5030A/5030B/5030C	EPA 5035/5035A/5035H/5035L
Alumina Clean-up	-----	EPA 3610B EPA 3611B
Florisil Clean-up	EPA 3620B/3260C	EPA 3620B/3620C
Silica Gel Clean-up	-----	EPA 3630C
Gel Permeation Clean-up	-----	EPA 3640A
Sulfur Clean-up	EPA 3660B	EPA 3660B
Sulfuric Acid/Permanganate Clean-up	EPA 3665A	EPA 3665A

1 – Calculated from silica determination

2 – Applicable only to liquid ‘Solid Hazardous Waste’, where liquids may include aqueous, non-aqueous, and oily wastes.

Solids may include soils, sediments, sludges, tissues, filters and any matrix deemed non-liquid.

3 – The referenced method is modified to include a simple prep for non-aqueous and/or solid matrix samples.

4 – The analytes may be determined by Selective Ion Monitoring (SIM) using either 8270C or 8270D.

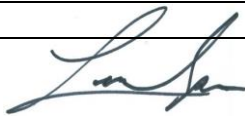
5 – 8330B analysis is performed on LC/MS/MS. 8330A may be performed on either LC/MS/MS or HPLC.

<u>Metals on Filters</u>	<u>Air Filters</u>
Aluminum	EPA 6010B/6010C/6010D NIOSH 7303
Antimony	EPA 6010B/6010C/6010D NIOSH 7303
Arsenic	EPA 6010B/6010C/6010D NIOSH 7303
Barium	EPA 6010B/6010C/6010D NIOSH 7303
Beryllium	EPA 6010B/6010C/6010D NIOSH 7303
Cadmium	EPA 6010B/6010C/6010D NIOSH 7303
Calcium	EPA 6010B/6010C/6010D NIOSH 7303
Chromium	EPA 6010B/6010C/6010D NIOSH 7303
Cobalt	EPA 6010B/6010C/6010D NIOSH 7303
Copper	EPA 6010B/6010C/6010D NIOSH 7303
Iron	EPA 6010B/6010C/6010D NIOSH 7303
Lead	EPA 6010B/6010C/6010D NIOSH 7303
Magnesium	EPA 6010B/6010C/6010D NIOSH 7303



Metals on Filters	Air Filters
Manganese	EPA 6010B/6010C/6010D NIOSH 7303
Molybdenum	EPA 6010B/6010C/6010D NIOSH 7303
Nickel	EPA 6010B/6010C/6010D NIOSH 7303
Phosphorous	EPA 6010B/6010C/6010D NIOSH 7303
Potassium	EPA 6010B/6010C/6010D NIOSH 7303
Selenium	EPA 6010B/6010C/6010D NIOSH 7303
Sodium	EPA 6010B/6010C/6010D NIOSH 7303
Strontium	EPA 6010B/6010C/6010D NIOSH 7303
Sulfur	EPA 6010B/6010C/6010D NIOSH 7303
Tin	EPA 6010B/6010C/6010D NIOSH 7303
Titanium	EPA 6010B/6010C/6010D NIOSH 7303
Uranium	EPA 6010B/6010C/6010D NIOSH 7303
Vanadium	EPA 6010B/6010C/6010D NIOSH 7303
Zinc	EPA 6010B/6010C/6010D NIOSH 7303

Drinking Water Organics	Drinking Water
1,2-Dibromo-3-chloropropane (DBCP)	EPA 504.1 EPA 524.2
1,2 Dibromoethane (EDB)	EPA 504.1 EPA 524.2
1,2,3-Trichloropropane	EPA 504.1
1,4-Dioxane	EPA 522
1,1,1,2-Tetrachloroethane	EPA 524.2
1,1,1-Trichloroethane	EPA 524.2
1,1,2,2-Tetrachloroethane	EPA 524.2
1,1,2-Trichloroethane	EPA 524.2
1,1-Dichloroethane	EPA 524.2
1,1-Dichloroethene	EPA 524.2
1,1-Dichloropropene	EPA 524.2
1,2,3-Trichlorobenzene	EPA 524.2
1,2,3-Trichloropropane	EPA 524.2
1,2,4-Trichlorobenzene	EPA 524.2
1,2,4-Trimethylbenzene	EPA 524.2
1,2-Dichlorobenzene	EPA 524.2
1,2-Dichloroethane	EPA 524.2
1,2-Dichloropropane	EPA 524.2
1,3,5-Trimethylbenzene	EPA 524.2



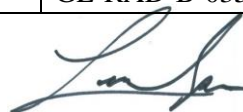
Drinking Water Organics	Drinking Water
1,3-Dichlorobenzene	EPA 524.2
1,3-Dichloropropane	EPA 524.2
1,4-Dichlorobenzene	EPA 524.2
2,2-Dichloropropane	EPA 524.2
2-Butanone (Methyl Ethyl Ketone)	EPA 524.2
2-Chlorotoluene	EPA 524.2
2-Hexanone	EPA 524.2
4-Chlorotoluene	EPA 524.2
4-Isopropyltoluene	EPA 524.2
4-Methyl-2-pentanone	EPA 524.2
Acetone	EPA 524.2
Benzene	EPA 524.2
Bromobenzene	EPA 524.2
Bromochloromethane	EPA 524.2
Bromodichloromethane	EPA 524.2
Bromoform	EPA 524.2
Bromomethane	EPA 524.2
Carbon disulfide	EPA 524.2
Carbon tetrachloride	EPA 524.2
Chlorobenzene	EPA 524.2
Chloroethane	EPA 524.2
Chloroform	EPA 524.2
Chloromethane	EPA 524.2
cis-1,2-Dichloroethene	EPA 524.2
cis-1,3-Dichloropropene	EPA 524.2
Dibromochloromethane	EPA 524.2
Dibromomethane	EPA 524.2
Dichlorodifluoromethane	EPA 524.2
Ethyl Benzene	EPA 524.2
Hexachlorobutadiene	EPA 524.2
Iodomethane	EPA 524.2
Isopropylbenzene	EPA 524.2
Methyl tert-butyl ether (MTBE)	EPA 524.2
Methylene chloride	EPA 524.2
m+p-Xylene	EPA 524.2
Naphthalene	EPA 524.2
n-Butylbenzene	EPA 524.2
n-Propylbenzene	EPA 524.2
o-Xylene	EPA 524.2
Sec-Butylbenzene	EPA 524.2
Styrene	EPA 524.2
tert-Butylbenzene	EPA 524.2
Tetrachloroethene	EPA 524.2
Toluene	EPA 524.2
trans-1,2-Dichloroethene	EPA 524.2
trans-1,3-Dichloropropene	EPA 524.2
Trichloroethene	EPA 524.2
Trihalomethanes	EPA 524.2
Vinyl chloride	EPA 524.2
Xylenes, total	EPA 524.2
Bromoacetic acid	EPA 552.2



Drinking Water Organics	Drinking Water
Bromochloroacetic acid	EPA 552.2
Chloroacetic acid	EPA 552.2
Dibromoacetic acid	EPA 552.2
Dichloroacetic acid	EPA 552.2
Trichloroacetic acid	EPA 552.2

Additionally, in recognition of the successful completion of the A2LA evaluation process (including an assessment of the laboratory's compliance with the 2009 TNI Environmental Testing Laboratory Standard Requirements), accreditation is granted to this laboratory to perform the following bioassay analyses on bone, tissue, urine, fecal, and nasal swabs.

<u>Bioassay Analysis(s)</u>	<u>Preparation SOP(s)</u>	<u>Analytical SOP(s)</u>
<u>Alpha Spectrometry:</u> Alpha: Am-241, Cm-242, Cm-243/244, Cm 245/246, Cf-252, Np-237, Po-208, Po-209, Po-210, Pu-236, Pu-238, Pu-239/240, Pu-242, Pu-244, Ra-224, Ra-226, Th-228, Th-229, Th-230, Th-232, U-232, U-233/234, U-235/236, U-238	GL-RAD-B-001, GL-RAD-B-002, GL-RAD-B-003, GL-RAD-B-010, GL-RAD-B-012, GL-RAD-B-013, GL-RAD-B-017, GL-RAD-B-038, GL-RAD-B-040, GL-RAD-B-041 GL-RAD-B-042	GL-RAD-B-009
<u>Liquid Scintillation Spectrometry:</u> C-14, Fe-55, Gross Alpha, H-3, Ni-59, Ni-63, Pu-241, Tc-99	GL-RAD-B-001, GL-RAD-B-008, GL-RAD-B-011, GL-RAD-B-012, GL-RAD-B-013, GL-RAD-B-016, GL-RAD-B-020, GL-RAD-B-023	GL-RAD-I-004, GL-RAD-I-014, GL-RAD-I-017
<u>Gas Flow Proportional Counting:</u> Beta: Sr-90	GL-RAD-B-001	GL-RAD-I-006, GL-RAD-I-015, GL-RAD-I-016
<u>Bioassay Analysis(s)</u>	<u>Preparation SOP(s)</u>	<u>Analytical SOP(s)</u>
Gross Alpha/Gross Beta	GL-RAD-B-022	GL-RAD-I-006
<u>Kinetic Phosphorescence Analyzer:</u> Total Uranium	GL-RAD-B-019	GL-RAD-B-018
<u>Radon Emanation:</u> Ra-226	GL-RAD-B-002	GL-RAD-I-007
<u>Refractometer:</u> Specific Gravity	GL-RAD-B-027	GL-RAD-B-027
<u>ICP-MS:</u> Uranium Isotopes	GL-RAD-B-035	GL-RAD-B-034



<u>Gamma Spectrometry:</u> Gamma: Ni-59, 46 to 1836 keV	GL-RAD-B-020, GL-RAD-A-013	GL-RAD-I-001
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Accredited Laboratory

A2LA has accredited

GEL LABORATORIES, LLC

Charleston, SC

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2009 TNI Environmental Testing Laboratory Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in Version 5.1 of the DoD Quality System Manual for Environmental Laboratories (QSM), accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).



Presented this 30th day of August 2017.

A handwritten signature in black ink, written over a horizontal line.

President and CEO
For the Accreditation Council
Certificate Number 2567.01
Valid to June 30, 2019
Revised June 26, 2018

For the tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

CH2M-9000-FZ12-0013, JUNE 2019
CH2M-9000-FZ12-0013, JUNE 2019



**CALIFORNIA STATE
ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM
Accredited Fields of Testing**



GEL Laboratories, LLC

2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171

**Certificate No. 2940
Expiration Date 10/31/2019**

Primary Accreditation
Body

Field of Testing: 106 - Radiochemistry of Drinking Water

106.010	001	Gross Alpha	EPA 900.0	UT
106.010	002	Gross Beta	EPA 900.0	UT
106.030	001	Radioactive Cesium	EPA 901.1	UT
106.030	002	Radioactive Iodine	EPA 901.1	UT
106.030	003	Gamma Emitters	EPA 901.1	UT
106.040	001	Radioactive Iodine	EPA 902.0	UT
106.050	001	Total Alpha Radium	EPA 903.0	UT
106.050	002	Radium-226	EPA 903.0	UT
106.051	001	Radium-226	EPA 903.1	UT
106.060	001	Radium-228	EPA 904.0	UT
106.070	001	Strontium-89, 90	EPA 905.0	UT
106.070	002	Strontium-89	EPA 905.0	UT
106.070	003	Strontium-90	EPA 905.0	UT
106.080	001	Tritium	EPA 906.0	UT
106.092	001	Uranium	EPA 200.8	UT
106.120	001	Gross Alpha	EPA 00-02	UT
106.230	001	Uranium	DOE U-02	UT
106.250	002	Radioactive Iodine	DOE 4.5.2.3	UT
106.250	003	Gamma Emitters	DOE 4.5.2.3	UT
106.480	001	Uranium	ASTM D5174-97	UT
106.610	001	Radon-222	SM7500-Rn	UT

Field of Testing: 108 - Inorganic Chemistry of Wastewater

108.020	001	Conductivity	EPA 120.1	UT
108.090	001	Residue, Volatile	EPA 160.4	UT
108.110	001	Turbidity	EPA 180.1	UT
108.112	001	Boron	EPA 200.7	UT
108.112	002	Calcium	EPA 200.7	UT
108.112	003	Hardness (calculation)	EPA 200.7	UT
108.112	004	Magnesium	EPA 200.7	UT
108.112	005	Potassium	EPA 200.7	UT
108.112	006	Silica, Dissolved	EPA 200.7	UT
108.112	007	Sodium	EPA 200.7	UT
108.113	001	Boron	EPA 200.8	UT

As of 11/5/2018, this list supersedes all previous lists for this certificate number.
Customers: Please verify the current accreditation standing with the State.

108.113	002	Calcium	EPA 200.8	UT
108.113	003	Magnesium	EPA 200.8	UT
108.120	001	Bromide	EPA 300.0	UT
108.120	002	Chloride	EPA 300.0	UT
108.120	003	Fluoride	EPA 300.0	UT
108.120	008	Sulfate	EPA 300.0	UT
108.120	012	Nitrate (as N)	EPA 300.0	UT
108.120	013	Nitrate-Nitrite (as N)	EPA 300.0	UT
108.120	014	Nitrite (as N)	EPA 300.0	UT
108.120	015	Phosphate, Ortho (as P)	EPA 300.0	UT
108.183	001	Cyanide, Total	EPA 335.4	UT
108.209	001	Ammonia (as N)	EPA 350.1	UT
108.211	002	Kjeldahl Nitrogen, Total (as N)	EPA 351.2	UT
108.232	003	Nitrate-Nitrite (as N)	EPA 353.2	UT
108.266	001	Phosphorus, Total	EPA 365.4	UT
108.323	001	Chemical Oxygen Demand	EPA 410.4	UT
108.362	001	Phenols, Total	EPA 420.4	UT
108.381	001	Oil and Grease	EPA 1664A	UT
108.385	001	Color	SM2120B-2001	UT
108.390	001	Turbidity	SM2130B-2001	UT
108.400	001	Acidity	SM2310B-1997	UT
108.410	001	Alkalinity	SM2320B-1997	UT
108.420	001	Hardness (calculation)	SM2340B-1997	UT
108.421	001	Hardness	SM2340C-1997	UT
108.430	001	Conductivity	SM2510B-1997	UT
108.439	001	Residue, Volatile	SM2540E-1997	UT
108.440	001	Residue, Total	SM2540B-1997	UT
108.441	001	Residue, Filterable TDS	SM2540C-1997	UT
108.442	001	Residue, Non-filterable TSS	SM2540D-1997	UT
108.465	001	Chlorine, Total Residual	SM4500-Cl G-2000	UT
108.470	001	Cyanide, Total	SM4500-CN B or C-1999	UT
108.472	001	Cyanide, Total	SM4500-CN E-1999	UT
108.473	001	Cyanide, amenable	SM4500-CN G-1999	UT
108.490	001	Hydrogen Ion (pH)	SM4500-H+ B-2000	UT
108.513	001	Kjeldahl Nitrogen, Total (as N)	SM4500-Norg D-1997	UT
108.529	002	Nitrite (as N)	SM4500-NO3 F-2000	UT
108.536	001	Oxygen, dissolved	SM4500-O G-2001	UT
108.545	001	Phosphorus, Total	SM4500-P H-1999	UT
108.560	001	Sulfite	SM4500-SO3 B-2000	UT
108.584	001	Sulfide (as S)	SM4500-S D-2000	UT
108.592	001	Biochemical Oxygen Demand	SM5210B-2001	UT
108.592	002	Carbonaceous BOD	SM5210B-2001	UT

108.595	001	Chemical Oxygen Demand	SM5220D-1997	UT
108.596	001	Organic Carbon-Total (TOC)	SM5310B-2000	UT
108.605	001	Surfactants	SM5540 C-2000	UT

Field of Testing: 109 - Toxic Chemical Elements of Wastewater

109.010	001	Aluminum	EPA 200.7	UT
109.010	002	Antimony	EPA 200.7	UT
109.010	003	Arsenic	EPA 200.7	UT
109.010	004	Barium	EPA 200.7	UT
109.010	005	Beryllium	EPA 200.7	UT
109.010	006	Boron	EPA 200.7	UT
109.010	007	Cadmium	EPA 200.7	UT
109.010	009	Chromium	EPA 200.7	UT
109.010	010	Cobalt	EPA 200.7	UT
109.010	011	Copper	EPA 200.7	UT
109.010	012	Iron	EPA 200.7	UT
109.010	013	Lead	EPA 200.7	UT
109.010	015	Manganese	EPA 200.7	UT
109.010	016	Molybdenum	EPA 200.7	UT
109.010	017	Nickel	EPA 200.7	UT
109.010	019	Selenium	EPA 200.7	UT
109.010	021	Silver	EPA 200.7	UT
109.010	023	Thallium	EPA 200.7	UT
109.010	024	Tin	EPA 200.7	UT
109.010	025	Titanium	EPA 200.7	UT
109.010	026	Vanadium	EPA 200.7	UT
109.010	027	Zinc	EPA 200.7	UT
109.020	001	Aluminum	EPA 200.8	UT
109.020	002	Antimony	EPA 200.8	UT
109.020	003	Arsenic	EPA 200.8	UT
109.020	004	Barium	EPA 200.8	UT
109.020	005	Beryllium	EPA 200.8	UT
109.020	006	Cadmium	EPA 200.8	UT
109.020	007	Chromium	EPA 200.8	UT
109.020	008	Cobalt	EPA 200.8	UT
109.020	009	Copper	EPA 200.8	UT
109.020	010	Lead	EPA 200.8	UT
109.020	011	Manganese	EPA 200.8	UT
109.020	012	Molybdenum	EPA 200.8	UT
109.020	013	Nickel	EPA 200.8	UT
109.020	014	Selenium	EPA 200.8	UT
109.020	015	Silver	EPA 200.8	UT
109.020	016	Thallium	EPA 200.8	UT

As of 11/5/2018 , this list supersedes all previous lists for this certificate number.
 Customers: Please verify the current accreditation standing with the State.

109.020	017	Vanadium	EPA 200.8	UT
109.020	018	Zinc	EPA 200.8	UT
109.020	021	Iron	EPA 200.8	UT
109.020	022	Tin	EPA 200.8	UT
109.020	023	Titanium	EPA 200.8	UT
109.190	001	Mercury	EPA 245.1	UT
109.191	001	Mercury	EPA 245.2	UT
109.361	001	Mercury	EPA 1631E	UT
109.445	002	Chromium (VI)	SM3500-Cr B-2009	UT

Field of Testing: 110 - Volatile Organic Chemistry of Wastewater

110.040	000	Purgeable Organic Compounds	EPA 624	UT
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Field of Testing: 111 - Semi-volatile Organic Chemistry of Wastewater

111.100	000	Base/Neutral & Acid Organics	EPA 625	UT
111.170	000	Organochlorine Pesticides and PCBs	EPA 608	UT

Field of Testing: 112 - Radiochemistry of Wastewater

112.010	001	Gross Alpha	EPA 900.0	UT
112.010	002	Gross Beta	EPA 900.0	UT
112.020	001	Total Alpha Radium	EPA 903.0	UT
112.021	001	Radium-226	EPA 903.1	UT
112.140	001	Cesium	EPA 901.1	UT
112.140	002	Gamma	EPA 901.1	UT
112.160	001	Radium-228	EPA 904.0	UT
112.170	001	Strontium	EPA 905.0	UT
112.180	001	Tritium	EPA 906.0	UT
112.490	001	Cesium	DOE 4.5.2.3	UT
112.490	002	Gamma Emitters	DOE 4.5.2.3	UT
112.500	001	Strontium	DOE Sr-01	FL
112.510	001	Strontium	DOE Sr-02	UT
112.520	001	Uranium	DOE U-02	UT

Field of Testing: 114 - Inorganic Chemistry of Hazardous Waste

114.010	001	Antimony	EPA 6010B	UT
114.010	002	Arsenic	EPA 6010B	UT
114.010	003	Barium	EPA 6010B	UT
114.010	004	Beryllium	EPA 6010B	UT
114.010	005	Cadmium	EPA 6010B	UT
114.010	006	Chromium	EPA 6010B	UT
114.010	007	Cobalt	EPA 6010B	UT
114.010	008	Copper	EPA 6010B	UT
114.010	009	Lead	EPA 6010B	UT
114.010	010	Molybdenum	EPA 6010B	UT
114.010	011	Nickel	EPA 6010B	UT

114.010	012	Selenium	EPA 6010B	UT
114.010	013	Silver	EPA 6010B	UT
114.010	014	Thallium	EPA 6010B	UT
114.010	015	Vanadium	EPA 6010B	UT
114.010	016	Zinc	EPA 6010B	UT
114.020	001	Antimony	EPA 6020	UT
114.020	002	Arsenic	EPA 6020	UT
114.020	003	Barium	EPA 6020	UT
114.020	004	Beryllium	EPA 6020	UT
114.020	005	Cadmium	EPA 6020	UT
114.020	006	Chromium	EPA 6020	UT
114.020	007	Cobalt	EPA 6020	UT
114.020	008	Copper	EPA 6020	UT
114.020	009	Lead	EPA 6020	UT
114.020	010	Molybdenum	EPA 6020	UT
114.020	011	Nickel	EPA 6020	UT
114.020	012	Selenium	EPA 6020	UT
114.020	013	Silver	EPA 6020	Aqueous Only UT
114.020	014	Thallium	EPA 6020	UT
114.020	015	Vanadium	EPA 6020	UT
114.020	016	Zinc	EPA 6020	UT
114.103	001	Chromium (VI)	EPA 7196A	UT
114.140	001	Mercury	EPA 7470A	UT
114.141	001	Mercury	EPA 7471A	
114.221	001	Cyanide, Total	EPA 9012A	
114.230	001	Sulfides, Total	EPA 9034	UT
114.241	001	Corrosivity - pH Determination	EPA 9045C	
114.250	001	Fluoride	EPA 9056	FL

Field of Testing: 115 - Extraction Test of Hazardous Waste

115.020	001	Toxicity Characteristic Leaching Procedure (TCLP)	EPA 1311 (TCLP)	
115.021	001	TCLP Inorganics	EPA 1311 (TCLP)	
115.022	001	TCLP Extractables	EPA 1311 (TCLP)	
115.023	001	TCLP Volatiles	EPA 1311 (TCLP)	
115.030	001	Waste Extraction Test (WET)	CCR Chapter11, Article 5, Appendix II	
115.040	001	Synthetic Precipitation Leaching Procedure (SPLP)	EPA 1312 (SPLP)	

Field of Testing: 116 - Volatile Organic Chemistry of Hazardous Waste

116.010	000	EDB and DBCP	EPA 8011	Aqueous Only
116.080	000	Volatile Organic Compounds	EPA 8260B	
116.080	120	Oxygenates	EPA 8260B	

Field of Testing: 117 - Semi-volatile Organic Chemistry of Hazardous Waste

117.110	000	Extractable Organics	EPA 8270C	
117.140	000	Polynuclear Aromatic Hydrocarbons	EPA 8310	

As of 11/5/2018, this list supersedes all previous lists for this certificate number.
 Customers: Please verify the current accreditation standing with the State.

117.170	000	Nitroaromatics and Nitramines	EPA 8330	FL
117.171	000	Nitroaromatics and Nitramines	EPA 8330A	
117.210	000	Organochlorine Pesticides	EPA 8081A	
117.220	000	PCBs	EPA 8082	
117.250	000	Chlorinated Herbicides	EPA 8151A	

Field of Testing: 118 - Radiochemistry of Hazardous Waste

118.010	001	Gross Alpha	EPA 9310	
118.010	002	Gross Beta	EPA 9310	
118.020	001	Radium, Total	EPA 9315	
118.030	001	Radium-228	EPA 9320	
118.070	001	Thorium	EPA (March, 1979), p33	
118.140	001	Radium-226	EPA Ra-04	
118.200	001	Gamma Emitters	DOE 4.5.2.3	UT
118.271	001	Strontium	DOE Sr-02	UT
118.290	001	Uranium	DOE U-02	UT

Field of Testing: 120 - Physical Properties of Hazardous Waste

120.020	001	Ignitability	EPA 1020A	
120.030	001	Corrosivity	EPA 1110	FL
120.040	001	Reactive Cyanide	Section 7.3 SW-846	FL
120.050	001	Reactive Sulfide	Section 7.3 SW-846	FL
120.070	001	Corrosivity - pH Determination	EPA 9040B	Aqueous Only
120.080	001	Corrosivity - pH Determination	EPA 9045C	

Attachment 5 Technical Systems Audit Checklist

Technical Systems Audit Checklist

Project No. _____ Date of Audit _____

Project Manager _____ Auditor _____

Facility Name _____

Location _____

Weather _____

Field Personnel **FTL:** _____ **SSHO:** _____

Chemist: _____

Description of Field Activities

Summary and Recommendations

Planning and Preparation

Yes or No

- | | |
|---|---|
| <p>1. Was the field audit announced or unannounced?
 Comments: _____
 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>2. Was a QA Project Plan prepared for this activity?
 Comments: _____
 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>3. Was a site Health and Safety Plan prepared for this activity?
 Comments: _____
 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>4. Were project instructions, work plan, and contractor SOWs distributed to the team?
 Comments: _____
 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>5. Were additional instructions given to project field participants (i.e., changes in project plan)?
 Comments: _____
 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>6. Was there a written list of sampling locations and descriptions?
 Comments: _____
 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>7. Was there a map of sampling locations available to field personnel?
 Comments: _____
 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |

Planning and Preparation (continued)

Yes or No

- | | | | |
|-----|--|--------------------------|--------------------------|
| 8. | Was equipment list given to equipment coordinator with adequate lead time?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 9. | Was laboratory given a list of sample containers with adequate lead time?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 10. | Were analyses scheduled with the laboratory in advance?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 11. | Was the project team provided with a contact list (names & phone #s)?
Comments: _____
_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 12. | Are inexperienced or poorly trained staff receiving adequate training and supervision?
Comments: _____
_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 13. | Was State "One Call" agency contacted prior to drilling, trenching, or excavation to identify buried utilities?
If yes, record Ticket No. _____, date of request _____, and renewal date _____
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 14. | Was an underground utility location contractor retained to identify buried utilities?
Describe means used to track and verify completion of location activities at each sampling station: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |

Planning and Preparation (continued)

- | | | <u>Yes or No</u> | |
|----|---|--------------------------|--------------------------|
| 15 | Are dig permits required?
If yes, record permit number: _____ date of issue _____,
and renewal date _____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 16 | Are hot work permits required?
If yes, record permit number _____, date and time of issue
_____, and expiration date and time _____ | <input type="checkbox"/> | <input type="checkbox"/> |

Monitoring Well Installation

- | | | <u>Yes or No</u> | |
|---|---|--|--|
| 1 | Was a daily tail gate safety briefing conducted?
If yes, list the items discussed: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 2 | Were the wells located properly with respect to potential
contaminant plumes?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 3 | If field conditions mandated selection of a new location, was the
new location properly selected?
If yes, were the reasons for the relocation properly documented? | <input type="checkbox"/>
<input type="checkbox"/> | <input type="checkbox"/>
<input type="checkbox"/> |
| 4 | Were the well locations surveyed?
Were the exact elevations determined as part of the survey?
Were elevations referenced to a bench mark?
Were horizontal coordinates established? | <input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/> | <input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/> |
| 5 | Describe the drilling techniques used.

_____ | | |
| 6 | Was all in-ground drilling equipment properly decontaminated
before initial use and between drilling locations? | <input type="checkbox"/> | <input type="checkbox"/> |

Monitoring Well Installation (continued)

Yes or No

7 Describe decontamination procedures (steam cleaner, pressure washer, type of soap used if any, solvent, etc.)

8 How was this equipment stored or otherwise protected after decontamination to prevent recontamination prior to use?

9 What types of casing/screen material were used (black iron, stainless steel, PVC, etc.)?

10 Were well casings/screens properly decontaminated before use? Describe decontamination procedure.

11 How was this equipment stored or otherwise protected after decontamination to prevent recontamination prior to use?

12 Were the wells completed to the proper depth?
 Were the wells screened at the proper interval?
 Comments: _____

13 Were the newly installed wells properly secured (sealed) during the overnight grout curing required before installation of protective outer casing?

Monitoring Well Installation (continued)

Yes or No

- 14 Was a locking cap or some other locking mechanism included as part of the protective outer casing?
- 15 Describe disposal/storage method used for drilling mud and cuttings.

- 16 Were samples of drilling mud, sand pack, gravel, grout, etc., collected for analysis?
 Comments: _____

- 17 Were the wells developed?
 If yes, describe method used

- 18 Did the drilling personnel follow required safety protocols?
 Comments: _____

Sampling

General Procedures

Yes or No

1. Were sampling locations properly selected?
 Comments: _____

General Procedures (continued)

Yes or No

- | | |
|--|---|
| <p>2. Were samples collected starting with the least likely contaminated and proceeding to the most likely contaminated?
 Comments: _____

 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>3. Were new disposable gloves worn during sample collection?
 Comments: _____
 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>4. Was sampling equipment wrapped in aluminum foil or otherwise protected from possible contamination prior to sample collection?
 Comments: _____

 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>5. If equipment was cleaned in the field, were proper procedures used? (This includes storage method for rinse water and solvents.)
 Comments: _____

 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>6. What field instruments were used during this investigation?

 _____</p> | |
| <p>7. Were field instruments properly calibrated?
 Comments: _____

 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |
| <p>8. Were calibration procedures documented in the field notes?
 Comments: _____

 _____</p> | <p><input type="checkbox"/> <input type="checkbox"/></p> |

General Procedures (continued)

Yes or No

9. Were samples chemically field preserved?
 Comments: _____

10. Were samples iced?
 Comments: _____

11. Were samples of drilling mud, sand pack, gravel, grout, etc., collected for analysis?
 If yes, please list parameters and procedures.

Groundwater Sampling

Yes or No

1. Was depth of well determined?
 Comments: _____

2. Was depth to water determined?
 Comments: _____

3. Was measuring tape properly decontaminated between wells?
 Comments: _____

4. Were the above depths to water converted to water level elevations common to all wells? Describe how the depths were determined.

Groundwater Sampling (continued)

Yes or No

5. How was the volume of water originally present in each well determined?
 Comments: _____

6. Was the volume determined correctly? Yes No
7. How was completeness of purging determined?
 Volume
 Measure
 Time/Flow Rate
 Cond./pH/T
8. Was a sufficient volume purged? Yes No

9. Describe the disposal of purge water.

10. Was a dedicated (in-place) pump utilized? Yes No
 If no, describe the method of purging (bailer - include type and construction material, pump - include type).

11. How were the samples collected?
 Bailer Passive diffusion bag
 Pump Peristaltic/Bladder/Centrifugal/Other (check one)
 Other

Groundwater Sampling (continued)

Yes or No

- 12 Construction material of bailer or tubing: Design of bailer:
- | | | | |
|--------|--------------------------|------------|--------------------------|
| S.S. | <input type="checkbox"/> | Open top | <input type="checkbox"/> |
| Teflon | <input type="checkbox"/> | Closed top | <input type="checkbox"/> |
| PVC | <input type="checkbox"/> | | |
| Other | <input type="checkbox"/> | | |

Comments: _____

- 13 If a pump was used, describe how it was cleaned before and/or between wells?
- _____
- _____
- _____

- 14 Were the samples properly transferred from bailer to sample bottles (i.e., was the purgeable sample agitated, etc.)?
- Comments: _____
- _____
- _____

- 15 Was the rope or line allowed to touch the ground?

- 16 Was the wetted rope or line discarded after use at each well?
- _____

Surface Water Sampling

Yes or No

1. What procedures were used to collect surface water?
- _____
- _____

2. Did the samplers wade in the stream during sample collection?
- If yes, did sampler face upstream while collecting sample?

Other Sampling

Yes or No

1. What other types of samples were collected during this investigation?

2. What procedures were used for the collection of these samples?

3. Note any deficiencies observed during the collection of these samples.

Quality Assurance/Quality Control

Yes or No

(While not all of these QA/QC procedures will be necessary during each sampling activity, the following techniques may be employed. If so, please note.)

- | | | | |
|----|--|--------------------------|--------------------------|
| 1. | Did sampling personnel utilize trip blanks? | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. | Did sampling personnel utilize preservative blanks?
If yes, to either of the above questions, list the types and handling of the blanks.

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. | Were any equipment blanks collected?
If yes, list.

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. | Was the water for field blank preparation appropriate for the parameter coverage?
Comments: _____
_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. | Were any duplicate samples collected?
If yes, list the types (parameter coverage, etc.) and describe their handling.

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. | Were any spiked samples collected?
If yes, list the types (parameter coverage, etc.) and describe their handling.

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 7. | Were the QA/QC samples collected in accordance with the QA Project Plan? | <input type="checkbox"/> | <input type="checkbox"/> |
| 8. | Were staff aware of sample holding times? | <input type="checkbox"/> | <input type="checkbox"/> |

Field Documentation and Chain-of-Custody

Yes or No

- | | | | |
|----|---|--------------------------|--------------------------|
| 1. | Were Sample I.D. Tags filled out completely (i.e., station no., location, date, time, analyses, signatures of samplers, type of preservative)?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. | Were Chain-of-Custody Records completed for all samples?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. | Did information on Sample I.D. Tags and Chain-of-Custody Records match?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. | Were samples shipped to the laboratory?
If yes, did the Chain-of-Custody Record indicate the method of sample shipment?

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. | Was a Chain-of-Custody Record included with the samples in the shipping container?

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. | Were samples properly secured to maintain custody after collection?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |

Field Documentation and Chain-of-Custody (continued)

Yes or No

- | | | | |
|----|--|--------------------------|--------------------------|
| 7 | Were sample tags, Chain-of-Custody forms, and field notebook signed by sampling personnel?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 8 | Does the field notebook contain adequate information about each sample including the sample I.D. number, date, location, and information necessary to reconstruct the sample?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 9 | Were entries to the field notebook made in ink?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 10 | Were corrections properly executed with one line through the error in the field notebook?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 11 | Was sampling documented with photographs?
If yes, was a photolog maintained? | <input type="checkbox"/> | <input type="checkbox"/> |
| 12 | Were amendments to the project plan documented (on the project plan itself, in a project logbook, elsewhere)?
Comments: _____

_____ | <input type="checkbox"/> | <input type="checkbox"/> |

Appendix C
Soil Reference Background Area
Work Plan



**Naval Facilities Engineering Command Southwest
BRAC PMO West
San Diego, CA**

FINAL

**SOIL REFERENCE BACKGROUND AREA
WORK PLAN**

**FORMER HUNTERS POINT NAVAL SHIPYARD
SAN FRANCISCO, CA**

June 2019



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Acronyms and Abbreviations

⁴⁰ K	potassium-40
⁹⁰ Sr	strontium-90
¹³⁷ Cs	cesium-137
²¹⁴ Pb	lead-214
²²⁶ Ra	radium-226
²³⁰ Th	thorium-230
²³² Th	thorium-232
²³⁴ U	uranium-234
²³⁵ U	uranium-235
²³⁸ U	uranium-238
²³⁹ Pu	plutonium-239
μR/hr	microrentgen(s) per hour
APP	accident prevention plan
ASTM	ASTM International (formerly American Society for Testing and Materials)
bgs	below ground surface
CDPH	California Department of Public Health
CH2M	HILL, Inc.
cpm	counts per minute
cpm/μR/hr	counts per minute per microrentgen per hour
DQO	data quality objective
DTSC	Department of Toxic Substances Control
ft ²	square feet
GIS	geographic information system
GPS	global positioning system
HPNS	Hunters Point Naval Shipyard
IDW	investigation-derived waste
KW	Kruskal-Wallis
m/s	meter(s) per second
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCA	multi-channel analyzer
MDCR	minimum detectable count rate
NaI	sodium iodide
NaI(Tl)	thallium-doped sodium iodide

Navy	Department of the Navy
NORM	naturally occurring radioactive material
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulatory Commission Regulation
pCi/g	picocurie per gram
PPE	personal protective equipment
PRSO	Project Radiation Safety Officer
Q-Q	quantile-quantile
RASO	Radiological Affairs Support Office
RBA	reference background area
RG	remediation goal
ROC	radionuclide of concern
ROICC	Resident Officer in Charge of Construction
RPM	Remedial Project Manager
SAP	sampling and analysis plan
SOP	standard operating procedure
SSHPP	site safety and health plan
TCRA	Time-critical Removal Action
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey

Introduction

This work plan provides the details for the radiological characterization of soil reference background areas (RBAs) at the former Hunters Point Naval Shipyard (HPNS) in San Francisco, California. Four onsite RBAs and one offsite RBA, located at the City of San Francisco's John McLaren (McLaren) Park, have been identified for radiological characterization. The radiological characterization will be conducted in accordance with the general approach and methodologies that are provided in the Parcel G Removal Site Evaluation Work Plan (Parcel G Work Plan) (Navy, 2018), Sampling and Analysis Plan (SAP) (included in the Parcel G Work Plan), and a separate Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP). Specific procedures to ensure data quality and worker safety will be described in the SAP and APP/SSHP.

Radiological surveys and remediation have been conducted at HPNS as part of a basewide Time-critical Removal Action (TCRA). Additional efforts to investigate and, if necessary, remediate radiologically impacted sites in Parcels B, C, D-2, E, G, UC-1, UC-2, and UC-3 are planned. The RBA data will be used to evaluate site investigation data to support a final decision on whether residual radioactivity is found to exceed the remediation goals (RGs). The RBA data will also be compared to site investigation data to determine whether further remediation is necessary.

Purpose and Data Quality Objectives

The reference background area data will be collected during the implementation of this work plan to support a final decision on whether residual radioactivity is found to exceed the RGs at HPNS. The RGs presented in **Section 3** specify that the radium-226 (^{226}Ra) RG be set at 1 picocurie per gram (pCi/g) above the background concentration. Previous site radiological surveys and remediation activities did not estimate a reference background concentration for other radionuclides, such as cesium-137 (^{137}Cs) and strontium-90 (^{90}Sr). Both ^{137}Cs and ^{90}Sr are common nuclear fission products that are present worldwide because of radioactive fallout from weapons testing. This work plan describes methods for obtaining RBA data sets for the radionuclides of concern (ROCs) by establishing the following:

- Descriptive statistics and distributions of background concentrations, in pCi/g, for the ROCs, including ^{137}Cs , ^{226}Ra , and ^{90}Sr
- Descriptive statistics and distributions of background concentrations for the naturally occurring radioactive material (NORM) radionuclides, including those associated with the uranium decay series, thorium decay series, and potassium-40 (^{40}K)

Additionally, the data collection protocols and RBA data sets may be used for site evaluation scenarios listed in the Parcel G Work Plan and other work plans (e.g., NORM evaluations, comparison to background, alternative statistical evaluations, and dose and risk analyses).

The data quality objectives for the RBA investigation are as follows:

- **Step 1-State the Problem:** HPNS was expanded over time using fill materials with a range of concentrations of NORM. Construction and remediation projects over the past 60 years have disturbed the surface soil, making a determination of background concentrations for anthropogenic radionuclides from fallout difficult. Previous HPNS soil background values did not provide ^{226}Ra concentrations representative of all fill materials found at HPNS and did not include other NORM or fallout radionuclides.
- **Step 2-Identify the Objective:** Establish representative background soil data sets for comparison and evaluation of soil data collected from HPNS.
- **Step 3-Identify Inputs to the Objective:** Soil analytical data for ROCs using analytical methods are summarized in **Section 3** and detailed in the SAP, included in the Parcel G Work Plan. Gamma scanning measurements will be performed within the RBAs to confirm the areas are free of elevated gamma levels and are suitable for sampling¹ (see **Section 4.1**).
- **Step 4-Define the Study Boundaries:** RBAs at HPNS in Parcels B, C, D-1, and D-2 (**Figure 3-1**), and in an undisturbed off-base location (**Figure 3-2**) will provide a range of background estimates. In Parcels B, C, D-1, and D-2, surface soil samples will be collected from 0 to 6 inches below ground surface (bgs), and subsurface soil samples will be collected from 1- to 2-foot bgs intervals to a depth of up to 10 feet bgs. At the off-base location, surface soil samples will be collected from 0 to 6 inches bgs, and subsurface soil samples will be collected from the 1- to 2-foot bgs interval.
- **Step 5-Develop Decision Rules:** RBA data sets will be compared and evaluated to provide representative RBA data sets with a description to assist in determining applicability for specific projects at HPNS. The data evaluation process is summarized in the following list and detailed in **Section 4**:

¹ If any RBA is found to have signs of contamination, then an alternate RBA will be proposed to regulatory agencies as a replacement.

- Identify outliers graphically or statistically using Dixon and Rosner’s tests for outliers by comparing the calculated Q values or R values to the critical value, corresponding to a confidence level of 95 percent.
 - If outliers are identified graphically or statistically (Q value or R value is greater than critical value), the outlier will be investigated to attempt to determine whether the outlier is the result of contamination, data quality issues, an environmental issue (e.g., different soil type), or an unidentified issue.
 - If no outliers are identified, the entire data set will be used in its entirety.
- Determine statistical difference between data sets using the non-parametric Kruskal-Wallis (KW) test by comparing the calculated p-value against 0.05 significance level.
 - If the results of the KW test indicate that two or more data sets are statistically similar (p-value is greater than significance level), those data sets may be combined to form a larger data set representing more of HPNS, such as a larger area, multiple soil depths, or additional soil types.
 - If the results of the KW test indicate that a data set is statistically different from other data sets (p-value is less than significance level), that data set will not be combined with other data sets and will be representative of a specific area, soil depth, or soil type.
- Evaluate secular equilibrium conditions.
- **Step 6-Specify the Performance Criteria:** A statistical data evaluation will be conducted to identify appropriate soil background data sets and calculate descriptive statistics to facilitate future comparisons with site-specific data. The purposes of the data evaluation are as follows:
 - Identify outliers using Dixon’s and Rosner’s tests for outliers.
 - Determine statistical differences between soil types using the KW test.
 - Compare soil data sets from surface gamma scan surveys, and surface and subsurface analytical concentrations against different identified soil types and against each RBA per sample depth.
 - Establish one or more representative RBA data sets.
- **Step 7-Develop the Plan for Obtaining Data:** RBAs will be characterized by conducting gamma scan surveys of the accessible surface areas and collecting systematic surface and subsurface soil samples, as follows:
 - In Parcels B, C, D-1, and D-2, surface soil samples will be collected from 0 to 6 inches bgs, and subsurface soil samples will be collected from 1- to 2-foot bgs intervals to a depth of up to 10 feet bgs.
 - At McLaren Park, an offsite location with undisturbed surface soil, surface soil samples will be collected from 0 to 6 inches bgs and subsurface soil samples will be collected from the 1- to 2-foot bgs interval.
 - During soil sampling activities, a professional geologist registered in California will annotate the lithologic characteristics and provide accurate and consistent descriptions of soil characteristics.
 - Soil samples will be analyzed for the applicable ROCs along with NORM radionuclides and fallout radionuclides by accredited offsite laboratories, and the results will be evaluated as described in Steps 5 and 6.

Survey Design and Implementation

3.1 Survey Design

The concentrations of NORM radionuclides and fallout radionuclides in soil at HPNS are variable because of the natural variability of native soil and the variability in erosion and deposition of surface soil and fallout radionuclides. In addition, portions of the site were created with fill materials originating from multiple offsite sources. Much of the fill was obtained by grading the hilltop immediately north of HPNS. The source of fill derived from the hilltop is the Hunters Point Shear Zone, a complex structural mixture of serpentinite, shale, sandstone, chert, and gabbro. Fill soil was also obtained from sediment dredged from San Francisco Bay and imported from local quarries and construction sites. Fill soil was generally placed in layers; however, the layering is not contiguous across the shipyard. Soil lithology in filled areas is not readily known at any given location.

Concentrations of fallout radionuclides are variable in soil at HPNS because of deposition, erosion, and mixing during placement of fill soil. Thus, the concentrations of naturally occurring and fallout radionuclides in soil vary by location and depth. The RBA is designed to capture data that are comparable to survey data collected during site investigations at HPNS and representative of the wide range of background concentrations present at HPNS.

Because of potential spatial variability across HPNS, four distinct onsite RBAs have been identified for characterization. In addition, one undisturbed offsite location was selected for characterization of fallout radionuclides. RBAs are geographical areas from which representative radioactivity measurements are collected for comparison with measurements collected in an impacted area (i.e., a survey unit). RBAs are areas that have been identified as non-impacted and should have physical, geological, chemical, radiological, and biological characteristics similar to those of the impacted area being investigated. The RBA characterization methodology will consist of a combination of radiological gamma surveys and soil sampling to establish the HPNS background conditions. Samples will be collected from independent surface and subsurface soil depth intervals. The analytical soil data from the RBAs will be used to generate background population statistics and establish parameters (e.g., mean, median, standard deviation, range).

3.1.1 Radionuclides of Concern

The ROCs vary across media and parcels at HPNS. Because the intent of this RBA characterization is to address all soil ROCs at HPNS, the various soil ROCs and their respective RGs in Parcels B, C, D-2, E, G, UC-1, UC 2, and UC-3 are presented in **Table 3-1**. RBA samples and measurements will be collected and evaluated to establish representative data sets defining natural background and fallout levels of anthropogenic radionuclides. The analytical methods and the radionuclides being analyzed for will be presented in the SAP and are summarized in **Section 3.1.7**.

Table 3-1. Radionuclides and Remediation Goals for Various Soil Areas at HPNS

Radionuclide	Residential Soil Remediation Goal ^a (pCi/g)
¹³⁷ Cs	0.113
²³⁹ Pu	2.59
²²⁶ Ra	1.0
⁹⁰ Sr	0.331
²³² Th	1.69
^{235+D} U	0.195

^aAll RGs will be applied as concentrations above background.

²³²Th = thorium-232

^{235+D}U = uranium-235+D

²³⁹Pu = plutonium-239

3.1.2 Survey Methodology Summary

The RBA characterization will incorporate three survey techniques: gamma spectroscopy scans, surface soil sampling, and subsurface soil sampling. The gamma spectroscopy scan will be performed by surveying the accessible surface areas, following removal of any durable cover (if applicable). Soil sampling will occur at various depths from 0 to 10 feet bgs. The sampling design is representative of the survey unit sampling designs in terms of sample depths, spatial distribution, and number of samples to be collected.

3.1.3 Reference Background Area Locations

As part of the previous HPNS TCRA activities, five areas were used as RBAs for soil and were characterized at different times beginning in 2006. Because of access restrictions, this work plan has been designed to use four of the previously established RBA soil areas with adjustments to the shape and size of the areas. In this work plan, the four historically non-impacted RBAs are identified as the following (shown on **Figure 3-1**):

- RBA-1, located on Parcel B
- RBA-2, located on Parcel C
- RBA-3, located on Parcel D-1
- RBA-4, located on Parcel D-2

These four historical RBAs are still considered non-impacted, representative of much of the soil at HPNS, and suitable for use as RBAs. Justification for selecting the non-impacted RBAs is as follows:

- RBA-1, located in the area behind Building 116 on Parcel B, is considered to contain material like that encountered in nearby soils and has been covered with asphalt since the early 2000s.
- RBA-2, southeast of Lockwood Avenue adjacent to Parcel C, is believed to be unimpacted, has no history of radiological use, and has been covered with asphalt since approximately 2015.
- RBA-3, the area between Building 526 and Berth 29 in Parcel D-1, is considered to contain material like that encountered in nearby soils in the Parcel E survey units and has no history of radiological use. The area has been paved with asphalt since the previous RBA characterization.

- RBA-4, located in the Building 813 parking lot in Parcel D-2, has no history of radiological use, is considered to contain material like that encountered in the Parcel G survey units, and has been paved with asphalt since the previous RBA characterization. The land area in Parcel G was originally part of Parcel D and is adjacent to RBA-4; therefore, RBA-4 is considered representative of Parcel G site conditions.

Following characterization of each RBA, a detailed data evaluation will be performed to confirm its suitability as an appropriate RBA. In addition to the four onsite RBAs, an offsite RBA has been identified for surface soil characterization. The City of San Francisco's McLaren Park is located roughly 2.5 miles west of HPNS. McLaren Park is non-impacted by the Department of the Navy (Navy) radiological activities and contains areas where surface soil has been undisturbed by construction activities since prior to atmospheric nuclear weapons testing. McLaren Park occupies 312 acres and includes a nine-hole golf course, playgrounds, amphitheater, and 350,000-gallon water tank. The land area between John F Shelley Drive and Mansell Street contains undisturbed terrain and has been selected as a potential location for the offsite RBA (RBA-McLaren). The RBA-McLaren is shown on **Figure 3-2**. The exact sample locations within McLaren Park may be adjusted based on consultation with the City of San Francisco. Other locations in the San Francisco Bay Area that have been similarly undisturbed may also be used as potential offsite RBA locations.

Both surface gamma scan surveys and surface soil samples will be collected from RBA-McLaren to provide a surface soil data set representative of undisturbed surface soil areas. Additional sample locations at McLaren Park or additional RBA locations may be added as necessary to characterize different soil types and depositional areas.

3.1.4 Number of Samples

The minimum number of samples to be collected was determined using the Parcel G Work Plan and Nuclear Regulatory Commission (NRC) criteria. The NRC criteria for providing characterization of a complex site, found in United States Nuclear Regulatory Commission Regulation (NUREG)-1505 (Section 13.5, page 13-11, last paragraph, second sentence), states that "four reference areas each with between 10 and 20 samples in each should generally be adequate" (NRC, 1998a). Table 13.5, *Power of the F-test when $\omega^2 = \sigma^2$* , in NUREG-1505, shows that 20 samples collected from each of 6 reference area data sets will provide 95 percent confidence that the reference area data sets can be combined if they are similar. In this example, the power of this test is 99 percent, meaning there is a 1 percent probability that the data sets will be incorrectly combined when they are not similar. The proposed RBA survey design includes collecting 25 samples from each of up to 10 reference area data sets, providing a power greater than 99 percent while maintaining 95 percent confidence that the data sets can be combined if they are similar.

The null hypothesis (H_0) is that the mean concentrations for each RBA data set are similar and can be combined. The alternative hypothesis is that the mean concentrations for at least one of the RBA data sets are not similar.

Type I decision error would occur when the data sets are not combined when the means are actually equal. The consequence of a Type I error includes having a smaller number of samples in the RBA data set, resulting in less statistical power for evaluating survey unit data sets, potentially resulting in removing soil that has ROC concentrations below the RGs.

Type II decision error would occur when the data sets are combined when the means are actually different. The consequence of a Type II error would include artificially increasing the variability in the combined RBA data set, thereby decreasing the required number of samples in each survey unit.

The Parcel G Work Plan provides a number for samples calculation and determines that a minimum of 18 samples will be collected in each survey unit and each RBA data set; however, that number will be

recalculated following the RBA characterization described in the work plan. In order to satisfy both the NRC criteria and the Parcel G Work Plan, the number of samples in each data set was increased to 25 to ensure that sufficient analytical data will be available. Therefore, 25 surface soil samples and 25 subsurface soil samples will be collected from RBAs 1 through 4 for a total of 100 onsite surface soil samples and 100 onsite subsurface soil samples. Additionally, 25 surface soil samples and 25 subsurface soil samples will be collected from RBA-McLaren. Overall, a minimum of 250 soil samples will be collected, as follows:

- 25 surface and 25 subsurface soil samples from RBA-1, located on Parcel B
- 25 surface and 25 subsurface soil samples from RBA-2, located on Parcel C
- 25 surface and 25 subsurface soil samples from RBA-3, located on Parcel D-1
- 25 surface and 25 subsurface soil samples from RBA-4, located on Parcel D-2
- 25 surface and 25 subsurface soil samples from RBA-McLaren, located offsite

This sampling effort will result in up to 10 RBA data sets of 25 samples each from 5 different RBA locations. Additional data sets may be defined based on soil type or other visual observations of the soil samples.

3.1.5 Sample Locations

To simplify the sampling design, the area of each onsite RBA was modified to establish approximately 2,500-square-foot (ft²) areas within each of the four historical RBA footprints.

3.1.5.1 RBA-1 through RBA-4

For the surface soil sample locations within RBA-1 through RBA-4, a triangular grid will be used to place 25 systematic sample locations. As illustrated on **Figure 3-3**, surface soil samples will be collected from the top 6 inches of soil material at each location for the surface soil data set. For the purposes of this investigation, onsite surface soil is defined as the uppermost 6-inch interval of soil beneath the asphalt and road base materials installed as part of the durable cover.

Within each 2,500-ft² surface area, 5 subsurface sampling locations have been established using 5 of the 25 systematic surface sample locations: 1 at the approximate center of each area, and the other 4 located near each of the 4 corners of the area. Subsurface soil samples will be collected from the five sampling locations. As illustrated on **Figure 3-3**, subsurface soil samples will be collected by drilling to a depth of approximately 10 feet bgs from which five subsurface soil samples will be extracted. The proposed subsurface sample depth intervals are the 1- to 2-foot bgs interval, the 3- to 4-foot bgs interval, the 5- to 6-foot bgs interval, the 7- to 8-foot bgs interval, and the 9- to 10-foot bgs interval. If the geologist determines that lithologic characteristics support modification of the proposed depth increments, additional samples may be collected, or the proposed sample depth may be adjusted to match the lithologic characteristics of the soil column. This is further described in **Section 3.2.5**.

Figures 3-4 through 3-7 show the planned surface and subsurface sample locations from RBAs 1 through 4.

3.1.5.2 RBA-McLaren

The planned area for RBA-McLaren, located offsite and within McLaren Park, is a square area measuring approximately 75 feet by 75 feet. Within the estimated 5,600-ft² (520-square-meter) surface area, 25 surface sampling locations have been established using a random start systematic triangular grid pattern. Surface soil samples will be collected as described in **Section 3.2** from the top 6 inches of soil at each location for the surface soil data set. Subsurface soil samples will be collected as described in **Section 3.2**, from the approximately 1- to 2-foot bgs interval at each location for the subsurface soil data set. **Figure 3-8** shows the planned sample locations for RBA-McLaren. Additional samples may be

collected from other locations if areas of relatively undisturbed surface soil with varying geological properties are identified during field sampling activities.

3.1.6 Field Instrumentation, Gamma Detectors

Gamma scanning instruments have been selected to provide a high degree of defensibility, based on their capability to measure and quantify gamma radiation and position. Because there are several specific gamma detection platforms that may be used during upcoming work at HPNS, the minimum requirements for a suitable gamma scan survey system are as follows:

- Thallium-doped sodium iodide (NaI[Tl]) or plastic gamma scintillator
- Equipped with spectroscopy
- Automatic data logging
- Real-time positioning (global positioning system [GPS] or equivalent)

During this initial RBA characterization, gamma scan surveys will be performed using one or more of the instruments shown in **Table 3-2** (or other instruments with equivalent detection sensitivity and meeting the minimum requirements listed above).

Table 3-2. Gamma Survey Instruments

Meter Manufacturer and Model	Detector Manufacturer and Model	Detector Type	Use
Ludlum 2221, Osprey MCA	Bicron 3x5x16 / 3SSL-X	3-inch x 5-inch x 16-inch NaI(Tl) detector	Soil gamma scan surveys
Ludlum 2221, MCA	Ludlum Model 44-20	3-inch x 3-inch NaI(Tl) detector	Soil gamma scan surveys, sample screening, soil core surveys

Note: Equivalent alternative instrumentation may be used following approval by the Project Radiation Safety Officer (PRSO) and Field Team Lead.

MCA = multi-channel analyzer

The field survey instrumentation will be calibrated, used, and maintained in accordance with the requirements and standard operating procedures (SOPs) provided in the Parcel G Work Plan and according to the SAP.

3.1.6.1 Instrument Detection Calculations

The equations to calculate efficiencies, minimum detectable concentrations (MDCs), and minimum detectable count rates (MDCRs) at HPNS are based on the methodology and approach used in *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* Chapter 6 (USEPA et al., 2000) and NUREG-1507 Chapter 6 (NRC, 1998b).

3.1.6.2 Gamma Surface Activity

Estimating the amount of radioactivity that can be confidently detected using field instruments is performed by adapting the methodology and approach used in MARSSIM Section 6.7.2.1 (USEPA et al., 2000) and NUREG-1507 Section 6.8.2 (NRC, 1998b) for determining the gamma scan MDC for photon-emitting radionuclides.

The scan MDC (in pCi/g) for areas is based on the area of elevated activity, depth of contamination, and the radionuclide (energy and yield of gamma emissions). The computer code Microshield can be used to model expected exposure rates from the radioactive source at the detector probe sodium iodide (NaI) crystal and includes source-to-detector geometry. The geometry is used to calculate the total flow of

photons incident upon the detector crystal, called the gamma fluence rate, ultimately corresponding to an exposure rate that is associated with a count rate in the instrument.

The amount of radiation the detector crystal is exposed to from the modeled source is used to determine the relationship between the detector's net count rate and the net exposure rate (counts per minute per microrentgen per hour [cpm/ μ R/hr]).

3.1.6.3 Gamma Scan Minimum Detectable Concentration

The minimum detectable number of net source counts in the scan interval is given by s_i , which can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in d'), as shown in **Equation 3-1** (Equation 6-8 of MARSSIM):

Equation 3-1

$$s_i = d' \sqrt{b_i}$$

Where:

- d' = index of sensitivity (α and β errors [performance criteria])
- b_i = number of background counts in scan time interval (count)
- i = scan or observation interval (seconds)

For scanning at HPNS, the required rate of true positives will be 95 percent, and the false positives will be 5 percent. From Table 6.5 of MARSSIM, the value of d' , representing this performance goal, is 3.28. The MDCR, in counts per minute (cpm), is calculated by **Equation 3-2** (Equation 6-9 of MARSSIM):

Equation 3-2

$$MDCR = s_i \times (60/i)$$

Where:

- s_i = minimum detectable number of net source counts in the scan interval
- i = scan or observation interval (seconds)

Next, the MDCR is used to calculate the *Surveyor* MDCR by applying a surveyor efficiency factor as follows in **Equation 3-3** (Page 6-45 of MARSSIM):

Equation 3-3

$$MDCR_{Surveyor} = \frac{MDCR}{\sqrt{p}}$$

Where:

- $MDCR$ = minimum detectable count rate
- p = surveyor efficiency

After a surveyor efficiency is selected, the relationship between the $MDCR_{Surveyor}$ and the radionuclide concentration in soil (pCi/g) is determined. This correlation requires two steps: 1) establish the relationship between the detector's net count rate and net exposure rate (cpm/ μ R/hr), and 2) determine the relationship between the radionuclide contamination and exposure rate. The relationship between the detector's net count rate and net exposure rate may be determined analytically using reference guidance documents, or obtained from the detector manufacturer. Modeling (using Microshield) of the source area is used to determine the net exposure rate produced by a given concentration of a radionuclide at a specific distance above the source. The scan MDC is calculated by **Equation 3-5** (Page 6-45 of MARSSIM):

Equation 3-5

$$\text{ScanMDC} = \left(\frac{\text{MDCR}_{\text{surveyor}}}{\epsilon_{\text{inst}}} \right) \times \left(\frac{\text{Radionuclide Concentration}[\text{pCi/g}]}{\text{Exposure rate}[\mu\text{R/h}]} \right)$$

Where:

$\text{MDCR}_{\text{surveyor}}$ = minimum detectable count rate surveyor

ϵ_{inst} = instrument efficiency (cpm/ $\mu\text{R/hr}$)

Radionuclide Concentration = modeled source term concentration (pCi/g)

Exposure Rate = result of model (microrentgen(s) per hour [$\mu\text{R/hr}$])

3.1.6.4 Example Gamma Scan Minimum Detectable Concentrations

An example a priori scan MDC calculation is provided herein for ^{226}Ra using a Ludlum 2221 with a Model 44-20 (3-inch by 3-inch NaI) detector. This example assumes a background level of 18,000 cpm, and 95 percent correct detections and 95 percent false positive rates resulting in a d' of 3.28. A scan rate of 0.5 meter per second (m/s) (19.7 inches per second) provides an observation interval of 2 seconds (based on a diameter of approximately 1 meter for the modeled area of elevated activity). The $\text{MDCR}_{\text{surveyor}}$ was then calculated assuming a surveyor efficiency (ρ) of 1 (assumes automated data logging). The scan MDC is calculated as follows:

$$s_i = 3.28 * \sqrt{\frac{18,000 * 2\text{sec}}{60\text{sec}}} = 80 \text{ counts}$$

$$\text{MDCR} = 80 * \left(\frac{60 \text{ sec}}{2 \text{ sec}} \right) = 2,410 \text{ cpm}$$

$$\text{MDCR}_{\text{surveyor}} = \frac{2,410 \text{ cpm}}{\sqrt{1}} = 2,410 \text{ cpm}$$

The relationship between the detector's net count rate and net exposure rate has been obtained from the detector manufacturer and is 2,300 cpm/ $\mu\text{R/hr}$. The relationship between the radionuclide contamination and exposure rate has been determined by modeling (using Microshield) the source area to determine the net exposure rate produced by a given concentration of a radionuclide at a specific distance above the source. The Microshield Version 11.20 model has a source activity of 1 pCi/g of ^{226}Ra , a circular area of elevated activity of 1 square meter, a contaminated zone depth of 15 centimeters (6 inches), and a soil density of 1.6 grams per cubic centimeter. The modeling code determined an exposure rate at the detector height (dose point) of 10 centimeters (4 inches) above the source to be 1.130 $\mu\text{R/hr}$. The scan MDC for this source geometry is calculated as follows:

$$\text{ScanMDC} = \left(\frac{2,410\text{cpm}}{2,300\text{cpm}/\mu\text{R/h}} \right) \times \left(\frac{1.0[\text{pCi/g}]}{1.130[\mu\text{R/h}]} \right) = 0.93 \text{ pCi/g}$$

Additional a priori determinations are provided in **Table 3-3**. The Microshield model parameters are identical to those described in the previous example, using either ^{226}Ra with a concentration of 1 pCi/g, or ^{137}Cs with a concentration of 0.113 pCi/g.

Table 3-3. A Priori Scan MDCs

NaI Detector	Remediation Goal	Scan MDC
Ludlum 44-20, 3x3	^{226}Ra , 1.0 pCi/g	0.93 pCi/g
	^{137}Cs , 0.113 pCi/g	2.30 pCi/g
Bicron 3SSL-X, 3x5x16	^{226}Ra , 1.0 pCi/g	0.21 pCi/g
	^{137}Cs , 0.113 pCi/g	0.46 pCi/g

After field mobilization, MDC calculations will be revised using actual site- and instrument-specific data. Observed MDCs will be provided to regulatory agencies and will be documented in the background report.

3.1.7 Laboratory Analysis

Soil samples will be collected from the RBAs and sent offsite to an analytical laboratory for various analyses. The analytical methods and the radionuclides being analyzed for are presented in the SAP and are summarized in **Table 3-4**. The SAP provides additional guidance on soil sampling, chain-of-custody, laboratory analysis, and quality assurance/quality control requirements.

Table 3-4. Analytical Sample Summary

Analytical Method	Radionuclide
Gamma Spectroscopy (gamma-emitting ROCs and naturally occurring radionuclides)	^{137}Cs ^{226}Ra (equilibrated; via ^{214}Bi and/or ^{214}Pb) ^{238}U Series (^{238}U via protactinium-234m, ^{214}Pb , ^{214}Bi) ^{232}Th Series (^{228}Ac , ^{212}Pb , ^{212}Bi , ^{208}Tl) ^{40}K ^{241}Am
Alpha Spectroscopy (alpha-emitting ROCs and naturally occurring radionuclides)	^{239}Pu / ^{240}Pu ^{241}Am ^{226}Ra Thorium (^{232}Th , ^{230}Th , ^{228}Th) Uranium (^{238}U , ^{235}U , ^{234}U)
Radon Emanation (Lucas Cell) (to support future NORM evaluations)	^{226}Ra
Gas Flow Proportional Counting	^{90}Sr

Notes:

- ^{208}Tl = thallium-208
- ^{212}Bi = bismuth-212
- ^{212}Pb = lead-212
- ^{214}Bi = bismuth-214
- ^{214}Pb = lead-214
- ^{228}Ac = actinium-228
- ^{228}Th = thorium-228
- ^{230}Th = thorium-230
- ^{234}U = uranium-234
- ^{238}U = uranium-238
- ^{240}Pu = plutonium-240
- ^{241}Am = americium-241

3.2 Survey Implementation

Prior to initiating the RBA characterization field activities, several premobilization and mobilization steps will be performed to ensure that work can be performed in a safe and efficient manner.

3.2.1 Premobilization Activities

The primary premobilization tasks include training of field personnel, procurement of support services, and obtaining access to onsite and offsite RBAs. Coordination with the City of San Francisco will be conducted to facilitate access and approval for sampling and ground disturbance activities at McLaren Park. Sampling at McLaren Park will only be conducted if access and approval are granted. The various support services that are anticipated to be required are as follows:

- Radiological analytical laboratory services
- Drilling subcontractor
- Civil surveying subcontractor
- Utility location subcontractor
- Vegetation clearance subcontractor

3.2.1.1 Training Requirements

Any non-site-specific training required for field personnel will be performed prior to mobilization to the extent practical. Training requirements are outlined in the Parcel G Work Plan and in SOP RP-115, *Radiation Worker Training*, included in the Parcel G Work Plan.

Medical examinations, medical monitoring, and training will be conducted in accordance with the APP/SSHP and Parcel G Work Plan requirements.

3.2.1.2 Permitting and Notification

Prior to initiation of field activities for the radiological investigation, the contractor will notify the Navy Remedial Project Manager (RPM), Resident Officer in Charge of Construction (ROICC), Radiological Affairs Support Office (RASO), Caretaker Site Office, and HPNS security as to the nature of the anticipated work. Any required permits to conduct the fieldwork will be obtained prior to mobilization.

The contractor will notify the California Department of Public Health at least 14 days prior to initiation of activities involving the Radioactive Material License (**Section 5**).

3.2.1.3 Pre-Construction Meeting

A pre-construction meeting will be held prior to mobilization of equipment and personnel. The purpose of the meeting will be to discuss project-specific topics, roles and responsibilities of project personnel, project schedule, health and safety concerns, and other topics that require discussions before field mobilization. Representatives of the following will be invited to/attend the pre-construction meeting:

- Navy (RPM, RASO, ROICC, and others as applicable)
- Contractor (Project Manager, Site Construction Manager, Project Quality Control Manager, PRSO, and Site Safety and Health Officer)
- Subcontractors as appropriate
- United States Environmental Protection Agency (USEPA), Department of Toxic Substances Control (DTSC), and California Department of Public Health (CDPH)

3.2.2 Site Survey Preparation Activities

The following steps will be implemented to prepare for the sampling activities and to facilitate access to the site:

- Review the applicable activity hazard analyses prior to starting work evolutions.
- Cut brush and weeds (if appropriate) within each RBA to a maximum height of 4 inches to facilitate scanning and sampling activities.

- Locate and mark utilities in the field.
- Verify that utilities have been deactivated (to the extent possible) and if not deactivated, the active utilities will be further identified and marked to ensure that field personnel understand the exact location and estimated depth. An exclusion area will be placed around the active utilities to prevent accidental exposure to the utility, based on the utility hazard or importance.
 - If utilities are in locations that interfere with planned RBA characterization activities, the area may be relocated, as long as the area remains within the historical RBA footprint.
- Remove debris or obstacles that could obstruct sampling and survey activities. Surface obstructions preventing access will be removed prior to direct-push activities.
- Locate and mark the planned sample locations.

3.2.3 Scan Measurements

Following the completion of the site preparation activities, 100 percent of the accessible surface (i.e., ground level surface) of each RBA will be scanned for gamma activity using one or more of the instruments specified in **Table 3-2** (or equivalent). Both gross gamma and gamma spectral measurements will be collected simultaneously during the gamma scan.

The gamma scans of the accessible surface areas will be performed using a GPS coupled with an appropriate gamma scintillation detector or meter (e.g., Ludlum 44-20 or Bicron 3x5x16/3SSL-X). Along with position, each gamma measurement will be coupled with a date and time stamp. The scans will be performed following a NUREG-1575 protocol by scanning straight lines at a rate of approximately 0.5 m/s in approximately 1-meter-wide swaths, with a consistent detector distance from the ground surface (4 inches above the surface) (USEPA et al., 2000). Generally, each RBA will be gamma scanned as follows (the following description assumes that the RBA is positioned such that the sides align with northern, southern, eastern, and western directions):

- Begin with the detector positioned in the southwestern corner of the RBA at a height of about 4 inches above the surface. Orient the system to face north and initiate data collection (detector is automatically logging radiation readings and GPS is automatically logging position readings) so that the system is recording at a rate of one reading per second (or other, as determined by the project health physicist).
- Move the detector in the northern direction at a not-to-exceed speed of 0.5 m/s.
- Once the detector has reached the edge of the RBA, turn the system around (now facing south) and offset the next detector path by approximately 1 meter (or appropriate based on the instrument's detector size) to allow for a small overlap in the detector field of view
- Move the detector in the southern direction at a not-to exceed speed of 0.5 m/s.
- Repeat these steps until the RBA has been scan surveyed.

Assuming a 2,500-ft² (232-square-meter) area for each onsite RBA plus 5,600-ft² (520-square-meter) area for the offsite RBA (or smaller as appropriate), a survey as described above moving at a speed of 0.5 m/s should result in the collection of a minimum of 1,450 scan measurements over the five RBAs (assuming 100 percent of each RBA is accessible). Offsite RBA locations are assumed to be radiologically non-impacted and in order to be minimally invasive to park areas, gamma scans may be limited to the immediate vicinity of sample locations instead of the whole RBA. Data will be documented and managed as described in **Section 3.2.8**. Data sets will be transferred from the data logger onto a personal computer to create spreadsheets and geographic information system (GIS)-plotted maps. These data sets will be evaluated in accordance with **Section 4**. Following the scan survey, the number of data points and the percent coverage (from a plot of the data) will be reviewed to ensure that the design

parameters of the gamma scan survey were satisfied. If elevated scan measurements are observed, follow-up investigations may be performed with static gamma measurements to delineate and characterize potential areas of interest. Areas with elevated scan measurements that are attributed to contamination or discrete radiological objects will not be sampled, and alternate locations will be selected.

3.2.4 Surface Soil Sampling Process at Onsite and Offsite RBAs

Prior to surface sampling, ensure that the necessary gamma scan measurements have been collected as described in **Section 3.2.3** and reviewed and accepted as described in **Section 4.1**. Surface soil samples will be collected in accordance with the *Soil Sampling* SOP, included in the Parcel G Work Plan.

Generally, the surface soil samples will be collected as follows:

- For areas without an asphalt cover, a clean shovel, hand auger, or other tool will be used to remove a small area (about 3 inches in diameter) of soil to a depth of 6 inches. For areas with an asphalt cover, sampling will follow the process described in **Section 3.2.5**
- The removed soil will be transferred directly into a clean stainless steel bowl for mixing.
- The soils removed from the sample location will be visually described in the field logbook in accordance with the *Preparing Field Log Books* SOP, included in the Parcel G Work Plan. Identify the sample as surface soil and include the approximate volume of the extracted soil. Color, moisture, texture, and clast composition (i.e., serpentine, shale, sandstone, chert, gabbro) will be identified.
- The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces and removing overburden gravel and biological material. The entire mixed sample, or aliquot thereof, will be placed in the designated laboratory sample container. A minimum of 200 grams of soil (approximately 1 cup) are required to complete all required analyses, or 400 grams if the sample is selected as a field duplicate.
- When a field duplicate sample is required (1 for every 10 field samples collected), the duplicate sample will be collected following mixing of the material and splitting the aliquot into an additional sample container.
- Samples will be identified, labeled, and cataloged according to **Section 3.2.7**, and then placed into the appropriate sample cooler (if required) for transport to the contract laboratory. Custody of the sample will be maintained according to the *Chain-of-Custody* SOP, included in the Parcel G Work Plan.
- No extra sample material is expected from surface soil sampling because the entire sample will be sent to the laboratory for analysis. Excess soil material that was not sampled will be returned to the hole from which it came or will be spread adjacent to the sample location.
- When possible, disposable sampling equipment will be used because clean, unused materials do not affect sample results. If reusable sampling equipment is used, it will be cleaned between each sampling event as appropriate. Cleaning of sampling equipment will be conducted using SOP RP-112, *Decontamination of Personnel and Equipment*, included in the Parcel G Work Plan.
- If fluids are generated during cleaning of sampling equipment, the fluids will be containerized and sampled for offsite analysis to determine radionuclide concentrations prior to disposal. Other investigation-derived waste (IDW), including used personal protective equipment (PPE) will be radiologically surveyed prior to disposal using SOP RP-105, *Unrestricted Release Requirements*, included in the Parcel G Work Plan.

Split samples will be available to USEPA and DTSC/CDPH to take for independent analysis either real-time during field activities, from the laboratory during analysis and storage, or after laboratory analysis from on-site storage.

3.2.5 Subsurface Soil Sampling Process at Onsite RBAs

3.2.5.1 Drilling Area Setup

Prior to the commencement of drilling at the sample location (RBAs 1 through 4), the drill site will be prepared by performing the following:

- Clear overhead obstacles, as necessary, to safely operate the drill rig (minimum of 10 feet of clearance between top of drill boom and obstacles).
- Review and ensure that subsurface clearance has been performed and drilling has been approved.
- If utility or other obstacles prevent safe working conditions, the sample location can be re-located at the discretion of the field team lead. To the extent practical, the new sample location should be moved to a safe location as close to the original planned location, while staying within the 400-ft² area.

3.2.5.2 Subsurface Soil Sample Collection

Prior to subsurface sampling, ensure that the necessary gamma scan measurements have been collected as described in **Section 3.2.3** and reviewed and accepted as described in **Section 4.1**. Subsurface soil samples will be collected by following the *Soil Sampling SOP*, included in the Parcel G Work Plan.

Subsurface soil samples will be collected using drilling-rig-mounted equipment to collect samples with thin-walled tube sampling or split-spoon sampling. Generally, drilling and retrieving the boring using the thin-walled tube method will be as follows:

- If an asphalt cover exists at the sample locations, the asphalt will be removed to facilitate soil sampling. Following completion of sampling, asphalt cores will be replaced and sealed.
- Using a drilling rig, a hole is advanced to the desired depth. The samples are then collected following the ASTM International (ASTM) D 1587 standard.
- The sampler is lowered into the hole so that the sample tube's bottom rests on the bottom of the hole. The sampler is advanced by a continuous, relatively rapid downward motion. The sampler is withdrawn from the soil formation as carefully as possible to minimize disturbance of the sample. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch-internal-diameter sampler may be required.
- Upon removal of the tube from the ground, drill cuttings in the upper end of the tube are removed, and the upper and lower ends of the tube are sealed. The soil tube will be turned over to the project geologist and radiation technician for sample preparation, radiological surveys, and containerization. Once retrieved from the hole, the tube is carefully cut open to maintain the material in the tube.

Generally, drilling and retrieving the boring using the split-spoon sampling method will be performed as follows:

- Using a drilling rig, a hole is advanced to the desired depth. The samples are then collected following the ASTM D 1586 standard.
- The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven down using a weight ("hammer"). To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch-internal-diameter sampler may be required.

- Upon removal of the soil core from the ground, the soil core will be turned over to the project geologist and radiation technician for sample preparation, radiological surveys, and containerization. Once retrieved from the hole, the sampler is carefully split open to maintain the material in the sampler.

Soil tubes and cores will be processed within the background areas; however, because these surveys are performed in reference areas, all locations inside the reference area (not necessarily within the RBA) should be acceptable. One central processing area may be established for the entire investigation, or separate processing areas may be established for each RBA.

Once the soil tube has been cut open or the core has been split open, soil examination and sample collection will occur as follows:

- The geologist will log the soil boring to provide accurate and consistent descriptions of soil characteristics. Soil boring logs will be maintained according to the *Logging of Soil Borings* SOP, included in the Parcel G Work Plan. The geologist will subdivide the soil boring into the 1-foot increments corresponding to the vertical demarcation in the design. Based on observations of the lithologic characteristics, if there is a visible change in soil types in the vertical column, the geologist may modify the proposed depth increments so that a sample volume is representative of a single soil type. The geologist may also recommend that additional samples be collected to adequately represent the observed soil types.
- The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces and removing gravel. The depth, recovery position, and scan measurement information should be correlated to each sample extracted from the core.
- A minimum of 200 grams of soil (approximately 1 cup) are required to complete the analyses, or 400 grams if the sample is selected as a field duplicate. If sample size requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the original sample location within the core and compositing the sample.
- The entire mixed sample will be placed in the designated laboratory sample container and the range of soil depths included in the sample recorded in the field logbook.
- Samples will be identified, labeled, and cataloged according to **Section 3.2.67**, and then placed into the appropriate sample cooler (if required) for transport to the contract laboratory. Custody of the sample will be maintained according to the *Chain-of-Custody* SOP, included in the Parcel G Work Plan.
- When a field duplicate sample is required (1 for every 10 field samples collected), the sample will be evenly split following mixing of the material and removal of extraneous material, and each aliquot placed into an appropriately labeled sample container.
- Excess soil material will be returned to the hole from which it came or will be managed in accordance with Section 7 in the Parcel G Work Plan.
- When possible, disposable sampling equipment will be used because clean, unused materials do not affect sample results. If reusable sampling equipment is used, it will be cleaned between each sampling event as appropriate. Cleaning of sampling equipment will be conducted using SOP RP-112, *Decontamination of Personnel and Equipment*, included in the Parcel G Work Plan.
- If fluids are generated during cleaning of sampling equipment, the fluids will be containerized and sampled for offsite analysis to determine radionuclide concentrations prior to disposal. Other IDW, including used PPE, will be radiologically surveyed prior to disposal using SOP RP-105, *Unrestricted Release Requirements*, included in the Parcel G Work Plan.

- Depth intervals that are not identified as samples or sent for analysis will be returned to the borehole or spread on the ground adjacent to the borehole.
- Split samples will be available to USEPA and DTSC/CDPH to take for independent analysis either real-time during field activities, from the laboratory during analysis and storage, or after laboratory analysis from on-site storage.

3.2.6 Subsurface Soil Sampling Process at Offsite RBA

To minimize the impact of the characterization on the offsite RBA (RBA-McLaren), subsurface samples will be collected from the 1- to 2-foot bgs interval using hand tools. Prior to subsurface sampling, ensure that the necessary gamma scan measurements have been collected as described in **Section 3.2.3**, and reviewed and accepted as described in **Section 4.1**, and that the surface soil sample has been collected from the top 6 inches of soil. Subsurface soil samples will be collected in accordance with the *Soil Sampling* SOP, included in the Parcel G Work Plan. Generally, the subsurface soil sample will be collected as follows:

- A clean shovel, hand auger, or other tool will be used to remove a small area (about 3 inches in diameter) of soil to a depth of 1 foot bgs. The removed soil will be placed adjacent to the sample location.
- A clean shovel, hand auger, or other tool will be used to remove a small area (about 3 inches in diameter) of soil from the 1- to 2-foot bgs depth.
- The removed soil will be transferred directly into a clean stainless steel bowl for mixing.
- The soils removed from the sample location will be visually described in the field logbook in accordance with the *Preparing Field Log Books* SOP, included in the Parcel G Work Plan. Identify the sample as surface soil and include the approximate volume of the extracted soil. Color, moisture, texture, and clast composition (i.e., serpentine, shale, sandstone, chert, gabbro) will be identified.
- The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces and removing overburden gravel and biological material.
- A minimum of 200 grams of soil (approximately 1 cup) are required to complete the analyses, or 400 grams if the sample is selected as a field duplicate. If sample size requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the original sample location within the core and compositing the sample.
- The entire mixed sample, or aliquot thereof, will be placed in the designated laboratory sample container.
- When a field duplicate sample is required (1 for every 10 field samples collected), the duplicate sample will be collected following mixing of the material and splitting the aliquot into an additional sample container.
- Samples will be identified, labeled, and cataloged according to **Section 3.2.6**, and then placed into the appropriate sample cooler (if required) for transport to the contract laboratory. Custody of the sample will be maintained according to the *Chain-of-Custody* SOP, included in the Parcel G Work Plan.
- Excess soil material will be returned to the hole from which it came or will be spread adjacent to the sample location.
- When possible, disposable sampling equipment will be used because clean, unused materials do not affect sample results. If reusable sampling equipment is used, it will be cleaned between each

sampling event as appropriate. Cleaning of sampling equipment will be conducted using SOP RP-112, *Decontamination of Personnel and Equipment*, included in the Parcel G Work Plan.

- If fluids are generated during cleaning of sampling equipment, the fluids will be containerized and sampled for offsite analysis to determine radionuclide concentrations prior to disposal. Other IDW, including used PPE, will be radiologically surveyed prior to disposal using SOP RP-105, *Unrestricted Release Requirements*, included in the Parcel G Work Plan.
- Split samples will be available to USEPA and DTSC/CDPH to take for independent analysis either real-time during field activities, from the laboratory during analysis and storage, or after laboratory analysis from on-site storage.

3.2.7 Sample Identification

Each surface and subsurface sample will be uniquely identified at the time of collection by the geologist or radiation technician. Samples will be identified as explained in this section.

Sample identifications will use the following format:

AABBBB-CCDD-EEFF-MMY

- Where:
- AA = facility (HP for Hunters Point will be used in this work plan).
 - BBBB = site location (RBAs 1 through 4 = RBA1, RBA2, RBA3, RBA4; RBA-McLaren = RBAM).
 - CC = sample type (options include SS for surface sample or SB for subsurface sample).
 - DD = sample location number (within each RBA there will be 01 to 25 sample locations; duplicate locations will be assigned the letter “P” after this number [DDP]).
 - EEFF = two-digit sample interval in feet bgs (EE feet = top of sample interval and FF feet = bottom of sample interval). EE and FF are whole numbers such that a value of “01” represents “1-foot bgs.” Surface samples (samples collected from the 0.0- to 0.5-foot bgs depth interval) will be designated as 000H; H is for half foot. If the surface sample is collected from a depth other than a half foot, the H designation will still be used; however, a note will be included in the field book to indicate the actual depth sampled.
 - MMYY = two-digit month (MM) and two-digit year (YY) corresponding to the collection month and year. Example for a sample collected in June of 2018 is MMYY = 0618.

For example, a surface soil sample collected from RBA-1 at sample Location 1 in March 2018 will be identified as follows:

HPRBA1-SS01-000H-0318

In this example, “HPRBA1” identifies Hunters Point Reference Background Area 1. “SS01” identifies the sample as a surface sample collected at sample location 01. “000H” represents the depth interval for a surface sample (000H is the agreed-upon code established for surface samples as explained above).

For example, a subsurface sample collected from RBA-4 at sample Location 5 from the 9- to 10-foot bgs interval in April 2018 will be identified as follows:

HPRBA4-SB05-0910-0418

A duplicate sample collected from the sample location will be identified as follows²:

² For USEPA and DTSC/CDPH split samples, the sample location number “DD” will be given additional letters.

HPRBA4-SB05P-0910-0418

An example of a surface sample collected from RBA-McLaren at sample Location 12 in June 2018 will be identified as follows:

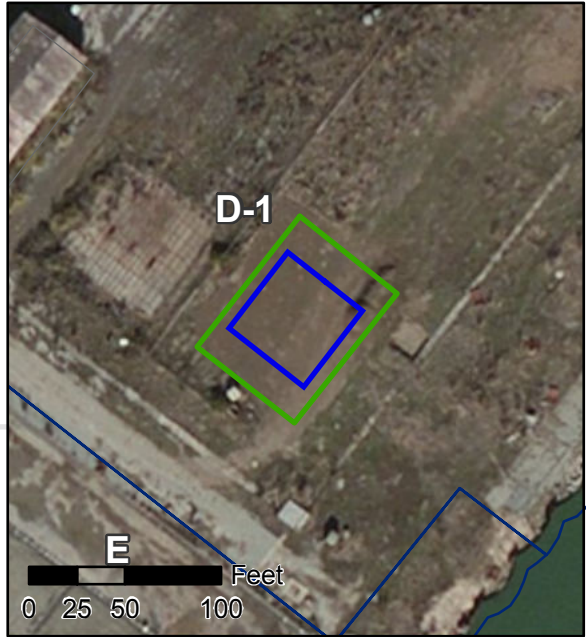
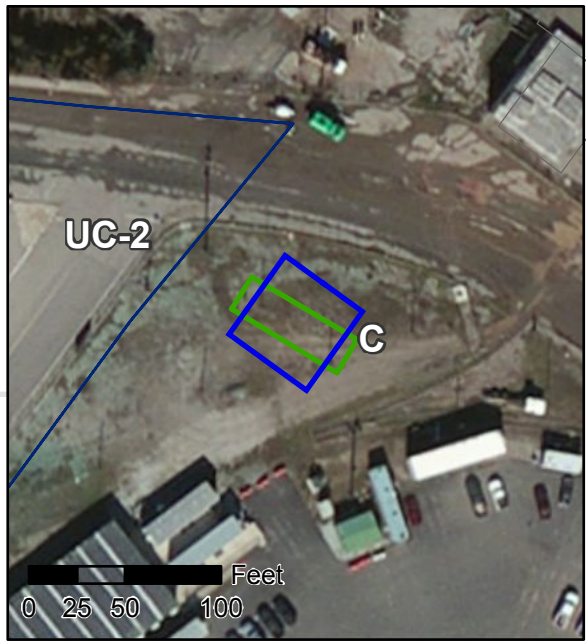
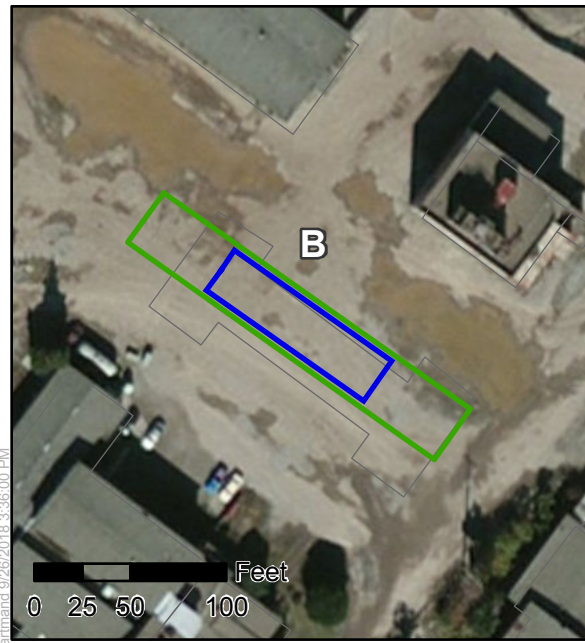
HPRBAM-SB12-000H-0618

3.2.8 Documentation and Sample Shipping

Samples will be documented in accordance with the general requirements in the *Preparing Field Log Books* and the *Chain-of-Custody* SOPs, included in the Parcel G Work Plan. These SOPs identify the requirements for sample labels, custody seals, and chains-of-custody. A digital sample documentation/tracking program may be used during the execution of the work plan to provide additional confidence in sample recordkeeping and to add efficiencies to the process.

Samples will be packaged and shipped for offsite analysis in accordance with the *Packaging and Shipping Procedures for Low-Concentration Samples* SOP, included in the Parcel G Work Plan.

Radiological surveys will be performed and documented in accordance with SOP RP-106, *Survey Documentation and Review*, included in the Parcel G Work Plan. Sample collection, field measurements, and laboratory data will be recorded electronically to the extent practicable. Electronically recorded data and information will be backed up to a SharePoint site or equivalent on a nightly basis, or as reasonably practical. Data and information recorded on paper will be recorded using indelible ink. Both electronic and paper records of field-generated data will be reviewed by the PRSO or a designee knowledgeable in the measurement method for completeness, consistency, and accuracy. Data manually transferred to paper from electronic data collection devices will be compared to the original data sets to ensure consistency and to resolve noted discrepancies. Electronic copies of original electronic data sets will be preserved on a nonmagnetic retrievable data storage device. No data reduction, filtering, or modification will be performed on the original electronic versions of data sets.



Legend:

- Reference Background Area
- Historical Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

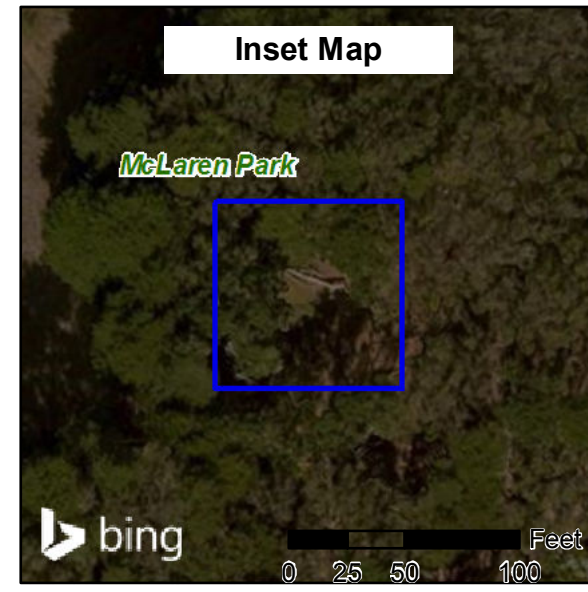
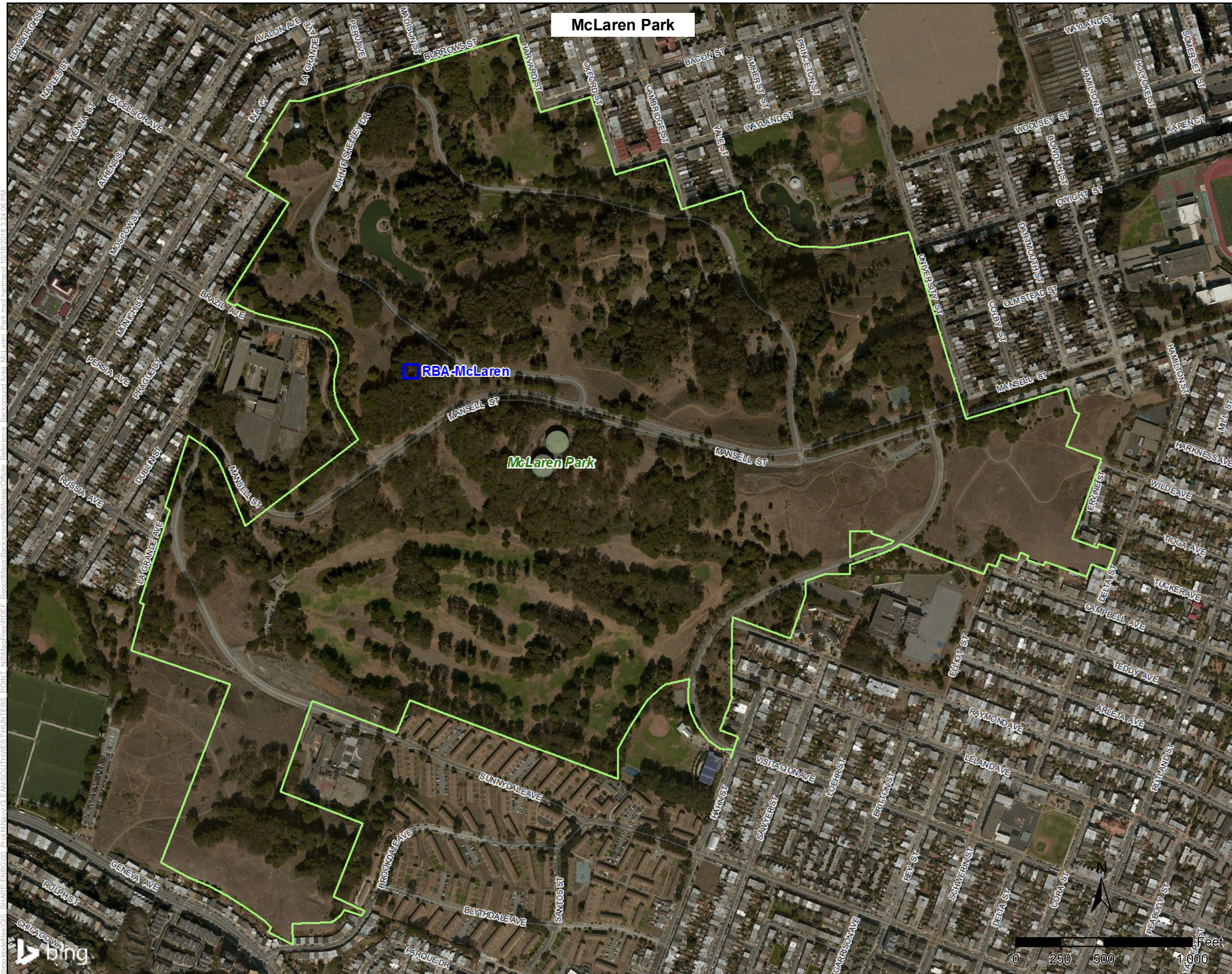


0 250 500 1,000 Feet

BASE MAP SOURCE:
 Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar
 Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the
 GIS User Community

**Figure 3-1
 HPNS Reference Background
 Areas**

Soil Reference Background Area Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



Legend:

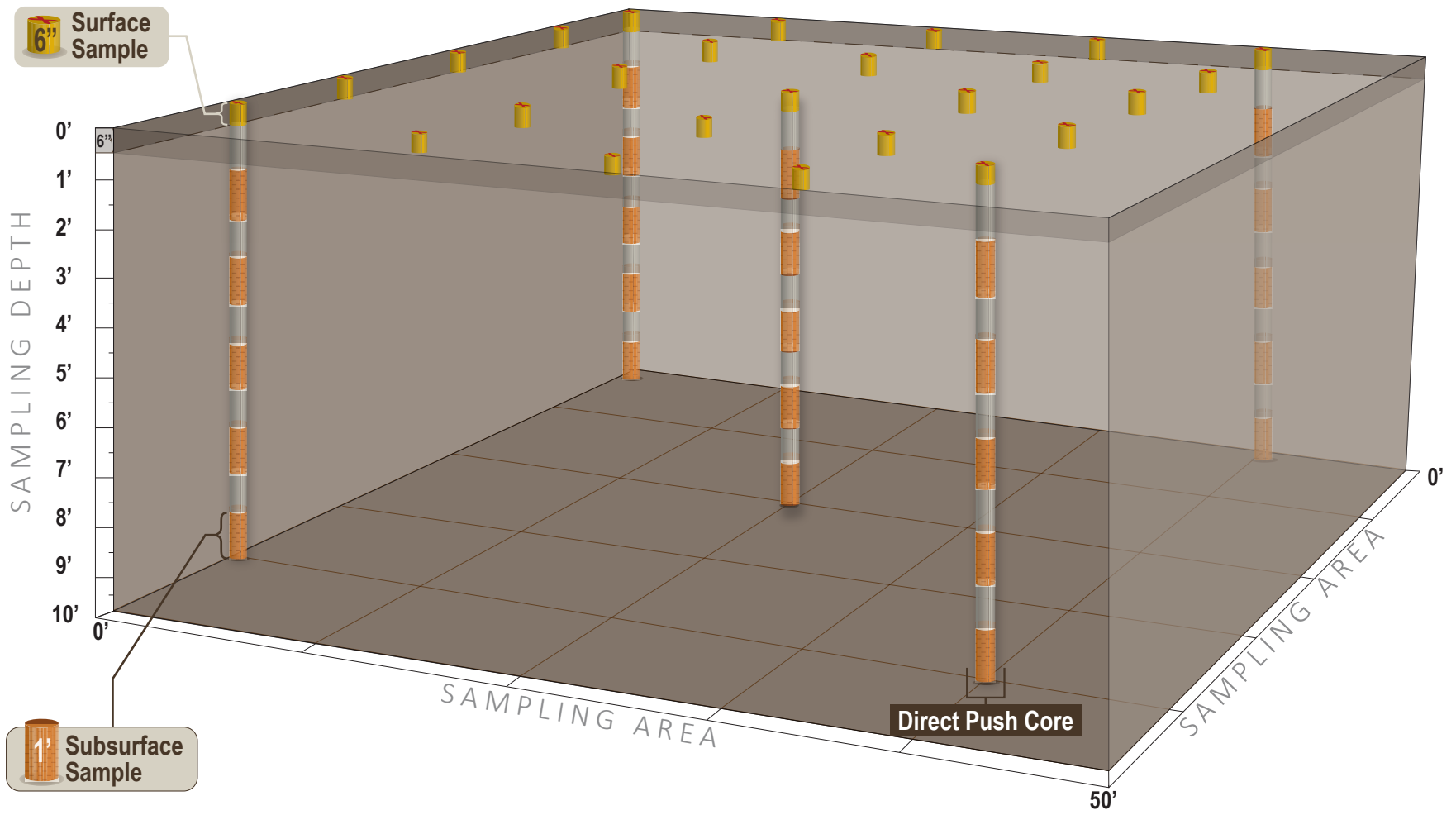
- Reference Background Area*
- Park
- Installation Boundary

*NOTE:
The exact location of the RBA within McLaren Park may be adjusted based on consultation with the City of San Francisco.

BASE MAP SOURCE:
Service Layer Credits: © 2018 Microsoft Corporation Earthstar Geographics SIO
© 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS
Park Lands layer developed by the San Francisco Recreation and Parks Department (2016).

Figure 3-2
Offsite Reference Background Area, McLaren Park
 Soil Reference Background Area Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

Onsite RBA



Offsite RBA

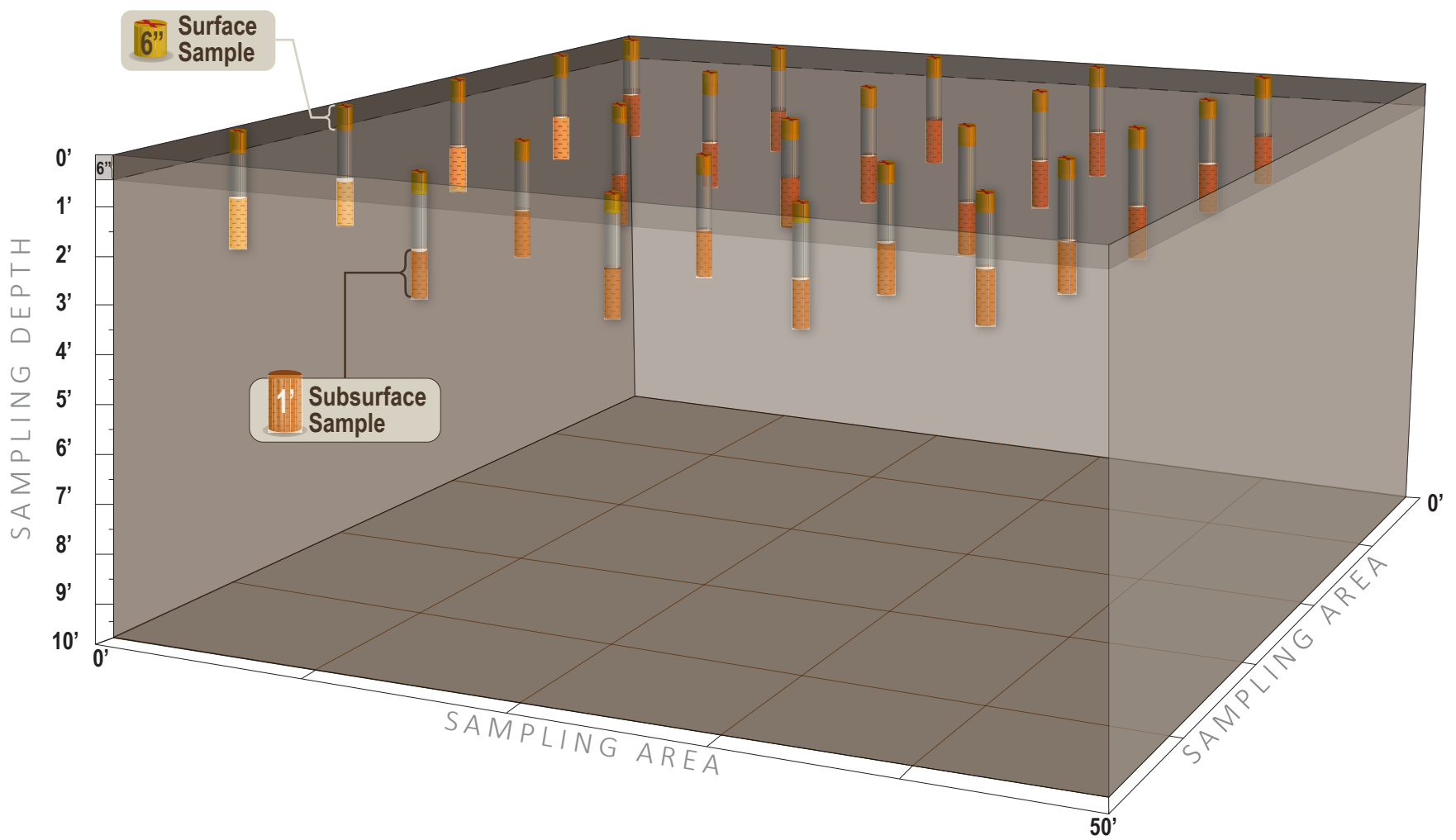


Figure 3-3
Example Surface and Subsurface Sample Locations
 Soil Reference Background Area Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, CA

\\broad\isid\files\GIS_SHARE\ENBG\00_Proj\N\Nav\Q_EAN\SOUTHWEST\HUNTERS_POINT_NS\MapFiles\IRDEF_Report\Maps\Background\Ref\Areas\Hunters_Point_Background_points.mxd hartmand 9/26/2018 4:01:50 PM



Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-4
HPNS Reference Background Area RBA-1
 Soil Reference Background Area Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-5
HPNS Reference Background Area RBA-2
Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-6
HPNS Reference Background Area RBA-3
 Soil Reference Background Area Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California



Legend:

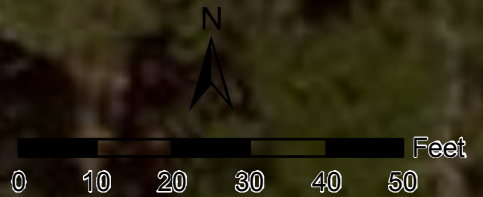
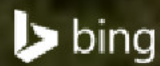
- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-7
HPNS Reference Background Area RBA-4
 Soil Reference Background Area Work Plan
 Former Hunters Point Naval Shipyard
 San Francisco, California

McLaren Park



OVERVIEW MAP



Legend:

- Surface and Subsurface Sample Location
- Reference Background Area*
- Park

* NOTE: The exact location of the RBA within McLaren Park may be adjusted based on consultation with the City of San Francisco.

COORDINATE SYSTEM: NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE: Service Layer Credits: © 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS

Park Lands layer developed by the San Francisco Recreation and Parks Department (2016).

**Figure 3-8
McLaren Park Reference Background Area
RBA-McLaren**

Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Data Evaluation and Reporting

Various types of radiological data are being collected from multiple RBAs during the execution of this work plan, from soils with potentially different distributions of naturally occurring and fallout radionuclides. Gamma scan data will be mapped and evaluated as detailed in **Section 4.1**. Analytical data (i.e., soil sample results) will be compiled and validated in accordance with the SAP. Following data validation, analytical sample results will be evaluated as detailed in **Section 4.2**. Once data is obtained and evaluated, the statistical data evaluation process will be presented to the regulatory agencies for concurrence. Following evaluation, the RBA characterization data will be compiled and submitted in a Soil RBA Report as detailed in **Section 4.4**.

4.1 Gamma Scan Data Evaluation

Gamma scan survey data from each RBA will be initially evaluated as individual RBA data sets for both gross gamma and gamma spectra. The purposes of the data evaluation are the following:

- Conduct a preliminary data review and compile basic statistics
- Perform graphical data review
- Identify outliers or data that are not representative of background conditions

4.1.1 Conduct a Preliminary Data Review

The spectra will be analyzed using regions of interest for known gamma-emitting ROCs and naturally occurring radionuclides. Radionuclide-specific (spectra) and gross gamma data set information will be gleaned by reviewing the distribution of the data; compiling basic statistics, including mean, median, minimum, maximum, and standard deviation; and creating plots such as histograms, box plots, and probability plots from each RBA.

Because position measurements were collected in conjunction with the radiological readings, gamma survey maps will be generated using the GPS locations to visually evaluate the geospatial measurements and to confirm the RBA classifications as being non-impacted and suitable for use as RBAs. The gamma survey map will be created as follows:

- Using GIS software, the gamma measurement will be spatially plotted using the GPS coordinates recorded during the scan survey.
- Measurements collected outside of the RBA footprints will be digitally cropped out of the survey maps so that only the designated RBAs will contain gamma measurements.
- Using contouring functions in GIS, a contiguous surface will be created and color-coded for visualization of the readings.

4.1.2 Identify Outliers

The gamma scan survey data will undergo an outlier evaluation using Dixon's and Rosner's outlier tests, supplemented by graphical plots. Dixon's test is valid for data sets with up to 25 data points while Rosner's test is recommended for larger data sets. Details of Dixon's and Rosner's tests for outliers are provided in **Section 4.2.2**. Both Dixon's and Rosner's tests assume that the data values (aside from those being tested as potential outliers) are normally distributed. Because environmental data tend to be right-skewed, a test that relies on an assumption of a normal distribution may identify a relatively large number of mathematical outliers. Outliers identified in this evaluation will be reviewed to determine that the outliers are attributable to elevated radioactivity or find out if any other causes (e.g., a potential

electronics error) exist. If elevated scan measurements are observed, follow-up investigations may be performed with static measurements to delineate and characterize potential areas of interest. Areas with elevated scan measurements that are attributed to contamination or discrete radiological objects will not be sampled, and alternate locations will be selected.

4.2 Analytical Data Evaluation

A statistical data evaluation will be conducted to identify appropriate soil background data sets and calculate descriptive statistics to facilitate future comparisons with site-specific data. The purposes of the data evaluation are the following:

- Conduct a preliminary data review, which includes the following tasks:
 - Compile basic statistics
 - Perform graphical data review
- Identify outliers or data that are not representative of background conditions.
- Conduct statistical tests, including determining statistical differences between data sets.
- Review equilibrium conditions of naturally occurring radionuclides.

4.2.1 Conduct a Preliminary Data Review

Analytical data set information will be reviewed by compiling basic statistics, including mean, median, minimum, maximum, and standard deviation. Graphical comparisons will be made using posting plots, histograms, box-and-whisker plots, quantile-quantile plots, and normal probability plots from each RBA. Review of the basic statistics and plots will provide useful information, such as revealing homogeneity or heterogeneities, spatial trends, data distributions, and skewness. RBA data from individual RBAs are assumed to follow a normal or log-normal distribution without bi-modalities or skewness. The results of the normality testing can be used to validate a data set as being consistent with assumptions concerning background.

4.2.2 Identify Outliers

Graphs of analytical data will be reviewed for indications of data values outside of the expected distribution (i.e., potential outliers). In addition, outlier evaluations will be performed using Dixon's and Rosner's tests or other appropriate tests, including non-parametric methods. Data review will be conducted initially using the current version of the USEPA's ProUCL tool, which uses Dixon's and Rosner's tests as well as box plots and quantile-quantile (Q-Q) plots to identify outliers. Tests for normality will be performed both prior to and following treatment for outliers. If data sets do not appear normally distributed following removal of outliers and more robust outlier detection methods beyond the scope of ProUCL are required, USEPA will be consulted. The following paragraphs provide additional details about the performance of Dixon's and Rosner's tests for outliers.

Dixon's test is valid for data sets with up to 25 data points while Rosner's test is recommended for larger data sets. Both Dixon's and Rosner's tests assume that the data values (aside from those being tested as potential outliers) are normally distributed. Both statistical outlier tests will be performed using statistical software or spreadsheets and are described here. The Dixon test will be performed by arranging the concentrations of a specific nuclide in ascending order from X_1 to X_N and using **Equation 4-1**:

Equation 4-1

$$Q_{exp} = \frac{X_2 - X_1}{X_N - X_1}$$

Where:

Q_{exp} = experimental Q-value

X_N = highest value of measurements

X_1 = value of smallest measurement

X_2 = value of second smallest measurement

The corresponding Q_{exp} value is compared to the critical value (Q_{crit}) obtained from a confidence level of 95 percent.

Because Dixon's test is appropriate for samples sizes with up to 25 data points, Rosner's test for outliers will be performed for sample sizes larger than 25. The Rosner's test is performed as follows:

- Arrange the concentrations of a specific nuclide in ascending order, and by simple inspection, identify the maximum number of possible outliers r_0 .
- Compute the mean and standard deviation of the data and determine the measurement furthest from the mean.
- Delete the measurement from the data set and compute the sample mean and standard deviation from the remaining observations. Again, find the value in the reduced data set furthest from the mean.
- Delete the measurement and recompute the mean and standard deviation until all potential outliers have been removed.
- Perform test for outliers, using **Equation 4-2**:

Equation 4-2

$$R_{r-1} = \frac{|y^{(r-1)} - \bar{x}^{(r-1)}|}{s^{(r-1)}}$$

Where:

R_{r-1} = test statistic for potential r outlier

$y_{(r-1)}$ = measurement value of outlier

$x_{(r-1)}$ = mean of reduced data set without $y_{(r-1)}$ value

$s_{(r-1)}$ = standard deviation of reduced data set with $y_{(r-1)}$ value

- Compare the test statistic (R_{r-1}) to the critical value corresponding to a confidence level of 95 percent.
- Perform the test statistic for the other possible outliers identified in Step 1 in the same fashion until the possible outliers have either been identified or Rosner's test finds no outliers.

Because environmental data tend to be right-skewed, a test that relies on an assumption of a normal distribution may identify a relatively large number of mathematical outliers. Outliers identified in this evaluation will be reviewed to determine whether any suitable reasons (e.g., a potential analytical error) exist to exclude them from further calculations. Confirmed outliers will be removed from individual data sets.

4.2.3 Conduct Statistical Tests

Background concentrations from each RBA for surface soil and subsurface soil will be compared statistically to test for differences between surface soil and subsurface soil concentrations and to test

for differences among soil types. If the data sets are not significantly different, then they will be combined to create a larger background data set. If the data sets are significantly different, then they will be treated separately for comparisons of site-specific data to background.

In addition to graphical inspection, central tendency comparisons will be performed to determine whether the centers of the distributions of the surface soil and subsurface soil data, and between the various soil types, are different or similar. Statistical tests for a normal distribution (symmetry) will be performed using computer software to conduct the Shapiro-Wilk/Lillifors testing for normality.

The RBA data sets will be compared to each other by applying the KW statistical test, detailed in Section 13.2 of NUREG-1505 (NRC, 1998a) to determine whether the reference areas have similar or significantly different background levels. If data sets are similar (i.e., pass the KW test), they may be combined. If data sets are significantly different (i.e., fail the KW test), further evaluation will be performed to determine the potential causes of the differences, such as soil type or depth bgs. Data may be plotted on site maps or plotted against gamma-scan data to look for visual clues as to ROC distribution and to evaluate spatial independence.

4.2.4 Review Equilibrium Conditions

The RBA data sets for ^{226}Ra and other naturally occurring ROCs will be selected to represent as much of the soil at HPNS as practical. However, the history of HPNS shows that a wide variety of fill materials have been used as part of construction and maintenance activities over the life of the site. These fill materials may have a wide range of naturally occurring radioactivity and could result in an incorrect identification of fill material with higher levels of NORM being identified as contamination. To avoid this situation, the Navy may perform additional evaluation of investigation samples where the ^{226}Ra gamma spectroscopy result exceeds the RG and the expected range of background but could still be associated with NORM instead of contamination.

The uranium natural decay series is one of the primordial natural decay series that are collectively referred to as NORM. The members of the uranium natural decay series are present in background at concentrations that are approximately equal, a situation referred to as secular equilibrium. Secular equilibrium for the uranium natural decay series is established over hundreds of thousands of years. Concentrations of ^{226}Ra higher than the concentrations of other members of the uranium natural decay series may indicate contamination, while ^{226}Ra concentrations consistent with other members of the series indicate natural background.

Determining the equilibrium status of the uranium natural decay series requires analyzing a sample for multiple radionuclides from the series using the same or comparable analytical techniques. Observed differences in concentrations result primarily from differences in concentrations, and the uncertainty is primarily associated with the analysis.

Radionuclides from the uranium natural decay series with ^{226}Ra as a decay product (i.e., ^{238}U , ^{234}U , and ^{230}Th) will be analyzed by alpha spectroscopy, along with ^{226}Ra . It is not necessary to analyze for the decay products of ^{226}Ra because these radionuclides re-establish secular equilibrium with ^{226}Ra over a period of several weeks. In addition, most of the ^{226}Ra decay products are not readily analyzed by alpha spectroscopy.

Alpha spectroscopy will be performed for uranium isotopes (^{238}U , ^{235}U , ^{234}U), thorium isotopes (^{232}Th , ^{230}Th , and ^{228}Th), and ^{226}Ra . If practical, the analyses will be performed using the same sample aliquot to reduce sampling uncertainty. The results of the four analyses will be compared, and the ratio between the ^{226}Ra and the other three radionuclides will be calculated to evaluate whether the radionuclides are in secular equilibrium.

4.2.5 Establish Background Data Sets

Once a determination has been made about combining data from the RBAs, one or more RBA data sets for each radionuclide will be established. Pending approval for their use, the data sets will be used for comparison with trench or surface soil data sets as described in the Parcel G Work Plan.

While the focus of the analytical evaluation will be on radioactivity, the evaluations may also identify and record relationships and correlations between lithologic characteristics of the samples and the radioactivity.

4.3 Review of Other RBA Data Sources

The history of HPNS shows that a wide variety of fill materials have been used as part of construction and maintenance activities over the life of the site. These fill materials may have a wide range of naturally occurring radioactivity. In order to gain a more comprehensive understanding of background conditions, previous offsite background studies that have been performed in and around the Bay Area over the past 20 years will be evaluated. Studies performed by the U.S. Geological Survey (USGS) (Bouse et al., 2010; Fuller et al., 1998; Nilsen et al., 2015; Higgins et al., 2007), Navy, and Lawrence Berkeley National Lab, among others, will be evaluated to determine whether the data may be comparable or representative of materials at HPNS. Review of the available information from the offsite studies will include analytical results of ROCs and NORM constituents, analytical methods, soil lithology, and geographic latitude.

4.4 Reporting

Following completion of RBA soil data evaluation, a report will be prepared to include a summary of the field activities, any deviations from the work plan, results of gamma scan surveys, and analytical and geotechnical data (including full data packages from the analytical laboratory and third-party validation reports), along with the results of the data evaluation. Based on the statistical evaluations, the report will include recommendations for combining similar data sets, and recommendations for selecting values or data sets representing background in soil, and conditions identifying situations when specific values or data sets may not be appropriate. Information from other San Francisco Bay Area radiological background studies may be referenced in the report as appropriate. If additional areas are selected for sampling, if other background data sets are identified, or if USGS is involved and provides input, details and justification will be provided in the report. The draft report will be submitted for regulatory review, and meetings will be held to discuss the results and facilitate consensus on appropriate background values prior to finalizing the report.

Radioactive Materials Management and Control

This work plan was prepared based on CH2M HILL, Inc. (CH2M) and its subcontractor, Perma-Fix, leading and conducting the field activities presented in this work plan. Prior to initiating field activities at HPNS, Perma-Fix will invoke their Radioactive Material License, as described in the Parcel G Work Plan. The Parcel G Work Plan includes the following contractor-specific information: Radioactive Material License, SOPs, Organizational Chart, and Radiation Protection Plan. The APP/SSHP outlines the health and safety requirements and procedures for the field activities included in this work plan.

References

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- Nuclear Regulatory Commission (NRC). 1998b. *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*. NUREG-1507. Washington, D.C. June.
- United States Environmental Protection Agency (USEPA), Department of Energy, Nuclear Regulatory Commission, and Department of Defense. 2000. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*. NUREG-1575, Rev. 1. EPA 402-R-97-016, Rev. 1. DOE/EH-0624, Rev. 1. August.

Appendix D
Contractor-specific Radioactive
Material License, Standard Operating
Procedures, Organizational Chart, and
Radiation Protection Plan

RADIOACTIVE MATERIAL LICENSE

Pursuant to the California Code of Regulations, Division 1, Title 17, Chapter 5, Subchapter 4, Group 2, Licensing of Radioactive Material, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, use, possess, transfer, or dispose of radioactive material listed below; and to use such radioactive material for the purpose(s) and at the place(s) designated below. This license is subject to all applicable rules, regulations, and orders of the California Department of Public Health now or hereafter in effect and to any standard or specific condition specified in this license.

<p>1. Licensee: Perma-Fix Environmental Services, Inc</p> <p>2. Address: 1093 Commerce Park Drive, Suite 300 Oak Ridge, TN 37830</p> <p>Attention: Samuel Eric Miller, CHP Radiation Safety Officer</p>	<p>3. License Number: 8188-07 Amendment Number: 2</p> <p>4. Expiration date: June 6, 2027 (3)</p> <p>5. Inspection agency: Radiologic Health Branch North</p>
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In response to the letter dated March 7, 2018, signed by Samuel Eric Miller, Corporate Radiation Safety Officer, License Number 8188-07 is hereby amended as follows:

6. Nuclide	7. Form	8. Possession limit
A. Any byproduct material with atomic numbers 1 through 83	A. Any	A. Total not to exceed 18.5 gigabecquerels (500 millicuries).
B. Any byproduct material with atomic numbers 84 through 103	B. Any	B. Total not to exceed 37 megabecquerels (1 millicurie)
C. Radium-226	C. Any	C. Total not to exceed 18.5 gigabecquerels (500 millicuries).
D. Any Source Material	D. Any	D. Not to exceed 200 kilograms (441 pounds).
E. Any Special Nuclear Material	E. Any	E. Total not to exceed 2 grams, Plutonium-238 not to exceed 0.9 grams.

9. Authorized Use

- A. - E. To be used for site characterization, decontamination, decommissioning, final status survey, packaging waste for transport, preparation and analysis of samples from various media as a customer service, and incidental to use for operational testing of radiation detection instruments.

LICENSE CONDITIONS

10. Radioactive material shall be used only at the following locations:

- (a) Temporary job sites of the licensee in areas not under exclusive (see Condition 21) federal jurisdiction throughout the State of California.

11. This license is subject to an annual fee for sources of radioactive material authorized to be possessed at any one time as specified in Items 6, 7, 8 and 9 of this license. The annual fee for this license is required by and computed in accordance with Title 17, California Code of Regulations, Sections 30230-30232 and is also subject to an annual cost-of-living adjustment pursuant to Section 100425 of the California Health and Safety Code.

RADIOACTIVE MATERIAL LICENSELicense Number: 8188-07Amendment Number: 2

12. Radioactive material shall be used by, or under the supervision of, the following individuals:

- | | |
|-----------------------------|--------------------------|
| (a) Jason Hubler | (h) Steve Green, CHP |
| (b) Andrew J. Lombardo, CHP | (i) Darin McEleney |
| (c) Samuel Eric Miller, CHP | (j) Andrew Williams |
| (d) Scott Walnicki | (k) Alejandro Lopez, CHP |
| (e) Jeffery L. Knight | (l) Javid Kelley, CHP |
| (f) Eric J. Laning | |
| (g) Brian Miller | |

13. Except as specifically provided otherwise by this license, the licensee shall possess and use radioactive material described in Items 6, 7, 8 and 9 of this license in accordance with the statements, representations, and procedures contained in the documents listed below. The Department's regulations shall govern unless the statements, representations, and procedures in the licensee's application and correspondence are more restrictive than the regulations.

- (a) The application dated December 16, 2016, with attachments, signed by Samuel Eric Miller, Radiation Safety Officer and attached Delegation of Authority form, dated December 16, 2016, signed by Andrew J. Lombardo, Senior Vice President and as revised by the letters dated March 14, 2017, and April 7, 2017, both with attachments, and both signed by Samuel Eric Miller, Radiation Safety Officer.

14. (a) The Radiation Safety Officer in this program shall be Samuel Eric Miller, CHP.

15. Except for calibration sources, reference standards, and radioactively contaminated equipment owned by the licensee, possession of licensed material at each temporary job site shall be limited to material originating from each site. This material must either be transferred to an authorized recipient or remain at the site after licensee activities are completed.

16. (a) At least 14 days before initiating activities at a temporary job site, including military or former military sites where the temporary job site is not under exclusive federal jurisdiction, the licensee shall notify, in writing, the California Department of Public Health, Radiologic Health Branch. The notification shall include the following information:

- i. Site-specific radiological procedures if they have not been previously approved by the Department of Public Health.
- ii. Estimated type, quantity, and physical/chemical forms of radioactive material.
- iii. Specification of the site location.
- iv. Description of project activities that are planned for the site, including management and disposition of radioactive material.
- v. Estimated project start date and duration of project.
- vi. Name, address, title, and phone number of a point of contact for the person managing radiological operations at the temporary job site.

(b) Within 30 days of completing activities at each job site, the licensee shall notify, in writing, the California Department of Public Health, Radiologic Health Branch, regarding the radiological status of the temporary job site and the disposition of any licensed radioactive material.

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17. This license does not authorize the use of licensed material at temporary job sites for uses already specifically authorized by a customer's license. If a customer also holds a license issued by the NRC or an Agreement State, the licensee shall establish a written agreement between the licensee and the customer specifying which licensee activities shall be performed under the customer's license and supervision, and which licensee activities shall be performed under the licensee's supervision pursuant to this license. The agreement shall include a commitment by the licensee and the customer to ensure safety, and any commitments by the licensee to help the customer clean up the temporary job site if there is an accident. A copy of this agreement shall be included in the notification required by License Condition 16.
18. The licensee shall maintain records of information important to decommissioning each temporary job site at the applicable job site pursuant to Title 17, California Code of Regulations, Section 30256. The records shall be made available to the Department for inspection and to the customer upon request during decommissioning activities, and shall be transferred to the customer for retention at the completion of activities at a temporary job site.
19. The licensee shall comply with all requirements of Title 17, California Code of Regulations, Section 30373 when transporting or delivering radioactive materials to a carrier for shipment. These requirements include; packaging, marking, labeling, loading, storage, placarding, monitoring, and accident reporting. Shipping papers shall be maintained for inspection pursuant to the U.S. Department of Transportation requirements (Title 49, Code of Federal Regulations, Part 172, Sections 172.200 through 172.204).
20. The total mass of special nuclear material possessed under this license at any one time or at any one authorized location of use shall not exceed that stated in the following formula: The number of grams of Uranium 235 divided by 350, plus the number of grams of Uranium 233 divided by 200, plus the number of grams of Plutonium (all isotopes) divided by 200, shall not exceed one (i.e. unity).
21. Before radioactive materials may be used at a temporary job site at any federal facility, the jurisdictional status of the job site must be determined. If the jurisdictional status is unknown, the federal agency should be contacted to determine if the job site is under exclusive federal jurisdiction. A response shall be obtained in writing or a record made of the name and title of the person at the federal agency who provided the determination and the date that it was provided. Authorization for use of radioactive materials at the job sites under exclusive federal jurisdiction shall be obtained either by:
 - (a) Filing an NRC Form-241 in accordance with the Code of Federal Regulations, Title 10, Part 150.20 (b), "Recognition of Agreement State Licenses", or
 - (b) By applying for a specific NRC license.Before radioactive material can be used at a temporary job site in another State, authorization shall be obtained from the State if it is an Agreement State, or from the NRC for any non-Agreement State, either by filing for reciprocity or applying for a specific license.
22. In accordance with the California Code of Regulations Title 17, Section 30195.1, the licensee shall maintain an acceptable financial instrument in the amount of \$52,000.00 that satisfies the requirements outlined in the decommissioning funding plan dated December 16, 2016.

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23. The licensee will provide the Low Level Radioactive Waste (LLRW) reports specified in the California Health and Safety Code section 115000.1(h) to the California Department of Public Health (CDPH) on an annual basis for both shipped and stored LLRW. Alternatively, LLRW shipment information may be provided on a per shipment basis. LLRW shipment information and annual reports shall be mailed to:

Attn: LLRW Tracking Program
California Department of Public Health
Radiologic Health Branch, MS 7610
P.O. Box 997414
Sacramento, CA 95899-7414

24. At least 30 days prior to vacating any address of use listed in Condition 10 of this license, the licensee shall provide written notification of intent to vacate to the California Department of Public Health, in accordance with Title 17, California Code of Regulations, Section 30256 (b). Control of all licensed areas must be maintained until such areas are released by the Department for unrestricted use or the license is terminated, in accordance with Title 17, California Code of Regulations, Section 30256 (j).

25. A copy of this license and a copy of all records and documents pertaining to this license shall be maintained available for inspection at **4585 Pacheco Blvd., Suite 200, Martinez, CA 94553.**

26. If approved by the Radiation Safety Officer specifically identified in this license, the licensee may take reasonable action in an emergency that departs from conditions in this license when action is immediately needed to protect public health and safety and no action consistent with all license conditions that can provide adequate or equivalent protection is immediately apparent. The licensee shall notify the CDPH-RHB before, if practicable, and in any case, immediately after taking such emergency action using reporting procedure specified in 10CFR30.50(c).

Issued for the State of California Department of Public Health

Date: March 20, 2018

By: _____



Ronald Rogus
Senior Health Physicist
Radiologic Health Branch
MS 7610, P.O. Box 997414
Sacramento, CA 95899-7414

Application and Description of Standard Operating Procedures

SOP Number	SOP Title	Application and Purpose
CH2M Document	Soil Sampling	Provides guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig-mounted equipment.
CH2M Document	Logging of Soil Borings	Provides guidance for obtaining accurate and consistent descriptions of soil characteristics during soil sampling operations.
CH2M Document	Decontamination of Equipment and Samples	Provides general guidelines for the decontamination of sampling equipment, and monitoring equipment used in potentially contaminated environments.
CH2M Document	Preparing Field Logbooks	Provides general guidelines for entering field data into logbooks during site investigation and remediation activities.
CH2M Document	Chain-of-Custody	Provides information on chain-of-custody procedures.
CH2M Document	Packaging and Shipping Procedures for Low-concentration Samples	Provides information on preparing, packaging, and shipping low activity radioactive samples for analysis.
RP-100	Radiation Protection Program	Describes the major elements of the Radiation Protection Program.
RP-102	Radiological Posting	Identifies the types of postings necessary and requirements to clearly identify radiological conditions in a specific area or location within an area for consistent posting and control of RCAs. It also specifies the requirements for access into and egress from RCAs.
RP-103	Radiation Work Permits Preparation and Use	Provides direction on the requirements of the application, preparation, approval, issuance, and use of general and specific Radiation Work Permits.
RP-104	Radiological Surveys	Specifies methods and requirements for radiological surveys, and the documentation required for the acquired survey data.
RP-105	Unrestricted Release Requirements	Describes the method of surveying equipment, materials, or vehicles for release for unrestricted use.
RP-106	Survey Documentation and Review	Provides the methodology for documenting radiological surveys and provides criteria for the review of these surveys.
RP-107	Measurement of Airborne Radioactivity	Provides the basis and methodology for the placement and use of air monitoring equipment, as well as the collection, analysis, and documentation of air samples.
RP-108	Count Rate Instruments	Provides the methods for setup, daily pre-operational check, and operation of portable count-rate survey instruments.
RP-109	Dose Rate Instruments	Provides the methods for performing source checks and operating portable gamma scintillation dose rate instruments, specifically, the Ludlum Model 12s uR and the Bicorn Model Micro Rem.
RP-111	Radioactive Materials Control and Waste Management Plan	Provides guidance and requirements for the control of radioactive materials, including the management of radioactive waste.
RP-112	Dosimetry Issue	Provides consistent methodology for the issuance of radiation monitoring dosimetry devices.

Application and Description of Standard Operating Procedures

SOP Number	SOP Title	Application and Purpose
RP-114	Control of Radiation Protection Records	Describes the requirements for controlling Radiation Protection Program records. It also establishes the requirements for review and temporary storage of these records.
RP-115	Radiation Worker Training	Provides consistent methodology for implementing Radiation Worker Training.
RP-130	Event Reporting and Notification for State of California	Provides a list of California regulatory contacts, a checklist for initiating emergency notifications, and general guidance for notification of incidents.
RP-132	Radiological Protective Clothing Selection, Monitoring, and Decontamination	Provides the guidance for selecting protective clothing, performing personnel surveys, and decontaminating personnel.

Note:

RCA = radiologically controlled area

Soil Sampling

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoop, coring device, hand auger, or other appropriate hand tool
- Split-spoon samplers
- Thin-walled sampling tubes
- Drilling rig or soil-coring rig
- Stainless-steel pan/bowl or disposable sealable bags
- Sample bottles

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP Decontamination of Drilling Rigs and Equipment. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. A decontaminated sampling tool will be used to collect the sample when the desired sampling depth has been reached. Soil for semivolatile organic and inorganic analyses is placed in the bowl and mixed; soil for volatile organic analysis is not mixed or composited but is placed directly into the appropriate sample bottles. A stainless-steel trowel or disposable plastic scoop is used to transfer the sample from the bowl to the container.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

More details are provided in the SOP Shallow Soil Sampling.

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight (“hammer”) dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless-steel tray or disposable sealable bag. The sample for semivolatile organic and inorganic analyses should be homogenized in the field by breaking the sample into small pieces and removing gravel. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

C. Thin-Walled Tube Sampling

Undisturbed fine grained samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) according to ASTM D 1587 (attached). Tubes will be 24- to 36 inches long and 3- to 4-inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends will be sealed with bees wax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample. Samples for geochemical analysis normally are not collected from thin-walled tube samples.

IV. Attachments

ASTM D 1586 Standard Penetration Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586.pdf)

ASTM D 1587 Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587.pdf)

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.



Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils¹

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in

parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,² NDA Drilling Safety Guide,³ drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 ASTM Standards:⁴

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
- D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
- D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- D 2488 Practice for Description and Identification of Soils

² Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, <http://www.osha.gov>.

³ Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, <http://www.nda4u.com>.

⁴ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

¹ This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

*A Summary of Changes section appears at the end of this standard.

(Visual-Manual Procedure)

- D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
- D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 4633 Test Method for Energy Measurement for Dynamic Penetrometers
- D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
- D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
- D 6026 Practice for Using Significant Digits in Geotechnical Data
- D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential
- D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
- D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
- D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N-value*, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m \pm 0.030 m) for each hammer blow.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N-value*, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N-value* should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

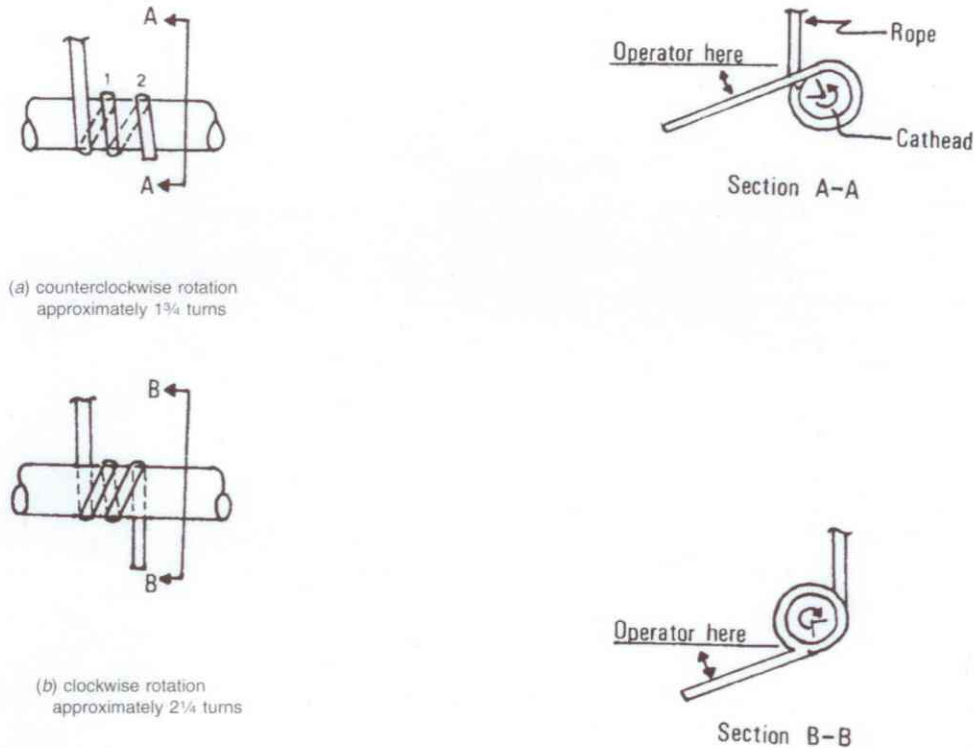


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

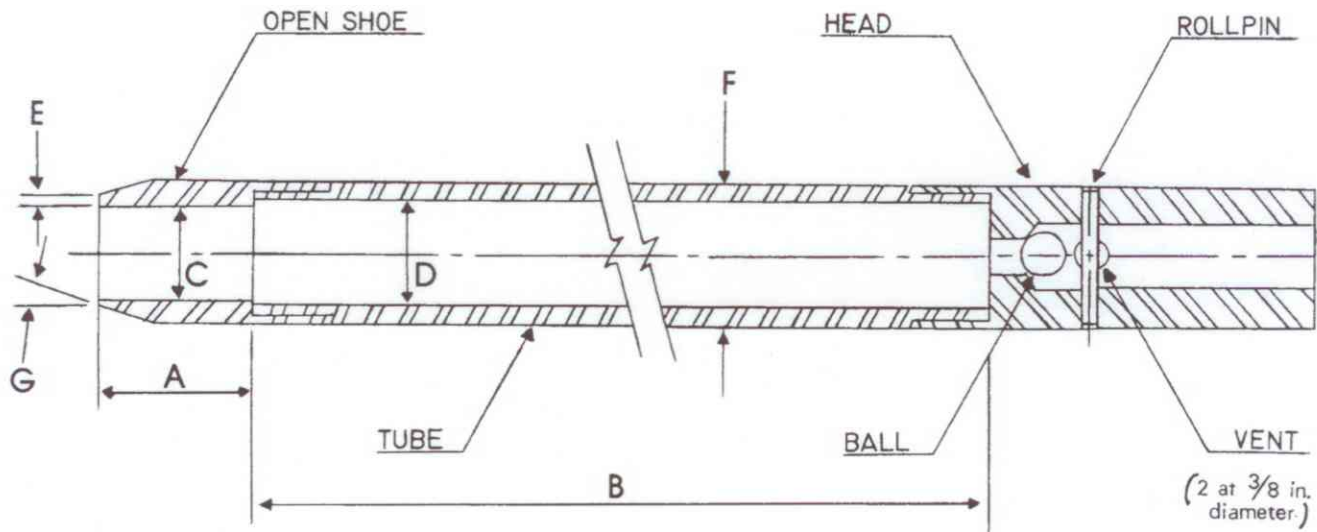
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall “A” rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm)).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



- A = 1.0 to 2.0 in. (25 to 50 mm)
- B = 18.0 to 30.0 in. (0.457 to 0.762 m)
- C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
- D = 1.50 ± 0.05 - 0.00 in. (38.1 ± 1.3 - 0.0 mm)
- E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
- F = 2.00 ± 0.05 - 0.00 in. (50.8 ± 1.3 - 0.0 mm)
- G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1/8-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1/2-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1/2 in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 Drive-Weight Assembly:

5.4.1 Hammer and Anvil—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbf (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 Hammer Drop System—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 Accessory Equipment—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

- 6.2.1 Open-hole rotary drilling method.
- 6.2.2 Continuous flight hollow-stem auger method.
- 6.2.3 Wash boring method.
- 6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

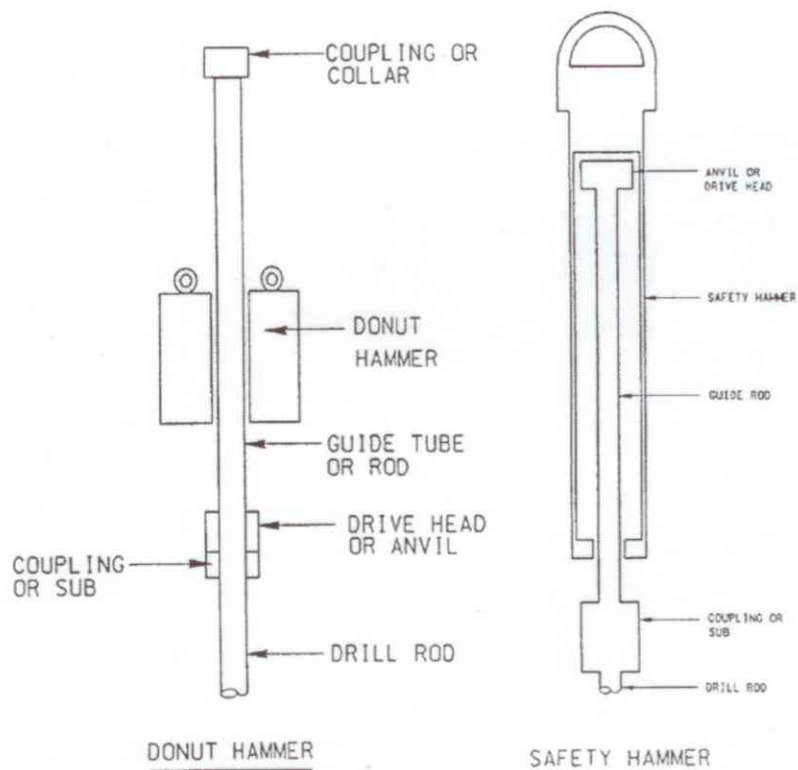


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare

the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

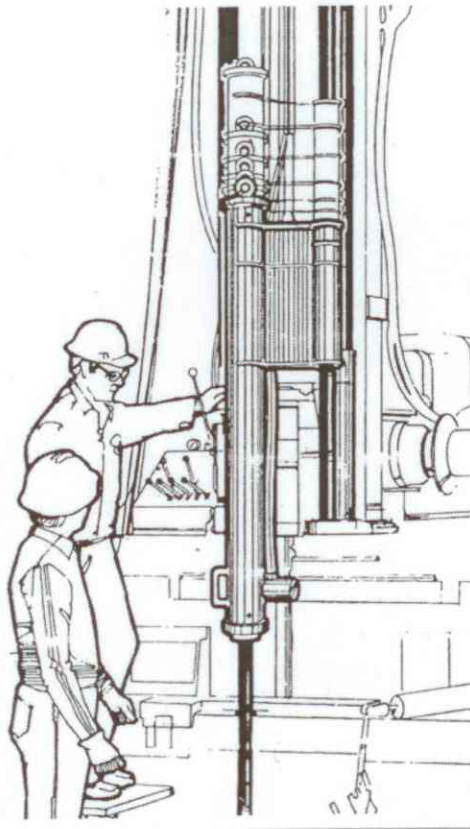


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (N) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the " N -value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) with limited unimpedance. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the N -value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

heights and Practice D 6066 provides information on adjustment of N -value to a constant energy level (60 % of theoretical, N_{60}). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

- 8.2.1 Name and location of job,
- 8.2.2 Names of crew,
- 8.2.3 Type and make of drilling machine,
- 8.2.4 Weather conditions,
- 8.2.5 Date and time of start and finish of borehole,
- 8.2.6 Boring number and location (station and coordinates, if available and applicable),
- 8.2.7 Surface elevation, if available,
- 8.2.8 Method of advancing and cleaning the borehole,
- 8.2.9 Method of keeping borehole open,
- 8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,
- 8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),
- 8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in N -values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, N -values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in N -values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

- (1) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
- (2) Scope was completely revised.
- (3) Referenced Documents updated to include new standards.
- (4) Terminology: added section on Definitions.
- (5) Significance and Use: clarified use of the SPT test.
- (6) Apparatus: general editorial changes.
- (7) Sampling and Testing Procedure: general editorial changes.
- (8) Data Sheets/Forms: general editorial changes.
- (9) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

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Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes¹

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

^{ε1} NOTE—Editorial changes were made in June 2007.

1. Scope*

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.

NOTE 1—This practice does not apply to liners used within the samplers.

1.2 This Practice is limited to soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing gravel or larger size soil particles cemented or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (D 1586, D 3550, and D 6151). For information on appropriate use of other soil samplers refer to D 6169.

1.3 This practice is often used in conjunction with fluid rotary drilling (D 1452, D 5783) or hollow-stem augers (D 6151). Subsurface geotechnical explorations should be reported in accordance with practice (D 5434). This practice discusses some aspects of sample preservation after the sampling event. For information on preservation and transportation process of soil samples, consult Practice D 4220. This practice does not address environmental sampling; consult D 6169 and D 6232 for information on sampling for environmental investigations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information purposes only. The tubing tolerances presented in Table 1 are from sources available in North

America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 ASTM Standards:²

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 1452 Practice for Soil Investigation and Sampling by Auger Borings
- D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
- D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
- D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock

¹ This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved May 1, 2007. Published July 2007. Originally approved in 1958. Last previous edition approved in 2003 as D 1587 – 03.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard.

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TABLE 1 Dimensional Tolerances for Thin-Walled Tubes

Size Outside Diameter	Nominal Tube Diameters from Table 2 ^A Tolerances					
	2 in.	50.8 mm	3 in.	76.2 mm	5 in.	127 mm
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	± 0.007	± 0.179	± 0.010	± 0.254	± 0.015	± 0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

^A Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i , or D_o and Wall thickness, or D_i and Wall thickness.

- as Used in Engineering Design and Construction
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
- D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
- D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
- D 6232 Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities

3. Terminology

3.1 Definitions:

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *inside clearance ratio*, %, n —the ratio of the difference in the inside diameter of the tube, D_i , minus the inside diameter of the cutting edge, D_e , to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.2 *ovality*, n —the cross section of the tube that deviates from a perfect circle.

4. Summary of Practice

4.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

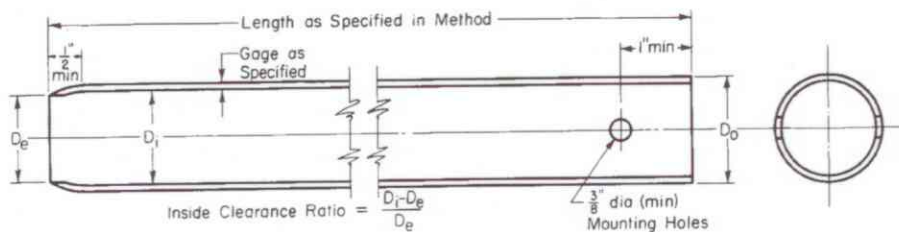
5. Significance and Use

5.1 This practice, or Practice D 3550 with thin wall shoe, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably



NOTE 1—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).

NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.

NOTE 3—Tube held with hardened screws or other suitable means.

NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for “undisturbed samples.” Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalent Conversions

in.	mm
3/8	9.53
1/2	12.7
1	25.4
2	50.8
3	76.2
4	101.6
5	127

FIG. 1 Thin-Walled Tube for Sampling

TABLE 2 Suitable Thin-Walled Steel Sample Tubes^A

Outside diameter (D_o):			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Inside clearance ratio, %			
	<1	<1	<1

^A The three diameters recommended in Table 2 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

6.3 *Thin-Walled Tubes*, should be manufactured to the dimensions as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having adequate strength for the type of soil to be sampled. Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here.

6.3.1 *Length of Tubes*—See Table 2 and 7.4.1.

6.3.2 *Tolerances*, shall be within the limits shown in Table 1.

6.3.3 *Inside Clearance Ratio*, should be not greater than 1 % unless specified otherwise for the type of soil to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled, except for sensitive soils or where local experience indicates otherwise. See 3.2.1 and Fig. 1 for definition of inside clearance ratio.

6.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is to be extruded less than 3 days. The type of coating to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. Galvanized tubes are often used when long term storage is required. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, zinc oxide, and others.

NOTE 3—Most coating materials are not resistant to scratching by soils that contain sands. Consideration should be given for prompt testing of the sample because chemical reactions between the metal and the soil sample can occur with time.

6.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube,

comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable check valve with the venting area to the outside equal to or greater than the area through the check valve. In some special cases, a check valve may not be required but venting is required to avoid sample compression. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 4—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1-ft (.03 m)

7.3.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.4 Advance the sampler without rotation by a continuous relatively rapid downward motion and record length of advancement to the nearest 1 in. (25 mm).

7.4.1 Determine the length of advance by the resistance and condition of the soil formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3-in. (75 mm) for sludge and end cuttings.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 2.

7.5 When the soil formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. The tube can be slowly rotated to shear the material at the end of the tube, and to relieve water and/or suction pressures and improve recovery. Where the soil formation is soft, a delay before withdraw of the sampler (typically 5 to 30 minutes) may improve sample recovery.

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube and measure the length of the soil

sample recovered to the nearest 0.25 in. (5 mm) in the tube. Seal the upper end of the tube. Remove at least 1 in. (25 mm) of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

8.1.1 Tubes sealed over the ends, as opposed to those sealed with expanding packers, should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Depending on the requirements of the investigation, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination and classification of the sample. Samples are extruded in special hydraulic jacks equipped with properly sized platens to extrude the core in a continuous smooth speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (D 4220). Bent or damaged tubes should be cut off before extruding.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Assure that the markings or labels are adequate to survive transportation and storage.

NOTE 6—Top end of the tube should be labeled “top”.

9. Field Log

9.1 Record the information that may be required for preparing field logs in general accordance to ASTM D 5434 “Guide

for Field Logging of Subsurface Explorations of Soil and Rock”. This guide is used for logging explorations by drilling and sampling. Some examples of the information required include;

9.1.1 Name and location of the project,

9.1.2 Boring number,

9.1.3 Log of the soil conditions,

9.1.4 Surface elevation or reference to a datum to the nearest foot (0.5 m) or better,

9.1.5 Location of the boring,

9.1.6 Method of making the borehole,

9.1.7 Name of the drilling foreman and company, and

9.1.8 Name of the drilling inspector(s).

9.1.9 Date and time of boring-start and finish,

9.1.10 Depth to groundwater level: date and time measured.

9.2 Recording the appropriate sampling information is required as follows:

9.2.1 Depth to top of sample to the nearest 0.1 ft. (.03 m) and number of sample,

9.2.2 Description of thin-walled tube sampler: size, type of metal, type of coating,

9.2.3 Method of sampler insertion: push or drive,

9.2.4 Method of drilling, size of hole, casing, and drilling fluid used,

9.2.5 Soil description in accordance with Practice D 2488,

9.2.6 Length of sampler advance (push), and

9.2.7 Recovery: length of sample obtained.

10. Keywords

10.1 geologic investigations; sampling; soil exploration; soil investigations; subsurface investigations; undisturbed

SUMMARY OF CHANGES

In accordance with committee D18 policy, this section identifies the location of changes to this standard since the last edition, 200, which may impact the use of this standard.

(1) Added parts of speech to terms.

(2) Corrected reference in Note 2 from D 5740 to D 3740.

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Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the soil boring log form (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for ASTM D1586 (attached), a standard soil boring log form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both sample jar labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, sonic). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A

partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil consistency of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual

procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch OD, and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch OD). A stiffer rod, such as an "N" rod (2-5/8-inch OD), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

Soil Boring Log Form with a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedures) (ASTM D2488.pdf)

ASTM 1586 Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP Decontamination of Drilling Rigs and Equipment.



PROJECT NUMBER <i>DEN 22371.G5</i>	BORING NUMBER <i>BL-3</i>	SHEET <i>1</i> OF <i>3</i>
SOIL BORING LOG		

PROJECT *Howard Ave Landslide* LOCATION *Howard & 24th Ave, Centennial, CO*
 ELEVATION *513 1/2 Feet* DRILLING CONTRACTOR *Kendall Explorations, Aspen, Colorado*
 DRILLING METHOD AND EQUIPMENT *4"-inch H.S. Augers, Mobil B-61 rotary drill rig*
 WATER LEVELS *3.2 Feet, 8/5/89* START *August 4, 1989* FINISH *August 8, 1989* LOGGER *J.A. Michner*

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)			
0					Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
2.5						
4.0	1-S	1.5	2-3-4 (7)		POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
5.0						Driller notes very soft drilling
6.5	2-S	0.9	WOH/12"-1		ORGANIC SILT, (OL), very dark, gray to black, wet, very soft; strong H ₂ S odor; many fine roots up to about 1/4 inch	4ft. dark grey, wet silty cuttings.
8.0						
10.0	3-ST	1.3			ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
11.5	4-S	1.3	2-2-2 (4)		SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730
15.0						Driller notes rough drilling action and chatter @ 13 ft
15.5	5-S	0.5	60/6"		SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
20.0						Driller notes smoother, firm drilling @ 19 ft
21.0	6-S	1.0	12-50/6"		LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ bot tip of 6-S, poss boulders or rock
23.0						Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
23.1	7-S	0	50/1"		NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM

(47)

MAY 12, 2003

EXAMPLE

0715 ARRIVE ON SITE AT XYZ SITE.
 CH2M HILL STAFF:
 John Smith: FIELD TEAM LEADER
 Bob Builder: SITE SAFETY COORD.
 WEATHER: OVERCAST + COOL, 45°F
 CHANCE OF LATE SHOWERS
 SCOPE: • COLLECT GROUNDWATER
 SAMPLES FOR LTM WORK AT SITE 14
 • SUPERVISE SURVEY CREW
 AT SITE 17

0725 BB ~~Calibrates~~ (JS) Calibrates

PID: 101 ppm / 100 ppm OK

PID Model #, SERIAL #

0730 BB Calibrates HORIBA METER

Model #, SERIAL #

→ List calibration Results

0738 Survey crew ARRIVES on site

→ List NAMES

0745 BB Holds H+S TALK on Slips,

Trips, Falls, Ticks + Air Monitoring

JS + SURVEY CREW ATTEND

No H+S ISSUES IDENTIFIED as
 CONCERNS. All work is in "Level D."

0755 JS conducts site-wide Air Monitoring

All readings = 0.0 ppm in

JS
5-12-03

MAY 12, 2003

EXAMPLE (48)

SITE 14 LTM

BREATHING ZONE (BZ)

0805 Mobilize to well MW-22 to
 SAMPLE, SURVEYORS SETTING UP
 AT SITE 17

0815 PM (PAUL PAPER PUSHER) CALLS AND
 INFORMS JS TO COLLECT GWO SAMPLE
 AT WELL MW-44 TODAY FOR 24 hr
 TAT ANALYSIS OF VOC'S

0820 Purging MW-22

→ RECORD WATER QUALITY DATA

JS
5-12-03

0843 Collect SAMPLE AT MW-22 for
 total TAT Metals AND VOC'S. NO
 Dissolved Metals Needed PER PM

0905 JS + BB Mobilize to site 17 to
 show surveyors wells to survey.

0942 Mobilize to well MW-22 to
 collect SAMPLE ...

0950 CAN NOT ACCESS WELL MW-22
 due to BASE OPERATIONS; CONTACT
 PAUL PAPER PUSHER AND HE STATED
 HE WILL CHECK ON GAINING ACCESS
 WITH BASE CONTACT.

0955 Mobilize to well MW-19

JS
5-12-03



Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)¹

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific precautionary statements see Section 8.*

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which*

the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 ASTM Standards:

D 653 Terminology Relating to Soil, Rock, and Contained Fluids²

D 1452 Practice for Soil Investigation and Sampling by Auger Borings²

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils²

D 1587 Practice for Thin-Walled Tube Sampling of Soils²

D 2113 Practice for Diamond Core Drilling for Site Investigation²

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)²

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction³

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)²

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75- μ m) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

¹ This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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² Annual Book of ASTM Standards, Vol 04.08.

³ Annual Book of ASTM Standards, Vol 04.09.

*A Summary of Changes section appears at the end of this standard.

limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

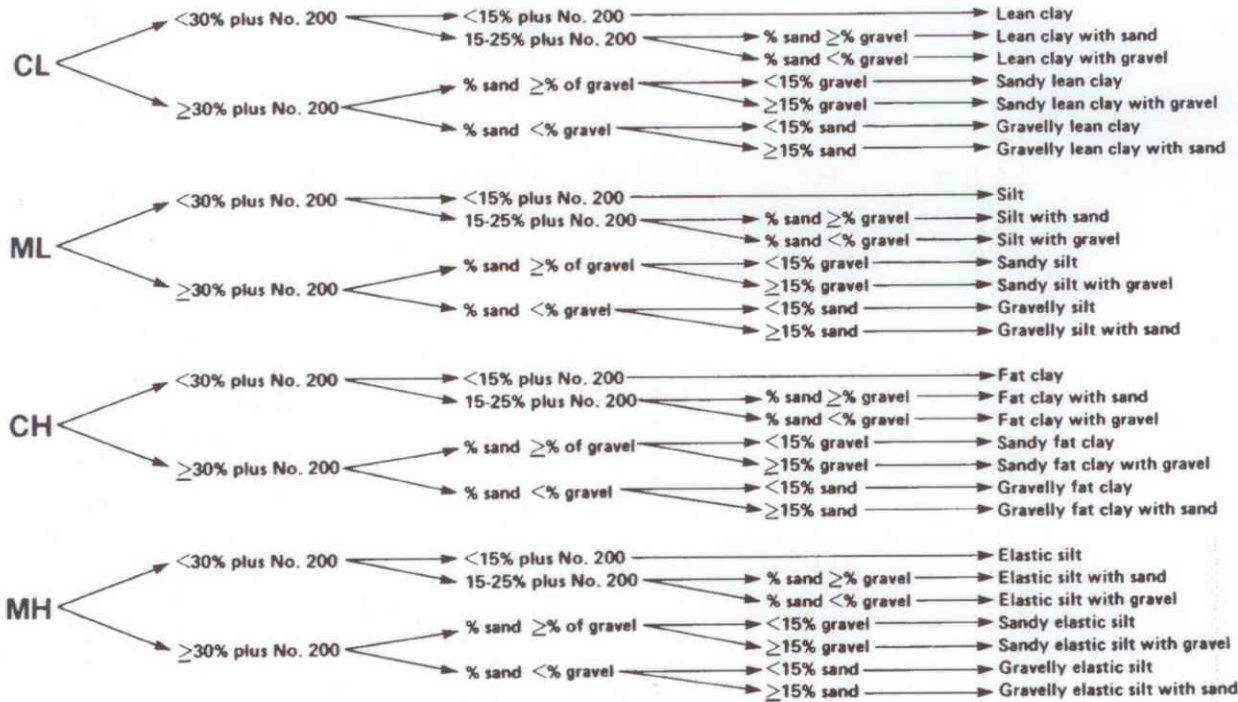
6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water

GROUP SYMBOL

GROUP NAME

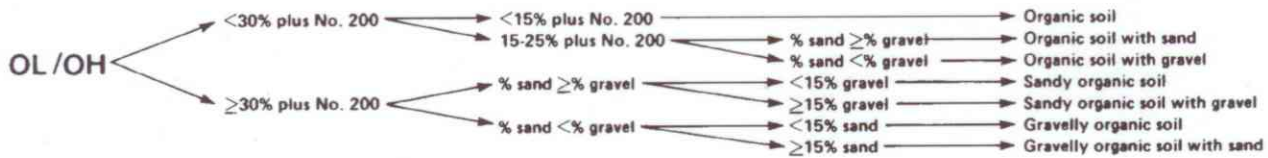


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

GROUP SYMBOL

GROUP NAME



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 N) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 N) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as

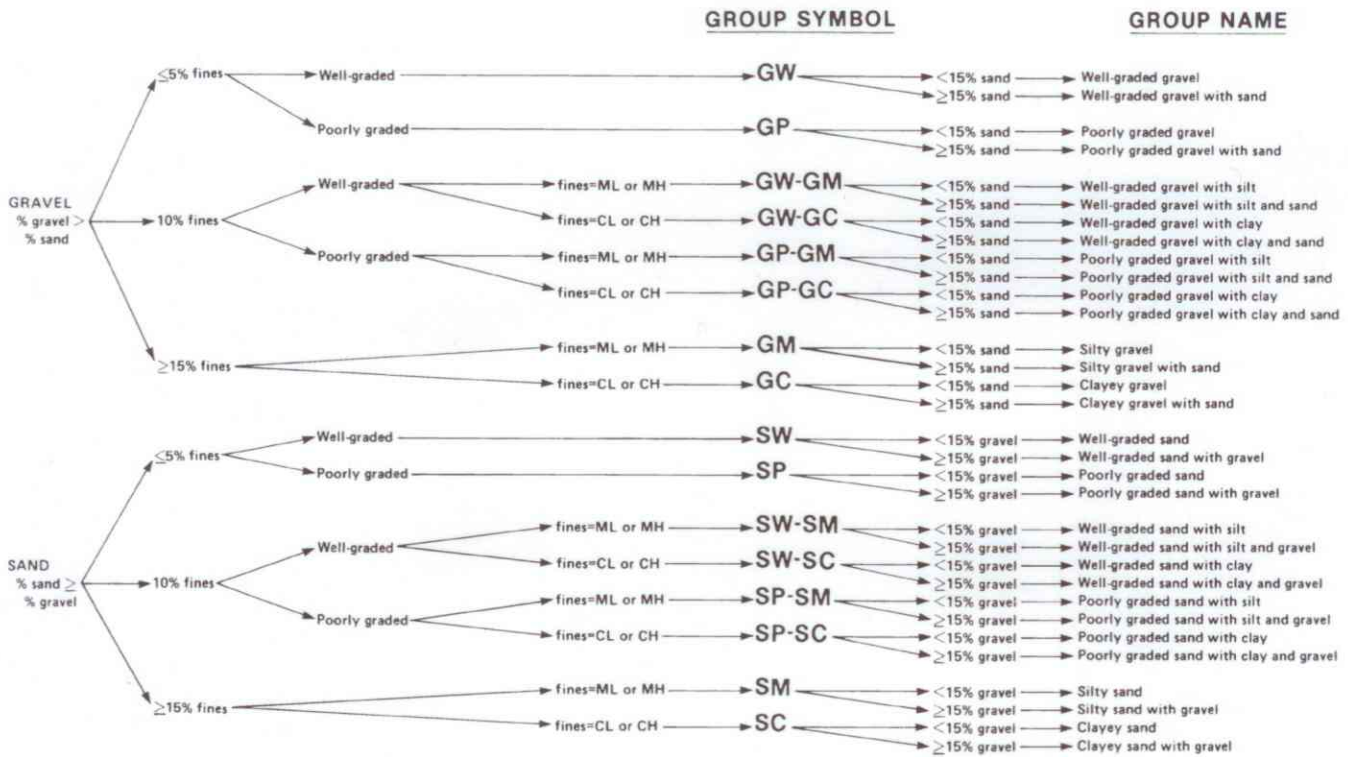
having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (¾ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 Angularity—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 Shape—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 Color—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 Odor—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 Moisture Condition—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 HCl Reaction—Describe the reaction with HCl as none, weak, or strong, in accordance with the criteria in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 Consistency—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 Cementation—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

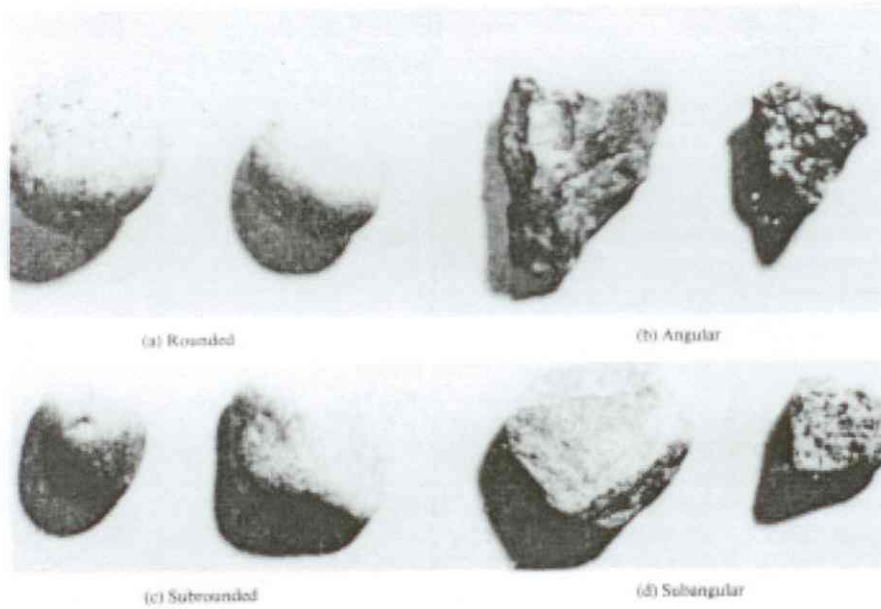


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

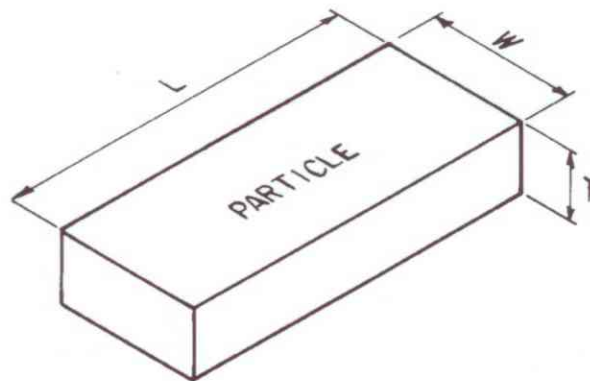
10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. “Hard” means particles do not crack, fracture, or crumble under a hammer blow.

PARTICLE SHAPE

W = WIDTH
T = THICKNESS
L = LENGTH



FLAT: $W/T > 3$
ELONGATED: $L/W > 3$
FLAT AND ELONGATED:
- meets both criteria

FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about 1/4 in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Dilatancy

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based

on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5%. The percentages of gravel, sand, and fines must add up to 100%.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5% of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100% for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50% or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50% fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 Dry Strength:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about 1/2 in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about 1/2 in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low,

medium, high, or very high in accordance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 Dilatancy:

14.3.1 From the specimen, select enough material to mold into a ball about 1/2 in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 Toughness:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1/8 in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 in. The thread will crumble at a diameter of 1/8 in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 Plasticity—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing Toughness

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 Identification of Inorganic Fine-Grained Soils:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.8 Identification of Organic Fine-Grained Soils:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words “with sand” or “with gravel” (whichever is more predominant) shall be added to the group name. For example: “lean clay with sand, CL” or “silt with gravel, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use “with sand.”

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words “sandy” or “gravelly” shall be added to the group name. Add the word “sandy” if there appears to be more sand than gravel. Add the word “gravelly” if there appears to be more gravel than sand. For example: “sandy lean clay, CL”, “gravelly fat clay, CH”, or “sandy silt, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use “sandy.”

15. Procedure for Identifying Coarse-Grained Soils
(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group

symbol plus the words “with clay” or “with silt” to indicate the plasticity characteristics of the fines. For example: “well-graded gravel with clay, GW-GC” or “poorly graded sand with silt, SP-SM” (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words “with gravel” or “with sand” shall be added to the group name. For example: “poorly graded gravel with sand, GP” or “clayey sand with gravel, SC” (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words “with cobbles” or “with cobbles and boulders” shall be added to the group name. For example: “silty gravel with cobbles, GM.”

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—Example: *Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
Gravel—fine, coarse
Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong
For intact samples:
18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only,

therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft³; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incorporated into a descriptive system for materials that are not

naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as “Sandy Lean Clay (CL)”; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; “Poorly Graded Sand with Silt (SP-SM)”; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; “Poorly Graded Gravel with Sand (GP).”

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; “Poorly Graded Gravel (GP)”; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard,

s = sandy
g = gravelly

s = with sand
g = with gravel
c = with cobbles
b = with boulders

Group Symbol and Full Name

CL, Sandy lean clay
SP-SM, Poorly graded sand with silt and gravel
GP, poorly graded gravel with sand, cobbles, and boulders
ML, gravelly silt with sand and cobbles

Abbreviated

s(CL)
(SP-SM)g
(GP)scb
g(ML)sc

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993^{e1}) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

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Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils¹

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in

parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,² NDA Drilling Safety Guide,³ drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 ASTM Standards:⁴

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
- D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
- D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- D 2488 Practice for Description and Identification of Soils

² Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, <http://www.osha.gov>.

³ Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, <http://www.nda4u.com>.

⁴ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

¹ This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

*A Summary of Changes section appears at the end of this standard.

(Visual-Manual Procedure)

- D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
- D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 4633 Test Method for Energy Measurement for Dynamic Penetrometers
- D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
- D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
- D 6026 Practice for Using Significant Digits in Geotechnical Data
- D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential
- D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
- D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
- D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N-value*, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m \pm 0.030 m) for each hammer blow.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N-value*, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N-value* should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

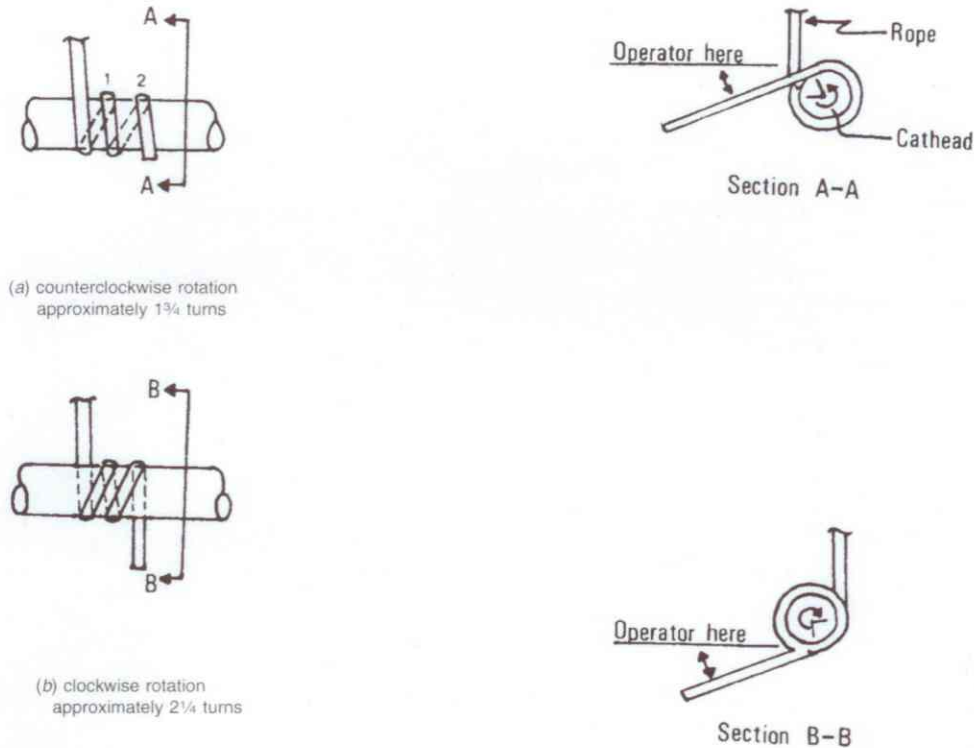


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

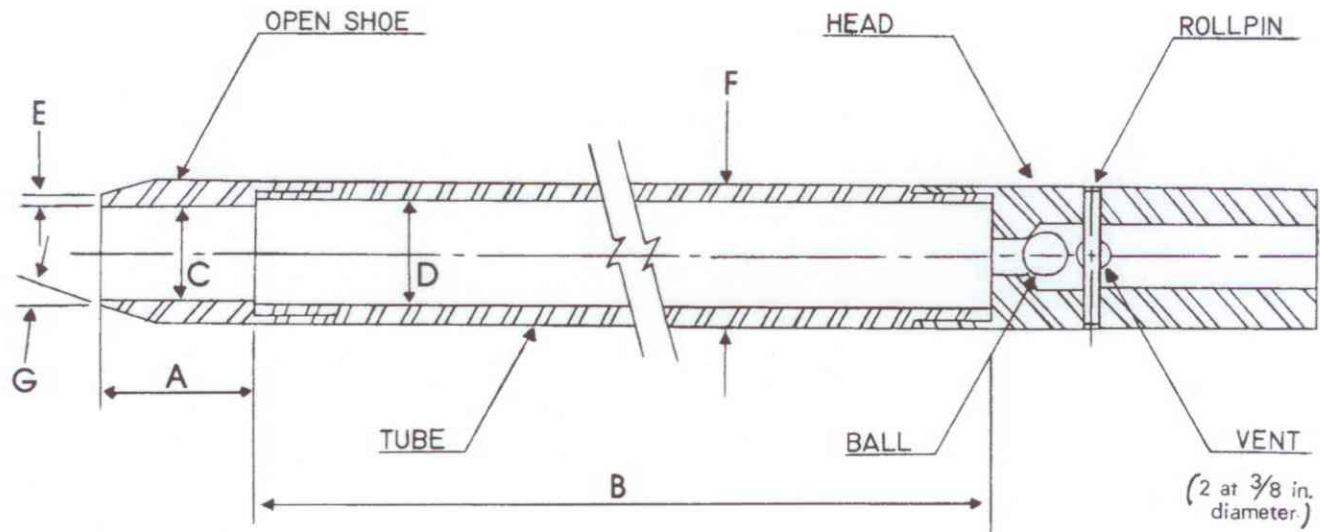
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall “A” rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm)).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



- A = 1.0 to 2.0 in. (25 to 50 mm)
- B = 18.0 to 30.0 in. (0.457 to 0.762 m)
- C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
- D = 1.50 ± 0.05 - 0.00 in. (38.1 ± 1.3 - 0.0 mm)
- E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
- F = 2.00 ± 0.05 - 0.00 in. (50.8 ± 1.3 - 0.0 mm)
- G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1/8-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1/2-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1/2 in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 Drive-Weight Assembly:

5.4.1 Hammer and Anvil—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbf (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 Hammer Drop System—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 Accessory Equipment—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

- 6.2.1 Open-hole rotary drilling method.
- 6.2.2 Continuous flight hollow-stem auger method.
- 6.2.3 Wash boring method.
- 6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

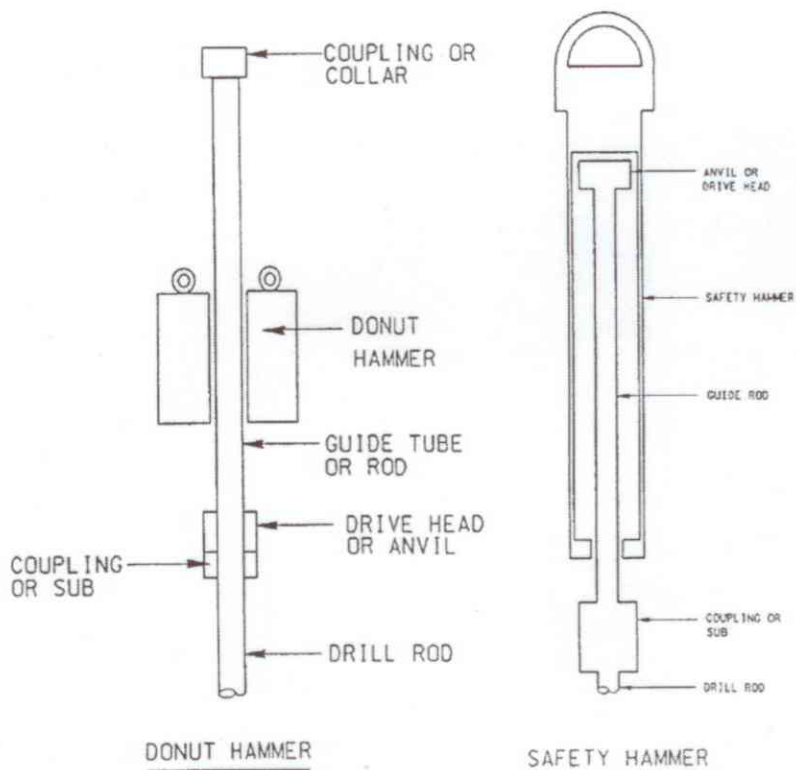


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare

the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

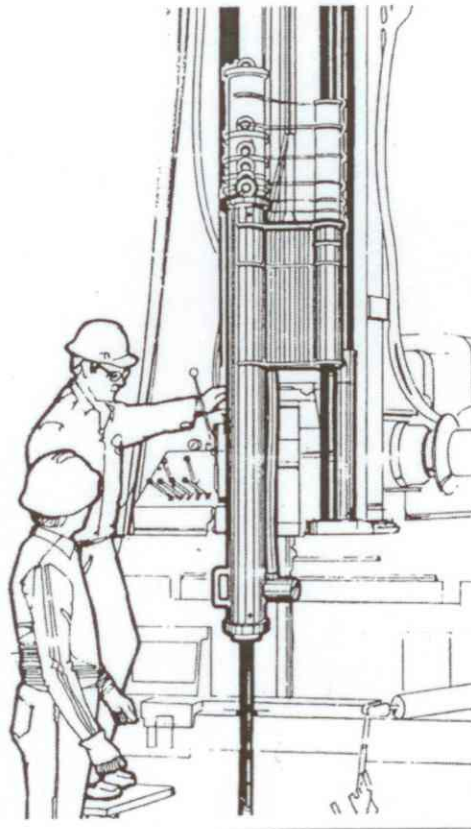


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (N) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the " N -value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) with limited unimpedance. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the N -value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, *N*₆₀). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

- 8.2.1 Name and location of job,
- 8.2.2 Names of crew,
- 8.2.3 Type and make of drilling machine,
- 8.2.4 Weather conditions,
- 8.2.5 Date and time of start and finish of borehole,
- 8.2.6 Boring number and location (station and coordinates, if available and applicable),
- 8.2.7 Surface elevation, if available,
- 8.2.8 Method of advancing and cleaning the borehole,
- 8.2.9 Method of keeping borehole open,
- 8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,
- 8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),
- 8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

- (1) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
- (2) Scope was completely revised.
- (3) Referenced Documents updated to include new standards.
- (4) Terminology: added section on Definitions.
- (5) Significance and Use: clarified use of the SPT test.
- (6) Apparatus: general editorial changes.
- (7) Sampling and Testing Procedure: general editorial changes.
- (8) Data Sheets/Forms: general editorial changes.
- (9) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

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**Table 1
EXAMPLE SOIL DESCRIPTIONS**

- POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size
- FAT CLAY (CH), dark gray, moist, stiff
- SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine
- WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max
- POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense
- ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica
- SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max
- INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick
- SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill
- SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation
- LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff
- WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

SF032/010.50

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

<u>Description</u>	<u>Criteria</u>
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

<u>Blows/Ft</u>	<u>Relative Density</u>	<u>Field Test</u>
0-4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb hammer
>50	Very dense	Penetrated only a few inches with ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

<u>Blows/Ft</u>	<u>Consistency</u>	<u>Pocket Penetrometer (TSF)</u>	<u>Torvane (TSF)</u>	<u>Field Test</u>
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized (“DI”) water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox[®] and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox[®] and water, scrub brushes, squirt bottles for Liquinox[®] solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.
2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.
3. Remove disposable coveralls (“Tyveks”) and discard into DOT-approved 55-gallon drum.
4. Remove respirator (if worn).
5. Remove inner gloves and discard.
6. At the end of the work day, shower entire body, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Spread plastic on the ground to keep equipment from touching the ground
3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.
4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.
5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)
6. Rinse with 1 gallon of tap water. (deionized water may be substituted for tap water)
7. Rinse with 1 gallon of deionized water.
8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.
9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox[®] solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox[®] solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.
2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, Liquinox® solution (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for all of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and SESCO, Inc. Pages should be water resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Rite in the Rain[®] or Sanford Sharpie[®] permanent markers. Note: for sites where PFC is being analyzed for, Rite-in-the-Rain[®], Sanford Sharpie[®], or anything water-resistant or with Teflon[®] cannot be used in the field. All field book materials must be "fluorine free". Acceptable substitutes would be a sewn notebook without a plastic cover, or loose-leaf notebook paper.
2. On the inside cover of the log book the following information should be included:

- Company name and address
 - Log-holders name if log book was assigned specifically to that person
 - Activity or location
 - Project name
 - Project manager's name
 - Phone numbers of the company, supervisors, emergency response, etc.
3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."
 4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.
 5. Daily entries will be made chronologically.
 6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.
 7. Each page of the log book will have the date of the work and the note takers initials.
 8. The final page of each day's notes will include the note-takers signature as well as the date.
 9. Only information relevant to the subject project will be added to the log book.
 10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.
2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.
4. Weather: Record the weather conditions and any significant changes in the weather during the day.
5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified, and corrective actions or adjustments made to address concerns/problems, and other pertinent information.
6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.
7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.
8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.
9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.
10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.
11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.
12. Health and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.
13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.
14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.
15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements

for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).
17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:
 - Description of the general sampling area – site name, buildings and streets in the area, etc.
 - Station/Location identifier
 - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
 - Sample matrix and type
 - Sample date and time
 - Sample identifier
 - Draw a box around the sample ID so that it stands out in the field notes
 - Information on how the sample was collected – distinguish between “grab,” “composite,” and “discrete” samples
 - Number and type of sample containers collected
 - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
 - Parameters to be analyzed for, if appropriate
 - Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).
2. Use tables to record sampling information and field data from multiple samples.
3. Sketch sampling locations and other pertinent information.
4. Sketch well construction diagrams.

V. Attachments

Example field notes.

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term “chain-of-custody” refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When in situ measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

Sample Label

Samples, other than for in situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project – Name of project site.
- Sample Identification - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 05/21/17).

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name or initials of the sampler.
- Remarks - Any pertinent additional information.

The field team should always follow the sample ID system prepared by the Project Chemist and reviewed by the Project Manager.

Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.
- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include only the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.
- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.
- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample locations in photographs, an easily read sign with the appropriate sample location number should be included.
- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a

pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under "Relinquished by" entry.
- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used and enter the airbill number under "Remarks," in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

- A. Sample Label
- B. Chain of Custody Form
- C. Custody Seal

VII References

USEPA. User's Guide to the Contract Laboratory Program. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Attachment A
Example Sample Label



Quality Analytical Laboratories, Inc.
 2567 Fairlane Drive
 Montgomery, Alabama 36116
 PH. (334)271-2440

Client _____
 Sample No. _____
 Location _____
 Analysis _____
 Preservative **HCL** _____
 Date _____ By _____

CEIMIC CORPORATION

10 Dean Knauss Drive, Narragansett, R.I. 02882 • (401) 782-8900

SITE NAME	DATE
ANALYSIS	TIME
	PRESERVATIVE
SAMPLE TYPE	
<input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Other _____	
COLLECTED BY:	

Attachment B
Example Chain-of-Custody Record

Attachment C
Example Custody Seal



CUSTODY SEAL

Date _____

Signature _____

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated Jacobs HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- Strapping tape
- Contractor bags
- Absorbent pads or equivalent
- Resealable bags
- Bubble bags (for glass bottle ware)
- Bubble wrap (if needed)
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

- A. Prepare coolers for shipment:
 - Tape drains shut.
 - Place mailing label with laboratory address on top of coolers.
 - Fill bottom of coolers with absorbent pads or similar material.
 - Place a contractor bag inside the cooler.
- B. Affix appropriate adhesive sample labels to each container. Protect with clear packing tape.
- C. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks. Cross check CoC to ensure all samples are present.
- D. Seal each glass sample bottle within a separate bubble bag (VOCs grouped per sample location). Sample labels should be visible through the bag. Whenever possible, group samples per location for all analytes and place in resealable bags. Make sure to release as much air as practicable from the bag before sealing.
- E. Arrange sample bottles in coolers so that they do not touch.
- F. If ice is required to preserve the samples, cubes should be repackaged in resealable bags and placed on and around the containers.
- G. Fill remaining spaces with bubble wrap if needed.
- H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.
- J. Close lid and latch.
- K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear packing tape.
- L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with clear packing tape to avoid seals being able to be peeled from the cooler.
- M. Relinquish to Federal Express or to a courier arranged with the laboratory. Scan airbill receipt and CoC and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier. If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result, only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated Jacobs HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radiation Protection Program

NO.: RP-100

PAGE: 1 of 6

DATE: May 2013

APPROVED:

Technical Services Manager

5/31/13

Date

Corporate Certified Health Physicist

5/31/13

Date

1.0 PURPOSE

This administrative procedure describes the major elements of the Radiation Protection Program for Perma-Fix Environmental Services, Inc. (PESI). As applicable, this administrative procedure references sections in the Radiation Protection Plan and project procedures which describe the program in more detail.

2.0 APPLICABILITY

These program descriptions apply to personnel who plan, review, supervise, or perform work involving radiation protection activities during remediation.

3.0 REFERENCES

References are listed in the specific Project Procedures that comprise this Radiation Protection Program.

4.0 DEFINITIONS

Radiation Work Permit (RWP): A document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions that exist in the work area and the radiological requirements for the job.

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and byproduct material procured and used to support the operation or remediation.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

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Radiation Protection Program	PAGE: 2 of 6

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO advises project management on all aspects of Radiation Protection and Operational Health Physics. The RSO directs all radiological safety activities on the project. The RSO has the authority to suspend operations and / or restrict personnel access at the project as a result of nonconformance to this SSHP, or other applicable regulations, and when radiological conditions change beyond the scope of an HWP. The RSO is responsible for:

- Implementing and ensuring compliance with RPP's policies and procedures.
- Inspect work activities to ensure operations, including off-normal activities, are being conducted according to the facility or project requirements, applicable federal regulations, and industry accepted As-Low-As-Reasonably-Achievable (ALARA) principles.
- Reviewing and approving work plans, Radiation Work Permits, and RPP procedures.
- Trending radiation work performance of project personnel including contamination and radiation exposure control.
- Identifying, reviewing, and documenting nonconformance, their causes and corrective actions for incidents associated with radiation protection.
- Ensuring an effective ALARA Program including conducting onsite radiation safety and health briefings.
- Ensuring documentation of any RPP safety violation.
- Reviewing survey data.
- Conducting briefings concerning radiological work activities.
- Ensuring that radiological records are complete, clear and legible, meet the intended purpose, and are regularly transmitted to document control for archive.
- Ensuring Restricted Areas are correctly identified, posted and marked.
- Performing or coordinating regular internal audits of the RPP.

5.2 Radiation Protection Technicians (RPTs)

RPTs report directly to the RSO. RPTs are assigned by the RSO to provide support to each major field activity for implementation of RPP requirements. RPTs provide guidance in RPP matters to field personnel. RPTs have stop-work authority for radiological safety matters and activities that could result in an unsafe condition being present. RPTs are responsible for the following:

- Conducting routine and job-specific radiological surveys (i.e., radiation, contamination, and airborne radioactivity).
- Establishing radiological postings.
- Implementing the personal protective equipment (PPE) and respiratory protection programs for the purpose of keeping radiation exposures ALARA.

TITLE:	NO.: RP-100
Radiation Protection Program	PAGE: 3 of 6

- Maintaining and operating portable Health Physics survey instrumentation used in the performance of Radiation Protection (RP) activities.
- Performing unconditional release surveys of material from the restricted area.
- Performing transportation radiological surveys according to applicable U.S. Department of Transportation (DOT) regulations.
- Assisting the SSHO with IH&S monitoring and inspections to a level commensurate with training and experience.

5.3 Project Supervisors

All Project Supervisors are responsible for:

- Ensuring personnel under their direction comply with RPP requirements.
- Providing information on projected work activities to the RPP organization.
- Notifying RP personnel of any radiological problems encountered.
- Ensuring workers are prepared for tasks with tools, equipment and training to minimize time spent in radiological areas.

5.4 Project Radiation Workers

All Project Radiation Workers and individuals entering radiologically controlled areas are responsible for:

- Obeying promptly “stop-work” and “evacuate” orders from RP personnel and the SSHO.
- Obeying posted, oral and written radiological control instructions and procedures, including instructions on Radiation Work Permits and those in the SSHP.
- Immediately reporting lost dosimetry devices to RP personnel.
- Reporting medical radiation treatments to the RSO and supervisor.
- Keeping track of personal radiation exposure status to ensure that administrative dose limits are not exceeded.
- Notifying RP personnel of faulty or alarming radiation protection equipment, and unsafe radiological conditions.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

None

8.0 APPARATUS

None

9.0 RECORDS

None

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Radiation Protection Program	PAGE: 4 of 6

10.0 PROCEDURE

10.1 Radiation Protection Organization

1. The RPP Organization will provide appropriate personnel and resources to verify and maintain a radiologically safe working environment.
2. RPP staffing levels will be periodically reviewed to ensure that adequate staffing levels are maintained consistent with current and planned remediation activities.
3. The Project RPP Organization will have access to engineering and other personnel needed to support the Radiation Protection Program.
4. The development and control of RPP Project Procedures will be in accordance with the following guidelines:
 - Clearly defined scope, tasks, applicability, limiting conditions, precautions, consideration of special controls, reference to acceptance criteria and quality requirements.
 - Clearly understood text, using standard grammar, nomenclature and punctuation, concise instruction steps in a logical sequence, and references.
 - Review, approval, issuance, and control of changes and permanent revisions.

10.2 ALARA Program

All activities involving radiation and radioactive materials shall be conducted in such a manner that radiation exposure to workers and the general public are maintained As-Low-As-Reasonably-Achievable (ALARA), taking into account current technology and the economics of radiation exposure reduction in relationship to the benefits of health and safety. ALARA concepts are implemented throughout the entire RPP. ALARA-program requirements include:

1. Administrative controls and procedures endeavor to reduce individual and collective radiation exposures ALARA. Minimizing radiation exposure is accomplished by preliminary planning and scheduling, using proven and innovative engineering techniques and performing engineering reviews of proposed work plan changes.
2. Worker involvement and acceptance in minimizing radiation exposure is a key component of the ALARA Program. Workers are responsible to incorporate ALARA principles into work performance.
3. Work shall be planned in accordance with ALARA principles, involving input from discipline engineers, the project RPP staff and implementing supervisors.
4. An Embryo-Fetus Protection Program has been established for the Project and is specified in RPP-113, "Embryo-Fetus Protection"

10.3 Radiation Protection Audit Program

1. Internal / External Audits of the Radiation Protection Program should be performed, documented, and be of sufficient scope, depth, and frequency to

TITLE:	NO.: RP-100
Radiation Protection Program	PAGE: 5 of 6

identify and resolve actual or potential performance deficiencies before significant quality problems are encountered. Audit frequency and criteria is determined by the RSO and / or SSHO.

2. The RSO and / or SSHO shall perform an annual review of RPP content and implementation as specified in 10 CFR 20.1101(c).

10.4 External and Internal Dosimetry Program

Internal and external dosimetry and exposure control requirements are defined in the PESI Radiation Protection Plan and includes:

- A discussion of applicable regulatory limits for occupational workers and members of the public.
- ALARA goals.
- Monitoring requirements.
- Recordkeeping requirements.
- Reporting requirements for both normal operations and incidents.

10.5 Radiation Protection Instrumentation Program

All instrumentation used to measure radiation and radioactive material will be maintained in accordance with their respective technical manuals and operating procedures. This includes establishing criteria and requirements for the operation, calibration, response testing, maintenance, inventory and control of radiation protection instrumentation and equipment to comply with applicable regulations and conform with applicable ANSI standards. The Instrumentation Program is detailed by specific procedures including RP-108, RP-109, and RP-110.

10.6 Access Control Program

Access controls to radiological areas will be maintained at all times at the PESI. The administrative and physical measures used to control access to Restricted and/or Radiological Areas are established procedures RP-101, RP-102, and RP-103

10.7 Radiation Protection Surveillance Program

The Radiation Protection Surveillance Program provides for the conduct of radiological surveys in all areas controlled for the purpose of radiation and/or radioactivity. The Program encompasses both routine and non-routine surveys to be performed within the PESI. The specific requirements for conducting and documenting radiological surveys at the PESI are detailed in procedures RP-104, RP-105, RP-106, and RP-107

10.8 Radioactive Material Control Program

This Program provides guidance and requirements for control of radioactive materials. The Radioactive Material Control Program includes receipt, inventory, handling, and release of materials. It also provides for radioactive sealed source control, control of materials entering Restricted Areas and control of contaminated tools and equipment. The requirements of this program are established in RP-111

TITLE:	NO.: RP-100
Radiation Protection Program	PAGE: 6 of 6

10.9 Respiratory Protection Program

It is not expected that respirators will be widely used by PESI staff for radiation protection purposes at PESI. As such the Respiratory Protection Program will be administered by the SSHO in accordance with the PESI Site Safety and Health Plan. The SSHO will consult with the RSO when respiratory protection is required for radiological purposes.

10.10 Radiological Training

The Radiological Training is required for PESI employees and/or subcontractors who perform work near, or in areas controlled for the purpose of radiation and/or radioactive materials as defined in Section 8.1 of the PESI Radiation Protection Plan. There are two basic levels of training: General Employee Radiation Training for visitors and non-radiation workers, Radiation Worker Training for workers who access Restricted Areas.

10.11 Radiation Protection Records

Radiation Protection Records are routinely developed to document all aspects of the Radiation Protection Program. Records are generated using clear concise text using standard grammar and punctuation. Records are reviewed for adequacy and completeness and transmitted to the Document Control organization for long-term retention.



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Access Control

NO.: RP-101

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for controlling the access of personnel, equipment, and vehicles into radiological areas.

2.0 APPLICABILITY

This procedure applies to all Project personnel and visitors, equipment, and vehicles entering Restricted Areas.

3.0 REFERENCES

1. 10 CFR 19, "Notices, Instructions and Reports to Workers Inspection."
2. 10 CFR 20, "Standards for Protection Against Radiation."
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)
4. RPP-102, "Radiological Posting Requirements."
5. RPP-103, "Radiation Work Permits Preparation and Use."
6. 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response."

TITLE:	Access Control	NO.:	RP-101
		PAGE:	2 of 8

4.0 GENERAL

4.1 Discussion

Access controls are used to ensure the radiological safety of personnel entering into Restricted Areas. These controls include, but are not limited to Training, Dosimetry, Posting, Area Monitoring, and Radiation Work Permits (RWP).

4.2 Definitions

ALARA: Means as low as reasonably achievable.

GET: General Employee Training

GERT: General Employee Radiation Training

HAZWOPER: 40-Hour Hazardous Waste Operations and Emergency Response training in accordance with 29 CFR 1910.120

Radiation Worker: An individual who accesses any Restricted Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Restricted Areas. **RPT:** Radiation Protection Technician

Radiation Work Permit (RWP): A document or series of documents prepared by the Radiation Protection Group to inform workers of the radiological, industrial hygiene and other safety conditions which exist in the work area and task-related radiological and other safety requirements.

RSO: Radiation Safety Officer

SSHO: Site Safety and Health Officer

SRD: Self-Reading Dosimeter

Visitor: An individual who accesses the project site for purposes other than for assignment as a Project Worker (e.g., site visit, performance of an essential short-term task).

5.0 RESPONSIBILITIES

5.1 Site Safety & Health Officer (SSHO)

- The SSHO is responsible for ensuring that all activities performed within this procedure conform to the requirements of the PESI Site Safety & Health Plan (SSHP).
- Authorizing escorted visitor entries into Restricted Areas. This responsibility may be designated.
- Evaluating visitor entries to Restricted Areas to minimize or eliminate exposure risk to personnel who lack adequate training.

5.2 Radiation Safety Officer (RSO)

- Implementing this procedure.
- Approving RWPs to control access to Restricted Areas.
- Reviewing and approving training programs related to work in Restricted Areas.
- Implementing the requirements of the PESI Radiological Protection Program.
- Providing direction to the Project Personnel regarding radiological matters.

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- Authorizing escorted visitor entries into Restricted Areas. This responsibility may be designated.
- Evaluating visitor entries to Restricted Areas to minimize or eliminate exposure risk to personnel who lack adequate training.

5.3 Radiation Protection Technician (RPT)

- Identifying and posting Restricted Areas.
- Providing RWP briefings to individuals entering Restricted Areas.
- Conducting radiation and contamination surveys, and keeping legible records.
- Monitoring work activities to ensure compliance with the requirements of the Radiological Protection Program.

5.4 Project Supervisor

- Ensuring that personnel assigned to work in Restricted Areas or with radioactive material, attend required training and perform work in a radiologically sound and safe manner.
- Contacting the RSO or designee, to obtain approval to bring escorted visitors into Restricted Areas.
- Notifying the RSO or designee, in advance (when possible) of the need to bring any non-project owned equipment/ vehicles into the Restricted Area to arrange for baseline contamination surveys.

5.5 Project Personnel

- Attending designated training classes.
- Following directions from the RPT with regards to Safety and Health.
- Maintaining their personnel exposures ALARA.
- Limiting the amount of material taken into Restricted Areas to that necessary for task performance.
- Working in a manner so as to prevent spread of contamination and reduce airborne radiological emissions to the extent possible.

6.0 PREREQUISITES

6.1 Individuals requiring unescorted access into a Restricted Area shall submit the following documentation to the RSO **prior** to entry:

- Evidence of initial 40-Hour and 8-Hour Refresher OSHA HAZWOPER Training (if applicable)
- Current medical examination performed within the past 12 months.
- Evidence of successful completion of Site Orientation Training (GET/GERT) and Radiation Worker Training (RWT).

6.2 Individuals requiring unescorted access into a Restricted Area shall meet the requirements for Restricted Area access and have the following at a minimum:

- Thermoluminescence Dosimeter (TLD) or Self-Reading Dosimeter (SRD).
- Personal Protective Equipment (PPE) specified by posting and/or RWP.

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6.3 Visitor access into Restricted Areas is limited to essential tasks which meet all of the following requirements:

- The task cannot be performed by appropriately trained Project Personnel
- The task is time critical in nature and would have a negative impact on safety & health or project operations if not performed.
- The task cannot be deferred until the Restricted Area is remediated or down posted.

7.0 PRECAUTIONS AND LIMITATIONS

- No unessential visitors shall be allowed access to the restricted areas.
- Visitors shall receive visitor specific site orientation training prior to accessing a restricted area. Training shall be documented.
- Personnel, equipment, and vehicle entry control shall be maintained for each radiological area.
- No radiological control(s) shall be installed in any area that would prevent the rapid evacuation of personnel in an emergency situation.
- Trained emergency response personnel (Fire Dept., Ambulance/EMT, Law Enforcement) responding to on-site emergencies are exempt from the requirements of this procedure.
- Any member of the public exposed to radiation and / or radioactive material shall not exceed 0.1 rem Total Effective Dose Equivalent per year.
- All visitors entering into a Restricted Area shall be escorted at all times by a qualified radiation worker. The RSO and SSHO or designee(s) shall approve these entries. The escort is responsible for visitor compliance with site protocols.
- Visitors may not enter a posted High Contamination Area, Radiation Area, High Radiation Area, or Airborne Radioactivity Area.
- Visitors shall not perform any work of an intrusive nature (i.e., digging, drilling, sampling, etc.) or an abrasive nature (i.e., welding, sanding, grinding, etc.) in Controlled Areas unless evaluated and approved by the RSO or designee.
- Visitors may only enter those areas where hazardous atmospheres do not exceed 50% of the Permissible Exposure Limit and where radiation exposures would not exceed the annual dose limit to a member of the public as specified in 10 CFR 20.
- The RSO shall ensure that risk of exposure to hazardous materials is minimized or eliminated prior to authorizing visitor entry into Restricted Areas. No work of an intrusive nature that may produce radioactive airborne particulates shall take place during visitor access to a restricted area.
- Visitors shall not be allowed to come into contact with tools, vehicles or materials that are contaminated above the release levels established in the SSHP.
- Project personnel who are required to escort individuals into a Restricted Area shall have successfully completed Radiation Worker Training (RWT), which includes training on the requirements of this procedure, and have a demonstrated knowledge of the site layout, site history, and emergency response protocols.

TITLE:	Access Control	NO.:	RP-101
		PAGE:	5 of 8

- Project personnel who are required to escort individuals into a Restricted Area shall ensure the visitors complete the “PESI Visitor Access Control Form” (see Attachment 1).
- RPTs shall perform exit frisking of visitors from Restricted Areas when frisking is required by RWP. Visitor access times and dates, PPE, controls and conditions shall be documented.

8.0 APPARATUS

None

9.0 RECORDS

- PESI Visitor Access Control Form
- RWP Access Registers are maintained under separate procedure.
- Quality Records generated under this procedure submitted to Document Control.

10.0 PROCEDURE

10.1 Restricted Areas

1. Enter the Restricted Area **ONLY** through the designated Access Control Point unless instructed otherwise by the RPT.
2. Inform the Access Control Point RPT of the nature of your work in the Restricted Area. Provide details as requested by the RPT.
3. Adhere to the requirements of Section 10.2 of this procedure if taking equipment or vehicles into the Restricted Area.
4. Review the applicable RWP and assemble and dress in the appropriate PPE.
5. Sign-in on the RWP Access Register. Signatures must be clear and legible, and must be accompanied by time of access.
6. Conduct all activities in a safe manner while working in the Restricted Area. Adhere to established safety and housekeeping protocols.
7. Exit the Restricted Area **ONLY** through the Access Control Point unless instructed otherwise by the RPT. Perform an exit frisk as required by RWP.
8. Sign-out on the appropriate RWP Access Register. Signatures must be clear and legible, and must be accompanied by time of egress.

10.2 Equipment and Vehicles Entering and Exiting Restricted Areas

1. Notify the RPT of any equipment / vehicles that need to be taken into a Restricted Area. Incoming surveys are performed on equipment and materials entering Restricted Areas. The purpose is to protect the client from financial liability associated with decontaminating equipment that arrived on the site with existing contamination. The decision regarding what must be surveyed will be made by the RSO. The degree of thoroughness of the survey and the requisite cleanliness of the equipment is at the discretion of the RSO.
2. Bring only the required equipment / supplies necessary for the task into the Restricted Area.

TITLE:	Access Control	NO.:	RP-101
		PAGE:	6 of 8

3. When practicable, use contamination prevention methods such as wrapping or sleeving of equipment taken into a CA or ARA.
4. Remove as much packaging material as possible (i.e., plastic or cardboard) prior to entering a Restricted Area.
5. Notify the RPT of any equipment / vehicles that need to be removed from a Restricted Area.

10.3 Visitor Escorts

1. Discuss planned activities, work locations, and site hazards with the Visitor. Discuss any restrictions on where the Visitor may go and what the Visitor may do within the Restricted Areas. Define the obligations of the Visitor with respect to following instructions of the escort and of safety personnel.
2. Provide the Visitor with a copy of the PESI Visitor Access Control Form (Attachment 1).
3. Instruct the Visitor to review the form, complete the top portion, and sign.
4. Answer any questions the Visitor may have. RP personnel are available to answer questions as needed.
5. Sign the PESI Visitor Access Control Form acknowledging escort responsibilities.
6. Obtain RSO and SSHO signature permitting Restricted Area access.
7. Give completed form to RP Personnel.
8. RP Personnel should assign a personnel dosimeter to the Visitor or group of visitors (this is a TLD unless otherwise instructed by the RSO). Note Self-Reading Dosimeter (SRD) in/out readings, if used, on the RWP Access Register.
9. Review the appropriate RWP with the Visitor, and ensure the Visitor dons PPE and signs and records the time of entry onto the RWP Access Register.
10. Escort the Visitor into the Restricted Area observing all escort responsibilities.
11. Upon completion of activities, assist visitor with PPE removal, and RWP sign-out. An RPT will perform the exit frisking.
12. Escort the Visitor out of the Restricted Area.
13. Take the personnel dosimeter and give it to the RP personnel. RP Personnel shall notify the RSO immediately if SRD readings indicate a personnel exposure.

11.0 ATTACHMENT

Attachment 1 PESI Visitor Access Control Form (FRONT & BACK)

TITLE: Access Control	NO.: RP-101
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ATTACHMENT 1
PESI VISITOR ACCESS CONTROL FORM (FRONT)

Name _____ Representing _____

SSN _____ - _____ - _____ Mailing Address _____

Some work at the PESI involves exposure to hazardous environments, radiation or radioactive materials. In keeping with the provisions of the Code of Federal Regulations Title 10, Part 19, this is to inform you of the extent of the hazards to which you may be exposed.

Radiation and radioactive materials on this project site are confined within clearly posted and delineated areas. Other hazardous materials may be present in these areas. Signs in these areas are magenta or purple and yellow in color and contain the international symbol for radiation, a trefoil or **three-bladed design**.
(ESCORT: SHOW VISITOR AN EXAMPLE OF A RADIOLOGICAL POSTING).

During your visit, you will be provided with an escort. You must remain with your escort at all times. In the unlikely event of an incident involving radioactive or other hazardous materials, your escort will provide you with instructions. Comply with the instructions of your escort. If exit frisking is required by the RWP, Radiation Protection Personnel will perform the exit frisk.

Do not enter any areas posted “RADIATION AREA” “HIGH CONTAMINATION AREA” or “AIRBORNE RADIOACTIVITY AREA.”

Do not perform work of an intrusive nature (i.e., digging, drilling, sampling, etc.) or any abrasive work (i.e., welding, sanding, grinding, etc.) without specific written approval of the RSO.

Nuclear Regulatory Guide 8.13, “Instructions Concerning Pre-natal Radiation Exposure” is available for review upon request.

Address any questions you may have to your escort or to the person you are visiting. Questions may also be directed to the Safety & Health Department.

I have read and understand the above. I agree to comply with the terms of this form.

Visitor Signature

Date

I have reviewed the above with the visitor and agree to comply in full with PESI established radiological escort protocols including, but not limited to, those specific requirements specified on the back of this form.

Escort Signature

Date

Restricted Area Access Authorized:

RSO or designee Signature

Date

SSHO or designee Signature

Date

ALL SIGNATURES MUST BE PRESENT ON THIS FORM PRIOR TO RESTRICTED AREA ACCESS!



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radiological Postings

NO.: RP-102

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for posting requirements for various radiological hazard areas on PESI Projects.

2.0 APPLICABILITY

This procedure applies to all which require radiological postings.

3.0 REFERENCES

1. 10 CFR 19, "Notices, Instructions, and Reports to Workers; Inspection."
2. 10 CFR 20, "Standards for Protection Against Radiation."
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)

4.0 GENERAL

4.1 Discussion

Radiological postings are used to delineate areas containing radiological hazards and to inform personnel of hazards. In addition, supplemental or informational postings may be included which provide personnel with entry requirements or protective equipment requirements. Barriers may be used in conjunction with postings to ensure that personnel do not inadvertently enter into an area with a radiological hazard. Barriers at the PESI and the vicinity properties are normally composed of rope, tape, or fencing.

4.2 Definitions

Posting: A standardized sign or label which bears the standard trefoil radiation symbol in magenta or black on a yellow background and information concerning a specific radiological hazard.

TITLE: Radiological Posting Requirements	NO.: RPP-102
	PAGE: 2 of 4

5.0 RESPONSIBILITIES

5.1 Site Safety & Health Officer (SSHO)

- The SSHO is responsible for ensuring all activities performed within this procedure conform to the requirements of the SSHP.

5.2 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Reviewing pertinent survey data and making periodic tours to verify all areas within the PESI are properly posted.
- Authorizing the de-posting or down-posting of areas.
- Providing technical direction to the Radiation Protection Technicians (RPTs).

5.3 Radiation Protection Technician (RPT)

- Directing the placement of radiological postings and barriers.
- Performing periodic radiation / contamination surveys to ensure radiological conditions have not changed.

5.4 Project Supervisor

- Ensuring that personnel working in their particular area obey all radiological postings.

5.5 Project Personnel

- Obeying all radiological postings.
- Following directions from the RPT with regards to radiological postings.
- Maintaining their personnel exposures as low as reasonably achievable (ALARA).

6.0 PREREQUISITES

RPTs will be trained to assess and recognize the various radiological hazards present at the PESI.

7.0 PRECAUTIONS AND LIMITATIONS

- Barriers and other means shall be used as required to maintain control of areas requiring posting.
- At a minimum, all access / egress points to areas requiring radiological posting shall be conspicuously posted with the appropriate signs which includes area descriptions and specific requirements for entry.
- Appropriate signs should be placed approximately every 40 feet around the perimeter of a posted area. At least one sign should be placed on each side of an area's boundary, visible from any normal avenue of approach. These signs require only area identifiers (e.g., Restricted Area, Radioactive Materials Area, Radiation Area, etc.) in addition to the standard "Caution" or "Warning" and the tre-foil.
- An RPT with the appropriate field survey instrumentation may serve as the radiological posting in situations where the task is of a short duration or at the discretion of the RSO.
- No radiological control(s) shall be installed in any area that would prevent the rapid evacuation of personnel in an emergency situation.

TITLE: Radiological Posting Requirements	NO.: RPP-102
	PAGE: 3 of 4

- Trained emergency response personnel (Fire Dept, Ambulance / EMT, Law Enforcement) responding to on-site emergencies are exempt from the requirements of this procedure.
- Postings should be as clear and concise as possible to prevent confusion on the part of personnel desiring to enter an area.
- Postings should not be hung from ladders, electrical wire, switches, vehicles, or any other item that could be damaged, moved, or could cause injury to personnel.
- If more than one level of radiological posting is required in an area, posting for each unique condition shall be identified starting with the highest hazard potential. However, it is not required to post areas with area identifiers that are superseded by postings identifying a higher hazard potential (e.g., posting a Contamination Area as a Radioactive Materials Area, etc.).
- Radiological postings shall not be moved or altered without approval from the RSO or the RPT covering the work.

8.0 APPARATUS

- Yellow and magenta barrier supplies (e.g., rad-rope, rad-tape, rad-ribbon, etc.)
- Signs and inserts as required
- Radioactive Material Labels or tags
- Stands or Stanchions

9.0 RECORDS

All surveys performed for radiological posting placement will be forwarded to project document control.

10.0 PROCEDURE

10.1 Controlled Areas

All access points to areas meeting the definition of a Controlled Area shall be posted with the words “CONTROLLED AREA,” or “US GOVERNMENT PROPERTY” plus any additional verbiage deemed appropriate by Project Management.

10.2 Restricted Areas

All access points to areas meeting the definition of a Restricted Area shall be posted with the words “RESTRICTED AREA.”

10.3 Contamination Areas

All access points to areas meeting the definition of a Contamination Area shall be posted with the words “CAUTION, CONTAMINATION AREA,” and with the words “RESTRICTED AREA,” as well as any special instructions deemed necessary by the RSO.

10.4 High Contamination Areas

All access points to areas meeting the definition of a Contamination Area shall be posted with the words “CAUTION, HIGH CONTAMINATION AREA,” and with the words “RESTRICTED AREA,” as well as any special instructions deemed necessary by the RSO.

TITLE: Radiological Posting Requirements	NO.: RPP-102
	PAGE: 4 of 4

10.5 Radiation Areas

All access points to areas meeting the definition of a Radiation Area shall be posted with the words “CAUTION, RADIATION AREA” as well as any special instructions deemed necessary by the RSO.

10.6 High Radiation Areas

All access points to areas meeting the definition of a High Radiation Area shall be posted with the words “DANGER, HIGH RADIATION AREA” as well as any special instructions deemed necessary by the RSO.

10.7 Radioactive Materials Areas

All access points to areas meeting the definition of a Radioactive Materials Area shall be posted with the words “CAUTION, RADIOACTIVE MATERIALS AREA” as well as any special instructions deemed necessary by the RSO.

10.8 Airborne Radioactivity Area

All access points to areas meeting the definition of an Airborne Radioactivity Area shall be posted with the words “CAUTION, AIRBORNE RADIOACTIVITY AREA” as well as any special instructions deemed necessary by the RSO.

10.9 Posting / De-Posting / Down-Posting

Posting, De-posting, and Down-posting activities should be noted in the appropriate technician logbook with reference to applicable survey number(s).

11.0 ATTACHMENTS

None



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radiation Work Permits
Preparation and Use

NO.: RP-103

PAGE: 1 of 7

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure describes the conditions under which a Radiation Work Permit (RWP) is required on PESI Projects. This procedure establishes consistent methodology and responsibilities for developing, utilizing and terminating an RWP. The procedure also describes the functions of the RWP (a sample is given in Attachment 1).

2.0 APPLICABILITY

This procedure applies to RWP requests, preparation, use, and termination. All personnel working on a task for which a RWP is required are required to comply with its conditions.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Section 30255, "Notices, Instructions and Reports to Workers, Inspections, and Investigations."
2. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
3. RP-101, "Access Control."

4.0 DEFINITIONS

Airborne Radioactivity Area: Means any area where the measured concentrations of airborne radioactivity above natural background exceed, or are likely to exceed, 25% of the Derived Air Concentration (DAC) values identified in Section 6.0 of the Radiation Protection Plan; and as listed in 10 CFR 20, Appendix B, Table I, Column 3

Contamination Area (CA): Means any area accessible to personnel with loose surface contamination values in excess of the values specified in the United States Army Corps of Engineers (USACE) Radiation Protection Manual, "Acceptable Surface Contamination Levels," (also refer to Table 1 of the Radiation Protection Plan; and procedure RPP-104, "Radiological Surveys,") or any additional area specified by the Radiation Safety Officer (RSO). The

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Contamination Area posting requirement is more restrictive than the Radioactive Material Area posting requirement. Any area posted as a Contamination Area shall also be considered to be a Radioactive Materials Area.

Radiation Work Permit (RWP): Means a document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions which exist in the work area and the radiological requirements for the job.

Radiation Area (RA): Means any area, accessible to personnel, where the whole body dose rate exceeds 5 mrem/hr but less than 100 mrem/hr at 30 cm from the source.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

High Radiation Area (HRA): Means any area accessible to personnel where the whole body dose rate exceeds 100 mrem/hr at 30 cm (12 inches) from the radiation source.

Radioactive Materials Area (RMA): Any area or room where quantities of radioactive materials in excess of 10 times the 10 CFR 20, Appendix C quantities are used or stored, or any area designated by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: Means any area to which access is limited by Project Management for the purpose of protecting individuals against exposure to radiation and radioactive materials.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Approving all protective measures incorporated into the RWP with regards to Radiological Safety.

5.2 Radiation Protection Technician (RPT)

- Conducting radiation and contamination surveys and keeping legible records.
- Preparing RWPs to control access to and activities in radiological areas.
- Monitoring worker compliance with RWP requirements.

5.3 Project Personnel

- Reviewing the correct RWP for the task to be performed.
- Accurately and legibly completing required information on the RWP Access Register.
- Observing radiological postings.
- Obeying oral and written radiological and industrial hygiene control instructions and procedures, including instructions on RWPs.
- Maintaining an awareness of radiological and industrial hygiene conditions in the work area.

6.0 PREREQUISITES

1. A RWP shall be required for the following:
 - All tasks requiring entries into Radiological Areas.

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- As specified by the RSO or their designees.
2. Prior to use of an RWP, the RSO or designee shall:
 - Define an access location appropriate for the RWP.
 - Review the inventory at the applicable Access Control Points and shall verify that Personal Protection Equipment (PPE), instruments and other safety-related equipment necessary to support the requirements of the RWP are available.
 3. Prior to entry, all personnel working under an RWP must:
 - Satisfy medical and training requirements as established in the Access Control procedure.
 - Be adequately briefed by the Radiation Protection Group regarding:
 - Work to be performed and the associated RWP requirements.
 - Safety procedures to be followed for its completion.

7.0 PRECAUTIONS AND LIMITATIONS

- Personnel shall not deviate from the requirements, precautions, or other instructions on the RWP without authorization from the RSO or designees.
- A copy of the RWP shall be posted at the work site. The original shall remain at a central location (Safety and Health office). Associated support documents containing environmental conditions (soil activities, contamination surveys, etc.) shall be maintained by the RSO and are available upon request.
- An RWP is not required when responding to emergency situations where serious consequences could result if time were taken to prepare the RWP.

8.0 APPARATUS

None

9.0 RECORDS

- Hazardous Work Permit (RWP)
- Hazardous Work Permit Access Register

10.0 PROCEDURE

10.1 Active RWP Use

1. The RP group will activate the RWP upon review and signature by the RSO.
2. A copy of active RWPs will be maintained at applicable Access Control Points.
3. The RSO or designee shall review the inventory and shall verify that PPE, instruments and other safety-related equipment necessary to support the requirements of the RWP are available at the applicable Access Control Points. Inventory reviews shall also be performed, as necessary, during the course of work on the RWP.
4. All workers who will be working on tasks supported by an RWP will be provided an initial briefing on the RWP by a Safety and Health representative:

- Upon their entry on the RWP.
 - Upon initial entry following revision of a RWP.
 - When significant changes occur in the work area.
5. The purpose of the briefing is to ensure:
- All Safety and Health conditions, requirements, special precautions, are fully understood by the workers.
 - Ensure that all anticipated tools, materials, and equipment are assembled for the work.
 - Ensure that work party members have been issued any radiological monitoring or protective devices specified for the work.
6. All personnel will read and verify that they understand and agree to comply with the terms of the RWP by signing in on the RWP Access Register (Attachment 2).
7. While working under an RWP, personnel are responsible to know and understand:
- The tasks that fall under the RWP.
 - Procedural controls and precautions taken to:
 - Reduce spread of contamination.
 - Reduce airborne emissions of radionuclides.
 - Reduce dose to workers and the public as low as reasonably achievable (ALARA).
 - Requirements to apply the sound radiological and safe work practices taught in indoctrination and continuing training.
8. The RSO or the attending RPT have stop work authority for all phases of work under an RWP. Stop work authority can be implemented when personnel safety is jeopardized due to:
- A change in the radiological (or other hazard) environment occurs, requiring additional controls and / or precautions.
 - If poor work practices are employed.
 - If RWP, ALARA, or procedural controls and / or precautions are violated.
9. Personnel shall sign in / out on the RWP Access Register for each entry into and egress from an area including when exiting the area for short break periods and when transferring to work on a different RWP.
10. Upon completion of work or at the end of the shift the Work Party Supervisor shall ensure that:
- Access Control Point and Work Area conditions are satisfactory. This includes housekeeping, safe storage of equipment, ensuring any required contamination control measures are implemented, and accurate completion of RWP Access Registers.

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- All radiological and Industrial Hygiene monitoring and protection devices that were issued have been returned to the Safety and Health (S&H) Group.

10.2 Termination of RWP

1. If the work was not or cannot be completed within the duration period of the RWP, an extension of the RWP should be requested.
2. An RWP is considered “terminated upon:
 - Signature by the RSO, or designee(s) in the appropriate section on the **original** RWP.
 - If the duration period for the RWP is been exceeded and the RWP was not extended.
3. Upon Completion of an RWP task, the Work Party Supervisor shall ensure that:
 - Access Control Point and Work Area conditions are satisfactory. This includes housekeeping, safe storage of equipment, ensuring any required contamination control measures are implemented, and accurate completion of RWP Access Registers.
 - All radiological and Industrial Hygiene monitoring and protection devices that were issued have been returned to the RP Group.
4. Upon completion of the job, the RWP copy and RWP Access register shall be returned to the RP Group for disposition.
5. Completed RWP forms (originals) and RWP Access Registers are quality records. These documents shall be maintained by the RP Group until transmitted to Project Records.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 Radiation Work Permit (Typical)

Attachment 2 Radiation Work Permit Access Register (Typical)

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Attachment 1 (Typical)

PESI RADIATION WORK PERMIT (RWP)		NO. <table border="1" style="display: inline-table; border-collapse: collapse;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px; text-align: center;">-</td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>			-		
		-					
		Revision Number <table border="1" style="display: inline-table; border-collapse: collapse;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>					
WORK DESCRIPTION:	WORK LOCATION(S):						
	Start Date /Time:						
	Est. Completion Date:						
	Requested by:						
	Request Date:						
HAZARDOUS CONDITIONS							
IS A RADIOLOGICAL / ALARA REVIEW REQUIRED ? No <input type="checkbox"/> Yes <input type="checkbox"/>							
I.H. LIMITS:	RADIOLOGICAL LIMITS	CURRENT CONDITIONS					
O₂:	Exposure Rate:	<i>IH/Rad conditions are evaluated by Safety & Health personnel, as necessary, during job coverage. The adjacent IH/Rad limits are the maximum allowed by this RWP.</i>					
LeL:	Alpha Contamination:						
Org. Vapors:							
DUST:	General Area Airborne:						
H₂S:	Limiting Isotope / DAC Value:						
REQUIRED PERSONAL PROTECTIVE CLOTHING & EQUIPMENT (PPE)							
HEAD / EYES	FEET / LEGS	BODY					
<input type="checkbox"/> Hard Hat <input type="checkbox"/> Safety Glasses <input type="checkbox"/> Monogoggles <input type="checkbox"/> Face Shield	<input type="checkbox"/> Sturdy Work Shoes <input type="checkbox"/> Disposable Shoe Covers <input type="checkbox"/> Rubber Over Shoes / Boots <input type="checkbox"/> Other (Specify):	<input type="checkbox"/> Cotton Coveralls <input type="checkbox"/> Tyvek Coveralls (Regular) <input type="checkbox"/> Tyvek Coveralls (Coated) <input type="checkbox"/> Other (Specify)					
RESPIRATORY	HANDS	MISCELLANEOUS					
<input type="checkbox"/> Full Face (Negative Pressure) * <input type="checkbox"/> Powered Air Purifying* <i>* Specify Cartridge or Canister Type Below</i> <input type="checkbox"/> Other (specify)	<input type="checkbox"/> Cotton / Work Gloves <input type="checkbox"/> Nitrile Surgeons Gloves <input type="checkbox"/> Rubber Gloves <input type="checkbox"/> Other (Specify):	<input type="checkbox"/> Tape Gloves & Boots to Coveralls <input type="checkbox"/> Fall Protection <input type="checkbox"/> Hearing Protection <input type="checkbox"/> Other (Specify)					
ADDITIONAL REQUIREMENTS / SPECIAL INSTRUCTIONS / MONITORING REQUIREMENTS							
Additional Requirements	Special Instructions	Dosimetry	Indiv.	Group			
<input type="checkbox"/> "Buddy System" in Effect <input type="checkbox"/> S&H Tech Job Coverage (Intermittent / Continuous) <input type="checkbox"/> Confined Space Entry Permit <input type="checkbox"/> HotWork Permit <input type="checkbox"/> Lockout-Tagout Permit <input type="checkbox"/> Excavation Permit <input type="checkbox"/> Review MSDS <input type="checkbox"/> Emergency Response Equipment <input type="checkbox"/> Communication Method (Radio / Voice) <input type="checkbox"/> Portable Eyewash Station <input type="checkbox"/> Pre-Entry Monitoring <input type="checkbox"/> S&H Tech Notification Prior to Work (Daily / Each Entry) <input type="checkbox"/> Personnel Frisking Required (Whole-Body / Hand & Feet) <input type="checkbox"/> _____ <input type="checkbox"/> _____ <input type="checkbox"/> _____		TLD Badge					
		Extremity TLD					
		Other (Specify):					
		Air Monitoring	Indiv.	Group			
		Lapel-Breathing Zone					
		Low Volume					
		Dust					
		PID / FID					
		4 Gas					
		Expiration Date/Time:					
		This permit will be reviewed for revision as conditions change and at 1-year from date of implementation.					
APPROVALS	DATE	TERMINATION	DATE				
RSO		RSO or SSHO					
SSHO		Reason:					



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radiological Surveys

NO.: RP-104

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure establishes consistent methodology for performing radiation and contamination surveys at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This procedure is applicable to all personnel trained and qualified to perform radiation and contamination surveys at PESI.

3.0 REFERENCES

1. 10 CFR 20, "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)"
3. RP-101, "Access Control."
4. RP-105, "Unrestricted Release of Requirements."
5. RP-106, "Survey Documentation and Review"

4.0 GENERAL

4.1 Discussion

Radiological surveys are performed to detect and assess radiological conditions, which may be encountered at PESI.

4.2 Definitions

Contact Dose Rate: A radiation dose rate as measured at contact or within 1/2 inch of the surface being measured.

CPM: Counts per minute

Dose Rate: The quantity of absorbed dose delivered per unit of time.

DPM: Disintegrations per minute

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General Area Dose Rate (GA Dose Rate): The highest radiation dose rate accessible to any portion of the whole body measured at a distance of 30 cm (12 inches) from a significant radiation source or combination of sources.

LAW: Large area Wipe (i.e., Masslinn)

MDA: Minimum Detectable Activity

Survey: An evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of ionizing radiation under a specific set of conditions.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Ensuring appropriate radiation surveys are performed to measure and document radiation levels.
- Ensuring all completed surveys are adequately reviewed.
- Providing technical direction to the RPTs.

5.2 Radiation Protection Technician (RPT)

- Conducting and documenting radiation surveys.
- Performing all necessary pre / post use operability checks.
- Creating neat, legible, and concise records.

6.0 PREREQUISITES

- Prior to performing a radiation survey, personnel should review previous survey data and familiarize themselves with possible radiological hazards.

7.0 PRECAUTIONS AND LIMITATIONS

- Personal Protective Equipment (PPE) should be appropriate for the level of contamination expected and shall be in compliance with Site Safety & Health Plan (SSHP), Radiation Work Permits (RWPs), or other work specific controlling documents. At a minimum, gloves or tweezers should be used when handling swipes.
- Direct probe surveys may be used to demonstrate compliance with removable limits given in Attachment 1 (Acceptable Surface Contamination Levels), and discussed in RPP-105, "Unrestricted Release of Requirements." When instrumentation is used in this manner it should be capable of achieving the removable minimum detectable count (MDC) requirements.
- Surface contamination limits are contained in Attachment 1.
- Instruments used in surveys should be capable of achieving a Minimum Detectable Activity (MDA) that is less than the applicable release limits.
- In high background areas it may not be possible to achieve the required survey MDAs for beta / gamma instruments.

8.0 APPARATUS

- Radiation and contamination survey instruments

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- Smears
- Masslinn
- Personal Protection Equipment

9.0 RECORDS

Survey documentation to be completed per RPP-106, "Survey Documentation and Review."

10.0 PROCEDURE

10.1 General Instructions

1. Select the survey instrument based on the anticipated hazards and dose rates as determined by a review of previous survey data and ongoing work activities.
2. Perform pre-operational and response checks in accordance with the operating procedures for the instrument.
3. Remove any defective instrument from service.
4. Obtain survey forms and any other material required to document survey results.
5. Contamination Surveys are normally done for alpha emitting constituents. In certain circumstances the RSO can dictate that a survey be performed for both alpha and beta emitting constituents.

10.2 Routine Survey Frequencies

1. The RSO shall specify areas for routine monitoring surveys and the frequency of such surveys. The RSO should maintain a routine survey frequency schedule. The schedule is NOT considered a record, and does not need to be retained.
2. The following areas should be considered for a routine survey on a DAILY basis:
 - Access Control Points.
 - Designated eating, drinking, and smoking areas within Restricted Areas.
 - Radiological Counting Labs and sample prep areas.
 - Any other area specified by the RSO.
3. The following areas should be considered for a routine survey on a WEEKLY basis:
 - High Traffic areas on the PESI Site.
 - Operating high-efficiency particulate air (HEPA) exhaust areas.
 - Highly occupied areas within the radioactive Materials Area that could be a source of personnel contamination or an intake of radioactive materials (e.g., the boot change area, equipment floorboards, and workshops).
4. The following areas and equipment should be considered for a routine survey on a MONTHLY basis:
 - Occupied offices.
 - Storage areas.

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- Occupied areas within the radioactive Materials Area that could be a source of personnel contamination or an intake of radioactive materials (e.g., equipment storage areas).
5. The following should be done on an as-needed basis:
- Incoming Surveys

The RSO can direct that incoming surveys be performed on equipment and materials arriving onto the site. The purpose of an incoming survey is to protect the client from financial liability associated with decontaminating equipment that arrived on the site with existing contamination. The degree of thoroughness of the survey and the requisite cleanliness of the equipment is at the discretion of the RSO.
 - Surveys of Materials Vehicles, and Personnel leaving Restricted Areas

All materials, vehicles, and personnel shall perform surveys upon leaving Restricted Areas that have a potential for spread of contamination. The RSO or designee can direct that additional surveys be performed as needed to monitor for spread of contamination.
 - Direct Total Contamination Surveys
 1. All items being surveyed should appear to be clean prior to being surveyed. To the extent possible, all interior and exterior surfaces should be free from oil and visible dirt. The RSO may dictate the required degree of cleanliness, based on the purpose of the survey and the history of the item being surveyed.
 2. Obtain proper instrumentation for the survey. Ensure that the instruments are currently calibrated and have been performance checked prior to the survey.
 3. Determine and record the background count in the area to be surveyed. Ensure that the background is representative of the measurement to be taken. Calculate and record the MDA on the appropriate survey form. Verify the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. In no case shall the background count time be less than the sample count time.
 4. Perform a scanning survey of the item. Concentrate survey measurements on areas most likely to be contaminated. The fraction of the total area scanned is subjective, based on technician experience, an item's use history, and RSO guidance. Typically, the scan frequency is a minimum of 10% of accessible surface areas.
 5. Obtain static measurements at locations with the highest potential for contamination. The number of survey points selected is subjective, based on technician experience, an item's use history, and RSO guidance. The count time should be consistent with the MDA calculation. A typical count times is one minute for digital scalers and until the meter reading stabilizes for analog ratemeters.

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6. Record and identify all locations surveyed on the appropriate survey form(s). The use of diagrams or sketches is recommended.
 - **Beta-Gamma Probe** - In high background areas it may not be possible to achieve the required survey MDAs. This should be noted on the survey cover sheet, and should be brought to the attention of the RSO.
 - **Alpha Probe** - The performance check background may be used in place of background count in the area to be surveyed. A good practice is to check the probe for light leaks or for faulty cables if positive results begin appearing.
7. All measurements shall be reported in units of “dpm” unless otherwise directed by the RSO. Examples include “dpm/100 cm²,” and “dpm/probe.”
8. Direct non-smearable hot spots may be averaged over 1 square meter to determine compliance with release levels. If the entire item is less than 1 square meter in area, the entire surface area may be averaged. Bolt on parts of a vehicle should not be considered separate items.
 - The method for determining an average activity is to mark a 1 square meter area on the piece to be surveyed that is roughly centered on the hot spot. Take 1 measurement at the highest activity point of the hot spot. Take 4 (or more) other measurements within the square meter at locations representative of the whole square meter. Record count-rate of each individual measurement. Calculate the activity of all measurements being averaged, including those that are less than the MDA and those with a calculated activity less than zero. Calculate the average of all measurements and record on the survey form.
9. Complete the appropriate survey form.

10.3 Removable Contamination

With RSO approval, removable contamination surveys may be disregarded, provided that direct survey measurements and instrument MDAs are below site removable contamination limits for release.

1. All items being surveyed shall be clean prior to being surveyed. All interior and exterior surfaces should be free from oil and visible dirt. The RSO may dictate the required degree of cleanliness, based on the purpose of the survey and the history of the item being surveyed.
2. Wipe each location of interest with moderate pressure area using a standard 1 ¾-inch swipe. The area wiped should be approximately 100 cm². Larger areas may be wiped. It can be inferred that if the wipe meets the required limit for 100 cm² when it was actually taken from a larger area, the object will pass the 100 cm² criteria. No special documentation is required if the wiped area exceeds 100 cm². If the object is smaller than 100 cm², the area of the entire object should be wiped.
3. Large area wipes (LAW), also commonly referred to by the trade name “Masslinn” may be used to supplement smear surveys for removable

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contamination. The use of LAWs should be documented on the survey form with the notation “LAW,” or equivalent.

4. Ensure each used swipe (i.e., smear or large area wipe) is handled, stored, and transferred in such a fashion as to prevent to loss of sampled material or cross-contamination with other personnel and other swipe samples.
5. Record the location of each wipe on the appropriate survey form. It is preferable to record the location by circling the sequential number location on a survey map where the wipe was taken.

10.4 Analyzing Swipes

1. Smear samples should be counted using available scintillation or gas-flow proportional laboratory counters, when practicable. Field instruments may be used for smear counting at the discretion of the RSO.
2. LAW samples may be counted using field instruments. The use of laboratory counters is inappropriate.
3. Determine and record the background count-rate. Calculate and record the MDA on the appropriate survey form. Verify the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. In no case shall the background count time be less than the sample count time.
4. Remove each swipe from the paper backing, as needed. The use of tweezers is recommended.
5. Place the swipe in the counter and close.
6. Count for the designated counting time.
7. Record the gross result under cpm in the appropriate column (either alpha or beta-gamma) of the survey form.
8. Calculate and record the activity. Removable contamination survey results shall be reported in units of “dpm” unless otherwise directed by the RSO. Examples include “dpm/100 cm²” and “dpm/LAW.”

10.5 Gamma Surveys

1. Routine gamma surveys may be used to detect the gradual buildup of gamma emitting contaminated materials in soils. This may occur at heavy equipment, heavy traffic, or egress points from contaminated areas. Normal uncontaminated trash should be gamma surveyed prior to leaving the site.
2. Obtain proper instrumentation for the survey. Ensure that the instruments are currently calibrated and have been performance checked prior to the survey.
3. Perform the survey with the appropriate detector using techniques specified by the RSO.
4. Complete the appropriate survey form.

10.6 Gamma Dose Rate Surveys

- Obtain proper instrumentation. Ensure that the instrument is currently calibrated and has been performance checked prior to the survey.

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- When entering areas with known radiation levels, select the appropriate scale.
 - Observe the meters as you enter the area. If necessary, change scales to maintain on-scale reading.
- Perform gamma dose rate surveys as follows:
 - Monitor dose rates from the lower thighs to head level, recording the highest level as General Area Dose Rate.
 - Monitor dose rates 30 cm (12 inches) from a significant radiation source recording the highest level as General Area Dose Rate.
 - Additional measurements are necessary to determine Transport Index for shipping per procedure PP-8-810, “Conveyance Survey.”
 - If dose rate sources are predominantly from overhead, then denote on survey.
 - Perform contact gamma dose rate measurements with the detector within ½-inch of the surface to be surveyed.
 - Additional measurement locations should be clearly identified in survey documentation.
 - Record all survey results on the appropriate survey form.

11.0 CALCULATIONS

11.1 Sample Activity

$$DPM = \frac{\left(\frac{TotalSampleCounts}{SampleCountTime} \right) - \left(\frac{TotalBkgCounts}{BkgCountTime} \right)}{(E)(A)}$$

where:

E = Instrument Efficiency
 A = Area correction factor, if applicable

11.2 Minimum Detectable Activity (MDA)

The following MDA equation is to be used for a background count time equal to the sample count time:

$$MDA = \frac{\left(3 + 4.65\sqrt{B} \right)}{(E)(A)(T_s)}$$

where:

T_s = Sample count time
 E = Instrument efficiency

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- A* = Area correction factor, if applicable
B = Background cpm

The following equation is to be used for a background count time equal to 5 or more times the sample count time:

$$MDA = \left(\frac{(3 + 3.29\sqrt{B})}{(E)(A)(T_s)} \right)$$

12.0 DOCUMENTATION

- Survey forms shall be completed in entirety. This includes attaching printouts, diagrams, or other supporting documentation, appending sequential page and survey tracking numbers, a review for completeness and accuracy, and appending the appropriate signatures of personnel performing the survey and / or analyzing samples.
- Once complete, the survey package shall be submitted to the RSO or designee, for final review and approval signature.
- Survey documentation shall be maintained according to established RP document control and retention requirements.

13.0 ATTACHMENT

Attachment 1 Acceptable Surface Contamination Levels

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Attachment 1

Acceptable Surface Contamination Levels

NUCLIDE^a	AVERAGE^{b c} dpm/100 cm²	MAXIMUM^{b d} dpm/100 cm²	REMOVABLE^{b e} dpm/100 cm²
U-nat, U-235, U-238 and associated decay products	5,000	15,000	1,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	15,000	1,000

Notes:

- ^a Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.
- ^b As used in this table, dpm means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
- ^c Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each object.
- ^d The maximum contaminated level applies to an area of not more than 100 cm².
- ^e The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

*Source:USCG / USEPA EM 385-1-80 Table 6-4 Acceptable Surface Contamination Levels, 1985.

Note: The acceptable surface contamination levels for Th-nat will be used unless subsequent sampling indicate the presence Ra-226, Ra-228, Th-230, Pa-231, or Ac-227 in concentrations greater than that of the parent nuclide. The RSO will determine if contamination limits should be modified for a specific activity or location based on available data.



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Unrestricted Release Requirements

NO.: RP-105

PAGE: 1 of 5

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This project procedure describes the method of surveying equipment, materials, or vehicles for release for unrestricted use at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This project procedure applies to all site personnel responsible for the unrestricted release of equipment and materials used in a Restricted Area. This procedure is not used for vehicles that are transporting radioactive materials. Vehicles conveying radioactive materials also must follow USDOT Regulation 49 CFR Part 173.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)"
3. NRC Regulatory Guide 1.86.
4. RP-104, "Radiological Surveys"

4.0 DEFINITIONS

CPM: Counts per minute

DPM: Disintegrations per minute

Equipment and Material: Equipment and material refers to any item used in a Restricted Area to support work activities (i.e., hand tools, heavy equipment, plastic, etc.).

LAW: Large Area Wipe (i.e., Masslinn)

Unrestricted Release: Release of equipment and / or material to the general public.

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5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Ensuring adequate staffing, facilities, and equipment are available to perform the survey tasks assigned to Radiation Protection personnel.
- Approving purchase or acquisition of equipment necessary to perform surveys.
- Ensuring that surveys take place in appropriately posted areas.
- Reviewing results of survey data as required to determine acceptability for release of items.
- Dispositioning materials that cannot be released based on survey results.
- Investigating and initiating corrective actions for the improper release of radiologically contaminated material.

5.2 Radiation Protection Technician (RPT)

- Identify equipment and material to be surveyed for unrestricted release.
- Performing and documenting contamination surveys.
- Posting, securing and controlling radioactive material that cannot be released.
- Releasing material in accordance with this and implementing procedures.

5.3 Project Personnel

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.

6.0 EQUIPMENT AND MATERIAL

- Alpha Detector
- Beta-Gamma Detector
- Portable Ratemeter / Scaler
- Scintillation or Gas-Flow Proportional Lab Alpha / Beta Counter
- Survey forms
- Cloth smears
- Masslinn™ type cloths

7.0 INSTRUCTIONS

7.1 General Instructions

Prior to conducting any surveys, ensure that all survey instrumentation has been response checked, is in operating within control limits and has not been removed from service.

- Response checks shall be performed daily.
- Background measurements are to be taken prior to use at the point of use. The background count time shall be greater than or equal to the sample count time.

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- Verify that the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. Refer to RPP-104, “Radiological Surveys,” for the MDA calculation.
- Survey results are converted from counts per minute (cpm) to disintegrations per minute (dpm). A sample “cpm to dpm” calculation is attached for review and use at the end of this procedure.

7.2 Release of Items for Unrestricted Use

1. Surveys for both total and removable contamination shall be made in accordance with Section 7.3 (below) on all equipment, materials or vehicles which have either been in a Restricted Area or which may be potentially contaminated.
2. With RSO approval, removable contamination surveys may be disregarded, provided that direct survey measurements and instrument MDAs are below site removable contamination limits for release.
3. RP personnel will determine which items located outside a Restricted Area may be potentially contaminated based on their use, site history, or previous survey data. The potential for these objects to have become contaminated by airborne radioactive materials must be considered. This could include items that are used to support site activities, such as office equipment, cleaning devices, furniture, trailers, etc., even though direct contact may not have occurred.
4. Items which have a potential for internal contamination of inaccessible surfaces shall be evaluated by the RSO or designee prior to release.
5. All items to be released shall be surveyed in such a manner as to fully demonstrate that accessible surfaces comply with the surface contamination release criteria specified in RP-104, “Radiological Surveys.”
6. Items that do not meet release criteria shall be decontaminated until release criteria is met or shall be disposed of as radiological waste.
7. Air intakes / filters on motorized equipment should be surveyed as an indicator of potential internal contamination. Notify the RSO or designee if air intake / filter surfaces indicate the presence of contamination. Contaminated air filters shall be removed and disposed of as radiological waste.
8. To the extent practicable, visible dirt and mud or other material shall be removed from surfaces prior to survey.
9. The RSO or designee, shall review all survey data prior to the release from the Controlled Area.

7.3 Direct Surveys Scans and Static Measurements

1. Surfaces shall be dry and cleaned, to the extent practicable prior to performing direct alpha measurements.
2. The RSO may authorize the short-term relocation or staging of equipment / vehicles for direct measurements in any portion of the Controlled Area. This is provided that the item has been verified to be clean of removable

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- contamination prior to removal from a Restricted Area and fixed contamination producing general area dose rates greater than 0.2 mrem/hr is not anticipated.
3. Alpha detectors should be placed within ¼-inch of the surface to be surveyed. Beta detectors should be placed within ½-inch of the surface to be surveyed. Use caution to not contaminate or damage the detector surface.
 4. Perform a scanning survey of the item. Concentrate survey measurements on areas most likely to be contaminated. The fraction of the total area scanned is subjective, based on technician experience, an item's use history, and RSO guidance. Typically, the scan frequency is a minimum of 10% of accessible surface areas.
 5. Obtain static measurements at locations with the highest potential for contamination. The number of survey points selected is subjective, based on technician experience, an item's use history, and RSO guidance.
 6. Static measurement count times shall be appropriate for desired MDAs. Typical count times are one minute for digital scalers and until the meter reading stabilizes for analog ratemeters.
 7. Record and identify all locations surveyed on the appropriate survey form(s). The use of diagrams or sketches is recommended.
 8. All measurements shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100 cm²" and "dpm/probe."

7.4 Removable Contamination Surveys

1. "Cloth" smears shall be used for smear surveys.
2. A notation (e.g., smear number, date, time, location, etc.) should be made on the smear envelopes to ensure proper smear tracking. Smears may also be numbered using a pen or marker prior to use.
3. Using moderate pressure, swipe an area of 100 cm² (4-inch square area or equivalent) of the surface at the selected location. Smear surveys should be performed at the same location that direct surveys were performed.
4. Large Area Wipes (LAW), also commonly referred to by the trade name "Masslinn," may be used to supplement smear surveys for removable contamination. The use of LAWs should be documented on the survey form with the notation "LAW" or equivalent.
5. Ensure each used swipe (i.e., smear or large area wipe) is handled, stored, and transferred in such a fashion as to prevent to loss of sampled material or cross-contamination with other personnel and other swipe samples.
6. Smear samples should be counted using available scintillation or gas-flow proportional laboratory counters, when practicable. Field instruments may be used for smear counting at the discretion of the RSO.
7. LAW samples may be counted using field instruments. The use of laboratory counters is inappropriate.
8. Removable contamination survey results shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100cm²" and "dpm/LAW."

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9. Ensure all results are documented on the appropriate survey form. Lab printouts may be attached and referenced on the survey form.

8.0 CALCULATIONS

MDA and Sample Activity formulas are located in RPP-104, "Radiological Surveys."

9.0 DOCUMENTATION

- Survey forms shall be completed in entirety. This includes attaching printouts, diagrams, or other supporting documentation, appending sequential page and survey tracking numbers, a review for completeness and accuracy, and appending the appropriate signatures of personnel performing the survey and / or analyzing samples.
- Once complete, the survey package shall be submitted to the RSO or designee, for final review and approval signature.
- Survey documentation shall be maintained according to established RP document control and retention requirements.

10.0 ATTACHMENT

None



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Survey Documentation and Review

NO.: RP-106

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure establishes consistent methodology for documenting radiological surveys and provides criteria for the review of these surveys.

2.0 APPLICABILITY

This procedure is applicable to all radiological surveys excluding air samples.

3.0 REFERENCES

1. 10 CFR 20, "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)"
3. RP-104, "Radiological Surveys."

4.0 GENERAL

4.1 Discussion

The results of surveys will be documented on survey forms or in designated logs as approved by the Radiation Safety Officer (RSO). Survey data will contain enough detail to provide personnel with adequate information concerning radiological conditions existing in the area surveyed.

The RSO or designee will review completed survey documentation to ensure appropriate, adequate and complete information is recorded. The individual reviewing the survey will ensure that the recorded results are legible, in accordance with Radiological Protection Program (RPP) implementing procedures, consistent with anticipated levels, and will determine the reason for any variances.

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4.2 Definitions

Airborne Radioactivity Area (ARA): Means any area where the measured concentrations of airborne radioactivity above natural background exceed, or are likely to exceed, 25% of the Derived Air Concentration (DAC) values listed in 10 CFR 20, Appendix B, Table I, Column 3.

Contamination Area (CA): Means any area accessible to personnel with loose surface contamination values in excess of the values specified in RP-104 , “Radiological Surveys, or any additional area specified by the Radiation Safety Officer (RSO). The Contamination Area posting requirement is more restrictive than the Radioactive Material Area posting requirement. Any area posted as a Contamination Area shall also be considered to be a Radioactive Materials Area.

Contact Dose Rate: A radiation dose rate as measured at contact or within 1/2 inch of the surface being measured.

General Area Dose Rate (GA Dose Rate): The highest radiation dose rate accessible to any portion of the whole body measured at a distance of 30 cm (12 inches) from a significant radiation source or combination of sources.

Radiation Work Permit (RWP): Means a document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions, which exist in the work area and the radiological requirements for the job.

Radiation Area (RA): Means any area, accessible to personnel, where the whole body dose rate can exceed 5 mrem in 1 hour at 30 cm from the source.

Radioactive Material: Material activated or contaminated by the operation or remediation activities and by-product material procured and used to support the operations.

Radioactive Materials Area (RMA): Any area or room where quantities of radioactive materials in excess of 10 times the 10 CFR 20, Appendix C quantities are used or stored, or any area designated by the RSO which does not exceed the site Contamination Area criteria.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- The Radiation Safety Officer (RSO) or designee is responsible for reviewing radiological surveys performed by Radiation Protection Technicians (RPT).

5.2 Radiation Protection Technician (RPT)

- RPTs are responsible for documenting surveys in a legible manner on approved forms.

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6.0 PREREQUISITES

- Surveys for radiation and contamination have been performed in accordance with RP-104 “Radiological Surveys”.

7.0 PRECAUTIONS AND LIMITATIONS

- Surveys for airborne radioactivity will be documented in accordance with RP-107, “Measurement of Airborne Radioactivity.”

8.0 APPARATUS

Survey Forms

9.0 RECORDS

- PESI Survey Form (Attachment 1)
- PESI Survey Log Number Form (Attachment 2)
- Radiation Protection Technician (RPT) Logbooks

10.0 PROCEDURE

The methods outlined in this procedure are intended to assure the clear and concise transfer of survey information. Variations or deviations from the protocols in this procedure are permitted if the clear transfer of information is maintained.

10.1 Documentation

10.1.1 General

1. Record all information on survey forms in a neat and legible manner.
2. Document all surveys on a form with approved project heading. Technician logbooks may be used for documenting surveys (e.g., daily routines, material transfers, minor posting changes, etc.) as authorized by the RSO and providing instrument serial numbers are documented with survey data.
3. When recording information on survey forms, check all appropriate boxes and circle all appropriate answers.
4. Use a survey form with pre-drawn diagrams when available. If not, draw a diagram or picture of the object surveyed. Should a diagram not be appropriate, use a lined survey form.
5. Assign the next sequential survey number to the survey from the survey number logbook.
6. Complete the following information for all surveys:
 - Date and time of survey
 - Location of survey
 - Instrument type and serial numbers and associated supporting information (i.e., detector efficiencies, calibration dates, background values, etc.)
 - HWP number, if applicable
 - Reason for survey

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- Name and signature of surveyor
7. Indicate Radiological Hazard Area boundaries on the survey form using x's and -'s (-x-x or **).
 8. Note the posted Radiological Hazard using common designator such as
 - Contamination Area = CA
 - Radiation Area = RA
 - Radioactive Material Area = RMA
 - Airborne Radioactivity = ARA
 9. The use of Greek alphabet and other nuclear industry standard nomenclature (e.g., “k” = 1000) is acceptable when documenting surveys.

10.1.2 Survey Log Number Book:

1. Survey log number book is to be used to assign a unique sequential number to each survey form package. This number provides the ability to track individual surveys as well as ensuring the submittal of a complete documentation package for archiving.
2. Unless otherwise directed by the RSO, survey numbers will be assigned with the following format:

NFSSyyRS.xxxx

“NFSS” corresponds to “Niagara Falls Storage Site,” yy is the last two digits in the year, “RS” refers to “Radiological Survey,” and xxxx refers to the sequential survey number.

3. As surveys are generated, the RPT will take the next sequential number on the form and fill in the remaining boxes with a brief description of the reason for the survey as well as the date and RPT’s initials.

10.1.3 Radiation Surveys

1. Indicate GA dose rates by underlining the radiation level on the Survey Form at the appropriate location (Example: 25 uR/hr).
2. Indicate CONTACT dose rates by recording the radiation level with an asterisk on the Survey Form at the appropriate location (Example: * 25 ur/hr). If there are corresponding 30 cm and GA readings, document them as follows:

* CONTACT / @ 30 cm / GA

3. Use a legend to inform the reviewer of any other notation utilized or if deviating from standard protocol.

10.1.4 Contamination Surveys

1. Indicate survey locations by placing sequential numbers within a circle on the Survey Sheet. The Survey Sheet has corresponding direct and transferable columns for both alpha and beta / gamma activity.
2. Use a legend to inform the reviewer of any other notation utilized or if deviating from standard protocol.
3. The use of the letter “k” to indicate units of a thousand is acceptable.

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10.2 Technician Review and Evaluation

- 10.2.1 After completing the surveys, evaluate the results against previous surveys or anticipated results.
- 10.2.2 Verify that radiological boundaries and postings are correct in accordance with RPP-102, "Radiological Posting Requirements."
- 10.2.3 Take any immediate actions required based on survey results.
- 10.2.4 Ensure all relevant supporting documentation (e.g., count room print-outs, etc.) are attached to the survey package and that the package is properly paginated.
- 10.2.5 Submit documentation to the RSO or designee for supervisory review.

10.3 Supervisory Review

- 10.3.1 Ensure that the survey form is complete and legible.
- 10.3.2 Ensure that all required information has been completed.
- 10.3.3 Ensure that any changes, single line cross-outs, or deletions are initialed and dated at time performed.
- 10.3.4 Verify that results are consistent with those anticipated.
- 10.3.5 If results are not consistent, ensure that appropriate actions have been taken to explain the results or re-examine the area.
- 10.3.6 Sign-off in the appropriate review section of the survey form and submit package to RP Document Control for retention / transmittal to Project Files.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 PESI Survey Form (Typical)

Attachment 2 PESI Survey Log Number Form (Typical)



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Measurement of Airborne Radioactivity

NO.: RP-107

PAGE: 1 of 12

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure establishes the basis and methodology for the placement and use of air monitoring equipment, as well as the collection, analysis, and documentation of air samples. Radiological air sampling and analysis is performed to monitor concentrations of radionuclides in the air for purposes of tracking internal radiation exposure to occupational radiation workers, determining appropriate respiratory protection devices, establishing radiological posting boundaries, verifying effluent airborne radioactivity concentrations, and providing information on radiological conditions in the work area.

2.0 APPLICABILITY

This procedure applies to all radiological air monitoring activities performed in support of Perma-Fix Environmental Services (PESI) activities.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
2. Perma-Fix Environmental Services (PESI), "Radiation Protection Plan (RPP)"
3. Rock, R.L., *Sampling Mine Atmospheres for Potential Alpha Energy Due to the Presence of Radon-220 (Thoron) Daughters*, Informational Report No. 1015, United States Department of the Interior, Mining Enforcement and Safety Administration, 1975.
4. Kusnetz, H.L., *Radon Daughters in Mine Atmospheres, A Field Method for Determining Concentrations*, Am. Ind. Hyg. Assoc. Quat., Vol. 17, No. 87, 1956.
5. ANSI N13.1, *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities*.
6. *Regulatory Guide 8.25, Air Sampling in the Workplace*.
7. 29 CFR 1910.1096, *United States Occupational Health & Safety, Ionizing Radiation*.

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4.0 DEFINITIONS

Airborne Radioactivity: Radioactive material in any chemical or physical form that is dissolved, misted, suspended, or otherwise entrained in air.

Ambient Air: Air in the volume of interest, such as room atmosphere, as distinct from a specific stream or volume of air that may have different properties.

Annual Limit on Intake (ALI): The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent (CEDE) of 5 rems or a committed dose equivalent (CDE) of 50 rems to any organ or tissue.

Breathing Zone (BZ): A uniform description of the volume of air around the worker's upper body and head which may be drawn into the lungs during the course of breathing.

Committed Dose Equivalent (CDE): The dose equivalent to tissues or organs of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed Effective Dose Equivalent (CEDE): The sum of committed dose equivalents (CDEs) to various tissues in the body, each multiplied by the appropriate weighting factors found in 10 CFR 20.

Derived Air Concentration (DAC): The concentration of a given radioactive nuclide in air which, if breathed by the reference man for a working year of 2000 hours under conditions of light work (1.2 m³ of air per hour), would result in an intake of one (1) ALI.

DAC-hour (DAC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide in hours. A facility may take 2000 DAC-hr to represent 1 ALI.

Grab Sample: A single sample of ambient air collected over a short time.

Maximum Permissible Concentration (MPC): That concentration of radionuclides in air or water that will result in the Maximum Permissible Body Burden or Organ Burden and result in a whole body or organ receiving the annual dose limit if breathed in by a worker for 2000 hours.

Monitoring: The measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation.

MPC-hour (MPC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the MPC for each radionuclide) and the time of exposure to that radionuclide in hours.

Occupational Dose: An individual's ionizing radiation dose (external and internal) received as a result of that individual's work assignment.

Protection Factor: The degree of protection given by a respirator. The protection factor is used to estimate radioactive material concentrations inhaled by the wearer and is expressed as the ratio

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of ambient concentration of airborne radioactive materials to the concentration that can be maintained inside the respirator during use.

Representative: Sampling in such a manner that the sample closely approximates both the amount of activity and the physical and chemical properties of the material (e.g., particle size and solubility in the case of aerosol to which workers are exposed). Air sampling performed within the Breathing Zone (BZ) is considered representative of the airborne radioactive material concentration inhaled by the worker.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Manages the implementation of this procedure.
- Ensures technicians performing activities under this procedure are competent and have sufficient experience to perform assigned tasks.

5.2 Radiation Protection Technician (RPT)

- Initiates, collects, submits, counts, and documents air samples according to the requirements of this procedure, and the SSHP.
- Ensures he / she has sufficient experience and / or knowledge to perform assigned duties under this procedure.

6.0 PRECAUTIONS AND LIMITATIONS

- Running air samplers for extended periods may cause excessive dust loading of the filter media. The frequency of filter change-out should be increased if excessive dust loading is observed.
- Air samplers shall not be used in combustible / explosive atmospheres.
- Air sampling and sample counting equipment shall not be operated beyond their respective calibration periods.
- Air samples shall be taken in such a manner as to not contaminate the filter with materials that were not airborne during the sample interval or by re-suspension of loose contamination from surfaces near the sampling head.
- Sampler exhaust may cause the re-suspension of loose surface contamination if the sampler is positioned improperly.
- Consider higher volume air samplers when covering short duration tasks.
- The decision to provide individual monitoring devices to workers is influenced by the expected levels of intake, likely variations in dose among workers, and the complexity of measurement and interpretation of results.

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7.0 ACTION STEPS

7.1 Air Monitoring Methods

1. Utilize the following monitoring methods to implement the radiological air monitoring program:
 - General Area (GA) Air Monitoring
 - Breathing Zone (BZ) Air Monitoring
 - Passive Radon Monitoring
 - Particulate Radon Grab Samples
 - Perimeter Monitoring, frequently referred to as Air Environmental (AE)
2. Air sampling equipment should be placed so as to:
 - Not directly contact a contaminated (transferable) surface.
 - Minimize interference with the performance of work.
 - Be easily accessible for changing filters and servicing.
 - Be downstream of potential release points.
 - Minimize the influence of supply airflow.
3. An airflow study of any indoor area to be monitored should be performed prior to placement of the sampler (other than BZ samplers). Additional studies should be performed after changes in the work area setup, ventilation systems, or seasons, if seasonal changes may affect airflow patterns.
4. Perform BZ air sampling in occupied areas where, under typical conditions, a worker is likely to be exposed to an air concentration of 10 % or more of the DAC.

7.2 General Area (GA) Air Sampling

1. GA samples are typically taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. GA sampling shall be performed with instrumentation operating at volumes capable of meeting the Minimum Detectable Concentration (MDC) values established in the Technical Basis Document for Dosimetry and Air Sampling.
3. GA samples should be collected:
 - During work activities as a supplement to Breathing Zone (BZ) sampling as deemed appropriate.
 - At site boundaries to confirm effluent air discharge concentrations. These are the Air Environmental (AE) type samples.
 - At discharge points to determine the worst case airborne radiological conditions.
4. Document airflow studies, if performed in the appropriate project logbook or as directed by the RSO.

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5. Select a calibrated low / high volume sampler with the appropriate glass fiber air filter and place the sample head into position. The fuzzy side of the filter should face outwards.
6. Turn the sampler ON. At a minimum, document the following information on the air filter envelope or log sheet:
 - Sampling station identifier (as determined by the RSO)
 - Sampler model
 - Serial number
 - Date / time on
 - Flow rate
 - On by (individual starting sampler)
7. When air monitoring is complete, observe the sampler flow rate and turn the sampler off. At a minimum, document the following information on the air filter envelope or logsheet:
 - Date / time off
 - Flow rate
 - Off by (individual terminating sample)
8. Remove and / or replace the sample head and filter using caution to prevent cross-contamination.
9. Store the filter in a protective container to minimize the loss of collected material.
10. Submit sample to counting lab for analysis.

7.3 Breathing Zone (BZ)

1. Specific instructions on the use and calibration of Lapel Samplers are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Collect BZ samples during entries into posted airborne radioactivity areas and during activities which have a reasonable potential of producing airborne radioactivity (e.g., excavating contaminated soils, surface destructive activities on surfaces with fixed contamination) as determined by the RSO.
3. Position the sampler on the individual representative of the worst-case exposure for the group if a single lapel sampler is used for multiple members of a work group. Base this selection on operating experience and consultation with the RSO. A single lapel sampler should be used for a group of no more than four workers spending greater than one hour in the work area under the same RWP.
4. Ensure the sample head is positioned as close to the breathing zone as practical without interfering with the work or the worker.
5. Operate lapel samplers according to the appropriate instrument use procedure. At a minimum, document the following information on the air filter envelope or log sheet:
 - Wearer's name(s)
 - Applicable Hazardous Work Permit (HWP) number

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- Sampler model / serial numbers
 - Date / time On
 - Flow rate (sampler must be running)
 - On by (individual starting sampler)
6. Upon exit from the work area, note the flow rate, turn the sampler OFF and detach from the worker / object. Note that sampling may be suspended / restarted during the workday to facilitate break periods. Accurate volume tracking is crucial during these periods of non-operation.
 7. Perform necessary post-operation sampler checks according to the specific instrument use procedure.
 8. Carefully, remove the air filter from the sample head and place in air filter envelope. Complete the pre-printed air filter envelope or sample log sheet:
 - Date / time off
 - Flow rate
 - Off by (individual stopping sampler)
 9. Submit sample to Counting Room for analysis.

7.4 Radon and Thoron Progeny

1. High volume or low volume grab samplers such as HV-1, LV-1, or RAS-1 (typically in the 35-75 lpm range) should be used for collecting radon and thoron samples.
2. Radon and thoron samples should be collected:
 - During work activities as deemed appropriate by the RSO or designee.
 - At restricted area boundaries as deemed appropriate by the RSO or designee.
 - Each frequently occupied work location should have its own samplers.
 - Airflow patterns should be considered in placing samplers so that the sampler is likely to be in the airflow downstream of the source.
 - A simultaneous background sample shall be taken upwind of all activities when radon and thoron sampling is performed. This sample is critically important.
 - When collecting a radon and thoron breathing zone sample, the sampler should be located in the breathing zone for the worker. Preferably it should be held immediately downwind of the worker and moved around with the worker.
3. Select a calibrated high volume sampler with a 47 mm filter and place the sample head into position. The preferred filter is a membrane filter such as the F&J Specialty Products, Inc. model number A020A047A or equivalent. Alternatively, a glass fiber filter such as the F&J Specialty Products, Inc. model number AE-47 or equivalent can be used

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4. Turn the sampler ON and complete the required information on the air filter envelope to include:
 - RWP number, if appropriate
 - Sampler model and serial number
 - On date, time, and flow rate
 - On by (site worker initials)
 - Sample location
5. Collect a sample for exactly 5 minutes, with no more than a 5-second uncertainty. Exercise caution when handling sample head so as not to cross-contaminate the air filter.
6. Remove air filter from sample head and place in air filter envelope. Complete the required information on the air filter envelope including:
 - Off date, time, and flow rate
 - Site worker stopping the sampler
7. Submit the sample to the counting room within 30 minutes after collection. Samples must be counted between 40 and 90 minutes, or they will be void.
8. Analyze the sample in accordance with Sections 8.1 or 8.2, whichever is appropriate.
9. Alternate industry-accepted methods for Radon-Thoron monitoring may be used at the discretion of the RSO with concurrence from the Project Certified Health Physicist.

7.5 Perimeter Environmental Air (AE) Sampling

1. Perimeter samples are taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Perimeter samples are collected to verify compliance with off-site release criteria.
3. Samples are collected at locations designated by the RSO. The air sampling locations should be established at the most likely downwind perimeter boundary, as determined by evaluation of local meteorological data, and / or the nearest perimeter boundary from active work areas.
4. Perimeter samplers should be operated 24 hours a day 7 days a week if possible.
5. Filters from continuously operating perimeter air samplers are normally changed out weekly. Filter change-out of perimeter air samplers will be performed at a frequency long enough to ensure acceptable counting statistics and short enough to maintain consistent sampler flow rates.
6. Perimeter sampler operation shall be verified on a daily basis around locations when airborne generating activities are in progress. This requirement may be relaxed by the RSO for samplers with data logging capability.

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7. Document daily verification (i.e., flow rate) and notify the RSO of any discrepancies. Replace filter and investigate pump operation if daily flow rates vary by greater than 20%.
8. Any sampler that is out of service due to malfunction for more than 1 hour and any invalid samples should be brought to the attention of the RSO.
9. Samples are to be collected in accordance with Section 7.2, Steps 5-10.

7.6 Passive Radon Monitoring

1. Passive radon monitoring methods include the use of either alpha track-etch detectors or electrets.
2. Detectors should be placed for a length of time, so that the minimum detectable concentration is 0.1 pCi/l or less, following manufacturer guidelines. The length of placement is generally 1 month or greater. Locations selected should be representative of the breathing zone, when practical. A simultaneous background sample should always be taken at a location unaffected by site activities. This sample is critically important.
3. Open the bag containing the detector and place the detector in a protective container to allow for air circulation. Follow manufacturer guidelines to activate the detector, as necessary.
4. Record in the logbook:
 - Sample location
 - Date and time of placement
 - Serial number of the detector
 - Initials of the worker placing the detectors
5. Ship the detector to the manufacturers processing center to read the results.

8.0 ANALYSIS OF AIR SAMPLES

General Area (GA), Breathing Zone (BZ), and Perimeter Air (PA) samples should be submitted to a counting room or off-site laboratory for gross alpha/beta analysis. Samples may be sent to an outside laboratory for isotopic analysis as necessary per the RSO.

8.1 Analysis for Radon and Thoron Progeny from a 5-Minute Low Volume Grab Sample

- 8.1.1 Count the sample twice for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The first count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of sample collection. The second count should start at least 5 hours after the end of the count, but not greater than 17 hours after the end of the first count. Count the sample for 5 minutes each time.

NOTE: It is not recommended that a gas flow proportional counter be used for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

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Measurement of Airborne Radioactivity	PAGE: 9 of 12

- 8.1.2 Calculate the thoron progeny (TDC) in working levels from the delayed (second) count as follows:

$$TDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Th}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Th} = Working level factor from Graph 1 (Attachment 1).

- 8.1.3 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{\left(\frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF} - TDC \times 16.5 \right)}{F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

TDC = Thoron Progeny determined from second count.

8.2 Alternate Method for the Analysis of Radon Progeny from a 5-Minute Low Volume Grab Sample

This section only applies to the determination of radon and not the determination of thoron.

- 8.2.1 Count the sample once for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of the count. Count the sample for 5 minutes.

NOTE: It is not recommended to use a gas flow proportional counter for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

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8.2.2 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

9.0 REPORTS

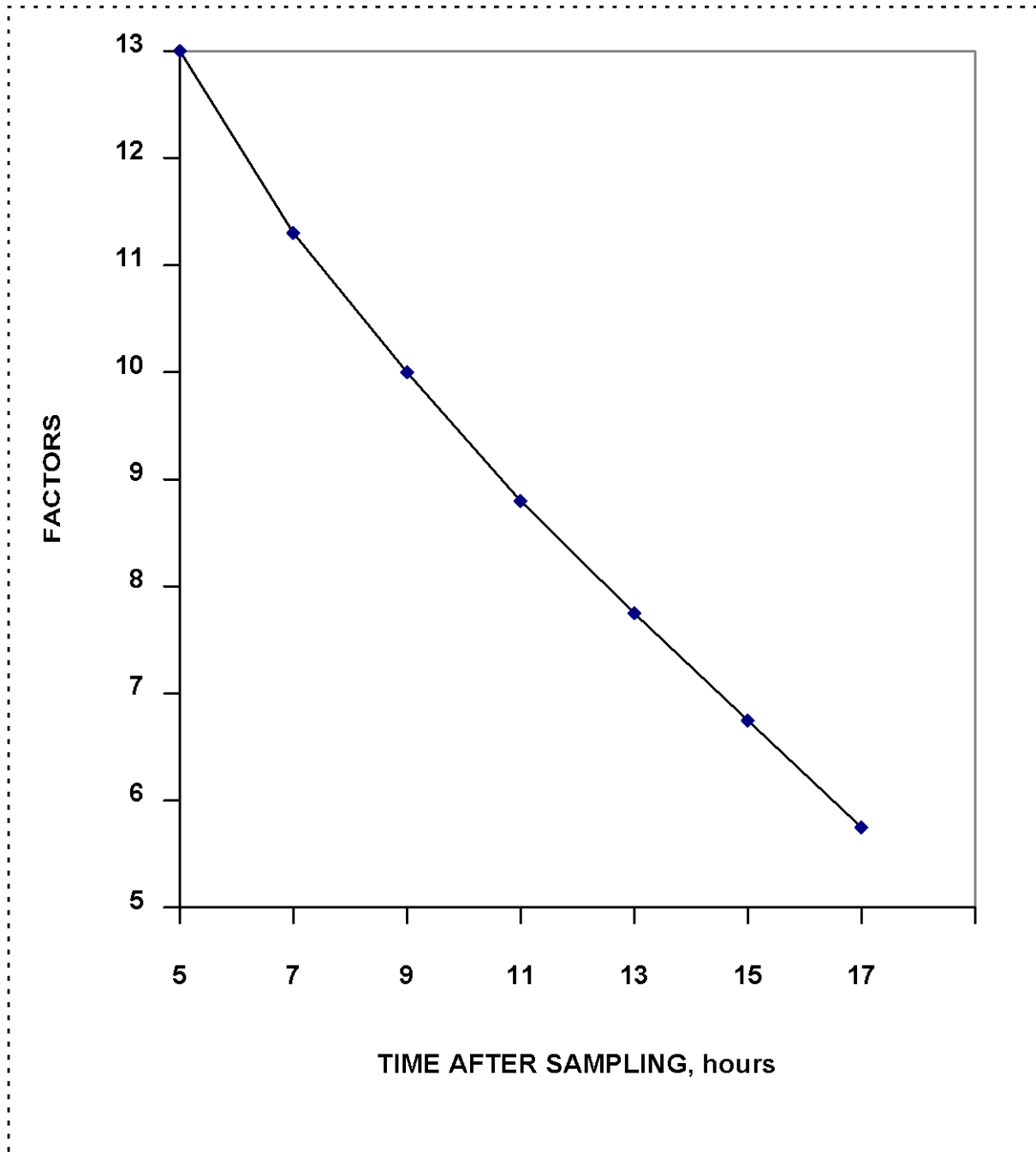
Maintain air monitoring instrument data, sampling data, and analysis results as a quality record.

10.0 ATTACHMENTS

Attachment 1 Graph 1, Thoron Working Level Factors

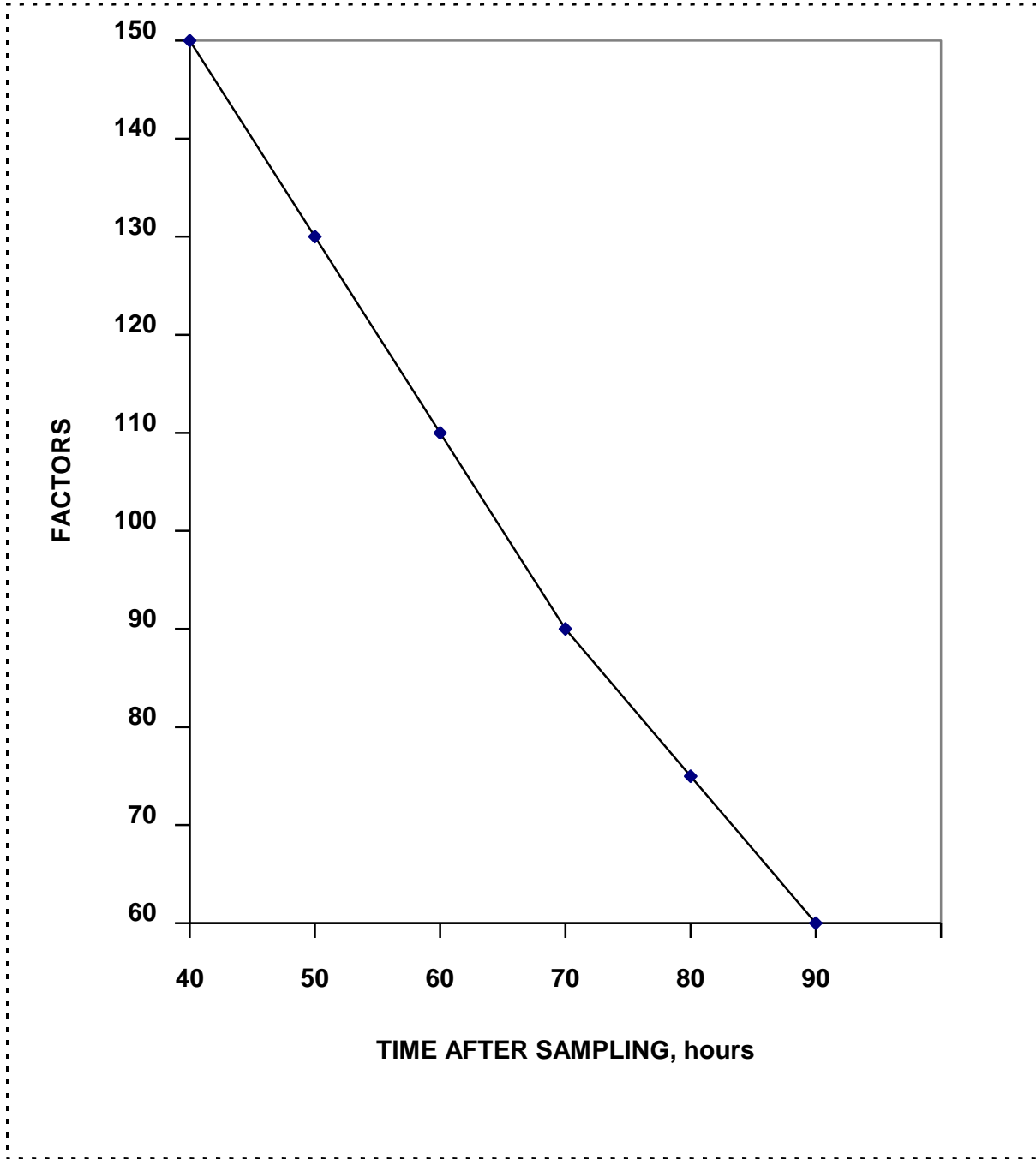
Attachment 2 Graph 2, Radon Working Level Factors

ATTACHMENT 1
GRAPH 1, THORON WORKING LEVEL FACTORS



Time factors versus time after sampling for thoron daughter samples.

**ATTACHMENT 2
GRAPH 2, RADON WORKING LEVEL FACTORS**



Time factors versus time after sampling for radon daughter samples.



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Count Rate Instruments

NO.: RP-108

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure specifies the methods for set-up, daily pre-operational check, and operation of portable count-rate survey instruments. These instruments are used for the detection of radioactivity on personnel, on or within material surfaces, and in the environment. This procedure does not include associated instrument calibrations or cover the operation of exposure rate instruments.

2.0 APPLICABILITY

This procedure specifically addresses those meter-probe combinations that report values in units of counts or counts per minute (cpm) such as Ludlum Measurements models 2221 and 2241 Scaler-Ratemeters; and the Ludlum Model 177 Alarming Ratemeter or equivalent. These meters are mated to probes including the Ludlum Model 44-10, 44-20, and 44-62 NaI Detectors, the Ludlum Model 43-5 Alpha Scintillation Detector, and the Ludlum Model 44-9 Pancake Geiger-Mueller detectors or equivalent. Additional equivalent meters and probes may be used under this procedure without revision as approved by the RSO.

3.0 REFERENCES

1. ANSI N323A-1997, Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments.
2. Instrument Technical Manuals.
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)
4. RP-104, Radiological Surveys

4.0 DEFINITIONS

cpm: counts per minute

DFSCL: Daily Field Source Check Logsheet.

dpm: disintegrations per minute

HV: High Voltage

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MDA: Minimum Detectable Activity

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Reviewing and approving changes to this procedure and ensuring compliance with applicable regulations.
- Ensuring an adequate inventory of Radiation Protection instruments are available to support remediation activities.
- Overseeing the issue, control, and accountability of Radiation Protection instrumentation per the requirements of this procedure.
- Ensuring transmittal of all issue, control and accountability records to the appropriate document control authority when applicable.

5.2 Radiation Protection Technician (RPT)

- Maintaining instrument documentation and records as required by this procedure.
- Maintaining adequate instrument and equipment availability.
- Verifying current calibration and response test dates prior to issue or use of instruments.
- Promptly returning instruments to their proper location when work is complete.
- Ensuring that instruments are properly surveyed for contamination and decontaminated as necessary after use.

6.0 PREREQUISITES

- Only personnel with appropriate documented training shall issue or use RP instrumentation.
- Instruments and detectors shall be inspected for mechanical damage, and response tested prior to issue.
- Any instrument to be used shall have a current calibration label affixed to the instrument.

7.0 PRECAUTIONS AND LIMITATIONS

- Portable count rate survey instrumentations are susceptible to damage from physical and environmental stresses.
- QA/QC requirements established by an approved survey plan (e.g., Master Final Status Survey Plan) supercede the requirements of this procedure.

8.0 APPARATUS

- Appropriate survey instruments

9.0 RECORDS

- Portable Instrument Set-Up Sheet
- Daily Field Source Check Logsheet

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10.0 PROCEDURE

10.1 General

1. Ensure the meter-probe combination selected is within their acceptable calibration periods. The swapping of probes between meters is permitted, but not encouraged. The following precautions and limitations must be observed and the following action steps must be taken:
 - If the meter-probe combination is calibrated as a set, Probe swapping is not permitted, without specific RSO approval.
 - The HIGH VOLTAGE (HV) and THRESHOLD settings for the meter-probe combination shall be identical. Note that the Ludlum 177 and 2241 do not have user adjustable settings for HV and THRESHOLD.
 - An initial set-up must be performed for each meter-probe combination prior to field use.
 - A source with known pedigree must be counted to verify the efficiency is within 10% of the calibrated efficiency, as applicable.
2. The RP Group will coordinate the calibration of boxes and probes on a minimum annual basis and after major repair operations. Battery and / or cable change-outs do not require re-calibration. Calibration procedures are outside of the scope of this instruction.
3. Pre-operational checks are required daily prior to use. Post-operational checks are performed as specified in work plans or procedures. Instruments used in the performance of daily activities do not normally require a post-operational check..
4. Instruments that fail operational checks or malfunction during use should be tagged or labeled “Out-of-Service” or “Do Not Use” and segregated from operational instruments. If possible, describe the problem on the tag / label and add initials and date.
5. Instruments leaving RP Group control (i.e., repair, calibration, excess, etc.) shall be surveyed for unconditional release according to the contamination criteria established in Table 1 of the Site RPP. The repair / calibration center may request a copy of the survey accompany any shipments of RP instruments.
6. Ensure meters with a “WINDOW” or “WIN” setting are set to “OUT.”
7. Instruments may be operated in the FAST response mode if necessary. This setting is recommended if the audible response cannot be heard. SLOW response shall be used when performing instrument set-up and operational checks.
8. Ludlum NaI crystals are located in the end of the probe opposite of the cable connection. Use this end for surveys.
9. Calibration stickers are attached to the instruments and detectors. Illegible stickers should be replaced prior to instrument use.
10. Instrument set-up and subsequent operational checks should be performed in the same location, with consistent temperature and background radiation levels.

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11. Source positioning devices (i.e., jigs) may be used to ensure a reproducible geometry between instrument checks. Source geometry must be consistent between initial instrument set-up and subsequent operational checks.
12. Instruments that do not have scaler capability should be set-up and checked by replacing 1-minute timed counts with static count rate measurements. Each static measurement should last until the meter reading fully stabilizes.

10.2 Instrument Set-Up

1. Inspect the meter-probe combination for physical damage or defect.
2. Complete Section A of the Portable Instrument Set-Up Sheet (Attachment 1).
3. Perform 10 1-minute source counts alternating with 10 1-minute background counts. Remove / replace the source and reposition the probe after each count. During alternating background counts, ensure that the source is sufficiently shielded so as not to impact background values.

NOTE: Counts (Source and Background) performed with a Ludlum 43-5, or other large surface area probe, should be alternated between the Heel, Center, and Toe Positions, if the source surface is smaller than the active surface area of the probe. Instrument response can vary greatly across the probe surface.

4. Document each count on the Portable Instrument Set-Up Sheet.
5. Calculate and record the net count value by subtracting the corresponding background count from each source count.

NOTE: Determining Sigma (Standard Deviation) values is useful when specific plans or activities require higher data quality objectives and / or when the development of control charts is necessary.

6. Calculate and record the following values from the obtained background counts:
 - Avg. Value (Sum of values / # of counts)
 - Sigma Value (Standard Deviation of all counts)
 - 20% Value (Avg. Value * 0.20)
7. Calculate and record the +/- 20% Values and the +/- 1,2, and 3 Sigma values using the AVG. VALUE as a reference point.
8. Repeat the previous two steps for determining NET COUNT acceptable ranges. The 3 Sigma value must be less than the +/- 20% value.
9. Obtain a blank Daily Field Source Check Logsheet (DFSCCL) (Attachment 2) and transfer the instrument, source, and acceptable range data, as applicable, from the Portable Instrument Set-Up Sheet.
10. Place the DFSCCL in the designated use location and forward the completed Portable Instrument Set-Up Sheet and submit to the RSO, or designee for review.
11. Ensure sources are stored properly after use in the designated source storage location.

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10.3 Operational Check

1. Obtain the selected meter-probe combination and corresponding DFSC (Attachment 2).
2. Record the date and time on the DFSC.
3. Perform and document the following checks on the DFSC, as applicable:
 - Perform a physical inspection. Observe for instrument damage. Alpha probes should be checked for light leaks by inverting the probe face towards a light source and observing instrument response. If the instrument fails to respond at all or over-responds this may be an indication of a light leak and should be investigated further, prior to proceeding.
 - Perform a battery check. Instrument Models differ in method. Some meters have a visible battery range on the meter face. The Ludlum Model 2241 has a battery indicator in the digital display that lights if the batteries require replacement. The Ludlum Model 2221 has a BAT button that brings up the battery level in the digital display. Ensure this value is at least 5.0v. Change batteries and retest as necessary.
 - Verify and adjust the HV, when possible, to match the initial set-up data. Minute differences in HV (+/- 5v) are acceptable without adjustment.
 - Perform an audio response check..
4. Perform and record a 1-minute background count. Report any abnormal background responses to the RSO, prior to instrument use. Normally acceptable background levels < 5 cpm for alpha probes, and < 300 cpm for Pancake G-M probes. Acceptable background levels for NaI probes are variable due to crystal size and based on technician experience.
5. Perform and record a 1-minute source gross count using the same source and geometry applied during initial set-up.
6. Calculate and record the net count value.
7. Compare the net count value to the acceptable range. If the instrument response is outside the acceptable range, the process may be repeated a maximum of 1 additional time before placing the instrument out-of-service.
8. If the instrument fails the pre-operational checks, mark FAIL, initial the DFSC, and place the instrument out-of-service. Deliver completed DFSC to the RSO or designee, and explain the failed condition(s).
9. If all checks pass, mark PASS, initial the DFSC, and return form to designated in-use storage location. This may be a binder, folder, or cabinet. The instrument is now ready for use.
10. If the instrument will be used for routine personnel exit monitoring ensure the alarm threshold is set to alarm and actuates at a level below the site removable contamination limits identified in Table 6-1 of the Site Safety & Health Plan (SSHP). Make adjustments as necessary.

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11. Ensure sources are stored properly after use in the designated source storage location.

10.4 Operations

1. Operate instrument in a manner that minimizes the potential for cross-contamination and physical damage.
2. Evaluate the surface or area to be surveyed for potential scanning interferences. For example, thin layers of water or soil can prevent the detection of alpha contamination. Another example is the use of a NaI probe to qualify soil contamination. The presence of standing water can have a significant impact on instrument response. Initiate necessary corrective actions prior to survey or note conditions during survey reporting.
3. Most instruments will operate in temperatures between 10 and 120 degrees Fahrenheit. However, anytime the temperature is outside of the 32 degree (freezing) or 100 degrees ranges, observe the following precautions:
 - Use particular caution with NaI crystals that may shatter under extreme temperature changes. If the temperature difference is greater than 30 degrees between storage and usage locations, wrap the probe tightly in a cloth towel or other insulator and allow warming or cooling over at least one hour prior to use.
 - Periodically check the instrument against a known source of radiation or contamination. If the instrument appears to be responding incorrectly contact the RSO or designee for guidance.
 - Contact the RSO for guidance anytime work is planned outside of the 10 to 120 degree range.
4. Protect instruments to the extent possible from exposure to moisture (i.e., rain, snow, etc.) during use. Instruments shall be stored in a safe manner when not in use.
5. Minimum Detectable Activities (MDA) for each survey should be determined by evaluating field background levels, not background values obtained during operational checks. Calculate MDA using the formula provided in PP-8-805, "Radiological Surveys."
6. Determining activity in disintegrations per minute (dpm) should be performed using the instrument efficiency obtained during calibration. Efficiencies are normally not established for NaI probes, and therefore should not be used for quantifying activity concentrations. The use of NaI probes for activity quantification shall be evaluated by the RSO prior to performance.
7. Observe the following when performing survey scans and static measurements:
 - Alpha probes should be held within ¼-inch of the surface being surveyed. Probe speed should not exceed 1 probe width per second.
 - Beta probes should be held within ½-inch of the surface being surveyed. Survey speed should not exceed one probe width per second.

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- NaI probes should be held as close as possible to the surface being surveyed without contaminating the probe housing. Note that the crystal is located in the probe end opposite the cable connection. Use appropriate sleeving or wrapping in wet or dirty environments.
 - The scan speed for performing Gamma Walkover Surveys is approximately 0.5 m/sec. Move the detector side to side using a 1-meter path length. Each side-side swing should take 2 seconds to traverse the 1-meter path. Advance the probe forward as you go at a rate of approximately 0.5 m/sec. Use the audio function. When increased counts are detected, slow down and locate the source as would be done in a normal survey. Walk parallel paths to ensure that 100% of the area is surveyed. Ensure that the survey extends to the boundaries of the survey unit. Pay particular attention to low lying areas, ditches, and points of possible contamination.
 - Static measurements should be performed in any location where scans indicated the presence of activity. This is due to the fact that instrument MDAs are normally based on a 1-minute static measurement.
 - All static measurements should be at least 1 minute, if the instrument has a scaler function. If the instrument is a ratemeter only, static measurements should last until the meter reading has fully stabilized.
8. Perform a post-operational check after use if directed by work plan, procedure, or the RSO.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 Portable Instrument Set-Up Sheet (Typical)

Attachment 2 Daily Field Source Check Logsheets (Typical)

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Attachment 1
Portable Instrument Set-Up Sheet (Typical)

PORTABLE INSTRUMENT SET-UP SHEET

Set-Up Location: _____

INSTRUMENT DATA		COUNT (n)	Source Counts	Source Count Time (min)	Source CPM	Background Counts	Background Count Time (min)	Background CPM	NET CPM
	INSTRUMENT	DETECTOR	1						
	MODEL								
	SERIAL #		2						
	CAL DUE								
	HV		3						
	THRESHOLD								
SOURCE DATA			4						
	ISOTOPE		5						
	SERIAL #		6						
				7					
	ACTIVITY (uCi)		8						
	ACTIVITY (dpm)		9						
				10					
REMARKS			CALCULATED VALUES			ACCEPTABLE RANGES			
			Background (CPM)		Net CPM	Background (CPM)		Net CPM	
				Average			+ 20 %		
				+/- Sigma			+ 3 Sigma		
							+ 2 Sigma		
							+ 1 Sigma		
							- 1 Sigma		
							- 2 Sigma		
Performed By:			Date / Time:	Reviewed By:	Date / Time:				

TITLE:

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Attachment 2
Daily Field Source Check Logsheet (Typical)

DAILY FIELD SOURCE CHECK LOG

MONTH / YEAR: _____

INSTRUMENT DATA		Date/Time	Physical	Battery	High Voltage	Audio	Background CPM {A}	Source CPM {B}	Net CPM {C}	PASS or FAIL	Tech. Initials
	INSTRUMENT	DETECTOR									
MODEL											
SERIAL #											
CAL DUE											
SOURCE DATA											
ISOTOPE											
SERIAL #											
ACTIVITY dpm											
INSTRUMENT RANGES											
	Background	Net CPM									
	+ 20 %										
	+ 3 Sigma										
	+ 2 Sigma										
	+ 1 Sigma										
	- 1 Sigma										
	- 2 Sigma										
	- 3 Sigma										
	- 20 %										
NET CPM CALCULATION											
		{B} - {A} = {C}									
Remarks:						Reviewed by:					



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Dose Rate Instruments

NO.: RP-109

PAGE: 1 of 6

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure specifies the methods for performing source checks and operating portable Gamma scintillation dose rate instruments, specifically, the Ludlum Model 12s uR and the Bicon Model Micro Rem. These instruments are used for the evaluation of exposure rates from radioactive materials and determining environmental radiation levels.

2.0 APPLICABILITY

This procedure addresses those instruments that measure dose rate from a scintillation detector and have displays that read in uR/hr, uRem/hr and/or mRem/hr such as Ludlum 12s, Bicon Micro Rem, or Eberline RO-2. Equivalent instruments that operate in a similar fashion to those identified in this section may be operated under this Project Procedure with RSO approval.

3.0 REFERENCES

1. ANSI N323-1978, Radiation Protection Instrument Test and Calibration.
2. Instrument Technical Manuals.
3. Perma-Fix Environmental Services (PESI) RPP

4.0 DEFINITIONS

None

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Reviewing and approving changes to this procedure and ensuring compliance with applicable regulations.
- Ensuring an adequate inventory of Radiation Protection instruments are available to support remediation activities.
- Overseeing the issue, control and accountability of Radiation Protection instrumentation per the requirements of this procedure.

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- Ensuring transmittal of all issue, control and accountability records to the appropriate document control authority when applicable.

5.2 Radiation Protection Technician (RPT)

- Maintaining instrument documentation and records as required by this procedure.
- Maintaining adequate instrument and equipment availability.
- Verifying current calibration and response test dates prior to issue or use of instruments.
- Promptly returning instruments to their proper location when work is complete.
- Ensuring that instruments are properly surveyed for contamination and decontaminated as necessary, after use.

6.0 PREREQUISITES

- Only personnel with documented training shall issue or use RP instrumentation.
- Instruments and detectors shall be inspected for mechanical damage, and response tested prior to issue.
- Any instrument to be used shall have a current calibration label affixed to the instrument.

7.0 PRECAUTIONS AND LIMITATIONS

- Portable count rate survey instrumentations are susceptible to damage from physical and environmental stresses.

8.0 APPARATUS

- Survey instrument
- Tech source
- Source positioning device (jig)

9.0 RECORDS

- Daily Field Source Check Log – Exposure Rate Instruments (Attachment 1)
- Exposure Rate Instrument Set-Up Sheet (Attachment 2)

10.0 PROCEDURE

10.1 General

1. Ensure the instrument selected is within their acceptable calibration periods. This is indicated on an attached calibration sticker. Illegible stickers should be replaced prior to instrument use.
2. The RP Group will coordinate instrument calibration on a minimum annual basis and after major repair operations. Battery change-outs do not require re-calibration. Calibration procedures are outside of the scope of this instruction.
3. Pre-operational source checks are required daily, or prior to each intermittent use, whichever is less frequent. Post-operational source checks are performed as specified in work plans or procedures. Instruments used in the performance of daily activities do not normally require a post-operational source check.

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4. Instrument set-up and subsequent operational checks should be performed in the same location, with consistent temperature and radiation background levels.
5. Use a gamma check source with an activity sufficient to produce contact exposure rates at least ten times higher than background. Cs-137 is typically since it emits 662 keV gamma rays which are representative of the mid-range of gamma energies encountered at NFSS. Alternate sources may be used with RSO approval.
6. Source positioning devices (i.e., jigs) should be used to ensure a reproducible geometry between instrument checks. Source geometry must be consistent between initial instrument set-up and subsequent operational checks.
7. The Ludlum 12s may be operated in the FAST response mode. Switch to SLOW response for obtaining precise readings.
8. Internal scintillation crystals are orientated towards the front of the instrument. Meter cases have visible indicators showing optimum locations to obtain measurements (i.e. effective detector center).
9. Allow instrument readings to maximize prior to recording instrument reading. This may take up to twenty seconds. Note that the needle may not rest on a single value, but may fluctuate slightly between two points on the scale. If this is the case, an average reading should be obtained by summing these two end points and dividing by two.
10. Instruments should be allowed to warm-up for at least one minute prior to obtaining readings.
11. Report any abnormal instrument readings (e.g., unstable analog meter fluctuations), or background inconsistencies to the RSO, prior to continuing instrument use.
12. Instruments that fail operational checks or malfunction during use should be tagged or labeled "Out-of-Service," or "Do Not Use," and segregated from operational instruments. If possible, describe the problem on the tag / label and add initials and date.
13. Instruments leaving RPP Group control (i.e., repair, calibration, excess, etc.) shall be surveyed for unconditional release. The repair / calibration center may request a copy of the survey to accompany shipments of RP instruments.

10.2 Instrument Source Check

1. Obtain the selected instrument.
2. Obtain the corresponding Daily Field Source Check Log – Exposure Rate Instruments form, Attachment 1. This form will be referred to as the "Source Check Log." Initiate a new Source Check Log, if necessary.
3. Perform a physical inspection of the instrument. Place particular emphasis on the following items:
 - Instrument case is not visibly damaged beyond minor scrapes and scratches.
 - Analog display is not cracked or otherwise damaged.

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- Switches and buttons are functional.
 - Audio, if present, is functional.
 - Calibration labels are legible and instrument is within calibration period.
4. Note results of physical inspection on the Source Check Log.
 5. Verify the battery level is within the acceptable range on the analog display. Replace batteries and re-verify, as necessary.
 6. Note battery check results on the Source Check Log.
 7. Verify the high voltage (HV) level is within the acceptable range on the analog display, if present. Place the instrument out-of-service if the HV is outside the acceptable range.
 8. Note the HV check results on the Source Check Log.
 9. If acceptable background ranges have not been established, perform the following:
 - Obtain a blank NFSS Exposure Rate Instrument Set-Up Sheet, Attachment 2. This form will be referred to as the “Set-Up Sheet.”
 - Record the basic source and instrument information at the top of the form.
 - Using the instrument and the source jig (without source), obtain and record ten background readings. The instrument should be removed from the source jig and repositioned after each reading is obtained. Make sure the location where readings are obtained has stable background levels and is the location used for subsequent source checks.
 - Calculate and record the average background value and +/- 20% values on both the set-up and source check logsheets.
 10. Obtain and record an average background reading on the source check log.
 11. Compare the average background reading to the acceptable range. If background response is outside this range, report the condition to the RSO for evaluation, otherwise continue with source check process.
 12. Obtain the source to be used for instrument source checks.
 13. If acceptable source check ranges have not been established, perform the following:
 - Obtain the Set-Up Sheet used to determine acceptable background ranges for the instrument.
 - Using the instrument and the source jig (with source), obtain and record ten contact source readings. The instrument and source should be removed from the source jig and repositioned after each reading is obtained. Make sure the location where readings are obtained is the same location where previous background readings were obtained.
 - Calculate and record the average source value and +/- 20% values on both the set-up and source check logsheets.

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14. Load the source and instrument onto the source jig.
15. Obtain and record the “CONTACT” reading.
16. Verify the contact reading is within the acceptable range (+/- 20%).
17. If the contact source reading falls outside the acceptable range, tag the instrument out of service and notify the RSO, otherwise continue.
18. Complete the source check log including technician initials. The instrument is now ready for use.
19. Ensure sources and forms are stored properly after use in the designated storage location. Forms are retained in RP Instrument logbooks of field files during instrument use (i.e. calibration) cycle. Records are then reviewed by the RSO, or designee for completeness and forward to Project Records for retention.

10.3 Operations

1. Verify that required source checks have been performed prior to initial instrument use.
2. Operate instrument in a manner that minimizes the potential for cross-contamination and physical damage.
3. Limit readings taken while the instrument is positioned sideways to minimize the effects of “geotropism” on the analog needle.
4. Obtain readings by positioning the instrument as close to the detector’s “effective center” as possible. The detector effective center is represented on the instrument housing a cross inside a circle on the Bicon Micro Rem, and a small circular depression on the Ludlum 12s. Overall optimum readings are collected from the front of the instrument housing.
5. Most instruments will operate in temperatures between 10 and 120 degrees Fahrenheit. However, anytime the temperature is outside of the 32 degree (freezing) or 100 degree ranges, observe the following precautions:
 - Be observant of instrument response to background. If the instrument begins to show a decreased response to expected background levels contact the RSO, or designee for guidance.
 - If practicable, perform a period response check of the instrument against a known source of radiation. If the instrument appears to be responding incorrectly contact the RSO or designee for guidance.
 - Contact the RSO for guidance anytime work is planned outside of the 10 to 120 degree range.
6. Protect instruments, to the extent possible, from exposure to moisture (i.e. rain, snow, etc.) during use. Instruments shall be stored in a safe manner when not in use.
7. Perform a post-operational source check after use, if directed by work plan, procedure, or the RSO.

TITLE: Dose Rate Instruments	NO.: RP-109
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11.0 ATTACHMENTS

Attached forms are examples and may be modified by the RSO, as needed, without revision to this procedure.

Attachment 1 Daily Field Source Check Log – Exposure Rate Instruments (Typical)

Attachment 2 Exposure Rate Instrument Set-Up Sheet (Typical)

TITLE:

Dose Rate Instruments

NO.: RP-109

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Attachment 1

Daily Field Source Check Log – Exposure Rate Instruments (Typical)

FMSS DAILY FIELD SOURCE CHECK LOG
- EXPOSURE RATE INSTRUMENTS

MONTH / YEAR: _____

INSTRUMENT DATA		Date/Time	Physical	Battery	High Voltage	Audio	Background	Contact Source	PASS or FAIL	Tech. Initials
INSTRUMENT										
MODEL										
SERIAL#										
CAL DUE										
HV										
SOURCE DATA										
ISOTOPE										
SERIAL #										
ACTIVITY uCi										
INSTRUMENT RANGES										
	Background	Contact Source								
+ 20 %										
- 20 %										
Units (Circle One)										
uR	urem	mR	mrem	R	rem					
Remarks:						Reviewed by:				

TITLE:

Dose Rate Instruments

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Attachment 2




Exposure Rate Instrument Set-Up Sheet (Typical)

FMSS EXPOSURE RATE INSTRUMENT SET-UP SHEET

Set-Up Location: _____

INSTRUMENT DATA		READING (n)	Background Rate	Contact Source Rate	CALCULATED AVERAGE AND RANGES		
INSTRUMENT		1			Background		Contact Source
MODEL		2				Average + 20%	
SERIAL #		3				Average	
CAL DUE DATE		4					
HV		5				Average - 20%	
SOURCE DATA		6			Units (Circle One)		
ISOTOPE		7			uR urem mR mrem R rem		
SERIAL #		8			REMARKS		
		9					
ACTIVITY (uCi)		10					
Performed By:		Date/Time:		Reviewed By:		Date/Time:	

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 <p>PERMA-FIX ENVIRONMENTAL SERVICES</p>	
TITLE: Radioactive Materials Control and Waste Management Program	NO.: RP-111
	PAGE: 1 of 6
	DATE: March 2017
APPROVED:	
	
_____	03/03/17
Technical Services Manager	Date
	
_____	03/03/17
Corporate Certified Health Physicist	Date

1.0 PURPOSE

This procedure provides guidance and requirements for the control of radioactive materials including the management of radioactive waste. The Radioactive Materials Control and Waste Management Program applies to the receipt, inventory, storage and handling of radioactive materials; the release of materials from Restricted Areas; the control of radioactive sealed sources; the control of materials and contaminated tools and equipment entering and/or leaving Restricted Areas; and the management of waste including transportation and disposal.

2.0 APPLICABILITY

This procedure applies to all PESI Project personnel and all decommissioning projects that involve radioactive materials. This procedure does not apply to the monitoring of liquid and gaseous effluents, radiological environmental monitoring, or final termination surveys of the reactor or facilities.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Radiation."
2. Title 22, California Code of Regulations, Division 4.5; Environmental Health Standards for the Management of Hazardous Waste
3. California Executive Order D-62-02 regarding disposal of decommissioned materials.
4. 10 Code of Federal Regulations (CFR) 20; Standards for Protection Against Radiation, and Transfer and Disposal and Manifests
5. 49 CFR, Subchapter C "Transportation – Hazardous materials Regulations"

RP-111 Radioactive Materials Control and Waste Management Plan

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6. 40 CFR, Subchapter I "Solid Wastes"
7. 40 CFR Part 260-273 "Hazardous Waste Management System"
7. USNRC Circular 81-07, "Control of Radioactively Contaminated Materials."
8. USNRC IE Information Notice No. 80-22, "Breakdowns in Contamination Control Programs."
9. ANSI N13.2-1969, "USA Standard Guide for Administrative Practices in Radiation Monitoring (A Guide for Management)."
10. RP -102, "Radiological Posting Requirements."
11. RP -104, "Radiological Surveys."
12. RP- 105, "Unrestricted Release Requirements."
13. RP -114, "Control of Radiation Protection Records."

4.0 GENERAL

4.1 Discussion

Radioactive material controls are established to provide positive control of radioactive material, prevent inadvertent release of radioactive material to uncontrolled areas, ensure personnel are not unknowingly exposed to radiation from lost or misplaced radioactive material, and to minimize the amount of radioactive waste material generated during PESI activities.

4.2 Definitions

Aggregate Material: Items or materials that by their physical nature do not lend themselves to being effectively surveyed using portable instrumentation and require bulk or composite survey techniques or representative sampling and analysis.

Conditional Release of Material: Items or materials that do not meet unconditional release criteria and that are released under the control of Radiation Protection personnel.

Contamination Area (CA): Means any area with loose surface contamination values in excess of the applicable values specified in RP-104 Acceptable Surface Contamination Levels that is accessible to personnel, or any additional area specified by the RSO. The Contamination Area posting is defined as more restrictive than Radioactive Material Areas, hence all Contamination Area postings are considered to be Radioactive Material postings.

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Minimum Detectable Activity (MDA): The smallest amount or concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal. MDA depends upon the type of instrument, the counting geometry, and the radionuclide to be detected. MDA has the same meaning as Lower Limit of Detection (LLD). (ANSI N13.3, 1989).

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and by-product material procured and used to support the operation or remediation.

Radioactive Material Area: Any area or room where quantities of radioactive materials in excess of ten times the 10 CFR 20 Appendix C quantities are used or stored, or any area designated a RMA by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

Unconditional Release of Material: Release of equipment or material to the general public. The equipment and / or material are deemed to meet site release criteria for both total and removable contamination.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO is responsible for:

- Ensuring adequate staffing, facilities and equipment are available to perform the radioactive material control functions assigned to Radiation Protection personnel.
- Investigating and initiating corrective actions for the improper handling of radioactive material.
- Approving purchase or acquisition of radioactive sources.
- Ensuring a source inventory and leak testing program is established.
- Authorizing the establishment of radioactive material and sealed source storage locations.
- Packaging and transferring radioactive material to appropriate authorities.
- Administering receipt / release survey programs of radioactive material.
- Administering radioactive source inventory and leak testing.
- Ensuring correct posting of radiological area.
- Reviewing results of sample analysis and survey data as required to determine acceptability for release of items.
- Ensuring packages for transport and disposal meet applicable regulations for integrity and dose limits.

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5.2 Certified Waste Shipper

The certified (as required by 49 CFR 172, Subpart H) waste shipper is responsible for:

- Identifying proper packaging and posting requirements for all offsite transport of radioactive and/or mixed wastes.
- Reviewing results of conveyance package radiation surveys and performing inspections of conveyance packages prior to approving packages to leave a site.
- Maintaining records of all waste shipments.
- Assisting the RSO in proper characterization, classification and sampling of any potentially radioactive or mixed waste
- Selecting the treatment, storage and disposal facility (TSDF) to be used for processing, treatment, and/or disposal of radioactive or mixed waste
- Preparing profiles and shipping paperwork for disposal of radioactive or mixed wastes generated
- Directing and performing inspections, marking, labeling and placarding of radioactive or mixed waste prior to shipment
- Selecting the proper packages to use for radioactive or mixed waste
- Maintaining an inventory of radioactive and mixed waste onsite and shipped off the project.
- Ensuring periodic inspections as required by regulation are performed and documented

5.3 Radiation Protection Technicians (RPTs)

The RPT is responsible for:

- Performing and documenting radiation and contamination surveys, inspections and leak tests.
- Posting, securing, and controlling radioactive material and source storage areas.
- Safely opening packages of radioactive material.
- Identifying radioactive material.
- Releasing material in accordance with this and implementing procedures.
- Notifying the RSO or designee on arrival of radioactive material.
- Performing pre-transportation surveys of radioactive materials packaging and conveyance vehicles.

5.4 Project Personnel

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Project personnel are responsible for:

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.
- Obtaining RSO authorization prior to accepting receipt of radioactive material at the project. This includes, but is not limited to items such as sealed sources, liquid standards, and contaminated equipment from other sites, and waste generated outside normal project remediation activities. This is to ensure that required receipt surveys are scheduled, appropriate ALARA considerations are implemented, and that the source term is evaluated for possible effects to the project waste stream criteria.
- Complying with direction from RP personnel regarding the proper methods for receipt, handling, decontamination, packaging, storage, transport and disposal of radioactive material.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

Packages of radioactive material or sources shall NOT be opened until the required receipt survey is performed by RP personnel.

Packages of radioactive waste shall not leave a site until approval to do so is granted by the Certified Waste Shipper.

8.0 RECORDS

- Receipt radiological surveys
- Radiological release surveys
- Radiological transportation surveys
- Source Inventory which includes Leak Test Results
- Transportation records including manifests, transportation checklists, and a transportation log

Records generated shall be transmitted to Project Document Control for filing according to procedure RPP-114.

9.0 PROCEDURE

9.1 Receipt of Radioactive Material

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1. Obtain RSO authorization prior to accepting receipt of radioactive material at the project.
 - Radioactive materials which may be received include, but are not limited to, items such as sealed sources, liquid standards, contaminated equipment from other sites, waste generated outside normal project remediation activities and shipments of radioactive materials from vicinity properties to the PESI for storage and / or transportation and disposal. This is to ensure that required receipt surveys are scheduled, appropriate ALARA considerations are implemented, and that the source term is evaluated for possible effects to the project waste stream criteria.
 - Refer to 10 CFR 71.4 and Appendix A to 10 CFR 71 for definition and limits for “Type A Quantities” of radioactive materials.
 - The RSO may direct receipt surveys to be performed on any incoming radioactive material shipment.
2. If an expected package exceeds Type A quantities, the package requestor shall make arrangements with RP and the carrier to receive or pick-up the shipment when the carrier makes notification of package availability.
3. RP personnel perform receipt inspections and surveys of incoming radioactive material shipments which exceed a Type A quantity (refer to 10 CFR 71.4 and Appendix A of 10 CFR 71) as follows:
 - The inspection and survey shall be performed within three hours of receipt. If received after normal work hours, the survey is required with three hours from the beginning of the next business day.
 - Don latex gloves, at a minimum, when performing incoming inspections and surveys.
 - Inspect the package for leaks or apparent damage.
 - Ensure the contents match the packing slip or shipping papers.
 - Perform a radiation survey of the package exterior.
 - Perform a removable contamination survey of the package interior and exterior.
4. RP Personnel shall store the package in a secure, radiologically posted area, notify the RSO or designee if any the following conditions are observed during receipt of a radioactive material shipment:
 - Contents do not match packing slip or shipping papers
 - The contents of the package do not contain the isotopes or quantities of material as ordered or expected.
 - Package is leaking or sufficiently damaged to compromise package contents.
 - The receipt survey results exceed any of the following limits:
 - Radiation (mrem/hr) – 200 @ Contact or 10 @ 1 meter from the package
 - Removable Contamination (dpm/100cm²) – 2200 Beta-Gamma, 220 Alpha

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9.2 Identification of Radioactive Material

1. Radioactive material exceeding limits specified in 10 CFR 20, Appendix C shall be identified and labeled by Radiation Protection personnel:
 - On receipt of packages containing radioactive material or sources.
 - During removal of items or material from contaminated systems or areas, or from radioactive materials areas.
 - In the course of performing area and job specific surveys.
 - In the course of surveying items for release.
2. Items that meet or exceed the contamination limits established in the PESI RPP should be labeled radioactive material.
3. Use the following guidance, as a minimum, when labeling radioactive material:
 - Labels shall only be placed or removed by Radiation Protection personnel.
 - Unique features (e.g., yellow plastic bags, yellow and magenta tags, purple paint, etc.) should be used to clearly identify the physical and radiological parameters of the material.
 - Labeling shall state "CAUTION - RADIOACTIVE MATERIAL."
4. Exceptions to labeling requirements for radioactive material are as follows:
 - The item or material is under the direct control of personnel who are aware of the contents and the associated radiological hazards.
 - The material is radiation protection equipment (e.g., respirators, instruments, etc.).
 - The material consists of radiological samples being analyzed or sampling equipment controlled by Radiation Protection personnel.
 - The material is packaged and labeled in accordance with DOT regulations while awaiting transport.
 - The material is contained in permanently installed equipment and / or potentially contaminated systems.
 - The material consists of permanently installed equipment or components, including check sources installed in radiation monitoring equipment, which have manufacturer supplied check source labels affixed. Radiation level posting requirements shall remain applicable.
 - The material consists of laundered protective clothing:
 - a. In controlled use, inside the Restricted Area; or
 - b. Stored in designated laundry containers.
 - The material consists of check sources or sealed sources and source storage containers identified as radioactive material with identifiable labels affixed to the source.

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- The material is stored or in-use in a posted Contamination Area or Airborne Radioactivity Area. All items in these areas are considered potentially radioactive/contaminated until properly dispositioned by RP personnel.
 - The material consists of contaminated items (e.g., hand tools) impractical to label, that are marked with magenta paint.
5. Project personnel should notify Radiation Protection of any items or containers with lost or damaged radioactive material labels.
 6. Material requiring labeling as radioactive material which is found uncontrolled and outside a Restricted Area shall be brought to the immediate attention of RP Personnel.

9.3 Storage of Radioactive Material

1. Radioactive Material Storage Areas shall be posted in accordance with RP -102, "Radiological Posting Requirements."
2. Radiation Protection personnel should consider the following when specifying radiological requirements for Radioactive Material Storage Areas:
 - Changes to radiation levels in an area as a result of material storage.
 - External environmental conditions are such that significant container degradation does not occur during storage.
 - Material is adequately packaged and controlled to minimize the potential for loss of radioactive material control
3. Unsealed radioactive materials e.g. soil, debris, liquids will be posted and controlled in accordance with RP-102, Radiological Posting Requirements.
4. Soil, debris, and materials will be staged in appropriate containers/bags or covered with tarps as necessary to prevent migration outside of radiological boundaries.
5. Liquids will be stored in appropriate containers (e.g. drums, totes, etc.)
6. All storage containers will be labeled with pertinent information including description and radiological data.
7. PPE requirements for handling radioactive materials are established in the applicable RWP and procedure RP-132, *Selection and Use of Radiological PPE*.

9.4 Special Considerations for Control of Accountable Radioactive Sources

1. The RSO, or designee shall serve as the Source Custodian and shall be responsible for the following:
 - Ensuring that all accountable radioactive sources are stored in their designated storage location when not in use.
 - Maintaining a source inventory that includes accountable source identification, isotopic content, activity, assay date, designated storage location, and date and results of most recent semi-annual leak test.

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2. Any individual planning to procure a radioactive source for the project shall request approval from the RSO in writing. This request shall include a justification for bringing additional sources onto the project and shall include all necessary source information to update the source inventory.
3. Licensed sources under the control of a licensee (e.g., radiography sources, soil density gauges, etc.) are not maintained in the project accountable source inventory. Project personnel requesting such vendor services shall ensure that the RSO receives evidence of the following prior to source mobilization to the project:
 - Source license including isotope and source activity
 - Semi-annual leak testing performed by the licensee
4. Source Custodian, or designee shall ensure that a leak test is performed and documented for any accountable source in inventory under any the following conditions:
 - Upon source receipt in inventory
 - Semi-annually
 - Prior to transfer to a new permanent storage location
 - Prior to disposal
 - If source integrity is compromised
5. A source leak test consists of a physical source inventory, a visual inspection for source integrity and a contamination survey capable of detecting the presence of 0.005 microcuries (200 Bq) of removable radioactivity.
6. If direct contact with the source is impractical (i.e., inaccessible, unsafe from an ALARA standpoint, or could potentially compromise source integrity) the source container or storage location may be surveyed as representative of the leak test.
7. All accountable sealed radioactive sources or their individual storage containers shall bear a durable label or tag which includes the following minimum information:
 - Source Identification
 - Radionuclide(s)
 - Source Activity
 - Assay Date
 - Source Custodian Name and Contact Number
8. The RSO shall establish designated locations for the storage of accountable radioactive sources using the following guidance:
 - Sources should be stored in a lockable location
 - Sources should be stored to minimize exposure to fire or combustible materials
 - Sources should be stored in such a manner to minimize radiation exposure to personnel routinely present in the area.

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9.5 Movement of Radioactive Material

1. Radioactive material or contaminated material shall be properly contained before moving to minimize radiation levels and prevent spread of contamination.
2. Obtain direction from the Project Transportation Specialist and / or the RSO prior to transporting radioactive materials across public highways or railroads regulated by the Department of Transportation. Transport shall be performed in accordance with this procedure and all applicable local, state, and federal regulations.

9.6 Control of Tools, Equipment and Material

1. All items to be released from radiological controls shall be surveyed by RP personnel.
2. The RSO may authorize the establishment of “Hot Tool” storage areas for reusable contaminated tools, components, equipment and material. If labeling of these items (e.g., hand tools) is impractical, magenta paint may be used to identify the item as radioactive material.
3. Project Management should ensure that adequate supplies of clean and “hot” tools are available project personnel. This maximizes worker effectiveness in radiological areas, minimizes survey and decontamination efforts, and reduces radioactive waste generated.
4. Radioactive waste receptacles will be established and maintained for the disposal of items.

9.7 Release of Items from Radioactive Material Controls

1. RP personnel shall perform surveys to release items from radioactive material controls, with the following exception:
 - Hand-carried items (e.g., pens, paper, flashlights, logbooks, clipboards, safety glasses, dosimetry, badges, etc.) under a single individual’s control and that are not expected to have come into contact with potentially contaminated surfaces may be monitored by that individual during the personnel frisking process.
2. RP personnel will survey items designated for unrestricted release according to RPP-105, “Unrestricted Release of Equipment.”
3. RP personnel shall ensure the labeling is appropriate and direct Project personnel as how to best disposition the item (i.e., decontamination, packaging, storage, or disposal as radioactive waste) if an item is contaminated and cannot be released for unrestricted use.
4. RP personnel shall ensure that any labeling or marking identifying the item as radioactive material is removed or thoroughly defaced if the release survey indicates that the item may be released for unrestricted use.

9.8 Transportation and Disposal of Radioactive Waste

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1. Characterization sampling and analysis of waste for radioactive and hazardous constituents shall be performed to ensure waste meets the selected waste facility's Waste Acceptance Criteria.
2. Waste which is considered "decommissioned waste" (waste with residual radioactivity distinguishable from background regardless if it meets alternative requirements for unrestricted release) shall not be disposed of in a Class III California land fill or in a California unclassified waste management unit in accordance with California Executive Order D-62-02.
3. Packaging of waste shall be commensurate with the radionuclide(s) activity and the physical form of the waste in accordance with 49 CFR 178.350 (if applicable).
4. Labeling and placarding of waste packages shall be performed in accordance with 49 CFR 178.350 (if applicable).
5. Radiation surveys shall be performed on waste packaging and/or conveyance vehicles. These surveys shall include dose rates as required by 49 CFR 173 and offsite transportation shall not be permitted if applicable dose limits are exceeded.
6. A transportation inspection shall be performed and documented on the "Transportation Checklist Form" (**Attachment 1**) prior to waste shipments leaving a site.
7. Proper shipping paperwork shall be completed and shall accompany all transports of radioactive waste.
8. Emergency response guidance and contact information shall be provided to all conveyors of radioactive waste (refer to **Attachment 2**).
9. Records of waste disposal shall be maintained sufficient to meet the requirements of CDPH 5314 (to support eventual license termination). Information required includes inventory of waste, dates of transfer, and recipient information. These records should be maintained even if license termination is not the immediate goal of a project.

10.0 ATTACHMENTS

1. Transportation Checklist Form
2. Emergency Response Instructions

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Attachment 1
Transportation Checklist Form



TRANSPORT VEHICLE INSPECTION CHECKLIST

Shipment No.		Carrier DOT Hazmat Registration No. / Exp. Date					
Carrier Name:		Tractor No.			Trailer No.		
Drivers Name:		State:		License No.		Exp. Date	
	ITEM	STATUS		STATUS		CRITERIA	
		Pre Load		Post Load			
		SAT	UNSAT	SAT	UN SAT		
1	Operator's License					Driver possesses a valid commercial driver's license (with a tank vehicle or hazardous materials endorsement) to operate the vehicle	
2	Windshield, Side Glass and Mirrors					No cracked or broken glass that would affect the vision of the driver. Mirror(s) in place and usable	
3	Wipers					Wipers operate and are in good condition	
4	Horn					Air/electric horn(s) work	
5	Suspension					Visually check for loose, broken, or damaged spring leaves, "U" bolts, shackles. Pads, torque arms, and locking pins	
6	Brake Lines					Brake lines and connectors do not have cracks, crimps, restrictions, or evidence of damage or audible air leaks	
7	Brake Pots, Cams					Brake pots are in good physical condition and mechanical linkages are intact and in good condition	
8	Exhaust System					No loose or broken brackets and no evidence of leaks which would affect driving/sleeping compartment	
9	Fuel System					No visible damage affecting fuel tank integrity, no visible leaks, no loose or broken mounting brackets, no evidence of damage to vents, and fuel cap is securely in place	
10	Structure, Welds					No visible significant cracks in major welds	
11	Frame					No cracked, loose, sagging, or broken frame	
12	Trailer Floor					No holes or projecting nails. Capable of bearing weight of load and fork truck (if used)	
13	Trailer Walls					No holes, severe dents or buckling	
14	Trailer End Gate					Can be closed and secured properly	
15	Rims					Rims are not bent or cracked and stud nuts are in place	
16	Tires					Tires appear properly inflated, tread depths appear greater than minimum (tread depth at least 1/8" on front and 1/16" on all others) and show no evidence of cuts or damage affecting the ply cord	
17	Hubs					No visible oil leakage from seals	
18	Head Lights					Both low beams working	
19	Running Lights					All affixed running lights operable	
20	Turn Signals					Front and back working	
21	Brake Lights					Must work on tractor and trailer	
22	Liner					Insure liner is properly installed	
23	Cleanliness					No amount of material from the site on external surfaces of the conveyance.	
PRE-LOAD INSPECTION		(Printed Name, below)				(Signature, below)	
INSPECTION DATE:							
POST-LOAD INSPECTION		(Printed Name, below)				(Signature, below)	
INSPECTION DATE:							
Comments:							
REVIEWED BY:		(Printed Name, below)				(Signature, below)	
REVIEW DATE:							

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Attachment 2
Emergency Response Instructions



EMERGENCY RESPONSE INSTRUCTIONS

Manifest No.: _____

EMERGENCY PHONE NUMBER:

MATERIAL DESCRIPTION:

IMMEDIATE ACTIONS:

RENDER FIRST AID TO INJURED PERSONS

SECURE THE IMMEDIATE AREA

REPORT THE EMERGENCY

FIRST AID:

Use First Aid according to the nature of the injury

Do not delay care and transport of a seriously injured person

Advise medical personnel that injured persons who may have contacted spilled material may be contaminated with low level radioactive material

SECURE THE IMMEDIATE AREA:

Keep unnecessary people at least 160 feet away in all directions and upwind of shipment

Fight small fires with portable extinguisher, *if safe to do so*

Isolate the area and deny entry to unnecessary personnel

REPORT THE EMERGENCY:

Contact the applicable Emergency Phone Number listed at the top of this page.



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Dosimetry Issue

NO.: RP-112

PAGE: 1 of 4

DATE: May 2014

APPROVED:

Technical Services Manager

5/31/14

Date

Corporate Certified Health Physicist

5/31/14

Date

1.0 PURPOSE

This procedure provides consistent methodology for the issuance of radiation monitoring dosimetry devices at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This procedure applies to all Safety and Health personnel issuing dosimetry devices.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."

4.0 GENERAL

4.1 Discussion

This procedure describes the requirements for the issuance of standard dosimetry devices to visitors and radiation workers accessing restricted areas of the remediation project.

The Thermoluminescent Dosimeter (TLD) normally provides the dose of record, while the Self-Reading Dosimeter (SRD) provides a means of deep dose tracking prior to TLD processing, as well as verifying the reasonableness of the results

4.2 Definitions

Radiation Worker: An individual who accesses any Radiological Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Radiological Areas.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

TITLE:	Dosimetry Issue	NO.: RP-112
		PAGE: 2 of 4

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

Self-Reading Dosimeter (SRD): A radiation monitoring device (either electrostatic or electronic) that can be read by the wearer at any time and indicates total accumulated dose.

Thermoluminescent Dosimeter (TLD): An integrating detector where radiation energy is absorbed (trapped) and can be read out later by thermal excitation of the detector (ANSI N13.15-1985).

Visitor: An individual who accesses the project site for purposes other than working (e.g., tour the site or meet with an individual).

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- The RSO is responsible for implementing this procedure.

5.2 Radiation Protection Technicians (RPTs)

- RPTs are responsible for the performance of this procedure.

5.3 Project Personnel

- Provide the RP Dosimetry Group with required personal information to track and report radiation exposures (e.g., Social Security/ID Number, Address, Date of Birth, Exposure History from Other Sites, etc.)
- Complying with Radiation Protection Program (RPP) requirements, including dosimetry care & use requirements identified in Attachment 1.

6.0 PREREQUISITES

Individuals who are planning to visit other radiologically monitored facilities while being monitored at PESI shall notify RSO prior to going to the other monitored facility(s).

7.0 PRECAUTIONS AND LIMITATIONS

- The NRC Form-4 for individuals with current year recorded or estimated exposures from other site(s) shall be reviewed by the RSO prior to issuance of dosimetry. The purpose of this review is to ensure that individuals would not exceed the quarterly exposure limit of 1.25 rem, or the annual exposure limit of 5 rem Total Effective Dose Equivalent.
- Any individual entering a Restricted Area, or performing work under a Radiation Work Permit shall wear dosimetry.
- TLDs will be changed out on a quarterly basis.
- Employee personal information shall be accessible only to personnel authorized by the RSO, SSHO, or Project Manager.

8.0 APPARATUS

- Self-Reading Dosimeters
- Thermoluminescent Dosimeters

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9.0 RECORDS

- Occupational External Radiation Exposure History (NRC Form-4)
- TLD Issue Form (e.g., TLD Processor Chain-of-Custody)
- TLD Use & Care Acknowledgement

10.0 PROCEDURE

10.1 Dosimetry Issuance for Visitors

- Dosimetry is issued to escorted visitors accessing Restricted Areas, and as required by the RSO.

10.2 Dosimetry Issuance for Radiation Workers

1. Ensure that Radiation Worker Training has been successfully completed by the worker prior to dosimetry issue.
2. Ensure the individual has completed an NRC Form 4 “Occupational Radiation Exposure History.”
3. Ensure the individual has completed the “TLD Use & Care Acknowledgement” form.
4. Ensure the worker understands the administrative dose limit and the fraction remaining (available dose) for the current year.
5. Review all other paperwork for completeness and legibility.
6. Issue a TLD to the individual by recording the pertinent information on the TLD Issue Form.

11.0 ATTACHMENTS

Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachment(s).

Attachment 1 Dosimetry Care & Use Acknowledgement Form

TITLE: <p style="text-align: center;">Dosimetry Issue</p>	NO.: RP-112
	PAGE: 4 of 4

Attachment 1

DOSIMETRY CARE & USE ACKNOWLEDGEMENT

1. Use **only** dosimetry specifically issued to you.
2. Verify that you are wearing the appropriate dosimetry **prior** to entering Restricted Areas.
3. Unless otherwise directed by the RSO, Dosimetry **shall** be worn facing out, and attached to clothing/lanyard on the front of the upper torso. **Do not** attach dosimetry to waist belt loops, safety glasses, or hard hats.
4. Dosimetry **shall** be stored in the designated location during non-work periods.
5. Dosimetry **shall** not be worn off-site or to another radiological facility unless specifically authorized by RSO.
6. If dosimetry is misplaced or damaged, **perform** the following:
 - a. Place work in a safe condition and exit the radiological area;
 - b. Report the lost dosimeter to RP Personnel;
 - c. RP shall initiate a Radiological Occurrence Report (ROR); and
 - d. Obtain RSO authorization to issue replacement dosimetry.
7. **Do not** tamper with or expose dosimetry to excessive heat, security x-rays, or medical radiation sources. Report instances of tampering or unnecessary exposure to the RSO immediately.

Dosimetry is used to monitor your exposure as required by Federal Law and Company Policy. Failure to comply with these or other Radiation Protection Program requirements implemented for your safety, and for the protection of the public and environment may result in revocation of RadWorker Training credentials and Restricted Area access privileges.



I have read and understood the information presented and will comply with Radiation Protection Program requirements as established in the FMSS Site Safety & Health Plan.

Signature

Date



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Control of Radiation Protection Records	NO.: RP-114
	PAGE: 1 of 6
	DATE: May 2014
APPROVED:	
 _____ Technical Services Manager	<u>5/31/14</u> Date
 _____ Corporate Certified Health Physicist	<u>5/31/14</u> Date

1.0 PURPOSE

This project procedure defines the requirements for controlling Radiation Protection Program records. It also establishes the requirements for review and temporary storage of these records at PESI Sites prior to transmittal to Document Control.

2.0 APPLICABILITY

The requirements of this procedure are applicable to records generated by the Radiation Protection Group, and apply to all documents considered to be records.

3.0 REFERENCES

1. 10 CFR 20 "Standards for Protection Against Radiation."
2. PESI, "Radiation Protection Plan (RPP)"

4.0 DEFINITIONS

Non-record: Non-record material includes those classes of documentary or other material that shall be disposed of without archival authority. Examples are copies of records transmitted to Document Control, paper copies of e-mail, and informal notes.

Records: For the purpose of this procedure, records shall be interpreted as radiation protection records. A record is considered to have been "generated" when it has been completed, signed (or initialed) by the generator, and completed required reviews. Examples of records are all survey forms and original Radiation Work Permits (RWP).

Retention Period: The period of time that a record may be retained by the Radiation Protection Group, prior to transmittal to Document Control.

TITLE: Control of Radiation Protection Records	NO.: RP-114
	PAGE: 2 of 3

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementing this procedure, and performing oversight activities to ensure compliance with the requirements of this document.
- Establishing an RP Record Retention Schedule.
- Ensuring adequate storage space and personnel are available to perform Records Management activities.

5.2 Radiation Protection Records Coordinator (RC)

- Acts as the departmental contact for records.
- Ensures that records are adequately controlled according to this procedure.
- Ensures that records are transmitted to Document Control in a timely fashion, as defined by this procedure.

5.3 Radiation Protection Technicians (RPT)

- Complying with the requirement for this procedure.
- Protecting records in their possession from loss or damage.

6.0 PROCEDURE

6.1 Radiation Protection Group Functions

6.1.1 All personnel assigned to the group shall control records in accordance with applicable requirements of this procedure beginning when a record is first generated.

6.1.2 Records shall be prepared in accordance with Project Procedures. Preparation of these documents shall conform to the following:

Document content, including signatures, shall be:

- Legible and reproducible
- Appropriate for the particular activity performed
- Complete per the applicable requirements
- Traceable to the activity or item to which it applies

6.1.3 If records are damaged (i.e., torn, lost, illegible, or incomplete), action shall be taken and documented to ensure that re-created records are as complete and accurate as possible. Re-created records shall be identified as copies and be signed and dated by the generator.

6.2 Records Coordinator (RC)

6.2.1 The Radiation Protection RC shall:

- Ensure that all records received for transmittal are included on the Record Retention Schedule. The RSO should be notified if any record is not on the schedule.
- Review the records for acceptability by ensuring the content of the record complies with this procedure. The RC shall review each record ensuring that the record is legible, complete, signed and dated, and that the record contains sufficient information to fulfill the intended purpose of the record.

TITLE: Control of Radiation Protection Records	NO.: RP-114
	PAGE: 3 of 3

NOTE: The RC is not responsible for the technical adequacy or correctness of the record.

- Coordinate appropriate corrective action with the RSO when the condition of the records is not acceptable.
- Transmit records according to Document Control
- Prepare a document transmittal form, attach the completed form to the documentation package, and forward the records to Document Control.
- Retain a copy of the returned document transmittal form, which documents transmittal to Document Control.
- Maintain a Records Retention Schedule, approved by the RSO and provide a copy to Document Control.

6.3 Control of Records



- 6.3.1 Records shall be controlled and properly maintained from the time the record is generated until it is transmitted to Document Control
- 6.3.2 Records shall be stored in a controlled environment that protects the records from damage (i.e., winds, floods, fires, high and low temperatures and humidity and infestation of insects, mold, or rodents).
- 6.3.3 Each record shall be reviewed by the RSO to ensure that:
 - The record contains sufficient information to fulfill the intended purpose of the document.
 - The content of the record is accurate and complete.
- 6.3.4 Records monitoring transmittal to Document Control shall be stored in a 1-hour fire-rated container, if possible.
- 6.3.5 Storage facilities or cabinets with confidential information should be locked when unattended. Storage facilities for other document should be locked when unattended as is practicable.
- 6.3.6 Records that are in the process of being generated may be controlled by electronic storage, provided there is data back-up available.
- 6.3.7 Following transmittal, Document Control shall review the documentation to ensure that it is complete as indicated on the transmittal form, sign and date the transmittal form signifying receipt of the record package, and return a copy of the signed and dated form to Radiation Protection RC.

7.0 ATTACHMENTS

None



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radiation Worker Training	NO.: RP-115
	PAGE: 1 of 6
	DATE: May 2014
APPROVED:	
 _____ Technical Services Manager	<u>5/31/14</u> Date
 _____ Corporate Certified Health Physicist	<u>5/31/14</u> Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for implementing Radiation Worker Training (RWT) at Perma-Fix Environmental Services, Inc. (PESI) Sites.

2.0 APPLICABILITY

RWT is applicable to ALL PESI employees and subcontractors who perform work within Restricted Areas.

3.0 REFERENCES

- 10 CFR 19, "Notices, Instructions and Reports to Workers: Inspections and Investigations."
- 10 CFR 20, "Standards for Protection against Radiation."

4.0 GENERAL

4.1 Discussion

Successful completion of the RWT will qualify employees for unescorted access into Restricted Areas, provided other access requirements are met as specified in procedure RP-101, "Access Control".

Qualified individuals with a demonstrated knowledge of radiological concepts should provide RWT instruction. The RSO approves RWT Instructors.

4.2 Definitions

Controlled Area: An area under the control of PESI management area to which access is limited by Project Management.

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	PAGE: 2 of 4

Practical Factors: The “performance-based” portion of RWT that focuses on demonstration and evaluation of safe radiation worker practices. Particular emphasis is given to the donning and doffing of protective clothing and self-monitoring for radioactive contamination.

Radiation Worker: An individual who accesses any Restricted Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Restricted Areas as specified this procedure.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

The RSO is responsible for implementation of this procedure and approval of course content and materials.

6.0 PREREQUISITES

Prior to obtaining RWT qualification, individuals shall have submitted evidence of completion of other medical / training requirements established in the PESI Site Safety & Health Plan.

7.0 PRECAUTIONS AND LIMITATIONS

- RWT shall be required on a bi annual basis. Active site personnel may be granted up to a 90-day extension beyond the RWT anniversary date, with RSO approval.
- Individuals must have documented evidence of completing both academic and Practical Factors objectives before being allowed to work unsupervised in a Restricted Area.
- Personnel may be allowed to challenge the academic examination portion of this training by passing the examination.
- Bi-Annual re-qualification of the Practical Factors portion of RWT may be by observation of actual work practices.
- A minimum passing score on the RWT exam and Practical Factors is 80%.
- Trained emergency response personnel (Fire Department, Ambulance/EMT, Law Enforcement) responding to on-site emergencies are exempt from this training.
- The RSO may waive the classroom portion of RWT provided the individual is able to show documented proof of successful completion of an equivalent level of training from another facility during the previous 12-month period.
- RP technicians are exempt from this training.

8.0 APPARATUS

None

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	PAGE: 3 of 4

9.0 RECORDS

The Site Safety & Health Group shall maintain a copy of the RWT certificate or attendance roster in each employee file.

10.0 PROCEDURE

10.1 RWT Classroom Training

- A. At a minimum, the following topics shall be discussed during RWT:
- Fundamental of Radioactivity
 - Prenatal Exposure Risks
 - Shaw Group Radiation Protection Plan
 - Site Specific Radiological Hazards / contaminants
 - ALARA Concepts
 - Radiological Postings / Barriers
 - Emergency Response / Evacuation Routes
- B. Provide the trainees with a copy of the course materials and all pertinent training forms.
- C. Present the course material including overhead slides.
- D. Lecture on the associated concepts.
- E. Answer any questions the trainees may have.
- F. Review the material with the trainees prior to administering the exam.
- G. Administer the RWT exam.
- H. The proctor will grade the test and review incorrect answers with the trainee.
- I. Submit the completed exam to RP Document Control.

10.2 RWT Practical Factors Training

- A. At a minimum, the following topics shall be discussed as part of Practical Factors training:
- Proper PPE donning and doffing procedures
 - Use of RWP
 - Recognition of postings
 - Utilization of ALARA concepts (time, distance, shielding)
 - Use of frisking equipment and proper frisking techniques
- B. Develop a mock-up area from which trainees may be evaluated. Include the following:
- RWP
 - Radiological postings
 - Ropes / barriers
 - Radiological hazards
 - Whole body frisking instrument
 - In-use work areas may be used, with RSO approval, and provided that airborne generating activities are not underway.

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- C. Introduce the practical training by relating it back to the academics the trainees have just completed.
- D. Explain what will be expected of each trainee.
- E. Demonstrate how to perform the tasks, talk about good practices while doing so.
- F. Allow the participants to practice as you coach.
- G. Proceed to the Mock-Up area and begin Practical Factors evaluation.
- H. Complete a Practical Factors Evaluation Form.
- I. Review evaluation results with the trainee and forward form to RP Document Control.

11.0 ATTACHMENTS

None



PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: RADIOLOGICAL PROTECTIVE CLOTHING SELECTION, MONITORING, AND DECONTAMINATION	NO.: RP-132
	PAGE: 1 of 9
	DATE: March 2017
APPROVED:  _____ Technical Services Manager  _____ Corporate Certified Health Physicist	
	<u>03/10/17</u> Date <u>0310/17</u> Date

1.0 PURPOSE

This procedure provides the guidance for selecting protective clothing, performing personnel surveys, and decontaminating personnel.

2.0 APPLICABILITY

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors while performing activities in areas with known or suspected radioactive contamination.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Radiation."
2. Title 22, California Code of Regulations, Division 4.5; Environmental Health Standards for the Management of Hazardous Waste
3. California Executive Order D-62-02 regarding disposal of decommissioned materials.
4. 10 Code of Federal Regulations (CFR) 20; Standards for Protection Against Radiation, and Transfer and Disposal and Manifests
8. USNRC IE Information Notice No. 80-22, "Breakdowns in Contamination Control Programs."
9. ANSI N13.2-1969, "USA Standard Guide for Administrative Practices in Radiation Monitoring (A Guide for Management)."
10. RP -102, "Radiological Posting Requirements."
11. RP -103, "Radiation Work Permits."

4.0 GENERAL

4.1 Discussion

Radioactive material controls are established to provide positive control of radioactive material, prevent inadvertent release of radioactive material to uncontrolled areas, ensure personnel are not unknowingly exposed to radiation from lost or misplaced radioactive material, and to minimize the amount of radioactive waste material generated during PESI activities.

4.2 Definitions

Contamination Area (CA): Means any area with loose surface contamination values in excess of the applicable values specified in RP-104 Acceptable Surface Contamination Levels that is accessible to personnel, or any additional area specified by the RSO. The Contamination Area posting is defined as more restrictive than Radioactive Material Areas, hence all Contamination Area postings are considered to be Radioactive Material postings.

Minimum Detectable Activity (MDA): The smallest amount or concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal. MDA depends upon the type of instrument, the counting geometry, and the radionuclide to be detected. MDA has the same meaning as Lower Limit of Detection (LLD). (ANSI N13.3, 1989).

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and by-product material procured and used to support the operation or remediation.

Radioactive Material Area: Any area or room where quantities of radioactive materials in excess of ten times the 10 CFR 20 Appendix C quantities are used or stored, or any area designated a RMA by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO is responsible for:

- Identifying the radiological personal protective equipment (PPE) and, when appropriate, ensuring that the radioactive work permit lists the proper radiological PPE.
- Providing guidance and direction for decontamination of personnel.
- Notifying the corporate RSO of any personnel contamination event.

- Reviewing the Personnel Contamination Report and verifying all information is accurate.
- Requesting support from the qualified medical personnel regarding management of personnel who have been exposed to radiological contamination, when appropriate.
- Determining reimbursements and disposition of personal property that cannot be decontaminated.

5.3 Radiation Protection Technicians (RPTs)

The RPT is responsible for:

- Ensuring that workers don and doff the correct PPE properly, and performing decontamination of personnel under the guidance and direction of the RSO.
- Performing and documenting radiation and contamination surveys.
- Posting, securing, and controlling radioactive material and source storage areas.

5.4 Project Personnel

Project personnel are responsible for:

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.
- Complying with direction from RP personnel regarding the proper methods for donning and doffing of PPE.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

PPE should be fully inspected prior to use.

8.0 RECORDS

- Personnel Contamination Reports
- Radiological surveys

Records generated shall be transmitted to Project Document Control for filing according to procedure RPP-114.

9.0 PROCEDURE

The following factors should be considered when selecting PPE:

- The levels and types of radiological material present, or expected, in the work area
- The presence of chemical hazards
- The base in which the contamination is carried (dry, wet, oily)
- The work to be performed, or work in progress
 - The location of the contamination (e.g., floor, walls, overhead, air handling systems, sewer systems)
- The physical configuration of the work area
- The environmental conditions, such as heat and humidity
- The exposure situation (vapor, pressured splash, liquid splash, intermittent liquid contact, and continuous liquid contact)
- The toxicity of the radioactive materials and/or chemical(s) (i.e., ability to permeate the skin, and systemic toxicity)
- The physical properties of the contaminant (vapor pressure, molecular weight, and polarity)
- The functional requirements of the task (dexterity, thermal protection, fire protection, and mechanical durability requirements)

Table 9-1 provides guidance for the selection of PPE when radiological hazards are present or suspected.

**TABLE 9-1
GUIDE FOR THE SELECTION OF RADIOLOGICAL PROTECTIVE CLOTHING**

Removable Contamination Levels	Clothing for Access Only No Work *	Clothing for Work or Access During Work *
General contamination levels < 1,000 dpm/100 cm ²	Level D PPE	Level D PPE
General contamination levels > 1,000 dpm/100 cm ² , but ≤ 10,000 dpm/100 cm ²	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**
General contamination levels > 10,000 dpm/ 100 cm ² , but ≤ 100,000 dpm/100 cm ²	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (or hood) Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**
General contamination levels > 100,000 dpm/100 cm ² See Note ***	Glove liners Gloves (2 pairs) Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**	Glove liners Gloves (2 pairs) Booties (2 pairs), cloth or PVC Tyvek (2 pairs) Cap Hood Rubber shoe covers**

The guidelines for PPE selection specified in Table 9-1 may be modified under certain circumstances, such as the following:

- Wet areas – Where splashing water or spray is present, use rain suits in addition to the protective clothing listed in Table 9-1. A second set of coveralls may not be necessary when a rain suit is worn.
- Standing water – In addition to the clothing requirements for wet areas, use hip boots or waders for deep standing water areas.
- Face shields – Consider for use when there is significant beta radiation, or a likelihood of water splashing and respirators are not required.
- High temperature areas – Consult with the RSO and Site Health and Safety Specialist (SHSS) prior to working in high temperature areas.

9.1 DONNING PROTECTIVE CLOTHING

- Select the appropriate PPE.
- Inspect coveralls, cotton glove liners, gloves, shoe covers, and hoods for rips, tears, and holes, or other indications of damage. If damaged, do not wear the damaged PPE and remove the PPE from service.
- Do not wear PPE that does not fit properly.
- Place dosimetry, if worn, in the upper body area on the interior of the breast tab with the window of the dosimeter facing out. When coveralls that do not have a breast tab or pocket are worn, dosimetry should be attached per the direction of the RSOR or designee. The dosimeter shall not be worn inside clothing or placed in pockets if exposure of bare skin to beta radiation is expected.
- If a respirator is specified in the Radiation Work Permit (RWP), then ensure that the individual using the respirator has been medically cleared for respirator use and is respirator qualified.; and a respirator fit test has been performed.
- Don the respirator.
- Don the hood, if required, allowing it to overlap the rubber around the lens of the face piece and fall over the shoulder.
- If required, tape the hood to the respirator and to the coveralls.
- Ensure that any required hood is slack enough around the shoulders to allow for full head movement.
- Don rubber gloves.
- Tape the innermost pair of rubber gloves to the coverall sleeves.
- Leather work gloves may be substituted for outer rubber gloves on some jobs as specified in the corresponding radiation work permit.
- If specified on the RWP, don additional PPE as required.

9.2 DOFFING OF PROTECTIVE CLOTHING

Before stepping out of the contamination area or airborne radioactivity area to the step-off pad, the worker should:

- Remove exposed tape and place it in the appropriate container.
- Remove rubber overshoes and place them in the appropriate container.
- Remove the outer pair of gloves and place them in the appropriate container.
- Remove the hood, from front to rear, and place it in the appropriate container.
- Remove coveralls, inside out, touching the inside only and place them in the appropriate container.
- Remove the respirator, as applicable, by bending forward at the waist slightly, pulling the respirator away from the face, and then rolling the straps/headbands to remove the respirator, and place it in the appropriate container.
- Take down the barrier closure, as applicable.
- Remove any tape or fastener from the inner shoe cover and place it in the appropriate container.
- Remove a shoe cover and place it in the appropriate container while simultaneously stepping onto the clean step-off pad with the shoe whose shoe cover was just removed. Repeat this process with the other shoe.
- Remove the cloth glove liners and place them in the appropriate container.
- Replace the barrier closure, as applicable.
- Have the Radiological Control Technician (RCT) commence whole body frisking.
- Monitor the dosimeter.

The sequence for the removal of primary and supplemental dosimetry is dependent upon where the dosimetry was worn and the potential for contamination. The sequence for removal of respiratory protection devices may be altered if it is determined that the potential for inhalation of airborne contamination or the spread of surface contamination is reduced by keeping respiratory protection devices on until all protective garments have been removed.

The sequence for protective clothing removal may vary from that described above, under the following circumstances:

- At the discretion of the RCT providing job coverage.
- As designated in the assigned RWP.
- Depending on radiological and hazardous material conditions encountered during the work evolution.

It is important to be aware that pushing clothing or trash into an already full collection container to compress the contents is forbidden as the act can result in the potential for airborne radioactivity.

9.3 MONITORING

During exit surveys, the following procedures should be followed.

- Use the portable instrument staged for the area of concern, which should have both a visual and an audible response.

- Ensure that the instrument is set on slow response, if available, and operating with an audible response.
- Verify that the instrument is operational on the lowest scale and that the area background count rate is acceptable.
- Hold the detector with the window approximately 1/4 inch from the surface being monitored.
- Move the detector over the surface being monitored at a rate not to exceed 2 inches per second. It should take at least 3 minutes to perform a whole body frisk.
- If an increase in the audible response is noted, then cease moving the detector and allow the meter 5 to 10 seconds to stabilize.
- Pause (approximately 5 seconds) at the nose and mouth area to check for indications of inhalation/ingestion of radioactive material.
- Pay particular attention to hands, feet (shoes), elbows, knees, or other areas with a high potential for contamination.
- If no contamination can be detected, as indicated by an alarm or by an audible or visual response distinguishable from background, then exit the area.
- If an audible or visual response distinguishable from background is noted, then the RCT will further investigate to verify if contamination is present.
- If personnel are found to be contaminated, proceed to the procedures outlined in Section 9.3.1.

9.3.1 CONTAMINATED PERSONNEL

When dealing with contaminated personnel, the following procedures should be followed.

1. Notify the RSOR of any individual with known or suspected contamination.
2. If the contamination is on a personal article of clothing, then perform the following:
 - Survey the inside surface that was against the skin.
 - Verify that no contamination was transferred to the skin.
3. If the contamination is on the skin, determine if the contamination is in the form of a hot particle.
4. If the contamination is a hot particle, then:
 - Quickly evaluate the particle size, radiation type, and visible characteristics.
 - Attempt to collect and retain the particle for subsequent evaluation.
 - Decontaminate the individual in accordance with Section 9.3.2.
5. If the contamination is not a particle, then:
 - Evaluate the contamination levels.
 - Decontaminate the individual in accordance with Section 9.
6. Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

9.3.2 PERSONNEL DECONTAMINATION

The steps to follow for personnel decontamination are presented below.

1. Perform personnel decontamination in a manner that prevents the spread of contamination to other body parts, or the ingestion or inhalation of radioactive material.
2. Take appropriate precautions to minimize the spread of contamination when proceeding from the control point or step-off pad to the decontamination area.
3. Refrain from releasing personnel if detectable skin contamination is present, unless authorized by the RSOR.
4. Perform skin decontamination as follows:
 - Exercise care to avoid damaging the skin.
 - Discontinue the decontamination and notify the RSOR if skin irritation becomes apparent.
 - Record results after each decontamination attempt.
 - indicate the method of decontamination used.
 - Decontaminate ears, eyes and mouth using damp swabs, water, or saline solution rinses that are performed by the individual. Perform further decontamination under the direction of qualified medical personnel.
 - Decontaminate nasal passages by having the individual repeatedly blow the nose. Perform supplemental nasal irrigations under the direction of qualified medical personnel, as required.
 - Use decontamination processes or materials other than those listed in Table 9-2, only under the specific direction of qualified medical personnel.
 - Report incidents of individual contamination immediately to the RSOR.
 - Note the final survey results and time of the survey.
 - Record the area of the skin contaminated in square centimeters (cm^2) on the Personnel Contamination Report (Attachment 1).
 - Assume the measured activity is distributed over the probe area (the area of a typical pancake probe is 15.5 cm^2) for contamination distributed over an area greater than or equal to the area of the probe.
 - Determine the actual area of the activity if the area of contamination is less than the area of the probe but greater than 1 cm^2 ,
 - Assume an area of 1 cm^2 if the contamination area is less than or equal to 1 cm^2 .
 - Obtain the information needed to complete the Personnel Contamination Report (Attachment 1) when skin decontamination has been successfully completed.
 - Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

Table 9-2 Decontamination Techniques

TABLE 4-2 PERSONNEL DECONTAMINATION METHODS METHOD	EFFECTIVE FOR	INSTRUCTIONS
Masking Tape	Dry contamination, hot particles	Apply tape to skin by lightly patting. Remove carefully.
Waterless Hand Cleaner	All skin contamination	Apply to affected area and allow it to melt onto the skin. Remove with cotton or soft disposable towel.
Soap and Tepid Water	All skin contamination except tritium	Wash area with soap and lukewarm water. Repeat until further attempts do not reduce the level. A cloth or surgical hand brush may be used with moderate pressure.
Soap and Cool Water	Tritium contamination	Wash area with soap and cool water. Repeat until further attempts do not reduce the level. A cloth may be used with moderate pressure.
Carbonated Water	All skin contamination	Apply to affected area with cotton or soft disposable towel and wipe with dry towel.
Cornmeal Detergent Paste	All skin contamination	Mix cornmeal and powder detergent in equal parts with enough water to form a paste. Rub onto affected area for 5 minutes. Remove with cotton or disposable towel.

**Attachment 1
Personnel Contamination Event Report (Front)**

Name: _____ Site Badge#.: _____ RWP No.: _____

Employer: _____ Date: _____ Time: _____ Location of Incident: _____

Description of Work Being Performed: _____

Description of Circumstances and the Suspected Cause: _____

Skin Contamination Survey Summary

Body Location *	Initial Levels dpm/100cm ²	1st Decon Method	Attempt Results dpm/100cm ²	2ND Decon Method	Attempt Results dpm/100cm ²	3rd Decon Method	Attempt Results dpm/100cm ²
A							
B							
C							
D							

* Indicate location on back of form

Nasal Swab Activity: Swab 1 _____ dpm/100 cm² Swab 2 _____ dpm/100 cm²

Clothing Contamination Survey Summary

Item	Initial Levels dpm/100 cm ²	Decon Method	Final Results dpm/100 cm ²	Released to employee (Y/N)

Bioassay Intake?

Scheduled / N/A
N

Skin Dose

Calculated / NA

ROR Follow-up

Initiated / NA

Potential for

Yes / N

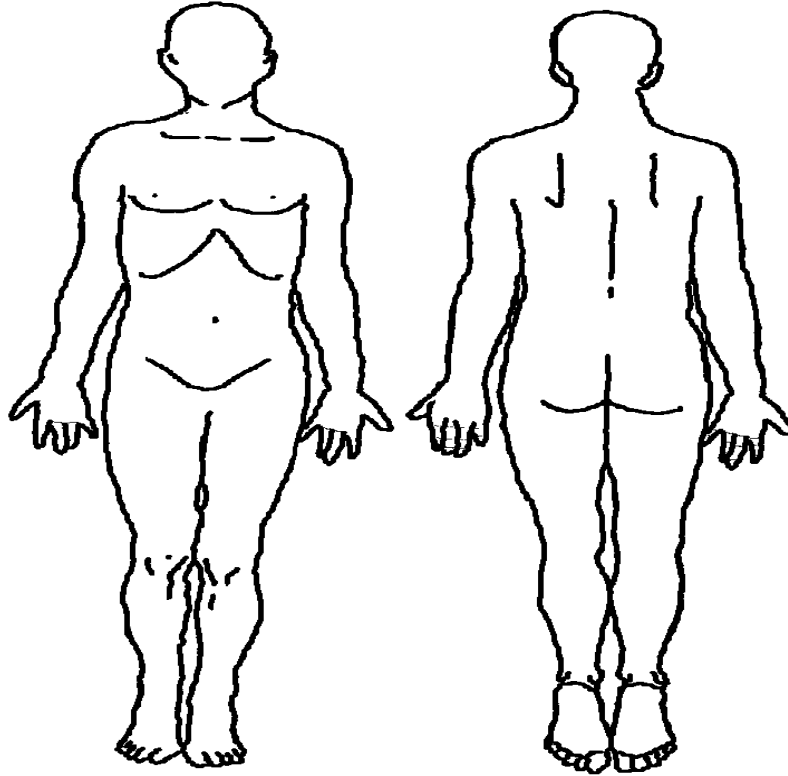
SRSO
Date

Date

RP Technician

**Attachment 1 (Back of Form)
Personnel Contamination Event Report**

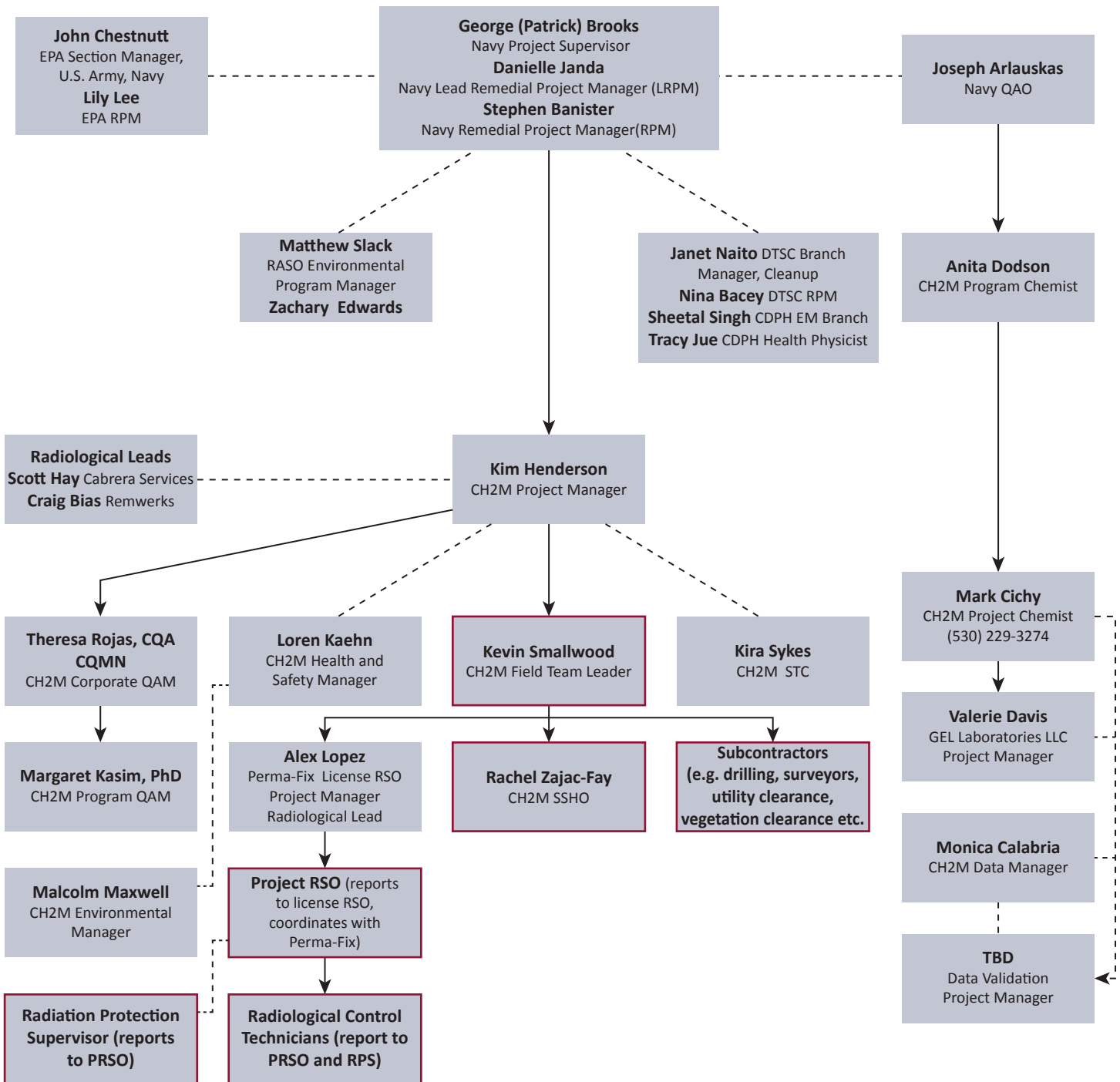
Comments and additional detail (identify by letter and include estimated area in square cm):



RP SURVEY INSTRUMENT(S) INFORMATION

Instrument Model	Serial Number	Cal. Due Date

HPNS Project Organization Chart



LEGEND

- Denotes In Field Role
- Lines of Authority
- - - Lines of Communication

**Radiation Protection Work Plan
Radiological Data Evaluation and
Confirmation Survey**

**Former Hunters Point Naval Shipyard
San Francisco, California**

**Department of the Navy
Naval Facilities Engineering Command
Base Realignment and Closure
Program Management Office West**

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Attachment

1	Radiation Protection Workplan Acknowledgment Form
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Acronyms and Abbreviations

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
APP	Accident Prevention Plan
CDPH	California Department of Public Health
CFR	<i>Code of Federal Regulations</i>
CRSO	Corporate Radiation Safety Officer
DAC	derived air concentration
DOT	Department of Transportation
EHS	Environmental Health and Safety
HRA	Historical Radiological Assessment
LLMW	low-level mixed waste
LLRW	low-level radioactive waste
millirem	milliroentgen equivalent man
mSv	millisievert
Navy	Department of the Navy
NRC	U.S. Nuclear Regulatory Commission
NRRPT	National Registry of Radiation Protection Technologists
Perma-Fix	Perma-Fix Environmental Services, Inc.
PM	Project Manager
PPE	personal protective equipment
PRSO	Radiation Safety Officer Representative
QC	quality control
RASO	Radiological Affairs Support Office
RCA	Radiologically Controlled Area
RCT	Radiological Control Technician
rem	roentgen equivalent man
RMA	Radioactive Materials Area
RML	Radioactive Material License
RPS	Radiation Project Supervisor
RPWP	Radiation Protection Workplan
RSO	Radiation Safety Officer
RWP	Radiation Work Permit
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
TEDE	total effective dose equivalent
TSP	task-specific plan

1 Purpose/Introduction

This Radiation Protection Workplan (RPWP) details Perma-Fix Environmental Services, Inc. (Perma-Fix) requirements for activities conducted as part of the radiological support activities at the former Hunters Point Naval Shipyard (HPNS), San Francisco, California. Work will be performed in accordance with the Perma-Fix State of California Radioactive Material License Number 8188-01 which is subject to all applicable rules, regulations, and orders of the California Department of Public Health (CDPH) and any standard or specific condition specified in the license. The following activities are subject to this RPWP: project activities that involve the use and/or handling of licensed by-product, source, and/or special nuclear material (hereafter referred to as radioactive material); tasks with the potential for radioactive material to be present based on available data and historical records; and work in locations posted and controlled because of radioactive material. Project activities will incorporate the requirements within this RPWP to maintain compliance with Perma-Fix's licensed Radiation Protection Program, RP-100.

Project activity performance steps are detailed in the site-specific work plans, standard operating procedures (SOPs), task-specific plans (TSPs), etc. (Agencies that may have jurisdiction over or an interest in project activities are also identified in such documents.) Project staff tasked to perform assignments involving the presence of radioactive material (for example, those identified in the applicable portions of **Section 2**) will complete a review of this document and indicate an understanding of all requirements by completing a Radiation Protection Plan Acknowledgement Form (**Attachment 1**).

1.1 Policy

It is Perma-Fix's policy that work with radioactive material be purposeful and performed in a manner that protects project staff, members of the general public, and the environment. Radiological work may not begin unless it can be performed in a safe and reliable manner that is compliant with the exposure reduction rules, regulations, and principles described in **Section 1.3**.

1.2 Project-specific Radiation Protection Plan

Perma-Fix's procedure RP-100, *Radiation Protection Program*, provides the foundation for the RPWP and its use for any project or activity that involves the possession or use of radioactive materials, including the subsequent potential for exposure to ionizing radiation. Content provided within this RPWP reflects corporate policy and provides the guidance needed for project management to execute the scope of work in a safe manner. Site-specific guidance for radiological safety and control is further detailed in SOPs. SOPs are subject to approval by the Radiation Safety Officer (RSO) or designee and may be revised separately from the RPWP.

1.3 As Low as Reasonably Achievable

Work involving radioactive material and any corresponding exposure to ionizing radiation must be purposeful and performed in a manner sufficient to ensure the protection of staff, members of the public, and the environment. Perma-Fix applies industry recognized principles to radiological work so that exposure to ionizing radiation is maintained as low as reasonably achievable (ALARA).

1.4 Authorization to Stop Work

In accordance with RP-100, *Radiation Protection Program*, and as detailed in **Section 2.9**, employees are authorized to stop work if an unsafe condition exists or safety protocol is being violated, and immediately report the condition to project management.

Work performed under a Radiation Work Permit (RWP) will stop, and the Radiological Affairs Support Office (RASO) will be notified if any of the following atypical work site conditions are encountered:

- Individual total effective dose equivalent (TEDE) exceeding 500 milliroentgen equivalent man (millirem)
- Collective TEDE for the job exceeding 1 roentgen equivalent man (rem)

- Individual airborne exposures exceeding 10 derived air concentration (DAC) hours in a 7-day period
- General area exposure rates exceeding limits of current radiological posting
- Contamination levels exceeding 100 times the limits requiring classification of an area as a Contaminated Area

In cases where the Department of the Navy (Navy) must be notified, the license RSO, with concurrence from the Navy, must approve the RWP prior to restarting work.

1.5 Scope of Work

The project-specific scope of work involves the following activities:

- Task-specific training of personnel
- Site controls and establishment of work zones at sites with, or having the potential for, radioactive commodities or contaminants.
- Handling and management of collected radioactive commodities, radiologically contaminated soil, or other radiologically contaminated material
- Site investigation and characterization surveys and sampling, screening for and removal of commodities, and surveys and sampling to document final conditions

1.6 Quality Control and Auditing

To maintain continued compliance and evaluate overall RPWP effectiveness, quality control (QC) measures including self-assessment and management reviews will be used. Formal audits, including those conducted at field projects, will be coordinated and tracked to completion by the RSO/designee as will any need for adjustments to audit frequencies

1.6.1 Self-assessment, Management Reviews, and Audits

A self-assessment and management review of RPWP use, as detailed in RP-100 will be conducted. Project personnel including the Project Manager (PM), project Radiation Safety Officer/Designee, and onsite personnel will support and cooperate with any audit conducted. At a minimum, Perma-Fix will perform an onsite audit of the project if the field work exceeds more than 90 calendar days in duration with a minimum frequency of at least once a year. Results of the audit will be documented and submitted to CH2M for approval.

1.6.2 Responses and Corrective Actions

Radiological deficiencies must be responded to in a timely fashion. Deficiencies that represent an imminent threat to radiological control or safety (such as compromise of procedural protocol) will be immediately reported to CH2M, the RSO, PM, or designee. Subsequent corrective actions will be tracked to completion by the RSO or designee. Radiological deficiencies, including corrective actions, will be promptly reported by the RSO to CH2M for submittal to the project client. Responses to findings will be documented by the RSO or designee for review, approval, and final disposition and submitted to CH2M.

1.6.3 Daily Instrumentation Check

As addressed in **Section 3.16**, survey instruments used during fieldwork will have proof of current calibrations in accordance with the manufacturers' procedures, employing applicable standards and sources traceable to the National Institute of Standards and Technology. Copies of instrument calibration certificates will be maintained onsite for reference. Instruments will be response-checked daily in accordance with applicable SOPs.

2 Radiation Protection Personnel

This section details the radiological safety responsibilities vested with key Perma-Fix personnel within the project as it relates to the radioactive material license. (Non-radiological safety responsibilities will be detailed in a separate project-specific Accident Prevention Plan [APP]/Site Safety and Health Plan [SSHP]). If a conflict exists in

Perma-Fix roles and responsibilities between this section and the Work Plan, the Work Plan shall take precedence. All contractor personnel shall be submitted to CH2M in advance for approval.

2.1 President of Perma-Fix

The President of Perma-Fix has overall responsibility for Perma-Fix's safety operations. The President of Perma-Fix is responsible for the following:

- Ensuring proper maintenance of the RPWP consistent with applicable regulatory mandates, Perma-Fix corporate policy, and recognized industry practice
- Establishing and maintaining all necessary management oversight specific to the RPWP
- Implementing a management review process to ensure applicable use of RPWP requirements

2.2 License Radiation Safety Officer

The Corporate Radiation Safety Officer (CRSO) is appointed by the President of Perma-Fix. The CRSO responsibilities are as follows:

- Review and make recommended revisions to:
 - The RPWP and associated procedures, radiation protection guidelines, and supporting documents
 - Project plans involving the use or handling of radioactive materials, or access to areas of radiological concern to ensure compliance with RPWP requirements and supporting guidelines
- Designate a Project Radiation Safety Officer (PRSO) to provide day-to-day guidance on radiological protection issues.
- Ensure communication with CH2M (prime contractor)
- Compliance as the license RSO, to include:
 - Serve as primary point of contact for all communications for license requirements to the U.S. Nuclear Regulatory Commission (NRC) and CDPH.
 - Identify and train Radioactive Material License (RML) authorized users.
 - Coordinate investigations involving radiological occurrences to include review and approval of a resulting Corrective Action Plan.
 - Provide advance NRC and/or CDPH notification in writing at least 14 days before initiating, at a temporary job site under Perma-Fix RML jurisdiction, any activity, or change to scope involving new activities, in areas of radiological concern (excluding routine packaging or repackaging for purposes of transporting and not requiring a job-or site-specific work package, and characterization and/or final surveys where radioactive materials and/or radiation are not likely to be detected).
 - Refrain from taking ownership of licensed materials in excess of possession limits without prior notification and written NRC and/or CDPH approval.
 - Provided advance NRC and/or CDPH notification in writing within 30 days of the temporary job site completion status involving decontamination and decommissioning activities, and disposition of any licensed material as related to RML jurisdiction.
 - Maintain radiological exposure records.
 - Develop and/or approve radiation safety training materials and/or courses.
 - Perform program audits as detailed in RP-100, *Radiation Protection Program*.
 - Provide guidance on radiological protection issues.
 - Identify appropriate project staffing needs to implement RPWP requirements.

- Assist with the development of site Environmental Health and Safety (EHS) plans and approval of EHS plans for projects that involve the use or handling of radioactive materials or access to areas of radiological concern.
- Delegate project responsibilities to company health physicists as necessary.

2.3 Project Radiation Safety Officer

The PRSO is assigned by the CRSO and is vested with corporate-level authority to implement the RPWP and the Perma-Fix RML at a project site. Whenever radiological work is actively ongoing under the Perma-Fix RML, the PRSO or designee identified as an authorized user will be present at the project site. The PRSO is vested with the following responsibilities at projects subject to jurisdiction involving the Perma-Fix RMLs:

- Provide health physics guidance on an as-needed basis.
- Conduct required radiological safety training.
- Review and approve project field procedures that involve the handling of radioactive materials or access to areas of radiological concern.
- Conduct radiation incident investigations and project inspections.
- Maintain a project site file that details radiological protection training provided, dosimetry records generated, radiological surveys performed, and other documentation pertinent to the RPWP, RML procedures, radiation protection guidelines, and supporting documents; copies of these will be provided to the Certified Health Physics Manager at the conclusion of the project.
- Arrange for and assist in program radiation protection audits as detailed in the most current version of RP-100, *Radiation Protection Program*.
- Assist in the development and approval of the site EHS plan.
- Help in the identification of project radiological analysis needs and selection of analytical support contractors.
- Coordinate required ALARA reviews.
- Ensure appropriate staff work practices are employed to maintain occupational radiation exposures ALARA.
- Ensure items needed to perform work in accordance with the RPWP and supporting documents are available, such as appropriate instrumentation, protective devices, dosimetry, etc.
- Direct the preparation, review and approval of RWPs.
- Stop work if necessary to ensure radiological safety.
- Communicate with the PM and CRSO as needed to ensure the RPWP is implemented correctly.
- Ensure proper operation of radiation-measuring equipment, including the performance of daily function and QC tests, and removing out-of-compliance instruments from service.
- Maintain radiation-measuring equipment in accordance with manufacturers' recommendations.
- Direct and supervise the performance of radiological surveys and sampling in accordance with the most current version of this RPWP and supporting Perma-Fix SOPs.
- Review survey reports and instrument performance data for accuracy, completeness, and compliance with project, procedural, and regulatory requirements.
- Ensure work is performed in accordance with current versions of project plans, procedures, and the RPWP.

The PRSO reports to and receives technical direction from the CRSO, advises the PM on radiation protection and radiological operation matters, coordinates with the PM on day-to-day project activities, and communicates and coordinates radiation protection and radiological operation activities with the CRSO and the client.

2.4 Project Manager

The Perma-Fix PM is responsible for:

- Ensuring the safe conduct of work in compliance with all permits, client contracts, and other controlling documents that apply
- Confirming exposure to radiation by project staff is maintained ALARA
- Allocation of adequate resources and staffing to develop and implement this RPWP in compliance with applicable regulations and requirements. The PM reports to the Perma-Fix Program Manager
- Ensuring coordination between the PRSO and other field personnel

2.5 Radiation Protection Supervisor

The Radiation Protection Supervisor (RPS) is the Perma-Fix representative responsible for overseeing Radiological Control Technicians (RCTs) and corresponding field operations conducted in areas of radiological concern. The PRSO may act as the RPS. Designated as an authorized user at projects subject to jurisdiction under the Perma-Fix RML, the RPS is vested with the following responsibilities:

- Supporting required ALARA reviews
- Coordinating plans for field activities with the to ensure exposure to radiation is maintained ALARA and in accordance with corresponding RWPs
- Supervising the preparation and review of RWPs
- Stopping work if necessary to ensure radiation safety
- Maintaining communication with the PRSO, PM, as needed to ensure the RPWP is fully implemented
- Confirming proper operation of radiation survey instruments, including the validation of daily function and QC checks, and removing noncompliant instruments from service
- Ensuring radiation survey instruments are maintained in a way that complies with manufacturer instructions and recommendations
- Directing and supervising the performance of radiological survey and sampling practices in accordance with the RPWP, current versions of applicable SOPs, and corresponding RWPs
- Validating field survey reports and instrument performance data for accuracy, completeness, and compliance with the RPWP, applicable SOPs, and corresponding RWPs
- Participating in periodic internal and external reviews of RPWP content and implementation
- Supporting self-assessments and management reviews as needed and correcting identified deficiencies within the allotted time frame

The PRS reports to and receives technical direction from the PRSO.

2.6 Radiological Control Technicians

The RCTs are responsible for:

- Ensuring occupational exposure to radiation is maintained ALARA
- Preparing, using, and adhering to RWPs
- Stopping work if necessary to ensure radiological safety
- Performing radiation surveys and other radiological safety tasks in accordance with the RPWP, applicable SOPs, and corresponding RWPs

- Confirming proper operation of assigned radiation survey instruments prior to field use to include verification of daily function and QC performance checks, and removing noncompliant instruments from service
- Using radiation survey instruments in accordance with the RPWP, applicable SOPs, and corresponding RWPs and maintaining the instruments in a way that complies with manufacturers' instructions and recommendations

The RCTs report to and receive technical direction from the PRSO and RTS, as applicable. All RCT's shall be qualified as senior RCT's (≤ 5 years as a qualified and documented RCT, either U.S. Department of Energy core, North East Utility Exam, National Registry of Radiation Protection Technologists [NRRPT], etc.). On a case by case basis, Jr RCT's will be evaluated by CH2M.

2.7 Radiation Workers (Field Personnel)

Project staff (including the general labor force associated with the company and subcontractors) who have the potential to receive occupational exposure to radiation while on the job site, and who are expected to work under the requirements of this RPWP as radiation workers, will:

- Receive sufficient training, prior to beginning work, in accordance with the most current version of document RP-115, *Radiation Worker Training*.
- Report to the RPS or RCT non-occupational radiation exposures that result from the use of medical or dental applications more aggressive than a standard X-ray.
- Comply with requirements of all procedures and guidelines applicable to the project.
- As required, exercise stop work authority and immediately report radiological safety issues or concerns, including incidents and unplanned events, to project management verbally or in writing, and respond promptly to any stop-work and/or evacuation orders.
- Adhere to industry-recognized radiological work practices when inside areas of radiological concern, and conform promptly to instructions when provided by RCTs.
- Strictly adhere to radiological control procedures, guidelines, and postings including information provided in RWPs.
- Immediately report lost dosimetry devices to the RCT.
- Report planned medical radiation treatments in advance to supervision and the PRSO and prior to entering areas of radiological concern or wearing dosimetry.
- Periodically confirm personal radiation exposure status and ensure that administrative dose guidelines are not exceeded.
- Notify the RCT of faulty or alarming radiological protection equipment.

When in areas of radiological concern, workers report to the PRSO or RPS, as applicable.

2.8 Stop Work Authority

CH2M, company, and subcontractor personnel will have the responsibility and authority to stop work when controls are inadequate or imminent danger exists.

In any situation in which stop work authority is used, the following requirements will apply:

- Exercise stop work authority in a justifiable and responsible manner.
- Once work is stopped, do NOT resume until proper controls have been established.
- Resumption of work will require concurrence by CH2M, the PM or designee, as well as the PRSO if the work stoppage was related to radiation safety.

3 Task-specific Hazard Analysis/Controls

A task-specific hazard analysis is performed on a daily basis to allow for risk identification associated with site work, including physical, chemical, and radiological components. (Radiation exposures that result from naturally occurring background sources and medical applications conducted under the care of a physician are examples of dose that is independent of occupational monitoring requirements but considered when planning task assignments. In instances of verifiable therapeutic applications, employee-furnished notifications will be used as an informational reference and included as part of a corresponding radiation exposure file.) Risk-based hazards and controls are defined in a site-specific Activity Hazard Analysis. Anticipated physical and chemical risks are described in detail in the project-specific APP/SSHP. Radiological risk controls are categorized in the sections to follow, and protective measures apply as defined in task-specific RWPs and corresponding SOPs.

3.1 Identification of Radiation Risks

Project tasks subject to RPWP protocol indicate a known or suspected likelihood of activities occurring in radiologically impacted areas (for example, locations with sources of radium-226, areas with similar radionuclides of concern as identified in the site-specific Historical Radiological Assessment [HRA]).

3.2 Controlling Documents

Unless indicated otherwise in **Section 1**, work conducted under the RPWP will be subject to requirements detailed in Perma-Fix RML No. 8188-01 and in accordance with any project-specific Memorandum of Understanding criteria and applicable radiological control work documents (for example, site-specific Radiological Plan, SOPs). Perma-Fix will incorporate site-specific versions of SOPs as needed to implement and satisfy license commitments. Title 10 of the *Code of Federal Regulations* Part 20 (10 CFR Part 20) applies to the RPWP standards used. In parallel, industrial safety requirements and United States Environmental Protection Agency regulations detailed in 29 CFR and 40 CFR also have applicability for a variety of regulatory subjects including Comprehensive Environmental Response, Compensation, and Liability Act of 1980; the Resource Conservation and Recovery Act; and the National Emission Standards for Hazardous Air Pollutants.

3.3 Evaluation of Potential Exposure to Workers

RPWP dose limits for the control of occupational exposure to ionizing radiation are listed in 10 CFR 20.1201–1208. Dose limits for individual members of the public are detailed in 10 CFR 20.1301–1302. Occupational exposures for project personnel will be maintained below Perma-Fix administrative values for annual TEDE. Occupational dose, if any, is expected to originate from external sources (for example, radium-226, cesium-137, strontium-90, or similar known radionuclides of concern as listed in a site-specific reference document [for example, HRA]). Dose resulting from internal exposures is not anticipated. External exposure controls are addressed in **Section 3.8**, and controls to prevent or limit internal exposures are detailed in **Section 3.9**. Dose rates for general area work sites are expected to reflect naturally occurring background values.

3.4 Evaluation of Public Dose

Based on the scope of planned work, the limited activity of radionuclides expected, and low concentration of naturally occurring radioactive material anticipated, public dose associated with tasks performed under this RPWP is not projected. To validate the maintenance of public dose goals, Perma-Fix will implement necessary survey and sampling protocols in areas of intrusive work, conspicuously post and restrict access to intrusive work locations that require monitoring (for example, areas where soil excavations and/or handling, etc., may disturb sources of radioactive material), and validate survey and sampling results and frequencies to ensure established controls are effective.

3.5 Training Program

Site radiation training will be conducted in accordance with Perma-Fix procedure RP-115 *Radiation Worker Training*. Site personnel tasked to conduct project-oriented activities must satisfy corresponding APP/SSHP and RPWP training requirements, depending on roles and responsibilities performed. Persons subject to assignments involving a known or suspected potential for occupational radiation dose will receive additional training commensurate with radiological awareness requirements as defined in 10 CFR 19.12, Instructions to Workers. Visitors and escorted persons must receive a site briefing and will be assigned to a qualified radiation worker aide when in an area of radiological concern (i.e. controlled or restricted areas).

3.5.1 Site Briefing

An RPWP site briefing is designed for an escorted person and is presented when access is needed to radiologically impacted locations. Specific to the area(s) of concern where access is needed, the RPWP brief will cover at a minimum:

- Applicable portions of 10 CFR 19, 10 CFR 20, the RPWP, RWPs, site-specific reference documents (for example, HRA), and supporting SOPs
- A description of radiation exposure risks and monitoring requirements
- Access and egress protocol specific to the radiologically impacted location(s) requiring entry
- Radiation exposure reduction techniques for an embryo/fetus
- Completion of applicable briefing/exposure monitoring documentation
- Notification of contacts as needed to complete training requirements

3.5.2 Radiation Worker Training

Radiation Worker training (RWT) is provided when unescorted access is needed to impacted site locations subject to radiological control. Inclusive of material that may be required by project-specific Work Plans and documents (for example, APP/SSHP), training may be presented in the form of a group overview, video presentation, etc., with use of printed handouts approved by the PRSO. The RWT requirements are listed in RP-115 *Radiation Worker Training* and include a classroom based and practical training modules. At a minimum the classroom training includes:

- Fundamental of Radioactivity
- Prenatal Exposure Risks
- Perma-Fix Radiation Protection Plan
- Site Specific Radiological Hazards / contaminants
- ALARA Concepts
- Radiological Postings / Barriers
- Emergency Response / Evacuation Routes
- Applicable portions of 10 CFR 19, 10 CFR 20, the RPWP, site-specific reference documents (for example, Hunters Point Naval Shipyard HRA), and supporting SOPs specific to task performance
- Required contacts and expected actions in the event of an emergency (in accordance with the current version of RP-130, *Event Reporting and Notification for State of California*)
- Expected actions and contacts if radioactive material is discovered in an area where it is not expected
- Understanding the requirements for and compliance with RWPs including protocol for dosimetry and personal protective equipment (PPE)

3.5.3 Radiological Control Technician Training Qualification

Perma-Fix will evaluate and ensure acceptable qualification of RCTs. RCTs are required to have successfully completed a RWT course within the past year (or refresher training), or have current NRRPT credentials or an equivalent RCT training/certification program. When selected for project assignment, RCT qualifications are evaluated in accordance with the requirements detailed in RML No. 8188-01. Project-specific training is provided to RCTs commensurate with anticipated duties and assignments.

3.6 Declared Pregnant Worker

To maintain embryo/fetus radiation exposure ALARA, female employees who are pregnant or attempting to become pregnant are encouraged to declare this information to project management in writing to allow for criteria to be exercised as detailed in:

- 10 CFR 20.1208, Dose Equivalent to an Embryo/Fetus
- NRC Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure, Revision 3, Washington, D.C. (NRC, 1999)
- NRC Regulatory Guide 8.29, Instruction Concerning Risks from Occupational Radiation Exposure, Revision 1, Washington, D.C. (NRC, 1996)

Because of the small anticipated annual dose for workers associated with project activities (that is, less than 10 millirem/year) it is unlikely in instances of pregnancy that separate dose tracking for the embryo/fetus will be necessary. Managing occupational exposures for all staff within annual Perma-Fix administrative TEDE guidelines is expected to satisfy the requirement of less than 500 millirem total dose for any declared pregnant female worker over the course of an entire gestation period.

3.7 As Low as Reasonably Achievable Program

Perma-Fix is committed to maintaining radiation exposure to workers and the public as far below company guidelines and regulatory limits as practical. RPWP requirements are established for field operations in an effort to meet that commitment in accordance with the current version of procedure RP-100, *Radiation Protection Program*.

3.8 External Exposure Control

The following steps will be taken to control external radiation exposure to levels that are ALARA:

- Employ basic dose reduction strategies as detailed in Perma-Fix RP procedures using the ALARA concepts of time, distance, and shielding.
- Use instruments at frequencies sufficient to accurately determine the level and extent of radiation fields.
- Present adequate staff training to ensure the ability to recognize situations involving objects that might be radioactive, to be wary of objects that are unfamiliar, and to rely on valid instrument readings to limit and safely manage external exposure.

3.9 Internal Exposure Control

Internal exposure is expected to be below all the recognized DAC values as specified in 10 CFR 20. If air sampling is required, air sampling will be performed in accordance with **Section 3.11**. Should the potential for internal dose be confirmed during fieldwork, the activity will be temporarily suspended and the work area secured pending determination and use of corrective protocol as decided among the PRSO and PM with concurrence from CH2M.

3.10 Monitoring and Measuring External Exposure

A vendor accredited by the National Voluntary Laboratory Accreditation Program will be used to provide project-related dosimetry services. Dosimetry applications and considerations will apply to field staff designated as radiation workers (that is, personnel needing unescorted access to impacted site locations subject to radiological control). Prior to dosimetry issue, a radiation worker will have satisfactorily completed requirements as detailed in **Section 3.5.2**.

3.11 Monitoring and Measuring Internal Exposure

The monitoring of work practices conducted in areas of radiological concern will be at frequencies established in RP-104, *Radiological Surveys*, necessary to confirm the application of correct techniques and PPE to minimize potential transfer of external contaminants inside the body.

Air sampling will be performed during intrusive activities conducted in areas of radiological concern in accordance with RP-107, *Measurement of Airborne Radioactivity*. Air sample results will be reviewed and tracked to determine whether trends (for example, concentrations greater than 10 percent of DAC) exist that require re-engineering of task-specific contamination controls or temporary pause of work activities.

3.12 Surveys and Monitoring for Radiological Controls

Protection of workers, the public, and the environment depends on accurate assessment and interpretation of past historic information as compared to present-day survey data collected in accordance with prescribed procedures and project support documents.

In situations subject to this RPWP, guidance for determining radiation protection survey frequency and technique is detailed in applicable portions of procedures RP-101, *Access Control*; RP-111, *Radioactive Material Controls and Waste Management Plan*; RP-104, *Radiological Surveys*; and RP-106 *Survey Documentation and Review*. Further detail is contained in RP-108, *Count Rate Instruments*, and RP-109, *Dose Rate Instruments*.

3.12.1 Surveys of Equipment and Materials

Equipment and material passing through areas controlled for radiological concern will be subject to survey criteria and techniques detailed in applicable portions of procedure RP-101, *Access Control*. This will include performing an incoming characterization survey of equipment and material. Further detail is contained in RP-105, *Unrestricted Release Requirements* and RP-111 *Radioactive Materials Control and Waste Management Plan*. If survey results indicate levels of contamination exceeding the release criteria provided in the RPWP for incoming equipment and material the equipment or material will not be used at the Site. If survey results indicate levels of contamination exceeding the release criteria provided in the RPWP for outgoing equipment or materials, appropriate decontamination methods will be performed using methods described in RP-132, *Radiological Protective Clothing Selection, Monitoring, and Decontamination*. Prior to offsite removal, unrestricted releases of materials and equipment will be submitted to CH2M for approval.

Release criteria are provided in the RMP.

3.13 Action Levels for Radiological Control

Action levels represent transition points at which concentrations of radioactivity require additional response (e.g., PPE upgrades or increased work technique controls). Action levels for radiological controls are detailed in procedure RP-101, *Access Control*, RP-102 *Radiological Postings*, and RP-103 *Radiation Work Permits*. These action levels are specific to radiological controls and are not associated with project specific requirements, such as, the need for further investigation or site release.

3.14 Radiologically Controlled Areas and Posting

Site structures, outdoor locations, and/or perimeter boundaries posted with yellow and magenta markings are established to identify areas designated for radiological control, prevent (to the extent practical) access by unauthorized persons, and protect members of the public from exposure to radiation. A description of scenarios and postings employed for control purposes are detailed in applicable portions of procedure RP-101 *Access Control*, RP-102 *Radiological Postings*.

3.14.1 Controlled Area

A Controlled Area may be established where access to impacted portions of a work site requires specialized qualification and approval. A Controlled Area (which may also be called a Restricted Area) is intended to serve as the outermost boundary around planned and established work zones.

Controlled Area access requires prior authorization and use of PPE as defined in a project-specific APP/SSHP. Visitors must have requisite training as specified in an SSHP. Personnel who enter a Controlled Area may not cross into more restrictive areas posted within unless prior authorization is obtained.

Where the perimeter to a Controlled Area is first encountered for radiological purposes, posting applications will have the wording "Caution Controlled Area" (or Restricted Area) and provide a contact phone number. (Supplemental information as specified by the PRSO or designee may also be included as magenta [preferred], purple, or black markings on a yellow [preferred] or white background). A minimum of one sign will be posted on each straight run of the Controlled Area (or Restricted Area) boundary. Note that areas not typically accessed by pedestrians (for example, windows) need not be posted. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.2 Access Control Point

When used, an Access Control Point is part of a Controlled Area (or Restricted Area) boundary. Intended to serve as a transition corridor, an Access Control Point allows for the accountability of personnel, tools, and equipment that pass through. When established as a radiological control mechanism, an Access Control Point RCT will be present any time activities within are ongoing. During periods of inactivity, control point gates (part of the contiguous area boundary) are closed

3.14.3 Radiologically Controlled Area

A Radiologically Controlled Area (RCA) represents an area in which a person who works for 1 year might receive a whole body dose in excess of 100 millirem from all pathways (excluding natural background and medical exposures). For external sources, the RCA is typically posted when an area, accessible to individuals, could expose an individual to a dose equivalent in excess of 0.005 rem (0.05 millisievert [mSv]) in 1 hour at 30 centimeters from the radiation source (equivalent to a "Radiation Area" in 10 CFR 20.1003). The RCA may be modified at the discretion of the PRSO based on accurately assessed occupancy factors. Intended to include (for posting purposes) the nearest boundary or perimeter associated with the affected area, RCA restrictions and corresponding access protocol can be located in site-specific documentation (for example, Hunters Point Naval Shipyard Action Memorandum) and authorized by the PRSO for use if more restrictive.

When used, a minimum of one sign will be posted on each straight run of the RCA boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary. For waterfront areas, signs should be posted at areas accessible by watercraft.

3.14.4 Radioactive Materials Area

A Radioactive Materials Area (RMA) identifies any area or room in which there is used or stored amount of licensed material exceeding 10 times the quantity of such material specified in Appendix C to Title 10 Part 20 of the CFR. Intended to warn of the potential for occupational dose, a description of RMA scenarios and postings employed for control purposes can be located in applicable portions of procedures RP-111, *Radioactive Material Controls and Waste Management Plan*, and RP-102 *Radiological Postings*. When used, a minimum of one sign will

be posted on each straight run of the RMA boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.5 Contamination Area

A Contaminated Area is any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors (AEC, 1974), but do not exceed 100 times those values. Contamination is radioactive material that is deposited on a surface where it is unwanted. Subject to license control, a description of Contaminated Area scenarios and postings employed for control purposes can be found in applicable portions of SOP RP-102, *Radiological Postings*. When used, a minimum of one sign will be posted on each straight run of the RCA boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.6 High Contamination Area

A High Contamination Area is any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in Regulatory Guide 1.86 (AEC, 1974). When used, a minimum of one sign will be posted on each straight run of the High Contamination Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary. High contamination areas are not anticipated for this project.

3.14.7 Radiation Area

A Radiation Area means any area accessible to individuals in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 5 mRem/hr (0.05 mSv per hour [hr]) at 30 centimeters, but does not exceed 100 mRem/hr (1 mSv/hr) at 30 centimeters from the source or from any surface that the radiation penetrates. A description of Radiation Area scenarios and postings employed for control purposes can be found in applicable portions of procedure RP-102, *Radiological Postings*. When used, a minimum of one sign will be posted on each straight run of the Radiation Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.8 High Radiation Area

A High Radiation Area means any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent equal to or greater than 100 mRem/hr (1 mSv/hr) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates, but less than 500 RAD/hr. A description of High Radiation Area scenarios and postings employed for control purposes can be located in applicable portions of procedure RP-102, *Radiological Postings*.

When used, a minimum of one sign will be posted on each straight run of the High Radiation Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary. High radiation areas are not anticipated for this project.

3.14.9 Airborne Radioactivity Area

An Airborne Radioactivity Area is a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations:

- In excess of the DACs specified in Appendix B to 10 CFR 20.1001–20.2401, or
- To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake or 12 DAC hours.

As an example, for radium-226, the most likely airborne contaminant at Navy radiological remediation projects, the applicable DAC value is 3.0E-10 microcuries/milliliter. A description of Airborne Radioactivity Area scenarios and postings employed for control purposes can be located in applicable portions of procedure RP-102,

Radiological Postings. When used, a minimum of one sign will be posted on each straight run of the Airborne Radioactivity Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary. Airborne Radioactivity Areas are not anticipated for this project.

3.15 Contamination Control

Contamination control practices are established to preclude the spread of contaminants into uncontrolled areas. Recognized applications are detailed in procedures RP-111, *Radioactive Materials Control and Waste Management*, and RP-105, *Unrestricted Release Requirements*.

3.15.1 Physical Boundary

A physical boundary will be established using criteria referenced in **Section 3.14** to fully enclose a location established as a Contaminated Area.

3.15.2 Entry

Entry into a Contaminated Area will be compliant with pre-established requirements as detailed on a job-specific RWP. In such instances, an RCT will be present to assist in radiological control and support. (See **Section 3.17.1** for details related to RWP use.)

3.15.3 Exit

Exit from a Contaminated Area will be compliant with pre-established requirements as detailed on a job-specific RWP. In such instances, an RCT will be present to assist in radiological control and support. (See **Section 3.17.1** for details related to RWP use.)

3.15.4 Limitations on Entry

Personnel with open wounds or sores are not generally granted access into a Contaminated Area. Entry may be authorized by the PRSO or designee, on a case-by-case basis, if appropriate protection of the wound or sore is verified, planned work activities are unlikely to compromise the protection, and there is no other medical reason to restrict entry. Unescorted personnel entering an RCA must be in compliance with RP-115 *Radiation Worker Training*.

Jewelry and personal items are not allowed in Contaminated Areas; only project-furnished tools, materials, and equipment necessary to accomplish the planned task are acceptable. Container wrappings, packing, and similar materials must be segregated from essential items prior to entry.

3.15.5 Control of Items

Items such as equipment and tools to be removed from a Contaminated Area must meet unrestricted release criteria as detailed in applicable portions of procedures RP-111, *Radioactive Materials Control and Waste Management*, and RP-105, *Unrestricted Release Requirements*.

3.16 Instrumentation Calibration

All instruments will have current calibrations for the radiations and energies found at the Site, using National Institute of Standards and Technology-traceable standards. Operational and background checks will be performed at the beginning of each day of survey activity and whenever there is reason to question instrument performance. A defective instrument will be removed from service, and data obtained with that instrument since its previous acceptable performance will be reviewed for acceptability.

All portable instrumentation will be QC source-checked on a daily basis to ensure instruments are responding within manufacturer specifications. QC checks will be conducted by comparing the instrument's response to a designated radiation source and to ambient background.

QC source checks will consist of one-minute integrated counts for detectors coupled to scaling instruments and enough time to establish a consistent response for rate meters with the designated source position in a reproducible geometry, performed at the designated location. Background checks will be performed in an identical fashion with the source removed. The results of the background and QC checks will be recorded in a field logbook.

3.17 Control of Radiological Work

All radiological work activities will be planned in consultation with the CH2M, PRSO, the PM, and other project personnel tasked with oversight responsibilities. Work performed in areas of radiological concern require establishment of an RWP, which details radiologically based requirements and protective measures.

3.17.1 Radiation Work Permits

RWPs detail the protective measures and controls needed to perform tasks in areas of radiological concern. Information considered during RWP development is detailed in applicable portions of procedure RP-103, *Radiation Work Permits*. RWPs will be submitted to CH2M for review.

3.17.2 Task-specific Plans

TSPs are used to supplement RWP requirements and address in greater detail corresponding activities planned while personnel are inside areas of radiological concern. These instructions are required for tasks scheduled to occur in locations as determined by the CH2M, the PM, PRSO, or the Construction Manager. The PRSO or designee will finalize, control, and issue radiologically based TSPs.

3.18 Procurement, Receipt, and Inventory of Sealed Radioactive Sources

It is not anticipated that field projects will receive radioactive material shipments other than exempt-quantity radioactive check sources. As detailed in procedures RP-111, *Radioactive Materials Control and Waste Management* Sealed Radioactive Source Control, check sources are controlled, stored, posted, and managed as radioactive material.

3.18.1 Leak Testing

Radioactive sealed sources will be leak-tested as detailed in applicable portions of procedures RP-111, *Radioactive Materials Control and Waste Management* upon receipt of sources at the Site, prior to transport from the Site, and/or annually

3.18.2 Transport of Sources

Check sources will be used on field projects only for the period of time necessary to execute planned work, will not be introduced onto a project location prior to project initiation, and will be returned to the provider immediately following the completion of planned field activities.

Check sources will be maintained as detailed in applicable portions of procedures RP-111, *Radioactive Materials Control and Waste Management*.

3.18.3 Reporting Lost, Damaged, or Stolen Sources

As detailed in applicable portions of procedures RP-111, *Radioactive Materials Control and Waste Management* if a check source is lost, damaged, or stolen, the event will be reported immediately to the PRSO or designee. The PRSO will immediately notify the RSO, the PM, and the client (Navy) and initiate appropriate recovery actions. In consultation with the client, a report will be filed by the RSO or designee with the appropriate law enforcement agency if it is determined that radioactive material was stolen. The RSO will make any necessary notifications to the NRC and/or CDPH.

3.19 Shipping and Transportation of Radioactive Materials

Offsite shipment of radioactive materials other than exempt-quantity radioactive check sources by Perma-Fix is not anticipated. Information pertinent to an authorized shipper for a field project is provided in **Section 6**.

3.20 Control of Radioactive Waste

Radioactive waste will be minimized by compliance with contamination control practices (**Section 3.15**) combined with segregation and survey practices. A waste shipment provider contracted to the client (for example, the Navy through the Army Joint Munitions Command) will provide brokerage services including waste characterization sampling, waste containers, and transportation of radioactive materials/waste generated from a field project. Soil and used PPE will typically be processed for final disposition in disposal bins, or other appropriate container. When filled, containers will be transferred to the custody and control of the authorized shipper. As detailed in procedure RP-111, *Radioactive Materials Control and Waste Management*, commodities are stored in a locked radioactive materials storage area, controlled by the PRSO or designee, and will periodically be packaged and transferred to the authorized shipper for disposal. Radioactive material will be packaged, stored, shipped, and disposed of as required by Department of Transportation (DOT) regulations. Additional controls will be implemented if the radioactive waste material also contains chemical hazards (i.e. storage, accumulation areas, etc.).

3.21 Radiation Protection Records

As detailed in the applicable portions of procedure RP-114, *Radiological Protection Records*, the PRSO or designee is responsible for ensuring that airborne monitoring, contamination surveys, and exposure/dose rate surveys are reviewed for accuracy and completeness as an on-going process. Individual exposure records including dosimetry and bioassay reports for personnel are reviewed for results as generated.

Project specific documentation is provided in Radiation Management Plan (Appendix B of the Work Plan for Radiological Data Evaluation and Confirmation Sampling).

3.22 Reports and Notifications

Workers who have previous occupational work history with radiological environments will supply the RSO or designee with prior estimated or reported dose histories on an NRC Form 4 or equivalent as defined in 10 CFR 20.2104.

Records of radiation exposures to workers who have been issued external dosimetry monitoring devices will be maintained. Dosimetry monitoring results for workers will be reported to the RSO annually at a minimum. Annual occupational exposure records will be provided to each employee monitored.

3.23 Licenses

Entities subject to the use of this RPWP will conduct radiologically based tasks with use of Perma-Fix RML No. 8188-01. Perma-Fix will ensure that the RPWP and work practices are implemented and performed in accordance with the RML requirements and the RWP. A certified waste broker contracted by the DoD Executive Agency for low-level radioactive waste (LLRW) will be used for all packaging, shipping, manifesting, transportation, and disposal of LLRW and low-level mixed waste (LLMW). The certified waste broker will coordinate closely with RASO. LLRW and LLMW inventories will be managed under the appropriate NRC license due to the radioactive constituents.

3.24 Review and Approvals of Radiation Protection Plans

The RSO or designee will prepare the RPWP, which will then be reviewed for approval by subject matter experts (for example, the PM or PRSO). In addition, the client CH2M and ultimate client (the Navy) will have an

opportunity to review the draft content, provide input, and indicate acceptance of the plan. Changes to the RPWP will be reviewed and accepted following the same process.

3.25 Planned Special Exposures

No anticipated event within work scopes subject to this RPWP will require use of a planned special exposure. In the event it is necessary to initiate such a need, an activity-specific TSP including a formal ALARA review and an RWP will be prepared and submitted for acceptance following the same process as the RPWP submittal in **Section 3.24**.

4 Personal Protective Equipment

Minimum PPE requirements based on chemical contaminants are established by the Health and Safety Manager (in a project- and task-specific APP/SSHP). This primary level of PPE, Modified Level D, is historically sufficient for radiological work activities and is supplemented by activity-specific RWPs based on the radiological conditions and field tasks required to perform planned activities. Information considered for PPE during RWP development is detailed in applicable portions of procedure RP-101, *Access Control*; RP-102, *Radiological Postings*; and RP-103, *Radiation Work Permits*.

4.1 Selection of Personal Protective Equipment

Personnel must wear PPE commensurate with contamination hazards associated with both the work area and the planned activity as detailed RP-132, *Selection and Use of Radiological PPE*. Activities that require heavy physical effort or that have an increased potential for damage to PPE may require additional layers or different PPE materials, even in areas of low contamination. Site- or task-specific PPE requirements beyond the minimum traditionally used will be detailed in a corresponding RWP.

4.2 Donning and Doffing PPE

To prevent contamination of personnel or the spread of contamination, PPE must be donned and doffed in a specific manner. Directions for donning and doffing standard PPE ensembles are provided in the applicable sections of procedure RP-115, *Radiation Worker Training*. Additional instructions for non-standard site- or task-specific PPE requirements will be provided in the applicable RWP.

5 Decontamination Procedures

Personnel and equipment decontamination is conducted following details identified in applicable portions of procedure RP-111, *Radioactive Material Control and Waste Management Plan*, RP-105 *Unrestricted Release Requirements*, and RP-132, *Radiological Protective Clothing Selection, Monitoring, and Decontamination*.

6 Shipping and Transportation of Radioactive Materials

Field projects subject to the use of this RPWP will conduct radiologically based activities with use of RML No. 8188-01. The client-designated waste broker associated with a field project may implement its RML to conduct waste characterization sampling of waste material in support of low-level radioactive waste shipment and disposal. Wastes sent off site for disposal will be done so in accordance with the DOT Radioactive Material Transportation regulations of 49 CFR, by a certified waste broker. Personnel having the required DOT training will perform all DOT functions as needed.

Additionally, hazardous wastes will be sent off site for disposal or recycling with appropriate land disposal restriction (LDR) certification notices per 40 CFR, Part 268, and 22 CCR, Section 66268. In addition, all broker,

shipper, waste management, transporter and disposal contractors will be subject to the subcontractor qualification process. Under no circumstances will Perma-Fix personnel sign hazardous waste manifests.

If material is hazardous, it will be managed and shipped under the appropriate hazard class. All hazardous waste will be transported under DOT hazardous material regulations. Each shipment of a suspected hazardous material will be properly classed using the Hazardous Material Table in 49 CFR, Part 172.101. DOT-trained personnel will make all determinations. All waste shipments will be reviewed and approved by the Navy (of approved contractor), prior to release of the shipment.

7 References

Atomic Energy Commission (AEC). 1974. Regulatory Guide 1.86. Termination of Operating Licenses for Nuclear Reactors. June.

U.S. Nuclear Regulatory Commission (NRC). 1996. Regulatory Guide 8.29, Instruction Concerning Risks from Occupational Radiation Exposure, Revision 1, Washington, D.C. February.

NRC. 1999. Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure, Revision 3, Washington, D.C. June.

Attachment 1
Radiation Protection Workplan
Acknowledgment Form

Appendix E
Memorandum of Understanding

MEMORANDUM OF UNDERSTANDING

US NRC License and California Agreement State License Use Hunters Point Naval Shipyard, San Francisco, California

This Memorandum of Understanding (MOU) replaces the preceding MOU of record dated December 2, 2016.

This action is necessary in order to reflect the following changes:

Gilbane transfer of Parcel D-1 control to CB&I.

Note: Parcel D-1 ground surface intrusive activities will be controlled by DON/CB&I

1.0 Background

A project team consisting of B & B Environmental Safety, Inc. (BBES), Gilbane Federal (Gilbane) and Chicago Bridge and Iron (CB&I) are performing work at the former Hunters Point Naval Shipyard (HPNS) in San Francisco, California. The work requires licensed controls due to the presence of radioactive materials and the subsequent potential for occupational exposures, both of which are subject to oversight by the Nuclear Regulatory Commission (NRC) and/or the California Department of Public Health (CDPH), depending on where the operations are conducted in relation to the regulatory jurisdictional dividing line at HPNS (See *CB&I Figure 1*).

The intent of this memorandum is to outline the general applicability and responsibilities of each project team organization as related to corresponding work scope and license compliance parameters.

BBES is providing brokerage services inclusive of the offsite transport and disposal of project generated radioactive and mixed waste and the staging of Department of Transportation (DOT) approved waste storage and transportation containers. The control of radioactive waste package activities and site locations designated for "post loading" LLRW container operations are subject to requirements in the BBES NRC RML No. 04-29369-01 and California Agreement State License 7540-39. The BBES area of jurisdictional control is limited to the location delineated in CB&I Figure 1. The BBES Empty Container Storage Area at Dry Dock 4 will be used for storage of empty containers and temporary waste shipment staging.

Gilbane is contractually bound to conduct various activities specific to the DON generated project awards, following the requirements in the Gilbane CA RML No. 7948-07, in RSY 4 in Parcel E.

CB&I is contractually bound to provide base-wide radiological support functions onsite that also include radiological support for non-radiological contractors performing work in HPNS radiologically impacted areas. CB&I is also contractually bound to provide remedial action services specific to DON award of CTO-013; Shoreline Revetment: Site Grading and Upland Slurry Wall Construction within Parcel E-2. Base-wide radiological support functions and the Parcel E-2 contract work effort performed by CB&I are in accordance with the DON contract and CB&I's NRC Radioactive Materials License (RML) No. 20-31340-01 and California Agreement State (CA) RML No. 7889-07 requirements.

CB&I's areas of control are delineated in CB&I Figure 1 and include radiologically-impacted sites not under the NRC/CA license jurisdictions of Gilbane or BBES.

1.1 General Use of Individual Licenses

Each organization within the team has distinct areas of operation and responsibility as defined by their respective clients (BBES for the Army Joint Munitions Command [AJMC], and Gilbane and CB&I for the DON). In parallel, each of the team members identified for license implementation will maintain specific controls associated with the following items and activities as applicable to respective work scope/areas and/or license requirements:

Training and record maintenance for employees of each company:

- BBES for BBES site staff
- Gilbane for Gilbane site staff
- CB&I for CB&I site staff

Training and record maintenance for site visitors and non-radiological contractors performing work:

- BBES for BBES areas
- Gilbane for Gilbane sites
- CB&I for CB&I sites

Airborne radioactivity monitoring:

- Gilbane for Gilbane sites
- CB&I for CB&I sites

Dosimetry (internal/external) management and associated record maintenance for onsite personnel:

- BBES for BBES site staff
- Gilbane for Gilbane staff
- CB&I for CB&I site staff

Note: Visitors or subcontractors entering a radiologically controlled area for less than one shift (8 hours) will not require dosimetry if escorted by a trained staff person with dosimetry who represents the responsible licensee. Dosimetry management will be conducted by the licensee (Gilbane, BBES, or CB&I) and will include site-specific radiological training for assigned personnel and contractors. Use of dosimetry by an individual demonstrates completion of prerequisite training for radiologically controlled area access.

Control of radioactive materials used for calibration or operational checks of radiation detection and laboratory equipment:

- BBES for BBES owned sources at HPNS
- Gilbane for Gilbane owned sources at HPNS
- CB&I for CB&I owned sources at HPNS

Control of individual work areas contractually designated for activities where radioactive materials are known or suspected to exist; incorporating postings that reflect a company identifier/symbol and which provides a point of control contact for such areas:

- BBES for site locations designated for LLRW container operations
- Gilbane for RSY 4 in Parcel E
- CB&I for all impacted sites excluding sites under Gilbane or BBES control

Control of waste materials in designated work areas:

- BBES for its designated LLRW container operations
- Gilbane for Gilbane sites
- CB&I for CB&I sites

Issuance and maintenance of Radiation Work Permits for controlled work:

- BBES for designated LLRW container operations
- Gilbane for Gilbane sites
- CB&I for CB&I sites and for non-radiological contractors performing work in radiologically impacted sites not under Gilbane or BBES control

Control of shipments failing portal monitor and/or handheld radiological surveys:

- Gilbane for Gilbane sites
- CB&I for CB&I and non-radiological contractors performing work in radiologically impacted sites not under Gilbane or BBES control

Inventories of radioactive materials, including waste:

- BBES for the BBES areas
- Gilbane for Gilbane sites
- CB&I for CB&I sites

Reports and other administrative requirements including those to the Radiological Affairs Support Office (RASO) and other regulatory agencies:

- BBES for the BBES areas
- Gilbane for Gilbane sites
- CB&I will provide a report indicating where radiological support was provided and what it consisted of for non-radiological contractors performing work in radiologically impacted sites not under Gilbane or BBES control

2.0 Handling and Control of Radioactive Materials

Transfer of radioactive materials from one licensee to another licensee is anticipated for certain routine activities including the transfer of packaged and/or containerized waste.

2.1 Packaged and/or Accumulated Waste

2.1.1 BBES LLRW Containers:

Radioactive material accumulated and identified as waste thus generated, will require ultimate transfer to the BBES designated storage and processing area. The radioactive material collection and transfer process will proceed as follows:

- Gilbane or CB&I will request BBES to deliver prepared LLRW containers for radioactive material accumulation to designated areas.
- Gilbane or CB&I will be responsible for control and maintenance of LLRW containers in their custody.
- Gilbane or CB&I are each responsible to properly load characterized waste into LLRW containers, per BBES recommendations, and shall facilitate the transfer and control of such materials by providing the following information on a corresponding BBES Radioactive Movement Form 1 for containers assayed as radioactive and BBES Commercial Commodity Transport Form for non-radioactive shipments. Form information includes but is not limited to:
 1. A brief description of the material involved
 2. An inventory of packages to include total number of packages and contents
 3. A label identifying the maximum dose rate and location, known or suspected isotope(s) and a curie content approximation for the package. Note that BBES provides the final curie content for the package based on the final weight determination and radioisotopic sampling
 4. Date, time, and signature of person(s) completing the transfer

- Gilbane or CB&I will notify BBES when a BBES LLRW container in their custody is full, request that the LLRW container be moved to the BBES storage area, and provide BBES, at the time of transfer, the corresponding BBES transport form container weights will be determined by BBES.
- BBES shall move filled LLRW containers from Gilbane or CB&I controlled areas to the BBES controlled storage yard for preparation for off-site disposal. LLRW containers are to be filled as full as practical up to a maximum net weight of approximately 48,000 lbs. depending on the type of material being loaded. LLRW containers may be returned to the generator for weight adjustment if deemed necessary by BBES.
- BBES will reference internal RASO authorized procedures and work instructions when coordinating the transfer of LLRW containers leaving a Gilbane or CB&I radiologically controlled area. Using RASO approved protocol detailed in the BBES HPNS Radiation Protection Plan (RPP) and supporting Base wide procedures/work instructions, Gilbane and CB&I will initiate RCA release surveys of the corresponding BBES LLRW container/truck, and monitor the assigned driver before the truck leaves a Gilbane or CB&I site. In conjunction with the exit survey, BBES will complete a visual assessment for removable contaminants on the exterior of the LLRW container itself.

2.1.1.1 BBES Management of Radioactive Waste

As documented on a completed BBES Transfer Document and when satisfactory contamination survey results are verified by BBES. LLRW container custody will transfer at the time of pick up and removal from the Gilbane or CB&I maintained RCA. Upon receipt of the filled LLRW container, BBES will begin the process of sampling, profiling, and preparation for transportation of the radioactive waste to an authorized and approved treatment and/or disposal facility. Subsequent BBES responsibilities include processes specific to waste handling, storage, sampling, required inspections, off-site shipment activities, and management and control of the LLRW container storage area.

If, after transfer to the LLRW container storage area, BBES identifies non-conforming material in an LLRW container, the entire LLRW container will be returned to the party initiating the transfer (i.e., the returned non-conforming material will revert back to the NRC/CA license inventory of the initiating party for further processing) with details documented on the corresponding Hunters Point Field Content Sheet and Transfer Document (HPFCS &TD). In addition to the minimum requirements for the transfer, BBES will also identify the non-conforming material that would need to be removed or further processed. The non-conforming material will be stored in an area controlled by the party initiating the transfer (e.g., Gilbane or CB&I) until the non-conforming material issue is resolved.

3.0 Occurrence Reporting

The responsible RSO (or RSO representative) will notify all other site RSOs (or designated representatives), as soon as practical, of any of the following occurrences that may affect personnel from other organization(s):

- Contamination events that require decontamination (personnel or equipment)
- Contamination levels including airborne radioactivity/dose rate events that stop operations
- Any regulatory reporting event
- Any noncompliance with the requirements of this MOU

The RSO or RSO representative of the responsible party shall report non-compliance issues to the applicable regulatory and/or oversight agencies.

4.0 Jurisdictional Issues and Changes

Jurisdictional issues or specific situations not covered under this agreement will be discussed between BBES, Gilbane or CB&I for resolution. Signatures placed within this MOU by each Radiation Safety Officer (or RSO representative) will indicate approval of the contents within this document, and concurrence with the resultant agreement.

Acknowledgment of the above referenced modification by designated Radiation Safety Officers or Radiation Safety Officer Representatives for the HPNS project teams is indicated by their signature as entered below.

Jerry Cooper, Gilbane Radiation Safety Officer

Date

Kenneth Baugh, BBES Radiation Safety Officer

Date

Mark O. Somerville, CB&I Radiation Safety Officer

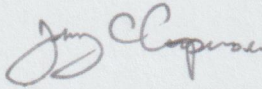
Date

Cc: All signatories
Zachary Edwards, Radiological Affairs Support Office, United States Navy
Matthew Slack, Radiological Affairs Support Office, United States Navy
Allen Stambaugh, Radiological Affairs Support Office, United States Navy
Steve Doremus, Radiological Affairs Support Office, United States Navy
Danielle Janda, Base Realignment and Closure Office, United States Navy
Leslie Howard, Base Realignment and Closure Office, United States Navy

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Acknowledgment of the above referenced modification by designated Radiation Safety Officers or Radiation Safety Officer Representatives for the HPNS project teams is indicated by their signature as entered below.



Digitally signed by Jerry Cooper, CHP
DN: cn=Jerry Cooper, CHP, o, ou,
email=jcooper@gilbaneco.com, c=US
Date: 2017.02.16 05:44:56 -08'00'

Jerry Cooper, Gilbane Radiation Safety Officer

16 Feb 2017

Date

Kenneth Baugh, BBES Radiation Safety Officer

Date

Mark O. Somerville, CB&I Radiation Safety Officer

Date

Cc: All signatories

Zachary Edwards, Radiological Affairs Support Office, United States Navy
Matthew Slack, Radiological Affairs Support Office, United States Navy
Allen Stambaugh, Radiological Affairs Support Office, United States Navy
Steve Doremus, Radiological Affairs Support Office, United States Navy
Danielle Janda, Base Realignment and Closure Office, United States Navy
Leslie Howard, Base Realignment and Closure Office, United States Navy

February 20, 2017

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Jerry Cooper, Gilbane Radiation Safety Officer

Date

Kenneth S. Baugh
Digitally signed by Kenneth S. Baugh
DN: cn=Kenneth S. Baugh, o=President / CEO, ou=B&B
Environmental Safety, Inc., email=Ken@bbesafety.com, c=US
Date: 2017.02.16 10:08:24 -0700

February 16, 2017

Kenneth Baugh, BBES Radiation Safety Officer

Date

Mark O. Somerville, CB&I Radiation Safety Officer

Date

Cc: All signatories
Zachary Edwards, Radiological Affairs Support Office, United States Navy
Matthew Slack, Radiological Affairs Support Office, United States Navy
Allen Stambaugh, Radiological Affairs Support Office, United States Navy
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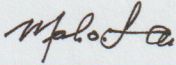
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Jerry Cooper, Gilbane Radiation Safety Officer

Date

Kenneth Baugh, BBES Radiation Safety Officer

Date



Digitally signed by Mark O. Somerville
DN: cn=Mark O. Somerville, o=CB&I Federal Services,
ou=Radiation Safety,
email=mark.somerville@cbifederalservices.com, c=US
Date: 2017.02.16 06:51:12 -08'00'

Mark O. Somerville, CB&I Radiation Safety Officer

2/16/2017

Date

Cc: All signatories

Zachary Edwards, Radiological Affairs Support Office, United States Navy
Matthew Slack, Radiological Affairs Support Office, United States Navy
Allen Stambaugh, Radiological Affairs Support Office, United States Navy
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