PHASE I REMEDIAL INVESTIGATION REPORT

Former Bay Head Road Annex IR Program Site 1
Former Naval Surface Warfare Center
Carderock Division
Annapolis Detachment
Annapolis, Maryland

Final

Prepared for:

Department of the Navy
Naval Facilities Engineering Command, Washington
1314 Harwood Street SE
Washington Navy Yard, DC 20374-5018

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilogram
µg/L	micrograms per liter
3D	three-dimensional
5YR	Five-Year Review
AFFF	aqueous film forming foam
amsl	above mean sea level
bgs	below ground surface
BRAC	Base Closure and Realignment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
COPC	chemical of potential concern
CTA	Children’s Theater of Annapolis
CSM	conceptual site model
DDT	dichloro-diphenyltrichloroethane
DoD	United States Department of Defense
DON	Department of the Navy
DPT	direct-push technology
EB	equipment-rinsate blank
EBS	Environmental Baseline Survey
EC	Electrical Conductivity
ELCR	Excess Lifetime Cancer Risk
Eurofins	Eurofins Lancaster Laboratories Environmental, LLC
FBP	Former Burn Pad
FD	field duplicate
FOST	Finding of Suitability to Transfer
FRB	field reagent blanks
HDPE	high-density polyethylene
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
H&S	H&S Environmental, Inc.
IC	institutional control
IDW	Investigation Derived Waste

IR	Installation Restoration
K	hydraulic conductivity
LC/MS/MS	Liquid Chromatography – Tandem Mass Spectrometry
LHA	Lifetime Health Advisory
LMR	Little Magothy River
MDE	Maryland Department of the Environment
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
Navy	United States Department of the Navy
NAVD 88	North American Vertical Datum, 1988
PA	Preliminary Assessment
PAHs	Polycyclic Aromatic Hydrocarbons
PFAS	Per- and Polyfluoroalkyl Substances
PFBS	Perfluorobutanesulfonic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanesulfonic Acid
QC	Quality Control
RBC	Risk-Based Concentrations
Resolution	Resolution Consultants, a Joint Venture of AECOM & EnSafe
RI	Remedial Investigation
ROD	Record of Decision
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SDG	Sample Delivery Group
SI	Site Investigation
TIR	Thermal Infrared Imaging
TtNUS	Tetra Tech, Inc.
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UU/UE	Unlimited Use/Unrestricted Exposure

EXECUTIVE SUMMARY

This Phase I Remedial Investigation (RI) Report is being submitted on behalf of the United States Department of the Navy (Navy), Naval Facilities Engineering Command (NAVFAC) Washington, and describes the investigations and data evaluation activities conducted at the former Bay Head Road Annex (BHRA), now Bay Head Park, in Annapolis, Maryland. This RI was conducted in accordance with Navy and the United States Environmental Protection Agency (USEPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements and in partnership with the Maryland Department of the Environment (MDE). This RI report was prepared by AECOM Technical Services, Inc., under the Comprehensive Long-Term Environmental Action Navy Contract No. N62742-17-D-1800, Contract Task Order (CTO) F4822.

The focus of this Phase I RI was to investigate the presence of per-and polyfluoroalkyl substances (PFAS) associated with historical operations at the Former Burn Pad (FBP) site located in the north central area of the former BHRA.

Prior environmental investigations at the former BHRA, which was designated as Installation Restoration (IR) Site 1, culminated in a RI report submitted in 2000 (EA, 2000). The 2000 RI included a human health risk assessment (HHRA) and an ecological risk assessment (ERA) followed by a groundwater-focused HHRA submitted in 2001 (EA, 2001). The results of the HHRA and ERA revealed no unacceptable risks, based on the intended non-residential future use of the site. The record of decision (ROD) for the facility was issued in March 2001 (DON, 2001a). The selected remedy, institutional controls (ICs), memorialized the prohibition against residential use of the site. The ICs were provided in the transfer deed and implemented in the form of deed restrictions at the time of any property transfer. The property was transferred to Anne Arundel County, Maryland in 2004. Copies of the deed are on file at the Anne Arundel County Courthouse at the Department of Public Land Records. The Anne Arundel County Office of Planning and Zoning has confirmed that this property is designated as recreational. The current and expected future land use for the site is recreational as Bay Head Park. In addition, the Children’s Theater of Annapolis (CTA) is a site tenant and currently conducts commercial operations at the site. The Navy is the lead agency at the site with MDE providing regulatory support.

In accordance with CERCLA Section 121, Five-Year Reviews (5YRs) have been conducted at the facility since 2001 in 2005, 2010 and 2015. The Technical Assessment process of the 2015 5YR identified an aqueous film forming foam (AFFF) fire extinguishing system used in conjunction with the FBP (H&S and TtNUS, 2015). Further, the 5YR noted that the primary formulations of AFFF used by the Navy at the time the FBP was used contained PFAS, which suggests the potential for the presence of PFAS in environmental media at the facility (H&S and TtNUS, 2015). PFAS are a group of compounds considered emerging contaminants, unknown at the time of the original RI. Therefore, the results of the 5YR indicated that a PFAS-focused RI at the former BHRA was warranted.

PFAS are a class of man-made chemicals found in many consumer products such as stain-resistant textiles, nonstick cookware, cleaning products, and cosmetics. In military applications, various PFAS compounds, including perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) were used in AFFF, which was historically used for firefighting and for firefighting equipment testing and training. Activities at the BHRA included fire testing and fire suppression research conducted in the vicinity of the FBP. More information can be found on the Navy's PFAS website at https://www.secnav.navy.mil/eie/pages/pfc-pfas.aspx.

In May 2016, the USEPA issued a Drinking Water Lifetime Health Advisory (LHA) for individual or combined concentrations of two PFAS, PFOS and PFOA, of 0.070 micrograms/liter (µg/L or 70 parts per trillion) (USEPA, 2016a,b). Additionally, in 2018, USEPA established the tapwater Regional Screening

Level (RSL) for Perfluorobutanesulfonic acid (PFBS) of 400 µg/L (USEPA, 2018). Potential impacts of PFAS exposure to human health and the environment are still being evaluated by USEPA.

The multi-stage Phase I RI field program conducted between 2016 through 2018 entailed the collection of environmental media samples (including field quality control [QC] samples) for laboratory PFAS analyses as follows:

- 26 soil samples from 12 on-site locations, which were selected to focus on the potential PFAS source areas, including a surface soil sample from 0-1 feet below ground surface (bgs) and a subsurface soil sample from a 1-foot interval between 12 to 20 feet bgs.
- 72 grab groundwater samples from 35 on-site locations within the shallow overburden aquifer at two different 4-foot depth intervals.
- 37 sediment samples from four on-site locations and 24 off-site locations located along the unnamed tributary draining from the site, and the wetlands area and southeast portion of the drainage basin of the Little Magothy River (LMR) receiving site drainage.
- 57 surface water samples, which were co-located with the sediment samples from the aforementioned on-site and off-site locations.

The cumulative PFAS dataset was used to assess the extent of PFAS impacts and to evaluate potential risk/hazard to human and ecological receptors, based on current and hypothetical future use exposure scenarios.

In addition, the Navy conducted a search of private residential drinking water wells near the BHRA that identified three proximal residences with shallow wells that appeared to be hydraulically down gradient (i.e., in the direction of anticipated groundwater flow) of the site. Two of the residences were sampled in the fall of 2016. PFAS were not detected in drinking water samples from either residence. The owner of the third residence declined the Navy's request to sample their well.

Phase I Remedial Investigation Findings

Sources

The primary source of PFAS in environmental media at the former BHRA and surrounding area was the PFAS-containing AFFF fire suppression system used in conjunction with the FBP. Secondary releases included FBP quench water leaks from the associated evaporation pond and possibly the regrading of PFAS-impacted silt soils during redevelopment of the site.

Distribution of PFAS in Soil

- PFAS were detected in surface and subsurface soil from all 12 locations sampled during the source-area focused sampling effort. The highest concentrations were detected at the suspected location of the AFFF fire suppression system, the FBP and the associated evaporation pond.
- These samples were biased in the area where former fire training activities took place, and not across the entire facility, so concentrations would be considered representative of likely worst-case concentrations at the site. Regardless, only one surface soil sample contained PFOS at a concentration exceeding the conservative USEPA RSL for residential soil of 130 µg/kg based on a hazard quotient (HQ) of 0.1.

Distribution of PFAS in Groundwater

- Evaluation and modeling of the grab groundwater PFAS data indicates that a PFAS groundwater plume emanates from the source area and flows north-northwest, discharging to the LMR, consistent with the direction of groundwater flow.
- PFAS concentrations were above the conservative USEPA RSL for tap water for PFOS and PFOA of 0.04 µg/L (based on an HQ of 0.1) used for screening in nearly all grab groundwater samples.

Distribution of PFAS in Sediment and Surface Water

- PFAS data from co-located sediment and surface water samples collected within the unnamed tributary, its wetlands and the portion of the LMR sampled, indicate that PFOS and PFOA are present throughout the entire area.

Fate and Transport

- Both PFOS and PFOA (and presumably other PFAS) are stable and mobile in environmental media because they are resistant to environmental degradation processes, such as biodegradation, photolysis, and hydrolysis and retardation processes such as sorption. PFAS released from the AFFF fire suppression system to soils at the FBP and associated evaporation pond during historical fire/burn testing area operations were likely distributed by soil erosion and overland stormwater runoff within site drainage features. PFAS in soil and surface water migrated horizontally and vertically to the groundwater and were transported through downgradient groundwater flow to the north/northwest, discharging to the unnamed tributary of the LMR.
- Sediment and surface water sample data from on-site and off-site locations indicate that PFAS are present in the site drainage features, which generally slope to the north, discharging to an unnamed tributary of the LMR, immediately to the north of the former BHRA. PFAS were also detected at downstream locations within the unnamed tributary, its surrounding wetlands, and in a portion of the LMR itself. PFAS likely migrated to these waterbodies through surface runoff, soil erosion, and groundwater discharge.

Risk Assessment

The HHRA and ERA were conducted in accordance with current Navy and USEPA guidance. The scopes of the HHRA and ERA were limited to the evaluation of three PFAS compounds, PFOS, PFOA, and PFBS due to the current lack of available toxicity values for other PFAS.

HHRA - Validated soil, groundwater, sediment, and surface water sample results were evaluated against conservative human health screening levels for the following current and reasonable future land-use scenarios and receptors:

- Current/future recreational user (adult/child)
- Current/future outdoor (commercial/industrial) worker
- Future construction/excavation/utility worker
- Hypothetical future on-site resident (adult/child)

Findings of the human health screening evaluation demonstrate that concentrations of PFOS, PFOA, and PFBS in soil, surface water, and sediment do not exceed risk-based human health screening levels and, therefore, do not pose a health concern to the above identified receptors. Groundwater concentrations of

PFOS and PFOA do exceed risk-based human health screening levels under the hypothetical future on-site resident use scenario in which groundwater underlying the site is used as a source of drinking water. However, the IC, which specifies non-residential use of the site, and county and state regulations prohibiting installation of water supply wells, preclude this exposure scenario. Therefore, at this time, no further evaluation is warranted for human receptors potentially exposed to PFAS associated with the operations of the former BHRA.

ERA – The initial evaluation of the validated soil, sediment, and surface water sample results for exposure pathways for plants, invertebrates, birds and mammals using the multi-tiered ERA process resulted in the identification of the following pathways for further evaluation:

- Terrestrial birds and mammals – PFOS in soil
- Aquatic-dependent birds and mammals – PFOS and PFOA in surface water

Results of the subsequent evaluations concluded that these pathways are complete but insignificant, based on currently available screening values. Based on the findings of the ERA, at this time no further evaluation is warranted for ecological receptors potentially exposed to PFAS associated with the operations of the former BHRA.

Recommendations

The only potentially unacceptable risk identified was for a hypothetical future resident, consuming groundwater as daily drinking water. Future actions are warranted to supplement the data generated and analyzed in this investigation, in particular for groundwater that was determined to be impacted due to historic releases in the former Burn Pad Area at the Site.

Additional investigation activities will refine the conceptual site model (CSM), including defining the nature and extent of PFAS groundwater impacts. These activities should include the completion of additional sampling of on- and off-site groundwater through temporary or permanent (monitoring wells) sampling points. Following completion of the additional activities, in accordance with the CERCLA process, the CSM and risk assessment will be updated as part of a RI Addendum.

1. INTRODUCTION

This Phase I Remedial Investigation Report presents the results of a multi-stage Remedial Investigation (RI) performed for per- and polyfluoroalkyl substances (PFAS) in soil, groundwater, surface water, and sediments at the former Bay Head Road Annex (BHRA) facility, Former Burn Pad (FBP), Annapolis, Maryland. This RI was conducted in accordance with the United States Department of the Navy (DON or Navy) and the United States Environmental Protection Agency (USEPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. This document was prepared by AECOM Technical Services, Inc. (AECOM), for the Naval Facilities Engineering Command (NAVFAC) Washington, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62742-17-D-1800, Contract Task Order (CTO) F4822.

Non-PFAS related site investigation activities and a separate RI were previously completed at the former BHRA and are summarized in Section 1.2. The objective of the current RI is to characterize the nature and extent of PFAS in environmental media that were likely impacted by historical facility operations and to assess the potential for risk to human health and the environment due to exposure to PFAS present in those media.

PFAS are a class of man-made chemicals consisting of fluorinated organic compounds found in many common consumer products such as stain-resistant textiles, nonstick cookware, cleaning products, and cosmetics. PFAS are of recent environmental concern and are considered an emerging contaminant by the USEPA and Navy. An emerging contaminant is a chemical or material characterized by a perceived, potential, or real threat to human health or the environment, or by a lack of published health standards. In military applications, various PFAS compounds, including perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are constituents of aqueous film forming foam (AFFF), which was historically used for firefighting and for firefighting equipment testing and training. Activities at the former BHRA included fire testing and fire suppression research conducted in the vicinity of the FBP. More information can be found on the Navy's PFAS website at: https://www.secnav.navy.mil/eie/pages/pfc-pfas.aspx.

PFAS RI activities were performed by Resolution Consultants (Resolution, a Joint Venture of AECOM & EnSafe) under CLEAN Contract No. N62470-11-D-8013, CTO JU06. Four stages of PFAS RI activities were conducted at the BHRA from 2016 through 2019. This Phase I RI Report provides a comprehensive presentation and analysis of the RI data from all stages of the investigation.

This RI was conducted in accordance with the Tier II Sampling and Analysis Plan (SAP) (Resolution, 2016a) and the Technical Memorandum - *Additional PFAS Testing at BHRA* (Resolution, 2018a). The additional testing included sediment and surface water collected from selected areas of the unnamed tributary draining from the site, located immediately to the north and northwest of the former BHRA, and the wetlands area and southeast portion of the drainage basin of the Little Magothy River (LMR) receiving site drainage.

This RI Report presents a summary of the Phase I PFAS RI activities and data review/reporting procedures. Protocols for sample collection, handling, storage, chain-of-custody, laboratory and field analyses, data validation, and reporting were outlined in the Tier II SAP and the additional PFAS testing technical memorandum and are summarized herein.

This RI Report was generated for, and complies with, applicable Navy, USEPA Region 3, and Maryland Department of the Environment (MDE) requirements, regulations, guidance, the approved SAP, and technical standards, as appropriate. All RI field activities were conducted in accordance with Resolution Standard Operating Procedures (SOPs) and the Accident Prevention Plan prepared for CTO JU06 (Resolution, 2016b).

1.1 SITE OVERVIEW

The former BHRA is located in Anne Arundel County, Maryland, approximately five miles northeast of the City of Annapolis. The former Navy base, now Bay Head Park, consists of a tract of land approximately 23.8 acres in size located on the peninsula between the Magothy and Severn rivers, and is less than two miles from the Chesapeake Bay (Figure 1-1). Residential areas to the north and west surround the BHRA. U.S. Routes 50 and 301 are located south of the site with undeveloped land, residential areas, and Sandy Point State Park to the east. Current land use at the property is recreational with soccer fields and playgrounds. In addition, the Children's Theater of Annapolis (CTA) is a site tenant and provides art education programs and theatrical performance opportunities for community children.

The BHRA Launch Area, designated W-26 Nike Battery, Installation Restoration (IR) Site 1, was used by the Army as part of the Nike Missile Defense System, designed to protect major metropolitan areas (e.g., Annapolis and Washington, DC) and strategic military installations from aerial attack. The facility was operated by the Army from 1954 until 1969. Operations and maintenance activities required the storage, handling, and disposal of missile components and propellants as well as solvents, fluids, fuels, and other materials. The missile launching pad consisted of three concrete structures, approximately seventeen feet deep, which were used to store the missiles. After Nike Battery deactivation, the facility was used by the Navy to conduct burn tests to determine heat resistant properties of materials for use onboard Navy ships. Materials were burned in the concrete FBP and analyzed for off-gas production and fire hazard potential.

The Navy's operations at the facility ended in the late 1990s. In 1999, the CTA officially became a tenant of the Department of Defense (DoD) and used the former Navy buildings for set construction and storage. In 2001, the Finding of Suitability to Transfer (FOST) process was completed for the BHRA (DON, 2001b) and the subject parcels were transferred from the DoD to Anne Arundel County, Maryland in 2004.

Based on the Record of Decision (ROD) signed in March 2001 (DON, 2001a), the FOST contained institutional controls (ICs) consisting of deed restrictions prohibiting future residential development of the facility. The land was subsequently redeveloped by Anne Arundel County Department of Park and Recreation to its current layout (Figure 1-2). The RI study area includes the former BHRA itself, as well as two off-site residences where drinking water samples were collected, the unnamed tributary of the LMR, and a portion of the LMR itself.

1.2 PREVIOUS BHRA INVESTIGATIONS

As indicated in the third Five-Year Review (5YR) Report for the BHRA (H&S and TtNUS, 2015), the chronology of site events is summarized as follows:

Event	Date
Bay Head Road Annex Launch Area, designated W-26 Nike Battery, was used by the Army for Nike missile defense operations	1954 - 1969
Property transferred from Army to Navy	1971
Navy conducted research related to burn testing	1972 – 1981
Property used as equipment/supply storage facility	1981 – 1985
Two Preliminary Assessment Reports were prepared for the Navy	1985 and 1990
Navy conducted a Site Inspection in accordance with the recommendations identified in the 1990 Preliminary Assessment	1991
Phase I Environmental Baseline Survey was performed	1995
Children's Theatre of Annapolis becomes tenant of property	1999

Event	Date
Remedial Investigation was performed	2000
Record of Decision completed and signed	2001
Finding of Suitability to Transfer completed and signed	2001
Facility transferred from the Department of Defense to Anne Arundel County	2004
First Five-Year Review completed and signed	
Demolition and removal of former Navy buildings began	2006
Construction of auditorium for the Children's Theatre of Annapolis completed	2008
Three soccer fields installed on property	2008
Permanent light structures installed for soccer fields	2009
Second Five-Year Review Completed and Signed	2010
Construction of a new children's playground and walking/bike path	2010
Third Five-Year Review completed and signed	2015

Two Preliminary Assessment (PA) Reports were prepared for the Facility in 1985 and 1990 by the Navy. The PAs identified potential locations of contamination (e.g., missile assembly building, missile fueling and war heading area, transformer locations, magazine drainage area, septic system, etc.). Test results of soil and sediment sampling from the 1985 PA revealed low levels of toluene, a common degreasing solvent, and the pesticide dichloro-diphenyltrichloroethane (DDT) and its breakdown products in several of the samples collected. The results of the 1985 groundwater sampling revealed low concentrations of oil and grease in one of the two samples collected. The 1990 PA concluded with recommendations for further evaluation in accordance with the Superfund Site Assessment process. Therefore, the former BHRA facility was officially established as IR Site 1, and a Site Inspection (SI) was scheduled under the Navy's IR program.

In 1991, the Navy conducted an SI in accordance with the recommendations identified in the 1990 PA to evaluate potential groundwater, surface water, sediment, and soil contamination (EA, 1991). The SI concluded that low levels of metals and organic contaminants were present in soil, sediment, surface water and groundwater at the site. The analytical results for metals in surface soil samples were compared with published background concentrations and were reported at levels that did not exceed the range of background concentrations established by the United States Geological Survey (USGS). The organics, specifically the polycyclic aromatic hydrocarbons (PAHs), were within ranges representative of urban areas; therefore, a RI was not recommended due to the low concentrations reported, and the lack of an active source of contamination.

A Phase I Environmental Baseline Survey (EBS) was conducted in 1995, as the site was scheduled for closure under the Base Realignment and Closure (BRAC) IV program (EA, 1997a; 1997b). The purpose of the Phase I EBS was to assess the existing environmental information related to storage, release, treatment, or disposal of hazardous substances or petroleum products and to document the environmental condition of the property. The septic system located near the center of the site was identified in the EBS as an Area of Concern due to the potential introduction of metals from the overflow of a thermal metal coating process used by the Navy. A further assessment was deemed necessary to determine the nature and extent of potential contaminants on site and if current and future exposures to the contaminants posed human and/or ecological risks based on the proposed recreational land use.

An RI was recommended at that time to further assess the septic system and the surrounding environment. The RI consisted of sampling surface and subsurface soil, sediment, and groundwater (EA, 2000). An assessment of the inactive septic system was also conducted, including collection of sludge and leaching well soil and water samples. Analytical sample results were compared to the USEPA's Region III Risk-Based Concentrations (RBCs) and ecologically-based screening values. RBCs were developed using highly conservative exposure scenarios suggested by the USEPA and the best available toxicological data. They represent conditions that are protective of human health. The ecologically-based screening values are designed to be protective of representative flora and fauna.

Several preliminary human and ecological chemicals of potential concern (COPCs) were identified in the 2000 RI after screening the analytical results against the identified human and ecological risk screening criteria. Organic and inorganic compounds with concentrations that exceeded the human and ecological risk screening criteria were identified as COPCs and the corresponding sample locations were plotted on a site drawing. Since the highest chemical concentrations are typically found closest to the source, sample concentrations were evaluated with respect to location to identify potential source areas.

Consequently, two potential source areas with elevated concentrations of human and ecological COPCs were identified: the bermed evaporation pond southwest of the FBP with PAHs as a concern for humans, and the surface area near soil sample S-5 (located in the wooded area in the northeaster portion of the site) with pesticides as an ecological concern. Although elevated levels of some metals and PAHs in individual surface soil samples appeared to be greater than background concentrations (indicating they occurred because of site-related activities), no additional source areas were identified.

An evaluation of the potential fate and transport of contaminants was conducted during the RI. Contaminant migration was assessed for groundwater, surface water, and air. In summary, it was determined that contaminants could leach from soil and sediment, and surface water and groundwater could transport contaminants offsite. However, potential down-gradient groundwater exposures were deemed low due to the low-level concentrations of the contaminants and the relative immobility of metals and pesticides in groundwater. A human health risk assessment (HHRA) and an ecological risk assessment (ERA) were conducted as part of the RI followed by a groundwater-focused HHRA submitted in 2001 (EA, 2001) to assess the human health and ecological risks that could result if the contamination at the site were not remediated. The results of the human and ecological risk assessments completed for the BHRA at this time revealed no unacceptable levels of risk based on the identified industrial levels of exposure. A residential risk assessment for soil at BHRA was not conducted.

During the 2000 RI, surface soil samples collected from the vicinity had elevated levels of dioxins, a by-product of combustion. Therefore, some of these locations as well as locations within, near and downgradient of the FBP and evaporation pond were identified for PFAS surface and subsurface soil sampling as part of this current Phase I RI.

The ROD for the facility was signed in March 2001 (DON, 2001a). The selected remedy, ICs, restricted permanent residential use of the facility and was incorporated into the transfer deed. The selected remedy protects human health by prohibiting future residential use, thereby limiting human exposure to contaminants present at the site. The Anne Arundel County Office of Planning and Zoning has confirmed that this property is designated as recreational. The current and expected future land use for the site is recreational as Bay Head Park. The CTA is also expected to continue commercial operations.

Three 5YRs have been conducted at the former BHRA since 2004. The most recent 5YR identified an AFFF fire extinguishing system used in conjunction with the FBP (H&S and TtNUS, 2015). Further, the 5YR noted that the primary formulations of AFFF used by the Navy at the time the FBP was used contained PFAS, which suggests the potential for the presence of PFAS in environmental media at the facility (H&S and TtNUS, 2015). Although the site and vicinity are connected to the Anne Arundel County Public Water system and county and state regulations prohibit the installation of water supply wells, the need to investigate the potential presence of PFAS was identified.

The initial EBS conducted in 1996 identifies a 20-foot by 20-foot burn pad next to Building 202 that was used to test burning of large materials like mattresses that go aboard Navy ships. This is the location of the FBP in the northern portion of the site, directly north and adjacent to Building 202 (Figures 1-2 and 2-1). The 20-foot by 20-foot FBP was a steel shed like structure that was exposed to the elements. There was potential for the substances on the interior of the structure to come in contact with the environment via air dispersion, stormwater penetration and runoff or simple settling of materials to the ground. The FBP was drained (quench water) by an overflow pipe that discharged to a shallow concrete evaporation pond located approximately 30 feet west of the FBP.

Beginning in November 2006, in total, nine buildings, two former missile launching pads, the burn pad, and the evaporation pond were all demolished and/or removed from the property. The two former missile launching pads have been covered to form a parking lot for the CTA complex. The baseball fields and former septic field have been replaced by three soccer fields, which were completed in September 2008. Permanent light structures were built in April 2009. A children's playground was constructed in April 2010.

1.3 REPORT ORGANIZATION

This report contains eight sections listed and described below. The report includes presentation of newly acquired information and a summarization of previously reported information to present a comprehensive overview of the Phase I PFAS investigations at the former BHRA.

Section 1: This section presents the RI objectives and report organization, as well as background information including a site description and regulatory history culminating in the current ROD and IC. Section 1 also summarizes previous investigations at the BHRA (former IR Site 1), as they pertain to potential PFAS impacts.

Section 2: This section presents and summarizes the methods and procedures implemented during the four stages of the Phase I RI program.

Section 3: This section presents a physical description of the former BHRA, including basic site features, topography and drainage, geology, hydrogeology, ecology and climate. Information collected and observations made during the RI field investigations are incorporated in the descriptions.

Section 4: This section presents information on the nature and extent of PFAS detected in site media, including analytical results of soil, groundwater, surface water, and sediment samples. Analytical data are presented on tables for each medium and figures for selected compounds within each medium.

Section 5: This section presents information on contaminant fate and transport, including identification of potential contaminant migration routes, factors that affect contaminant migration, and a summary of the conceptual site model (CSM).

Section 6: This section presents summaries of the HHRA and ERA conducted for the former BHRA based on data collected during this Phase I RI.

Section 7: This section presents a summary of findings, draws conclusions from those findings and offers recommendations as to the path forward at the former BHRA.

Section 8: This section identifies the references cited herein.

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2. STUDY AREA INVESTIGATION

The Phase I RI consisted of four stages of investigation as discussed below. Sampling procedures and methodologies used for the RI were presented in the Tier II SAP (Resolution, 2016a) and in the additional PFAS testing technical memorandum (Resolution, 2018a). Pertinent technical memoranda, boring logs, analytical laboratory reports, data validation reports, and the complete HHRA and ERA are included as appendices to this report. Field logbooks and equipment calibration logbooks are maintained in the RI project file and are available upon request.

Findings of each stage of the RI are discussed in Section 4 Nature and Extent of Contamination, Section 5 Contaminant Fate and Transport, and potential risks to humans and ecological receptors due to potential PFAS exposure are discussed in Section 6 (Risk Assessment) and provided in Appendices E and F, respectively.

2.1 SAMPLING APPROACH AND METHODOLOGY

As described in the SAP, the approach for the on-site investigations assumed that the area around the FBP and the associated evaporation pond likely served as the primary point of release of PFAS into the surface and subsurface soils and ultimately into the shallow groundwater and nearby surface water and sediment. During the 2000 RI, surface soil samples collected from the vicinity of the FBP had elevated levels of dioxins, a by-product of combustion. Therefore, locations within, near and downgradient of the FBP and evaporation pond were selected for PFAS testing (Figure 2-1).

Special precautions were taken for all fieldwork related to PFAS sampling. Sampling precautions, which were adhered to during all stages of the RI are outlined in Worksheet #14 of the SAP (Resolution 2016a).

All reusable equipment was decontaminated using Alconox® and laboratory supplied PFAS-free water prior to use and after sampling at each location. Disposable plastic scoops and bowls were used to collect some of the sediment samples.

Excess soil, decontamination water, and groundwater generated during the RI activities were containerized, managed and disposed of as investigation derived waste (IDW) by Capitol Environmental Services, Inc. in accordance with Navy requirements.

Environmental media (soil, groundwater, sediment and surface water) samples were analyzed using USEPA Modified Method 537 as presented in the SAP. Data for all PFAS analyzed under this method were reported and data for those PFAS compounds with published toxicity values, PFOS, PFOA, and perfluorobutanesulfonic acid (PFBS), were considered in the RI.

2.2 STAGE 1 - RESIDENTIAL DRINKING WATER TESTING

Prior to conducting subsequent field investigations, the Navy conducted a records search of private drinking water wells near the former BHRA to identify residences that may be affected if PFAS were flowing with shallow groundwater from the former BHRA to those residences. The search identified nine downgradient and two upgradient residences with private wells. Of these, only three had wells installed in the shallow, surficial aquifer. As discussed below, the Navy sampled the wells at two of the three residences. The owner of the third residence declined the Navy's request to sample their well.

In November 2016, the Navy sampled the two shallow, private drinking water wells for the three PFAS, which have USEPA published toxicity values (i.e., PFOS, PFOA, and PFBS).

Per the SAP, residential drinking water samples DW-16-01 and DW-61-02 were collected from cold-water spigots located as close to the residential wells as possible and before any water distribution treatment system. Water was allowed to run three to five minutes prior to sample collection to flush stagnant water from piping.

Drinking water samples were collected in laboratory-provided 250-ml high-density polyethylene (HDPE) bottles containing Trizma® preservative, accompanied by preserved field reagent blanks (FRBs) prepared at each location, packed on ice in coolers and shipped priority overnight to SGS Accutest-Orlando laboratory for analysis. Samples and FRBs were analyzed for PFOS, PFOA, and PFBS using USEPA Method 537 for drinking water analysis.

2.3 STAGE 2 - ON-SITE INVESTIGATIONS

Stage 2 of the RI was conducted from November 2016 through January 2017 and consisted of sampling of environmental media from 39 sampling locations as shown on Figure 2-1. Thirty-five locations involved intrusive sampling using direct-push technology (DPT) drilling techniques to advance soil borings, perform Geoprobe® Hydraulic Profiling Tool (HPT) logging, and conduct subsurface soil and grab groundwater sampling. Four locations were at culvert outfalls within and along the length of the unnamed tributary of the LMR, on the east side of Bay Head Road, where co-located surface water (if present) and sediment samples were collected.

A site survey was performed by Resolution surveying staff licensed in the State of Maryland, to document the horizontal locations and elevations of all sample locations. Horizontal coordinates were tied to the Maryland Coordinate System NAD83 (Zone 1900) in U.S. Survey Foot units and the vertical datum to NAVD88. The survey data was digitized for subsequent site mapping.

Prior to conducting intrusive sampling, the utility clearance process was completed for all proposed DPT locations by obtaining dig permits through Miss Utility of Maryland. In addition, each proposed boring location was pre-cleared to a depth of five feet below ground surface (bgs) using a hand auger to verify that no utilities were present.

Completed borings were abandoned by backfilling with granulated or pelletized bentonite and hydrating in layers with potable water, proceeding from the bottom of the hole to the surface.

Field quality control (QC) samples were also collected and consisted of: field duplicates (FD), matrix spikes and matrix spike duplicates (MS/MSD), and equipment-rinsate blanks (EB). QC sample frequencies followed the protocols outlined in the SAP. Samples were packed on ice in coolers and shipped priority overnight to TestAmerica Sacramento laboratory for analysis of PFOS, PFOA, and PFBS using Modified USEPA Method 537 for environmental media.

2.3.1 HPT Survey

Hydraulic profiling using a DPT Geoprobe® HPT System was conducted as the initial step of the intrusive investigation to evaluate surficial aquifer geology and hydraulics, which guided subsequent subsurface soil and grab groundwater sampling for PFAS.

The HPT System was developed for the hydrogeologic characterization of saturated and unsaturated soils. It consists of the HPT steel probe, which contains an electrical conductivity (EC) measurement array, a water injection port, and a data logging system. As the HPT probe is advanced through the subsurface, an EC data log of particle size is created, which is for stratigraphic interpretation. In addition, as the HPT advances, water is continuously injected through the port, which creates a pressure response. The pressure response is used to estimate hydraulic conductivity (K) values. The resulting logs of EC and K as a function of depth, provide hydrostatic profiles at each location, which show preferred flow pathways and subsurface soil types.

The logs are then used to determine the likely depth intervals for subsurface soil and grab groundwater sampling to identify contaminants, if present.

HPT logging was conducted at ten locations as indicated on Figure 2-1 with the HPT probe advanced until refusal, which occurred at depths ranging from approximately 46 to 71 feet bgs. The HPT data logs are provided in Appendix A.

2.3.2 Soil Sampling

Co-located surface and subsurface soil samples were collected from 12 locations. Ten samples were collected in the vicinity of the FBP and evaporation pond and encompass an area of less than 0.5 acres, and two samples were collected approximately 700 feet to the southwest of the FBP (Figure 2-1).

Surface soil samples were collected from a depth interval of 0-1-foot bgs. Stainless-steel scoops were used to scrape off vegetative covering (except locations DPT-16-19 and DPT-16-35, which were beneath asphalt and required coring to access), collect soil into stainless-steel bowls and homogenize the samples. Soil was then placed into 4-ounce high-density polyethylene (HDPE) jars for shipment to the laboratory.

One subsurface soil sample was collected from each of the 12 locations at depth intervals ranging from 12-13 feet bgs to 19-20 feet bgs based on permeability data from the HPT logs. A Geoprobe® Dual Tube DT22 Soil Sampling System was used to collected continuous 5-foot soil cores down to and encompassing the identified sampling depth. Clear PVC sleeves were used to line the 5-foot sampling tools and facilitate soil core recovery for logging. Subsurface soil samples were collected using the same method as surface soil.

DPT boring logs based on the Unified Soil Classification System (USCS) descriptions of recovered soil from selected borings, including soil and groundwater sampling intervals, are provided in Appendix B.

2.3.3 Grab Groundwater Sampling

Grab groundwater samples were collected from 35 locations (Figure 2-1) at depth intervals decided upon after reviewing HPT logs, to evaluate PFAS horizontal and vertical migration into the surficial aquifer. A Geoprobe® Groundwater Sampler with a deployable stainless-steel screen was used to collect grab groundwater samples from depth intervals ranging from 6-10 feet bgs to 31-35 feet bgs. A peristaltic pump and HDPE tubing were used to purge and collect groundwater into laboratory provided 250-ml HDPE bottles for analysis.

2.3.4 Sediment and Surface Water

Co-located sediment and surface water samples were collected from four on/near site locations east of Bay Head Road (SWSD-16-01 through SWSD-16-04) and within the stormwater drainage system as depicted on Figure 2-1. Samples SWSD-16-01 and SWSD-16-04 were collected from within the two grass-lined stormwater swales discharging into the larger intermittent drainage feature located just north of the park. Samples SWSD-16-02 and SWSD-16-03 were respectively collected from the beginning and end of this feature, which drains to the unnamed tributary of the LMR. The samples were intended to evaluate PFAS migration with surface run-off and soil erosion. Sediment samples were collected using the same method as soil. Grab surface water samples were collected directly from the unnamed tributary by submerging the laboratory-provided sample container (250-ml HDPE bottles) just below the surface until the container was full (note: at the time of sampling in December 2016, surface water was only present at SWSD-16-01 and SWSD-16-02). Surface water samples were collected prior to the co-located sediment samples, to minimize the entrainment of sediment or other suspended particles in the aqueous samples.

2.4 STAGE 3- INITIAL OFF-SITE SEDIMENT AND SURFACE WATER SAMPLING

The Stage 2 RI activities confirmed the presence of PFAS in all sampled environmental media at the former BHRA (the results are discussed in detail in Section 4 Nature and Extent of Contamination). Therefore, the Navy conducted Stage 3, which consisted of collecting additional co-located sediment and surface water samples from downstream, off-site (west of Bay Head Road) locations. The samples were collected from five locations (SWSD-18-01 through SWSD-18-05) along the unnamed tributary of the LMR, in April 2018 (Figure 2-2). Consistent with Stage 2, surface water samples from these off-site locations were collected prior to the co-located sediment samples using the same method, to minimize the entrainment of sediment or other suspended particles in the aqueous samples. However, a disposable plastic scoop was used to transfer sediment from the grab sampler into a disposable plastic bag to facilitate mixing and homogenization of the sample prior to placement into the laboratory-provided sample container.

Samples of both media including QC samples were packed on ice in coolers and shipped priority overnight to TestAmerica Sacramento laboratory and analyzed for PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/PFAS Isotope Dilution Method.

The results of Stage 3 sampling (discussed in Sections 4.5 and 4.6) indicate that PFAS are present in downstream sediment and surface water suggesting that off-site PFAS migration has likely occurred or is occurring via surface-water runoff, soil erosion, and groundwater discharge.

2.5 STAGE 4- THERMAL INFRARED IMAGING AND ADDITIONAL PFAS SAMPLING

Based on the Stage 3 findings, the Navy conducted a Stage 4 investigation that included a thermal infrared imaging (TIR) survey and additional PFAS sampling. The effort was designed to: 1) identify preferred pathways for groundwater-to-surface water discharge, which would be used to focus sampling; and 2) determine to what extent PFAS exists in surface water and sediment accessible to recreational users of the LMR. The sampling was also intended to identify potential ecological risk from PFOS, PFOA, and PFBS. The Stage 4 activities were conducted in accordance with the technical memorandum (Resolution, 2018a) as described below.

2.5.1 TIR Survey

The TIR survey was conducted in September 2018 (Resolution, 2018b). The TIR survey entailed the use of a hand-held TIR camera to identify thermal anomalies indicative of areas of groundwater discharge from groundwater to surface water along the unnamed tributary of the LMR. The survey identified several preferred discharge pathways, which were selected as the locations for sampling (SWSD-18-06, SWSD-18-07, and SWSD-18-24; Figure 2-2).

2.5.2 Additional Off-Site Sediment and Surface Water Sampling

Additional sediment and surface water sampling for PFAS analyses was conducted at the off-site locations shown on Figure 2-2 as follows:

- Recollected co-located sediment and surface water samples at the 5 previously sampled locations (SWSD-18-01 through SWSD-18-05) along the unnamed tributary draining into the river to evaluate seasonal variability in PFAS concentrations.
- Collected sediment and surface water samples at 3 additional locations along the unnamed tributary (SWSD-18-06, SWSD-18-07, and SWSD-18-24) based on the presence of seeps identified during the TIR survey to potentially refine the area of BHRA site groundwater discharge into the unnamed tributary.

- Collected an additional 16 (SWSD-18-08 through SWSD-18-23) co-located sediment and surface water samples at approximate 100-foot intervals as shown on Figure 2-2 along the river shoreline with the bay.
- Recollected co-located sediment and surface water samples at all 24 locations during the low tidal stage and collected an additional round of surface water samples only at the high tidal stage at all locations except SWSD-18-01, SWSD-18-02, SWSD-18-06, SWSD-18-07, and SWSD-18-24, which are above tidal influence due to their locations and elevations above mean sea level (amsl).

Field QC samples including FDs were collected at a frequency of 10%; MS/MSD samples were collected at a frequency of 20%, and one EB sample was collected for sediment sampling equipment.

Sediment samples were collected using a stainless-steel Ekman Dredge with extension handle that had been decontaminated in PFAS-free water. Disposable plastic bowls and scoops were used to collect and homogenize sediment samples consistent with the Stage 3 approach. Surface water samples were collected using the same method as Stages 2 and 3.

Samples of both media, including QC samples, were packed on ice, in coolers and shipped priority overnight to Eurofins Lancaster Laboratories Environmental, LLC (Eurofins), Lancaster, PA (who purchased TestAmerica in 2018 but provided uninterrupted project support) for PFAS analyses by LC/MS/MS Compliant with QSM 5.1 Table B-15/PFAS Isotope Dilution Method.

While data for all PFAS analyzed for Stage 3 and Stage 4 samples under USEPA Modified Method 537 were reported, only data for PFOS, PFOA, and PFBS are discussed and included in the risk evaluations due to a lack of current USEPA-recommended toxicity values for the other PFAS. Data for these additional compounds will be archived for future evaluation, as warranted.

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3. PHYSICAL CHARACTERISTICS OF THE STUDY AREA

The physical characteristics of the former BHRA and surrounding area, which have been compiled using a combination of prior reports and site data, and field measurements and observations during the Phase I RI field program, are provided below.

3.1 SURFACE FEATURES AND LAND USE

Bay Head Park is generally cleared with the exception of a few trees and other vegetation. There is a small wooded area to the north, which is within the property boundary but not part of the park's infrastructure (Figure 1-2). Elevations range from 13 to 28 feet amsl. The lowest elevations are in the northern portion of the park, which borders Bay Head Road to the west, and the unnamed tributary of the LMR. The highest elevations are found in the southeastern portion of the park centered on the paved parking area surrounding the three former missile magazines. The property is relatively flat but has a gradual decrease in grade to the north, coinciding with the unnamed tributary.

Two north-trending, shallow, grass-lined swales provide storm water drainage (Figure 1-2). The western swale encircles the former septic system and drains to the north where it intersects with an east-trending swale that discharges to the wooded area along the northern property boundary. The eastern swale is less pronounced and discharges both along the eastern and northeastern property boundaries. There are no perennial water bodies at the park. Stormwater runoff from the park is directed to the swales, through storm water drainage inlets and culvert outflows to the larger stormwater drainage feature to the north with discharge via the unnamed tributary, which runs through wetlands into a bay of the LMR and ultimately to the Chesapeake Bay.

The facility's soil type is Orthello silt loam, which consists of poorly drained, highly silty soils that have a mottled subsoil. This soil type primarily occurs at low elevations, having formed in a silt mantle overlying older sedimentary deposits that are mostly sand. The native vegetation is wetland hardwoods containing oaks, gums, swamp maple, and holly.

The park consists of recreational areas (i.e., athletic fields, playgrounds, and a picnic pavilion), a restroom/locker room located in the southern portion of the park, and the CTA (Figure 2-1). A fenced area in the northeastern corner of the paved area contains some of the remaining infrastructure from the former BHRA. It is used by the Anne Arundel County Department of Parks and Recreation for storage. The original septic system, which consisted of two septic tanks and a series of five leaching pits branching out from the septic tanks, was deactivated but not removed when the facility connected to public sewer in 1992. The leaching field is still present but no longer functional.

3.2 CLIMATE AND METEOROLOGY

Annapolis and its environs, which include the former BHRA, have a humid, temperate climate that is typical of the Mid-Atlantic Region. Average annual precipitation in the County is approximately 43 inches. While precipitation is generally uniformly distributed throughout the year, summer usually has the highest values and winter the lowest. In winter, the precipitation is generally in the form of light snows and showers. Winter is moderately cold and sometimes wet with summer usually hot and humid. Located at the convergence of the Severn River and the Chesapeake Bay, the Annapolis region features an insular climate marked by relatively even day and night temperatures with an average annual temperature of 56°F.

3.3 GEOLOGY

The former BHRA is located within the Atlantic Coastal Plain Physiographic Province of Maryland, which is bounded by the Piedmont Plateau on the west and the edge of the continental shelf on the east. The Atlantic Coastal Plain is underlain by a series of southeasterly dipping layers or formations of relatively unconsolidated sand and clay with a decreasing percentage of gravel. These sedimentary strata contact the continuation of crystalline rocks of the Piedmont Plateau. The former BHRA is approximately 25 miles southeast of the Fall Line, and the crystalline rock surface occurs at approximately 1,700 feet bgs.

The younger Talbot Formation is mapped at the surface within the area of the former BHRA. This formation ranges in thickness from 3 to 35 feet. It is composed primarily of sand, silt, and clay, which grade downward from finer to coarser-grained material. Based on boring log data from previous investigations and this Phase I RI, portions of the site are immediately underlain by clay and/or silt material approximately 5 to 10 feet thick. At depths varying from approximately 4 to 18 feet bgs, the clay and/or silt grades to a poorly sorted fine to medium silty and clayey sand. At depths varying from approximately 5 to 20 feet bgs, a silty sand layer grades to a clayey silt from north to south. Sandier material is interbedded and discontinuous throughout the upper 25 to 30 feet of subsurface material where the Terrace Deposits are encountered. These deposits generally consist of coarser material than the Talbot Formation, such as interbedded sand, gravel, and silt-clay. The thickness of this unit ranges from 3 to 40 feet.

3.4 HYDROGEOLOGY

Sedimentary sand and gravel strata comprise the major water-bearing units of the Atlantic Coastal Plain. The five major water-bearing geologic units in use in the project area include: (1) Aquia, (2) Magothy, (3) Upper Patapsco, (4) Lower Patapsco, and (5) Patuxent. The Maryland Geologic Survey lists the Aquia, the Magothy, the Upper Patapsco, and the Lower Patapsco Aquifer systems underlying the former BHRA and surrounding area as “important source[s] of water supply in Anne Arundel [and other] Counties.” http://www.mgs.md.gov/groundwater/coastal_plain_aquifers_mobile.html

The Aquia greensand is the surficial, unconfined (water table) aquifer at the site and extends to a depth of 100 to 150 feet bgs to the Monmouth Formation, which acts as an underlying confining unit. Since this confining unit separates the unconfined Aquia aquifer from deeper aquifers, potential impacts to the underlying water-supply aquifers from former operations at the BHRA are extremely unlikely.

Depth to groundwater varies from 16 feet amsl in the southeast portion of the site to shallower than 3 feet amsl at the northwest corner near Bay Head Road. Flow is north/northwesterly, toward the unnamed tributary of the LMR at an estimated velocity of 0.48 feet per day (DON, 2001a).

3.5 GROUNDWATER USE

The residences surrounding the former BHRA obtain their water supply from either private residential wells or the Anne Arundel County Public Water system. As mentioned in Section 2.2, the Navy identified nine downgradient and two upgradient residences with private wells. Of these, only three had wells installed in the Aquia aquifer with the others installed in the deeper Magothy or Upper Patapsco aquifers.

Two nearby subdivisions west of the BHRA, Revel Downs and Woods Landing, obtain their water supply from the Anne Arundel County Public Water system. County production wells are screened in the Patapsco and Patuxent aquifers and are located about eight miles northwest of the site.

3.6 ECOLOGICAL SETTING

Currently, most of the park has been cleared of trees and redeveloped, with only a small portion along the north covered in natural vegetation (Figure 2-1). There are no permanent water bodies at the site. Surface water runoff from the site is directed to the on-site stormwater drainage system, located east of the Bay Head Road. The on-site drainage system runs intermittently and discharges to the unnamed tributary of the LMR. The LMR itself flows approximately 2.5 miles, discharging to the Chesapeake Bay. The LMR is bordered by the community of Cape Saint Claire to the west, and the communities of Revel Downs and Woods Landing to the south. To the east of the LMR near the former BHRA are a small number of homes and farmland.

The Chesapeake Bay's tidal freshwater tributaries provide habitat for a range of fish, shellfish, and benthic invertebrates, various reptiles and amphibians, and several aquatic mammals. Numerous waterfowl and other migratory birds also utilize the Chesapeake Bay watershed extensively for foraging and shelter including the loons, swans, Canada geese, and various ducks. It is also a nesting area for the bald eagle, brown pelican, double-crested cormorants, and osprey. Year-round avian residents of the watershed include the great blue heron and the belted kingfisher. Additional information about the ecological setting of the BHRA study area and specific species inhabiting the area is presented in the ERA provided in Appendix F.

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4. NATURE AND EXTENT OF CONTAMINATION

Section 4 summarizes the analytical results obtained during the four stages of RI investigations, performed to characterize the nature and extent of PFAS contamination in environmental media at the former BHRA. Stage 1 entailed residential drinking water sampling and Stages 2 through 4 focused on characterization of PFAS present in on-site soil, groundwater, sediment, and surface water, which included sampling sediment and surface water from the unnamed tributary of the LMR, its surrounding wetlands and within a portion of the LMR itself.

PFAS analytical data generated from drinking water, soil, groundwater, sediment, and surface water samples were subject to a “Stage 2A” data validation. The process, outlined in the approved SAP, includes a comparison of the site data to corresponding blank (laboratory, field, equipment, and trip) concentration data.

Estimated concentrations, those generated from samples containing PFAS above the detection limit but below the limit of quantitation, are “J” qualified. Non-detect concentrations, those generated from samples did not contain PFAS at or above the detection limit, are flagged with “U” or “UJ”.

All data were found to be of acceptable quality and can be used without limitations as qualified to meet the investigation objectives. Laboratory Technical Reports for each Sample Delivery Group (SDG) are provided in Appendix C. Further details on data validation are provided in the Data Validation Reports for each SDG, which are included as Appendix D.

4.1 INITIAL SCREENING LEVELS

Based on DoD technical guidance (DoD, 2019), the soil and groundwater PFAS detections from the Stage 2 effort were compared to the USEPA human health risk-based regional screening levels (RSLs) for PFOS, PFOA, and PFBS in residential soil, commercial/industrial soil and tap water for initial screening of PFAS testing results to determine whether PFAS in these media were above RSLs and whether further sampling and/or evaluation is recommended.

Concentrations equal to or below the RSLs are not expected to pose an unacceptable risk/hazard to human health, as applicable, and do not require further evaluation of potential risk/hazard. Concentrations greater than the RSLs do not necessarily pose an unacceptable risk/hazard, but indicate further evaluation is needed to make a determination of the associated potential risk/hazard on a site-specific basis.

RSLs for PFOS and PFOA were calculated using the USEPA RSL Calculator (USEPA, 2019) using the chronic oral reference dose (RfD) for PFOS and PFOA of 2×10^{-5} (0.00002) milligrams of chemical per kilogram of body weight per day (mg/kg-day). The RSL for PFBS was calculated using an RfD of 2×10^{-2} (0.02) mg/kg-day. When multiple PFAS are encountered at a site, a 0.1 factor is conservatively applied to the screening level to account for potential cumulative effects of multiple chemicals. Calculated RSLs for soil and groundwater are summarized in Table 4-1.

Published USEPA human health screening levels for sediment and surface water are not available. Therefore, site-specific screening levels were calculated for the HHRA using site-specific information to be protective of current and potential future use scenarios.

Ecological screening levels are media, receptor, and exposure pathway specific, based on a combination of multiple criteria. Further details of the procedures used to select PFAS COPC and calculate appropriate screening criteria used for the BHRA site-specific HHRA and ERA per media are included in the stand-alone HHRA and ERA presented in Appendices E and F, respectively.

4.2 RESIDENTIAL DRINKING WATER

Drinking water samples were collected from the two permanent shallow wells, via cold-water spigots, located at residential properties adjacent to the site during the November 2016 sampling event. A summary of drinking water sample analytical data for PFBS, PFOS, and PFOA is presented in Table 4-2.

Drinking water PFAS analytical data are presented in SDGs, FA38820 and FA38917. PFAS were not detected in drinking water samples from either residence.

4.3 SOIL

Surface and subsurface soil samples were collected from 12 locations during Stage 2 of the Phase I RI. The effort was focused on characterizing PFAS concentrations in soil around suspected source areas including the FBP and associated evaporation pond.

Soil analytical data are provided in SDGs, J23256, J23651, J23718, J23783, and J24995. A summary of soil sample analytical data is provided in Table 4-3 and soil sample locations with associated analytical results are presented on Figure 4-1.

4.3.1 Surface Soil

Surface (0-1 foot bgs) soil samples collected from 12 locations within the former BHRA indicate that PFOS and PFOA are present in the soil surrounding and down-slope from the FBP. Detected concentrations of PFOS, the PFAS present at the highest concentrations in surface soil, ranged from 170 µg/kg at boring DPT-16-19 (located approximately 50 feet east of the FBP) to 0.25 µg/kg at boring DPT-17-26 (located near the southern boundary of the park). Detected concentrations of PFOA in surface soil ranged from 12 µg/kg at boring DPT-16-35 (located approximately 25 feet east of the FBP) to 0.22 J µg/kg at boring DPT-17-26. PFOS and PFOA concentrations in surface soil from the boring located at the FBP (DPT-16-34) were 80 µg/kg and 8.9 µg/kg, respectively. PFBS was only detected in surface soil at four of the borings with concentrations ranging from 0.12 J µg/kg to 0.21 J µg/kg.

It should be noted that PFOS and PFOA were detected at very low concentrations in the two up-slope surface soil samples from DPT-17-26 and DPT-17-27. While detected concentrations (0.25 J µg/kg of both PFOS and PFOA) were orders of magnitude less than those from source-area samples, it suggests that PFAS detections occur beyond the source area, likely resulting from soil grading during redevelopment.

As indicated on Table 4-3, the reported PFOS concentration of 170 µg/kg from boring DPT-16-19 was the only PFAS sample that exceeded the conservative residential scenario RSL with a Hazard Quotient (HQ) of 0.1 for PFOS of 130 µg/kg (Table 4-1). However, the concentration in this boring falls well below the adjusted residential RSL based on a HQ of 1 (or 1,300 µg/kg).

4.3.2 Subsurface Soil

Subsurface soil samples were collected at each of the 12 boring locations from 1-foot depth intervals ranging from 12-13 feet bgs to 19-20 feet bgs. The analytical results for the subsurface soil samples indicate that PFAS are present in subsurface soils in the area surrounding and down-slope from the FBP. PFAS were not detected in either of the samples collected from the borings located near the southern boundary of the park (DPT-17-26 and DPT-17-27).

Detected concentrations of PFOS ranged from 57 µg/kg at boring DPT-16-30 (located just east of the former evaporation pond) to 1.5 µg/kg at boring DPT-16-29 (located approximately 50 feet east of the FBP). Detected concentrations of PFOA ranged from 5.5 µg/kg at boring DPT-16-30 to 0.27 J µg/kg at boring DPT-

17-31 (within the former evaporation pond footprint). PFBS was not detected in subsurface soils at any of the borings.

In two of the 12 locations (DPT-16-30 and DPT-16-32) concentrations of PFOS and PFOA in subsurface soil samples were approximately three to five times higher than concentrations in their respective surface soil samples, indicating vertical migration of PFAS at these locations. In the remaining ten locations, PFAS concentrations were higher or similar in the surface soil than in the deeper soil samples.

4.4 GROUNDWATER

Grab groundwater samples were collected at 35 boring locations during Stage 2 of the Phase I RI. Shallow groundwater samples were collected from 4-foot depth intervals at 33 of the 35 locations (locations DPT-16-1 and DPT-16-5 did not produce sufficient groundwater for sampling) ranging from 6-10 feet bgs to 21-25 feet bgs to target the upper portion of the surficial aquifer based on approximate depths to groundwater derived from the HPT logs. Deeper groundwater samples were collected from 4-foot depth intervals at all 35 locations ranging from 17-21 feet bgs to 31-35 feet bgs to assess vertical migration of PFAS in the surficial aquifer.

Groundwater analytical data are presented in SDGs, J23501, J23542, J23651, J23718, J23783, J23830, J23890, J23998, J24060 and J24961. A summary of groundwater analytical results is presented in Table 4-4 and groundwater sample locations with associated analytical results are presented on Figure 4-2.

The analytical results for the shallow and deeper groundwater samples from the surficial aquifer indicated that PFAS are present in groundwater in the area surrounding, and down-gradient (i.e., to the northwest) from the FBP and former evaporation pond. Detected concentrations of PFOS in shallow groundwater, the PFAS present at the highest concentrations, ranged from 42 J µg/L at boring DPT-16-31 (located approximately 25 feet west of the former evaporation pond) to 0.0071 J- µg/L at boring DPT-16-03 (located in the wooded area approximately 300 feet east of the former evaporation pond). Detected concentrations of PFOA in shallow groundwater ranged from 28 J µg/L at boring DPT-16-31 to 0.00092 J- µg/L at boring DPT-16-03. PFBS concentrations in shallow groundwater ranged from 1.1 µg/L at borings DPT-16-21 and DPT-16-31 to 0.0011 J µg/L at DPT-16-26.

Detected concentrations of PFOS in deeper groundwater in the surficial aquifer ranged from 11 J µg/L at boring DPT-16-30 (located within the former evaporation pond foot print) to 0.0016 J- µg/L at boring DPT-16-04 (located in the wooded area approximately 300 feet east of the former evaporation pond). Detected concentrations of PFOA in deeper groundwater ranged from 2.3 µg/L at boring DPT-16-16 (located within the former evaporation pond foot print) to 0.0021 J- µg/L at boring DPT-16-09 (located in the wooded area approximately 200 feet west of the FBP). PFBS was detected in deeper groundwater at 29 locations with concentrations ranging from 0.38 J- µg/L at boring DPT-16-35 (approximately 25 feet east of the FBP) to 0.0027 J- at DPT-16-09 (located in the wooded area approximately 200 feet west of the FBP).

Very low (< 0.009 µg/L) PFAS concentrations were detected at DPT-17-26, which is one of the two up-gradient locations near the southern boundary of the park; however, trace levels of PFAS were detected in the EB so it is likely that this value is the result of sampling-related cross-contamination, not the presence of PFAS in groundwater at this location.

As indicated by the total PFAS concentration contours on Figure 4-2, the PFAS plume is migrating to the north/northwest as expected, given the groundwater flow direction. In addition, elevated PFAS concentrations were detected up gradient of the evaporation pond indicating that process water infiltration possibly occurred over a larger area than the historically depicted pond footprint.

Incremental PFAS concentration values for PFBS, PFOS and PFOA in groundwater samples are plotted on Figure 4-3 to better evaluate PFAS distribution. The figure reinforces that PFOS was detected at higher concentrations over a greater extent than PFOA and PFBS.

C-Tech Environmental Visualization System (EVS) software was used to prepare a three-dimensional (3D) hydrogeological model of the PFAS plume based on the HPT and grab groundwater sample data collected during the Stage 2 effort. The model incorporated the estimated K values generated from the HPT survey as well as the total PFAS concentrations from the grab groundwater samples to model the PFAS plume as well as site stratigraphy. Figure 4-4 depicts plan and cross-sectional views of the 3-D plume model projecting the area of the plume with total PFAS concentrations greater than 1 µg/L as yellow. The area of the projected plume is approximately 3.8 acres.

PFAS concentration in the shallow and deeper grab groundwater samples are depicted in Figure 4-4, as color-coded cylinders along the gray lines representing the HPT borings. Sample cylinder colors correspond to the PFAS concentration color scale bar. Stratigraphic materials with K values above 1 foot/day are represented on the oblique view as light to dark green solid features with materials having K values less than 1 foot/day depicted as transparent. These features represent layers of stratigraphic material with K greater than 1 foot/day (e.g., fine sands), which may represent preferential groundwater flow paths. Based on the grab sample data, the modeled >1 µg/L PFAS plume emanates from the source areas and migrates horizontally and vertically through the shallow aquifer to the north, extending to a depth of approximately 40 feet bgs.

4.5 SEDIMENT

Sediment samples were collected during multiple phases of site investigation in 2016 and 2018. Sediment samples were collected from 4 locations on or adjacent to the park during the Stage 2 effort (November 2016). In addition, samples were collected from 24 downstream, off-site locations within the unnamed tributary of the LMR; 5 locations sampled in both April-Stage 3 and November 2018-Stage 4; and 19 additional locations sampled in November 2018-Stage 4. Sediment samples were collected during the low tidal stage during Stage 4 to facilitate sample collection.

Analytical data for sediment and surface water samples are provided in SDG J38603 (Stage 3) and SDGs, TAK08 through TAK17 (Stage 4). A summary of sediment sample analytical results is presented in Table 4-5 and sediment sample locations with associated analytical results are presented on Figures 4-2, 4-5 and 4-6.

As with soil and groundwater, PFOS was the most frequently detected PFAS detected in sediment (detected in 37 of 38 samples, including field duplicates) with concentrations ranging from 44 µg/kg (during Stage 3) at location SWSD-18-02 (located approximately 450 feet west of Bay Head Road) to 0.32 J µg/kg at SWSD-18-10 located along the western shore of the bay on the LMR. PFOA was detected in 16 of the 38 samples at concentrations ranging from 4.5 µg/kg at location SWSD-18-02 (in the field duplicate sample during Stage 3) to 0.18 µg/kg J at SWSD-16-04. PFBS was only detected in sample SWSD-18-03 at 0.28 J µg/kg.

Seasonal variability between the Stage 3 and Stage 4 results for locations SWSD-18-01 through SWSD-18-05 was apparent with PFAS concentrations being higher during the spring sampling (April 2018-Stage 3) than in the fall sampling (November 2018-Stage 4). This may be due to higher surface runoff levels and increased groundwater flow associated with general increased precipitation during the spring months. PFAS concentrations generally decreased with distance downstream from the site except that the highest concentrations were observed at locations SWSD-18-02 and SWSD-18-03 in the unnamed tributary approximately 450 to 900 feet west of Bay Head Road and downstream of locations SWSD-18-01, SWSD-18-06, and SWSD-18-07. The relatively elevated concentrations at these locations suggest that PFAS-impacted groundwater originating from the site is infiltrating along this stretch of the unnamed tributary. PFAS concentrations decreased rapidly in the LMR beyond the discharge point of the unnamed tributary.

4.6 SURFACE WATER

Surface water samples were also collected during multiple phases of site investigation in 2016 and 2018. Surface water samples were collected from two locations on or adjacent to the park during Stage 2 (November 2016). In addition, surface water samples were collected at 24 downstream, off-site locations from the unnamed tributary of the LMR; 5 locations sampled in both April 2018-Stage 3 and November 2018-Stage 4; and 19 additional locations sampled in November 2018-Stage 4.

Five locations west of Bay Head Road (i.e., SWSD-18-01, SWSD-18-02, SWSD-18-06, SWSD-18-07 and SWSD-18-24) and the two locations east of Bay Head Road (i.e., SWSD-16-01, SWSD-16-02) are considered to be above tidal influence due to their elevations amsl. For the remaining 19 locations, surface water samples were collected during both high and low tidal stages during Stage 4 sampling to evaluate variability in PFAS concentrations due to tidal cycles.

A summary of surface water sample analytical results is presented in Table 4-6 and surface water sample locations with associated analytical results are presented on Figures 4-2, 4-5 and 4-6.

As with sediment, PFOS was the PFAS most frequently detected in surface water and detected at higher concentrations than PFOA or PFBS. PFOS was detected in all 57 samples and concentrations ranged from 0.66 J µg/L (during Stage 3) at location SWSD-18-02 (located approximately 450 feet west of Bay Head Road) to 0.0032 µg/L at SWSD-18-11 located along the western shore of bay on the LMR. PFOA was also detected in all 57 samples at concentrations ranging from 0.53 J µg/L (in the field duplicate) at SWSD-18-03 (located approximately 850 feet west of Bay Head Road) to 0.0033 µg/L at SWSD-18-11. PFBS, also was detected in all 57 samples at concentrations ranging from 0.057 µg/L at SWSD-18-03 to 0.0015 J µg/L (in the field duplicate sample) at SWSD-18-05.

In general, when samples were collected under both low and high tidal stages, PFAS concentrations were higher in the sample collected under the low tidal stage. This trend is less apparent for sampling locations along the eastern shore of the bay on the LMR (i.e., SWSD-18-18, SWSD-18-19, SWSD-18-20, SWSD-1821, and SWSD-18-23) where there was little difference in concentrations between tidal stages or in some instances the high tidal stage showed a slightly higher concentration. It is expected that lower concentrations on the high tide, particularly within the unnamed tributary, are the result of dilution by clean water from the LMR moving up the unnamed tributary. Higher PFAS concentrations under low tidal conditions may be more impacted by groundwater discharge or by surface runoff during precipitation events. As with sediment, PFAS concentrations in surface water also decreased with distance downstream from the site except in the stretch of the unnamed tributary encompassing locations SWSD-18-02 and SWSD-18-03. Again, the relatively elevated concentrations at these locations suggest that PFAS-impacted groundwater originating from the site is infiltrating along this stretch of the unnamed tributary. PFAS concentrations decreased rapidly in the LMR beyond the discharge point of the unnamed tributary.

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5. CONTAMINANT FATE AND TRANSPORT

This section includes information on the physical and chemical properties of PFAS, provides a discussion of release mechanisms and migration routes, and culminates in the CSM, which represents a summary of the processes affecting PFAS at and down gradient/downstream of the former BHRA.

5.1 PHYSICAL AND CHEMICAL PROPERTIES OF PFAS

AFFF containing PFAS were developed in the early to mid-1960s for use in Class B (i.e., flammable liquids, fuels) fire suppression. AFFF is composed of complex mixtures of fluorocarbon surfactants (including both PFOS and PFOA) designed to spread over fuel fires, extinguish the flames and prevent re-ignition. Investigations into AFFF formulations indicate that prior to 2003 PFOS was present at a higher amount per unit of volume than PFOA (Seow, 2013).

Typically, AFFF concentrate was proportionally mixed into water lines using an in-line inductor or other proportioning device to create a thick and fast-spreading foam blanket that limited oxygen from contacting the surface of the ignited fuel, while simultaneously cooling the surface temperature with the high-water content (USEPA, 1999). Details regarding when or exactly how AFFF containing PFAS were first put into use at the BHRA are not clear but it reportedly was used at the site prior to 1986.

The primary PFAS of interest at the former BHRA are PFOS and PFOA due to their widespread detection and increased regulatory scrutiny. The features of the fate and transport of PFOS and PFOA can be extrapolated to the other PFAS chemicals investigated during this RI (i.e., PFBS).

Both PFOS and PFOA are highly stable, long-chain compounds that consist of a carbon backbone with fluorine atoms attached. The strong carbon-fluorine bond makes PFOS and PFOA extremely persistent and stable in environmental media. These chemical bonds are resistant to environmental degradation processes, such as biodegradation, photolysis, and hydrolysis. In natural waters, no degradation process has been observed, and dissipation is by advection, dispersion, and sorption to particulate matter. PFOS and PFOA both have low volatility in ionized form but can adsorb to particles and be deposited on the ground and into water bodies. Because of their persistence, they can be transported long distances in air or water and have been detected in ambient air and seawater globally (USEPA, 2016a).

PFOS and PFOA are known to bioaccumulate in wildlife and humans. Further, PFOS and PFOA are toxic, producing reproductive, developmental, and systemic effects in laboratory tests. Shorter-chain PFAS such as PFBS are generally less toxic and less bioaccumulative in wildlife and humans and alternative products containing these shorter-chain chemicals have been introduced as replacements for long-chain PFAS (Buck et al, 2011).

5.2 RELEASE MECHANISMS AND MIGRATION ROUTES

The PFAS release mechanisms at the former BHRA are related to the use of AFFF in the fire suppression system used at the FBP. The FBP was exposed to the elements, creating opportunities for precipitation to wash PFAS-containing residues into the ground surface. Quench water discharged from the FBP was also drained into the shallow concrete evaporation pond located approximately 30 feet west of the FBP. Cracks were noted in the concrete berm of the evaporation pond during the 2000 RI, which functioned as conduits for the release of PFAS-containing quench water onto the ground (EA, 2000).

Once released to the environment, PFAS may migrate through soil, groundwater, sediment, and surface water routes at the former BHRA as discussed in the following sections.

5.2.1 Soil

PFAS released to the ground surface may be transported down through the soil with infiltrating rainwater. The shallow soils at the FBP are characterized as silt and clay overlying sandier material below and near the water table. The PFAS concentrations are typically much higher in surface soil samples (with higher clay content) indicating that vertical transport of the mass of PFAS adsorbed to the shallower soils in this area is occurring by rainfall recharge, albeit slowly. PFAS soil concentrations appear to increase with depth at the locations near the evaporation pond (DPT-18-30, DPT-18-31, and DPT-18-32) indicating that the infiltration of leaking quench water was a more predominant factor than rainwater in the vertical transport of PFAS from soil at the former BHRA presumably due to the relatively large volume of process water discharge to the pond.

5.2.2 Groundwater

Given enough time and enough rain events (or leaking quench water), PFAS released to the soil are likely to reach the water table, thereby impacting groundwater. Once in groundwater, PFOS and PFOA will travel towards and discharge to a nearby waterbody. Based on the BHRA site groundwater flow projections from the 2000 RI (EA, 2000), flow is northwest towards the unnamed tributary draining into the LMR. Grab groundwater sample data confirm that elevated PFAS concentrations are associated with the FBP, evaporation pond, and AFFF fire suppression system and that the resulting PFAS groundwater plume is flowing off site towards the unnamed tributary to the LMR.

The surface water and sediment data suggest that PFAS-impacted groundwater originating from the site and infiltrating into the unnamed tributary may be the primary migration route still in effect since current conditions at the site (i.e., stable vegetation cover, minimal soil erosion in most portions of the site) have greatly minimized the transport of PFAS-impacted soil and sediment by surface water runoff/erosion.

Based on the 3-D hydrogeological model of the PFAS groundwater plume generated by groundwater sample data, and the wide-spread presence of PFAS in downstream sediment and surface water, groundwater transport is considered the primary migration route of concern.

5.2.3 Sediment

Sediment transport is governed by surface water runoff and surface cover. Site topography at the former BHRA is generally flat, and most of the developed site is stabilized by vegetation, primarily grass. Although the former BHRA contains little exposed soil conditions, the potential for historical sediment transport by erosion to have occurred is supported by the PFAS detected in sediment samples collected along the western drainage swale and the surface water drainage feature north of the site. Storm events could result in the movement of sediments present within the unnamed tributary. Consequently, sediment transport is considered a migration route of concern.

PFAS in surface water may be impacting co-located sediments within the unnamed tributary. However, reported concentrations were higher in sediment and surface water at sample locations further downstream than at locations closer to the former BHRA, which suggests PFAS impacted groundwater originating from the site and infiltrating through the various seeps may be the dominant pathway for PFAS transport to sediment, rather than surface water transport.

5.2.4 Surface Water

Surface water runoff can provide a pathway for PFAS to migrate offsite via channelized or sheet flow. PFAS adsorbed to soil particles can be conveyed via overland flow suspended in runoff that occurs during heavy precipitation, which settle in the downstream waterbodies as sediment. PFAS may also become solubilized in rainwater or snowmelt and be conveyed in the precipitation runoff. The presence of PFAS in surface water and sediment samples collected along the western stormwater drainage swale running through the site and the larger surface water drainage feature north of the site that discharges to the unnamed tributary confirms that surface water transport is occurring.

5.2.5 Other Routes of Migration

Air Transport: The air transport pathway for non-volatile PFAS is formed by wind movement of surficial soil particles, particulates created during burning operations, and possibly vapors and particulates generated during AFFF application. Transport is limited by the particle size, wind speed, and surface conditions. While the former BHRA is primarily grass covered or paved, there are areas of exposed silty soil so PFAS on impacted soil particles could be transported by wind movement. PFAS vapors and particulates may also have been dispersed during historical AFFF use/application and associated burn testing. However, under current site conditions, air transport is not a significant migration route.

Bioaccumulation: Levels of PFAS, which are bioaccumulative chemicals, can significantly increase in concentration up the food chain, typically having greatest concentrations in the tissue of tertiary level carnivorous or piscivorous (fish-eating) receptors. The bioaccumulation process is further discussed in the ERA but is not considered a significant migration route.

5.3 BHRA CONCEPTUAL SITE MODEL

This CSM summarizes site information, describes PFAS source areas and summarizes impacted media, migration pathways, fate and transport and potential exposure routes for human and ecological receptors. This CSM may require updating and will continue to evolve and be refined as additional site information is obtained, as warranted. The goal of this CSM is to provide a description of the relevant site features and the surface and subsurface conditions to understand the extent of PFAS contamination (primarily PFOS and PFOA) and the potential risk they pose to receptors. The CSM is also used to help identify investigative data gaps and ultimately to support remedial decision making, if necessary.

5.3.1 Summary of Site Information

The site overview and history are presented in Sections 1.1 and 1.2 and the geology and hydrogeology are presented in Section 3.3. Briefly, the BHRA Launch Area (IR Site 1) was used by the Army for the Nike Missile Defense System from 1954 until 1969. After Nike Battery deactivation, the facility was used by the Navy to conduct burn tests to determine heat resistant properties of materials for use onboard Navy ships. The Navy operated the fire testing area (consisting of the FBP, evaporation pond and a PFAS-containing AFFF fire suppression system) from approximately1969 through 1986. Numerous environmental investigations were subsequently conducted at the site culminating in closure under BRAC and transfer to Anne Arundel County in 2004. The 2000 ROD included IC prohibiting future residential development of the site. The current and expected future land use for the site is recreational as Bay Head Park. In addition, the CTA is a site tenant and currently conducts commercial operations at the site. Drinking water is provided to the surrounding community by the Anne Arundel County Public Water system.

Overburden at the site ranged up to 20 feet bgs and is underlain by the Talbot Formation Terrace Deposits and the Aquia Formation, which are part of the surficial Aquia greensand aquifer that extends to a depth of 100 to 150 feet bgs to the Monmouth Formation that acts as an underlying confining unit. Depth to groundwater ranges from 3 to 16 feet bgs.

5.3.2 Description of Source Areas

The Phase I RI identified the primary source of PFAS in environmental media at the former BHRA as surface releases from historic fire/burn-testing operations entailing the use of PFAS containing AFFF in the fire suppression system and apparent application at the FBP. Secondary releases included FBP quench water leaks from the associated evaporation pond. The regrading of PFAS-impacted silt soils during redevelopment of the site is also a possible secondary source of PFAS.

5.3.3 Summary of Impacted Media

PFOS, PFOA and PFBS have been detected in site soil and groundwater and in down stream sediment and surface water. Concentrations of PFOS and PFOA detected in site groundwater exceeded the conservative (i.e., HQ = 0.1) RSL of 0.04 µg/L in the majority of the site samples. The maximum concentration of PFOS detected in surface soil (170 µg/kg) from boring DPT-16-19 exceeded the conservative (i.e., HQ = 0.1) PFOS RSL of 130 µg/kg (but was well below the adjusted residential RSL based on a HQ of 1 (or 1,300 µg/kg).

5.3.4 Fate and Transport

Both PFOS and PFOA (and presumably other PFAS) are stable in environmental media because they are resistant to environmental degradation processes, such as biodegradation, photolysis, and hydrolysis. In natural waters, no degradation has been demonstrated, and dissipation is by advection, dispersion, and sorption to particulate matter. PFOS and PFOA can bioaccumulate through the food chain.

Fate and transport of PFOS and PFOA at the former BHRA is primarily associated with surface water and groundwater since these and other PFAS are highly soluble in water. Surface releases of PFOS- and PFOA-containing AFFF to the FBP and the associated evaporation pond impacted the soil and these PFAS are desorbing and migrating with precipitation recharge vertically through the unsaturated zone to the groundwater table.

PFOS and PFOA surface releases during historical fire testing operations also resulted in impacts to soil and surface water resulting in the transport of impacted soil particles (sediment) and dissolved PFOS and PFOA being conveyed over land suspended in runoff that occurs during precipitation events or to a lesser extent through the wind erosion of contaminated soils. Contaminants adsorbed to surface particles may also become solubilized in rainwater or snowmelt and be conveyed over land in the precipitation runoff.

In surface water and sediment samples collected from within the unnamed tributary, concentrations of PFOS and PFOA were higher in downstream sample locations (SWSD-18-02 and SWSD-18-03) than at locations closer to the former BHRA, suggesting that PFOS and PFOA impacted groundwater originating from the site and infiltrating through the various seeps may be the dominant pathway for PFOS and PFOA transport to sediment, rather than surface water transport.

5.3.5 Description of Receptors

Detailed discussions of the human and ecological receptors that may be potentially exposed to soil, groundwater, sediment, and/or surface water associated with the former BHRA are provided in the HHRA and ERA and summarized in Section 6.

6. RISK ASSESSMENT

This section presents summaries of the PFAS HHRA and ERA conducted for the former BHRA. The complete, stand-alone HHRA and ERA reports are provided as Appendices E and F, respectively.

6.1 HUMAN HEALTH RISK ASSESSMENT

The primary objective of the HHRA is to evaluate the potential risk/hazard to human receptors associated with exposure to PFOS, PFOA and PFBS in soil, groundwater, drinking water, sediment, and surface water attributable to past operations at the site. The HHRA was conducted in accordance with current USEPA CERCLA risk assessment guidance and policies and the Navy Policy for Conducting Human Health Risk Assessments Under the Environmental Restoration Program (DON, 2001c) and included the following tiers of evaluation:

- Tier I Screening (COPC selection) – Compared the maximum detected concentration of chemicals within each medium and exposure point to generic (Tier IA) screening levels (available for soil and groundwater) and site-specific (Tier IB) screening levels (derived for soil, groundwater, sediment, and surface water). Chemicals detected at concentrations above the screening levels were further evaluated in the Tier II site-specific risk evaluation for the associated media, receptor/exposure scenario, and exposure point.
- Tier II Baseline HHRA - Performed a quantitative estimation of potential excess lifetime cancer risk (ELCR) and noncancer hazard index (HI) to current and potential future human receptors for which COPCs were identified in the Tier I screening evaluation. The cumulative potential ELCR and noncancer HI; per target endpoint for each exposure scenario were evaluated in comparison to USEPA's CERCLA target risk range of 10^{-6} to 10^{-4} for potential carcinogens and target HI of 1 for non-carcinogenic chemicals. Cumulative potential ELCR's were also discussed in comparison to MDE's target ELCR of 1×10^{-5} (MDE, 2019). For each associated exposure scenario with a potential ELCR/HI above USEPA target levels, chemicals of concern (COCs) were defined as COPCs with an individual ELCR greater than (>) 10^{-6} or HI > 1.

6.1.1 HHRA Data Set

The dataset evaluated in the HHRA is as follows:

- **Soil** - Results from surface soil samples collected from 0-1 foot bgs and subsurface soil samples collected from a 1-foot depth interval between 12 and 20 feet bgs, from 12 on-site locations sampled during the November 2016 and/or January 2017 sampling events.
- **Groundwater** - Results from grab groundwater samples collected from 35 locations across the site during the November/December 2016 and January 2017 sampling events.
- **Drinking Water** - Results from drinking water samples collected from two permanent shallow wells, via cold-water spigots, at residential properties within one-half mile of the site during the November 2016 sampling event.
- **Sediment** - Results for sediment samples collected from four locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016, and from 24 locations at downgradient off-site locations to the north of the site (off-site, west of Bay Head Road) in April and/or November 2018.
- **Surface Water** - Results for surface water samples collected from two locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016, and from 24 locations at downgradient off-site locations to the north of the site (off-site, west of Bay Head Road), including

5 locations along the unnamed tributary in April 2018 and 24 locations along the unnamed tributary and within the bay in November 2018.

6.1.2 Receptors and Exposure Scenarios Evaluated

The HHRA evaluated the following potentially complete exposure pathways for human receptors identified based on current and reasonable future land-use scenarios in accordance with the CSM (depicted on Figure 4 of the HHRA report provided in Appendix E):

- Current/future recreational user (adult/child)
- Current/future outdoor (commercial/industrial) worker
- Future construction/excavation/utility worker
- Hypothetical future on-site resident (adult/child)

The above receptors may be exposed to soil (all receptors) and/or sediment (recreational user) via incidental ingestion and dermal contact; and groundwater via incidental ingestion (workers) or ingestion as drinking water (hypothetical future resident; evaluated to represent an unlimited use/unrestricted exposure [UU/UE] scenario and provide information for decision-making purposes). The inhalation exposure pathway was not quantitatively assessed for PFAS due to the absence of currently recommended toxicity values by USEPA, and dermal contact with PFAS in groundwater was not quantitatively evaluated in accordance with the approach used by USEPA (2019) due to the limited dermal absorption of PFAS in water through human skin.

6.1.3 Summary of HHRA Findings

The results of the Tier I screening evaluation are as follows:

- No soil or groundwater COPCs were identified for the on-site outdoor (commercial/industrial) worker or construction/excavation/utility worker exposure scenarios. Therefore, these scenarios do not pose an unacceptable risk/hazard and were not further evaluated in the Tier II HHRA;
- No soil, sediment, or surface water COPCs were identified for the recreational user; therefore, exposure to soil, sediment, or surface water by this receptor does not pose an unacceptable risk/hazard and was not further evaluated in the Tier II HHRA;
- PFOS was selected as a surface soil and combined surface and subsurface soil COPC for further evaluation of a hypothetical future on-site residential exposure scenario; and
- PFOS and PFOA were selected as groundwater COPCs for further evaluation of a hypothetical future on-site residential exposure scenario (which is also protective of potable use of groundwater by commercial/industrial receptors).

The results of the Tier II Baseline HHRA are as follows:

- The potential cumulative ELCR for the hypothetical future on-site residential exposure scenario is within USEPA's target ELCR range of 10^{-6} to 10^{-4}, and is also less than MDE's target ELCR of 1×10^{-5} when compared;
- The noncancer HI for the hypothetical future on-site residential exposure scenario is greater than the USEPA target HI of 1, and is primarily driven by the potential ingestion/consumption of site groundwater as a drinking water source if used in the future;

- PFOS and PFOA were identified as site-related COCs in groundwater for a hypothetical future use scenario in which groundwater underlying the site is used as a source of drinking water or other potable use; and
- No soil COCs were identified based on all the exposure scenarios evaluated, including the hypothetical future on-site residential scenario.

There are currently no residents located on the site and there are no plans for residential use of the site in the future. Current ICs restrict use of the property to non-residential development (DON, 2001a). In addition, groundwater underlying site is not used for drinking water and the county and state regulations prohibit the installation of water supply wells. Therefore, the overall conclusions of the HHRA are that concentrations of PFOS, PFOA, and PFBS present in site-related soil, groundwater, surface water, and sediment do not pose an unacceptable risk to current and anticipated future human receptors.

Therefore, at this time, no further evaluation is warranted for human receptors potentially exposed to PFAS associated with the operations of the former BHRA.

6.2 ECOLOGICAL RISK ASSESSMENT

The primary objective of the ERA is to evaluate the potential for risks to ecological receptors potentially exposed to PFOS, PFOA, and PFBS in soil, sediment, and surface water attributable to past operations at the site. The ERA includes an assessment of potentially complete exposure pathways in the upland portion of the site that currently supports recreational use, as well as the on-site drainage features and downstream off-site aquatic habitats that meander through residential areas before discharging into the LMR.

The ERA was conducted in accordance with current USEPA CERCLA ecological risk assessment guidance (USEPA, 1997) and with Navy Policy for Conducting Ecological Risk Assessments and Navy Guidance for Conducting Ecological Risk Assessments (DON, 1999a,b). Various additional USEPA and Navy guidance documentation was also referenced in the preparation of the ERA.

The ERA includes the Tier 1 ecological screening risk assessment (SRA) described by Navy policy and guidance (DON, 1999a,b), which is consistent with Steps 1 and 2 of the USEPA eight-step tiered ERA process. Based on the results of the SRA, the first step of the Tier 2 baseline ecological risk assessment (BERA) was also conducted (which is consistent with Step 3a of the USEPA CERCLA ERA process).

6.2.1 ERA Data Set

The dataset evaluated in the ERA is as follows:

- **Soil -** Results from surface soil samples collected from 0-1 foot bgs from 12 on-site locations sampled during the November 2016 and/or January 2017 sampling events.
- **Sediment -** Results for sediment samples collected from four locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016, and from 24 locations at downgradient off-site locations to the north of the site (off-site, west of Bay Head Road) in April and/or November 2018.
- **Surface Water -** Results for surface water samples collected from two locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016, and from 24 locations at downgradient off-site locations to the north of the site (off-site, west of Bay Head Road) in April and/or November 2018.

6.2.2 Receptors and Exposure Scenarios Evaluated

The following exposure pathways were evaluated in the ERA:

- Soil invertebrates and terrestrial plants directly exposed to PFAS in soil in the vicinity of the former fire testing area of the former facility.
- Terrestrial birds and mammals exposed to PFAS in soil in the vicinity of the former fire testing area of the former facility through incidental ingestion of soil and by ingestion of contaminated prey items impacted by soil.
- Benthic invertebrates and aquatic (water-column) organisms directly exposed to PFAS in surface sediment and surface water in the on/near-site drainage features and off-site wetlands, the unnamed tributary, and the bay of the LMR.
- Aquatic-dependent birds and mammals exposed to PFAS through incidental ingestion of sediment or surface water, and by ingestion of contaminated prey items impacted by sediment or surface water in the on-site drainage and off-site wetlands, the unnamed tributary, and the bay of the LMR.

6.2.3 Summary of ERA Findings

Upon completion of the Tier 1 ecological SRA, it was determined that, based on the evaluation of the maximum detected concentrations in each media, there is a concern for ecological receptors from exposure to on-site surface soil and on/near-site and off-site surface water that warranted further evaluation. Therefore, the following receptors and COPCs were evaluated further:

- Terrestrial birds and mammals – PFOS in soil
- Aquatic-dependent birds and mammals – PFOS and PFOA in surface water

The Tier 2, Step 3a evaluation is based on the Tier 1 SRA dataset and considers site-specific adjustments to exposure and toxicity assumptions. The Tier 2, Step 3a evaluation included comparisons of site data to literature-based screening levels and food web modeling to further assess the potential for risks to higher trophic level wildlife receptors. The findings of the Tier 2, Step 3a evaluation indicated that:

- The bioaccumulation pathway for upland wildlife exposed to PFOS in soil is considered a complete but insignificant pathway based on currently available screening levels, and further evaluation at this time is not warranted.
- The bioaccumulation pathway for aquatic dependent wildlife exposed to PFOS (and PFOA, which has a much lower capacity for bioaccumulation in the aquatic food web than PFOS) in surface water is considered a complete but insignificant pathway based on currently available screening levels, and further evaluation at this time is not warranted.

Based on the findings of the ERA, at this time no further evaluation is warranted for ecological receptors potentially exposed to PFAS associated with the former BHRA.

7. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This section presents a summary of findings, draws conclusions from those findings, and offers recommendations as to the path forward. The primary objectives of this RI, to characterize the nature and extent of PFAS contamination at the former BHRA and surrounding area and quantify the potential risks posed to human health and ecological receptors, was accomplished, though some data gaps remain.

7.1 SUMMARY OF FINDINGS AND CONCLUSIONS

Findings and conclusions of the Phase I RI are summarized in the following sections.

7.1.1 PFAS Sources Related to Former BHRA Operations

The primary source of PFAS in environmental media at the former BHRA and surrounding area was the PFAS-containing AFFF fire suppression system used in conjunction with the FBP. Secondary releases included FBP quench water leaks from the associated evaporation pond and possibly the regrading of PFAS-impacted silt soils during redevelopment of the site.

7.1.2 Nature and Extent of PFAS in Soil

The highest concentrations of PFAS-impacted soil were identified at the former fire-testing operation area (location of the reported AFFF fire suppression system, FBP and associated evaporation pond) thereby confirming that this is the primary PFAS source area. In most locations, PFAS concentrations were higher in the surface soil (0-1 feet bgs) than in the deeper soil samples (collected between 12 and 20 feet bgs). However, PFOS and PFOA concentrations in subsurface soil from borings DPT-16-30 and DPT-16-32 were approximately three to five times higher than concentrations in surface soil at these locations indicating vertical migration of PFAS.

The maximum concentration of 170 µg/kg of PFOS detected in surface soil from boring DPT-16-19 exceeded the conservative (i.e., HQ = 0.1) PFOS RSL of 130 µg/kg (but was well below the adjusted residential RSL based on a HQ of 1 (or 1,300 µg/kg).

7.1.3 Nature and Extent of PFAS in Groundwater

A dissolved-phase PFAS plume exists at the former BHRA, originating near the FBP and evaporation pond and includes areas to the north and northwest, in the direction of groundwater flow. The plume terminates at the unnamed tributary of the LMR, where local groundwater discharges.

The highest PFOS and PFOA concentrations are observed in the source area in the low tens of µg/L and decrease rapidly to the north and northwest (Figure 4-2). A groundwater sample at the northernmost property boundary (DPT-16-05) contained PFOS and PFOA at a combined, estimated concentration of just under 3 µg/L.

7.1.4 Nature and Extent of PFAS in Sediment and Surface Water

Low levels of PFAS were detected in all surface water and sediment samples collected at the former BHRA. However, their concentrations are well below human health screening levels suggesting that the PFAS-impacted groundwater originating from the former fire-testing area discharging into the unnamed tributary draining the site is not resulting in significant human health impacts in the unnamed tributary or in the bay of the LMR.

Based on the detections of PFAS in surface water and sediment samples collected along the unnamed tributary, wetland and in the bay of the LMR where the unnamed tributary discharges, the findings of the TIR survey, and the modeled extent of the on-site groundwater plume, PFAS impacted groundwater originating from AFFF releases at the BHRA appears to be discharging to the unnamed tributary. Based on the findings of the risk assessment, no additional evaluation of PFAS in surface water or sediment is warranted at this time.

7.1.5 Fate and Transport of PFAS

Both PFOS and PFOA (and presumably other PFAS) are stable in environmental media because they are resistant to environmental degradation processes, such as biodegradation, photolysis, and hydrolysis. In natural waters, no degradation has been demonstrated, and dissipation is by advection, dispersion, and sorption to particulate matter. Weight of evidence suggests that PFOS and PFOA can bioaccumulate.

- Fate and transport of PFAS at the former BHRA is associated with surface water and groundwater since PFAS are highly soluble in water. Releases of PFAS containing AFFF to the FBP and the associated evaporation pond impacted the soil and PFAS are desorbing and migrating with precipitation recharge vertically through the unsaturated zone to the groundwater table.

- PFAS surface releases during historical fire testing operations also resulted in impacts to soil and surface water resulting in the transport of impacted soil particles (sediment) and dissolved PFAS being conveyed over land suspended in runoff that occurs during precipitation events or to a lesser extent through the wind erosion of contaminated soils. Contaminants adsorbed to surface particles may also become solubilized in rainwater or snowmelt and be conveyed over land dissolved in the precipitation runoff.

- Concentrations of PFOS and PFOA were higher in co-located sediment and surface water collected from sample locations downstream in the unnamed tributary (SWSD-18-02 and SWSD-18-03) rather than in samples collected closer to the former BHRA, which suggests PFOS and PFOA impacted groundwater originating from the site and infiltrating through the various seeps may be the dominant pathway for PFAS transport to sediment, rather than surface water transport.

7.1.6 Risk Assessments

The HHRA concluded that, based on currently available risk screening criteria, concentrations of PFOS, PFOA, and PFBS present in site-related soil, surface water, and sediment do not pose an unacceptable risk to current and anticipated future human receptors. Therefore, at this time, no further evaluation is warranted for human receptors potentially exposed to PFAS associated with the operations of the former BHRA. It should be noted, however, if additional risk screening evaluation criteria are released in the future, the current data will be reevaluated.

The HHRA concluded that groundwater, if there were a complete drinking water pathway, would present a potential risk to human health. However, at this time this is an incomplete exposure pathway, and thus there are no associated risks. Groundwater underlying the park is not used for drinking water. Further, the drinking water of the surrounding community is primarily supplied by the Anne Arundel County Public Water system. There are a small number of private drinking water wells in the surrounding area. However, they are screened at depths at which impacts from surficial contamination is extremely unlikely.

The ERA concluded that, based on currently available risk screening criteria, concentrations of PFOS, PFOA, and PFBS present in site-related soil, surface water, and sediment do not pose an unacceptable risk to ecological receptors. Therefore, no further evaluation is warranted for ecological receptors at this time. As with the HHRA, if additional risk screening evaluation criteria are released in the future, the current data will be reevaluated.

7.2 RECOMMENDATIONS

The only potentially unacceptable risk identified was for a hypothetical future resident, consuming groundwater as daily drinking water. Future actions are warranted to supplement the data generated and analyzed in this investigation, in particular for groundwater that was determined to be impacted due to historic releases in the former Burn Pad Area at the Site.

Additional investigation activities will refine the CSM, including defining the nature and extent of PFAS groundwater impacts. These activities should include the completion of additional sampling of on- and off-site groundwater through temporary or permanent (monitoring wells) sampling points. Following completion of the additional activities, in accordance with the CERCLA process, the CSM and risk assessment will be updated as part of a RI Addendum.

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Figures

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CHECKED BY A. Gupta	DATE January 2016
SCALE 1" = 49,500'	SHEET 1 of 1
Fig_10-1_Site_Location_Map.mxd	

Figure 1-1
Site Location
Former Bay Head Road Annex Facility
Annapolis, MD

Source: Bing Maps, 2015; USGS NHD, 2015; ESRI, 2015

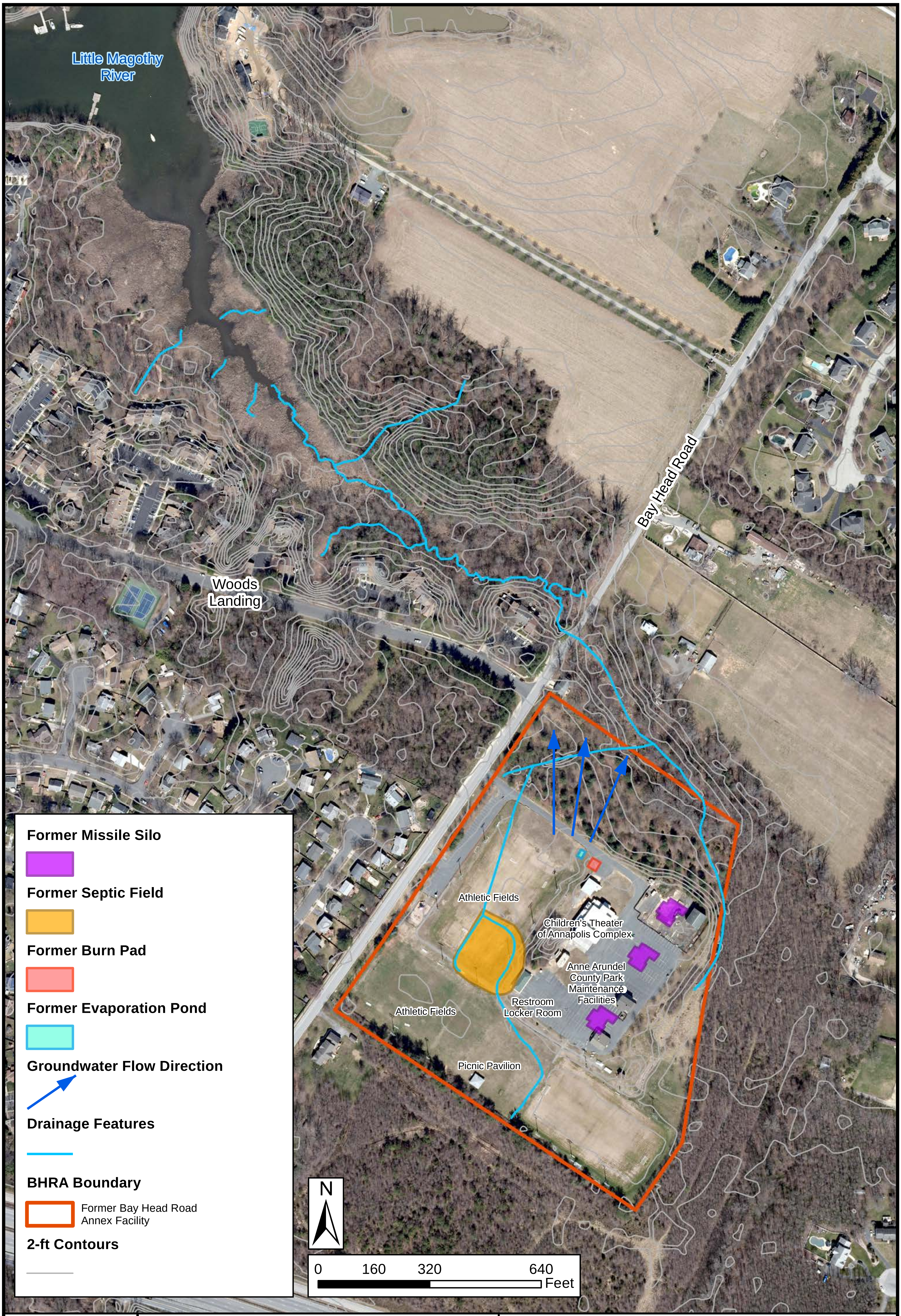

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Figure 1-2
Site Layout and RI Study Area
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

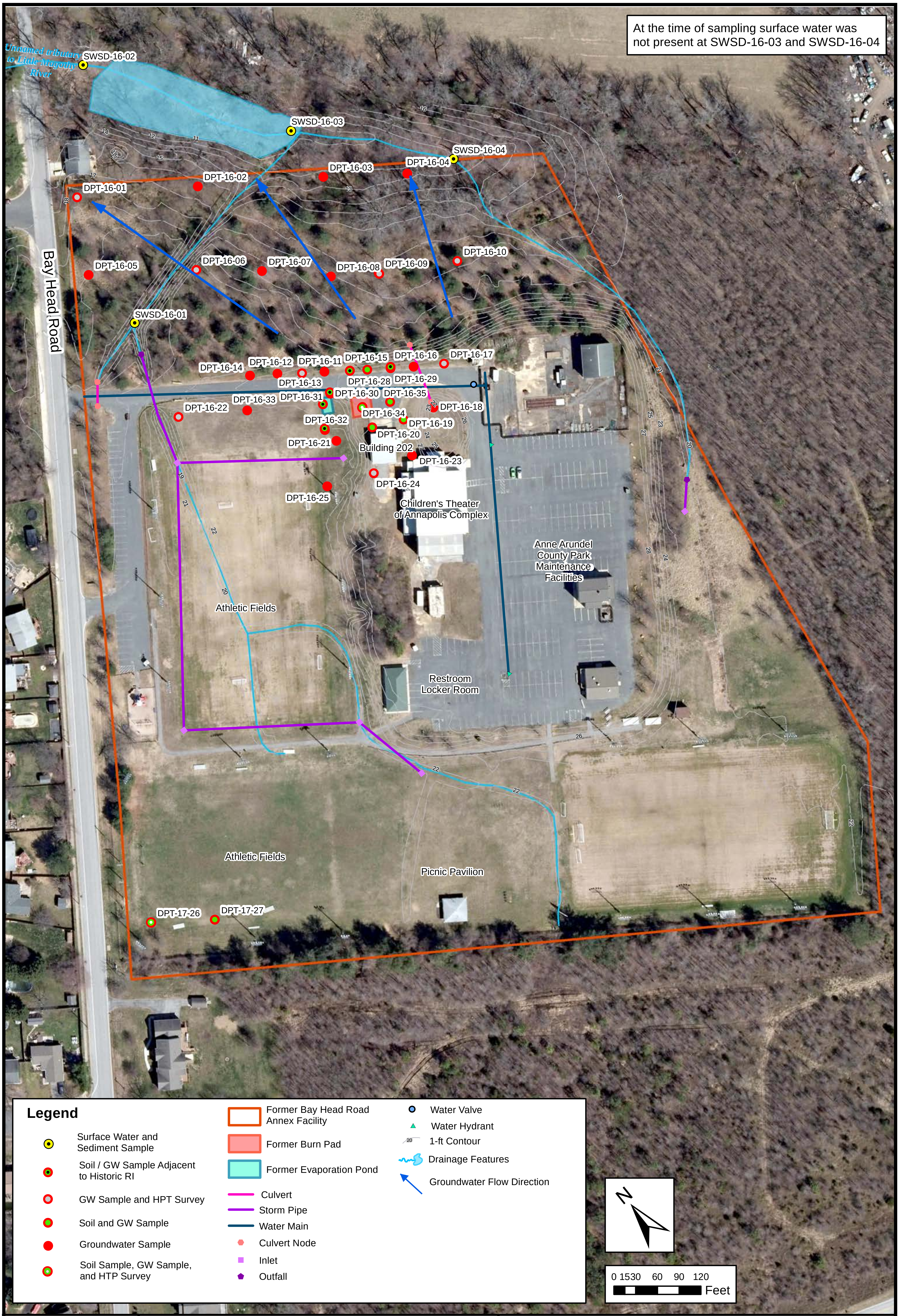

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Fig_10-3 _Historic_and_Proposed_Sample_Locations.mxd

Figure 2-1
Soil, Groundwater and On/Near Site
(East of Bay Head Road) Sediment and Surface
Water Sampling Locations
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

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S. Tjan

DATE
February, 2020

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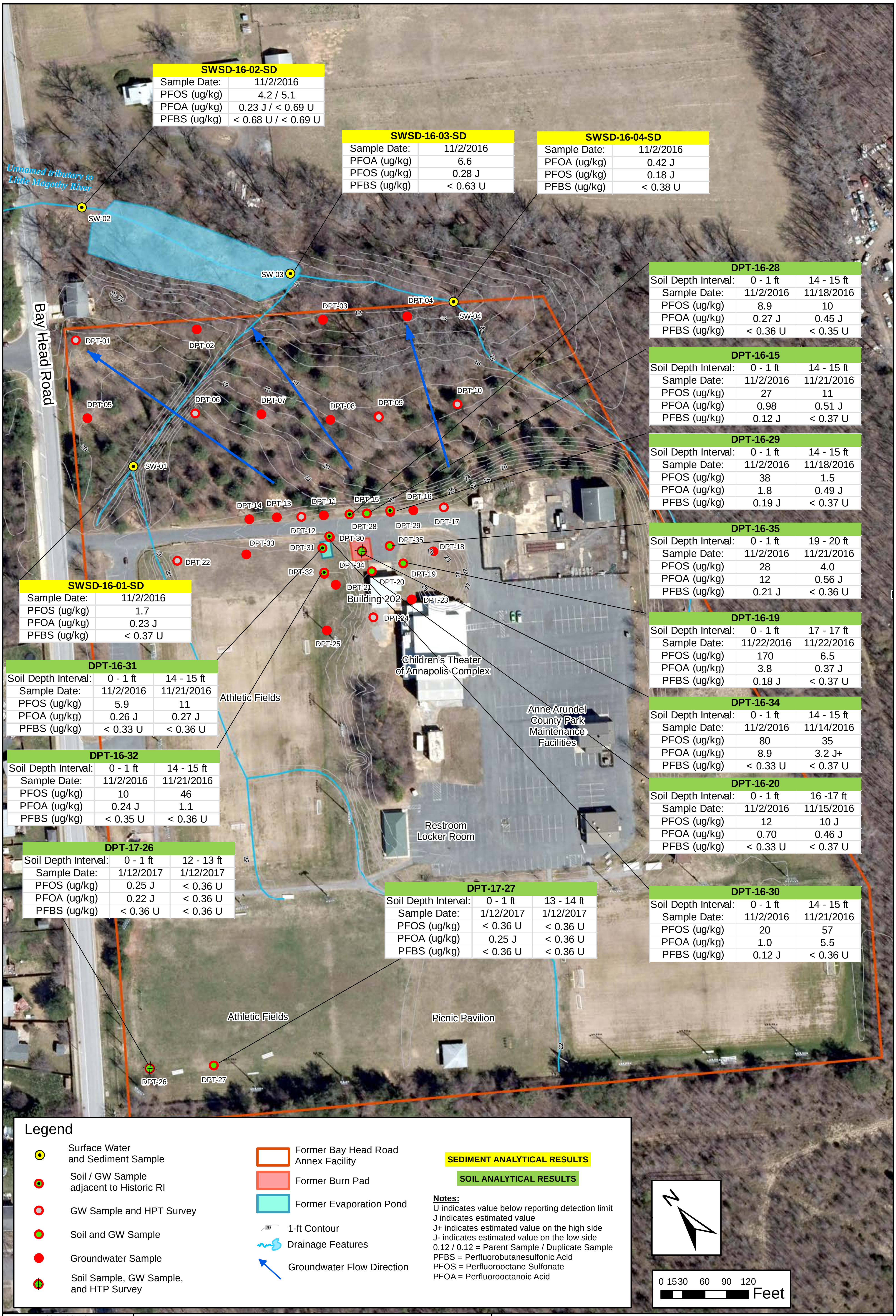
Figure 2-2
Off-Site (West of Bay Head Road) Sediment and
Surface Water Sampling Locations
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005



SWSD-16-02-SD	
Sample Date:	11/2/2016
PFOS (ug/kg)	4.2 / 5.1
PFOA (ug/kg)	0.23 J / < 0.69 U
PFBS (ug/kg)	< 0.68 U / < 0.69 U

SWSD-16-03-SD	
Sample Date:	11/2/2016
PFOA (ug/kg)	6.6
PFOS (ug/kg)	0.28 J
PFBS (ug/kg)	< 0.63 U

SWSD-16-04-SD	
Sample Date:	11/2/2016
PFOA (ug/kg)	0.42 J
PFOS (ug/kg)	0.18 J
PFBS (ug/kg)	< 0.38 U

SWSD-16-01-SD	
Sample Date:	11/2/2016
PFOS (ug/kg)	1.7
PFOA (ug/kg)	0.23 J
PFBS (ug/kg)	< 0.37 U

DPT-16-28		
Soil Depth Interval:	0 - 1 ft	14 - 15 ft
Sample Date:	11/2/2016	11/18/2016
PFOS (ug/kg)	8.9	10
PFOA (ug/kg)	0.27 J	0.45 J
PFBS (ug/kg)	< 0.36 U	< 0.35 U

DPT-16-15		
Soil Depth Interval:	0 - 1 ft	14 - 15 ft
Sample Date:	11/2/2016	11/21/2016
PFOS (ug/kg)	27	11
PFOA (ug/kg)	0.98	0.51 J
PFBS (ug/kg)	0.12 J	< 0.37 U

DPT-16-29		
Soil Depth Interval:	0 - 1 ft	14 - 15 ft
Sample Date:	11/2/2016	11/18/2016
PFOS (ug/kg)	38	1.5
PFOA (ug/kg)	1.8	0.49 J
PFBS (ug/kg)	0.19 J	< 0.37 U

DPT-16-35		
Soil Depth Interval:	0 - 1 ft	19 - 20 ft
Sample Date:	11/2/2016	11/21/2016
PFOS (ug/kg)	28	4.0
PFOA (ug/kg)	12	0.56 J
PFBS (ug/kg)	0.21 J	< 0.36 U

DPT-16-19		
Soil Depth Interval:	0 - 1 ft	17 - 17 ft
Sample Date:	11/22/2016	11/22/2016
PFOS (ug/kg)	170	6.5
PFOA (ug/kg)	3.8	0.37 J
PFBS (ug/kg)	0.18 J	< 0.37 U

DPT-16-34		
Soil Depth Interval:	0 - 1 ft	14 - 15 ft
Sample Date:	11/2/2016	11/14/2016
PFOS (ug/kg)	80	35
PFOA (ug/kg)	8.9	3.2 J+
PFBS (ug/kg)	< 0.33 U	< 0.37 U

DPT-16-20		
Soil Depth Interval:	0 - 1 ft	16 -17 ft
Sample Date:	11/2/2016	11/15/2016
PFOS (ug/kg)	12	10 J
PFOA (ug/kg)	0.70	0.46 J
PFBS (ug/kg)	< 0.33 U	< 0.37 U

DPT-16-30		
Soil Depth Interval:	0 - 1 ft	14 - 15 ft
Sample Date:	11/2/2016	11/21/2016
PFOS (ug/kg)	20	57
PFOA (ug/kg)	1.0	5.5
PFBS (ug/kg)	0.12 J	< 0.36 U

DPT-16-31		
Soil Depth Interval:	0 - 1 ft	14 - 15 ft
Sample Date:	11/2/2016	11/21/2016
PFOS (ug/kg)	5.9	11
PFOA (ug/kg)	0.26 J	0.27 J
PFBS (ug/kg)	< 0.33 U	< 0.36 U

DPT-16-32		
Soil Depth Interval:	0 - 1 ft	14 - 15 ft
Sample Date:	11/2/2016	11/21/2016
PFOS (ug/kg)	10	46
PFOA (ug/kg)	0.24 J	1.1
PFBS (ug/kg)	< 0.35 U	< 0.36 U

DPT-17-26		
Soil Depth Interval:	0 - 1 ft	12 - 13 ft
Sample Date:	1/12/2017	1/12/2017
PFOS (ug/kg)	0.25 J	< 0.36 U
PFOA (ug/kg)	0.22 J	< 0.36 U
PFBS (ug/kg)	< 0.36 U	< 0.36 U

DPT-17-27		
Soil Depth Interval:	0 - 1 ft	13 - 14 ft
Sample Date:	1/12/2017	1/12/2017
PFOS (ug/kg)	< 0.36 U	< 0.36 U
PFOA (ug/kg)	0.25 J	< 0.36 U
PFBS (ug/kg)	< 0.36 U	< 0.36 U

Legend

●	Surface Water and Sediment Sample
●	Soil / GW Sample adjacent to Historic RI
○	GW Sample and HPT Survey
●	Soil and GW Sample
●	Groundwater Sample
⊕	Soil Sample, GW Sample, and HTP Survey
▭	Former Bay Head Road Annex Facility
🟥	Former Burn Pad
🟦	Former Evaporation Pond
20	1-ft Contour
~	Drainage Features
↖	Groundwater Flow Direction

SEDIMENT ANALYTICAL RESULTS

SOIL ANALYTICAL RESULTS

Notes:
U indicates value below reporting detection limit
J indicates estimated value
J+ indicates estimated value on the high side
J- indicates estimated value on the low side
0.12 / 0.12 = Parent Sample / Duplicate Sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

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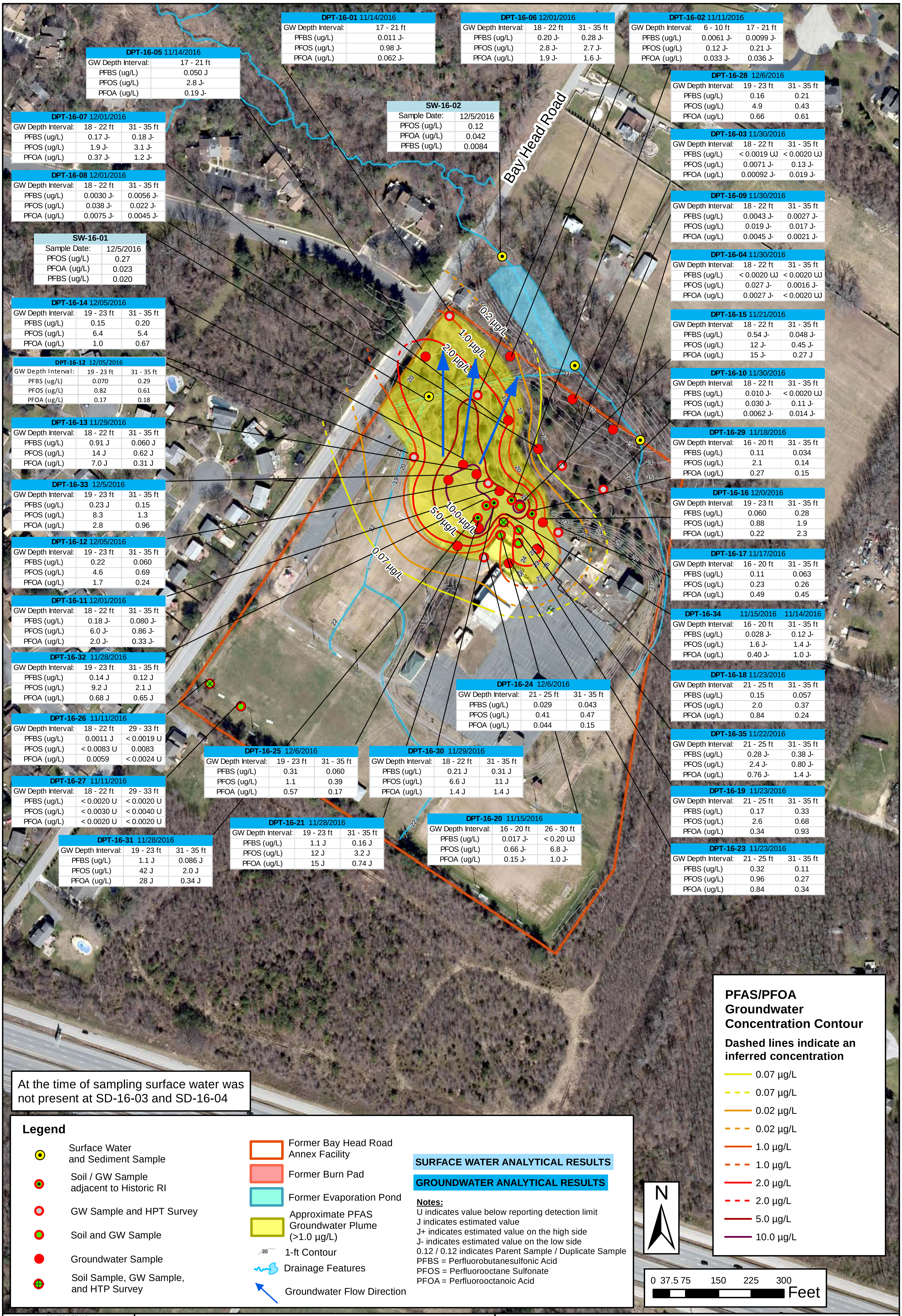
Figure 4-1
On/Near Site (East of Bay Head Road)
Soil and Sediment Analytical Results
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005



DPT-16-05 11/14/2016	
GW Depth Interval:	17 - 21 ft
PFBS (ug/L)	0.050 J
PFOS (ug/L)	2.8 J-
PFOA (ug/L)	0.19 J-

DPT-16-01 11/14/2016	
GW Depth Interval:	17 - 21 ft
PFBS (ug/L)	0.011 J-
PFOS (ug/L)	0.98 J-
PFOA (ug/L)	0.062 J-

DPT-16-06 12/01/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	0.20 J-	0.28 J-
PFOS (ug/L)	2.8 J-	2.7 J-
PFOA (ug/L)	1.9 J-	1.6 J-

DPT-16-02 11/11/2016		
GW Depth Interval:	6 - 10 ft	17 - 21 ft
PFBS (ug/L)	0.0061 J-	0.0099 J-
PFOS (ug/L)	0.12 J-	0.21 J-
PFOA (ug/L)	0.033 J-	0.036 J-

DPT-16-07 12/01/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	0.17 J-	0.18 J-
PFOS (ug/L)	1.9 J-	3.1 J-
PFOA (ug/L)	0.37 J-	1.2 J-

SW-16-02	
Sample Date:	12/5/2016
PFOS (ug/L)	0.12
PFOA (ug/L)	0.042
PFBS (ug/L)	0.0084

DPT-16-28 12/6/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	0.16	0.21
PFOS (ug/L)	4.9	0.43
PFOA (ug/L)	0.66	0.61

DPT-16-03 11/30/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	< 0.0019 UJ	< 0.0020 UJ
PFOS (ug/L)	0.0071 J-	0.13 J-
PFOA (ug/L)	0.00092 J-	0.019 J-

DPT-16-08 12/01/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	0.0030 J-	0.0056 J-
PFOS (ug/L)	0.038 J-	0.022 J-
PFOA (ug/L)	0.0075 J-	0.0045 J-

DPT-16-09 11/30/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	0.0043 J-	0.0027 J-
PFOS (ug/L)	0.019 J-	0.017 J-
PFOA (ug/L)	0.0045 J-	0.0021 J-

SW-16-01	
Sample Date:	12/5/2016
PFOS (ug/L)	0.27
PFOA (ug/L)	0.023
PFBS (ug/L)	0.020

DPT-16-04 11/30/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	< 0.0020 UJ	< 0.0020 UJ
PFOS (ug/L)	0.027 J-	0.0016 J-
PFOA (ug/L)	0.0027 J-	< 0.0020 UJ

DPT-16-14 12/05/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	0.15	0.20
PFOS (ug/L)	6.4	5.4
PFOA (ug/L)	1.0	0.67

DPT-16-15 11/21/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	0.54 J-	0.048 J-
PFOS (ug/L)	12 J-	0.45 J-
PFOA (ug/L)	15 J-	0.27 J

DPT-16-12 12/05/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	0.070	0.29
PFOS (ug/L)	0.82	0.61
PFOA (ug/L)	0.17	0.18

DPT-16-10 11/30/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	0.010 J-	< 0.0020 UJ
PFOS (ug/L)	0.030 J-	0.11 J-
PFOA (ug/L)	0.0062 J-	0.014 J-

DPT-16-13 11/29/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	0.91 J	0.060 J
PFOS (ug/L)	14 J	0.62 J
PFOA (ug/L)	7.0 J	0.31 J

DPT-16-29 11/18/2016		
GW Depth Interval:	16 - 20 ft	31 - 35 ft
PFBS (ug/L)	0.11	0.034
PFOS (ug/L)	2.1	0.14
PFOA (ug/L)	0.27	0.15

DPT-16-33 12/5/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	0.23 J	0.15
PFOS (ug/L)	8.3	1.3
PFOA (ug/L)	2.8	0.96

DPT-16-16 12/0/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	0.060	0.28
PFOS (ug/L)	0.88	1.9
PFOA (ug/L)	0.22	2.3

DPT-16-12 12/05/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	0.22	0.060
PFOS (ug/L)	4.6	0.69
PFOA (ug/L)	1.7	0.24

DPT-16-17 11/17/2016		
GW Depth Interval:	16 - 20 ft	31 - 35 ft
PFBS (ug/L)	0.11	0.063
PFOS (ug/L)	0.23	0.26
PFOA (ug/L)	0.49	0.45

DPT-16-11 12/01/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	0.18 J-	0.080 J-
PFOS (ug/L)	6.0 J-	0.86 J-
PFOA (ug/L)	2.0 J-	0.33 J-

DPT-16-34	11/15/2016	11/14/2016
GW Depth Interval:	16 - 20 ft	31 - 35 ft
PFBS (ug/L)	0.028 J-	0.12 J-
PFOS (ug/L)	1.6 J-	1.4 J-
PFOA (ug/L)	0.40 J-	1.0 J-

DPT-16-32 11/28/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	0.14 J	0.12 J
PFOS (ug/L)	9.2 J	2.1 J
PFOA (ug/L)	0.68 J	0.65 J

DPT-16-18 11/23/2016		
GW Depth Interval:	21 - 25 ft	31 - 35 ft
PFBS (ug/L)	0.15	0.057
PFOS (ug/L)	2.0	0.37
PFOA (ug/L)	0.84	0.24

DPT-16-24 12/6/2016		
GW Depth Interval:	21 - 25 ft	31 - 35 ft
PFBS (ug/L)	0.029	0.043
PFOS (ug/L)	0.41	0.47
PFOA (ug/L)	0.044	0.15

DPT-16-26 11/11/2016		
GW Depth Interval:	18 - 22 ft	29 - 33 ft
PFBS (ug/L)	0.0011 J	< 0.0019 U
PFOS (ug/L)	< 0.0083 U	0.0083
PFOA (ug/L)	0.0059	< 0.0024 U

DPT-16-35 11/22/2016		
GW Depth Interval:	21 - 25 ft	31 - 35 ft
PFBS (ug/L)	0.28 J-	0.38 J-
PFOS (ug/L)	2.4 J-	0.80 J-
PFOA (ug/L)	0.76 J-	1.4 J-

DPT-16-25 12/6/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	0.31	0.060
PFOS (ug/L)	1.1	0.39
PFOA (ug/L)	0.57	0.17

DPT-16-30 11/29/2016		
GW Depth Interval:	18 - 22 ft	31 - 35 ft
PFBS (ug/L)	0.21 J	0.31 J
PFOS (ug/L)	6.6 J	11 J
PFOA (ug/L)	1.4 J	1.4 J

DPT-16-27 11/11/2016		
GW Depth Interval:	18 - 22 ft	29 - 33 ft
PFBS (ug/L)	< 0.0020 U	< 0.0020 U
PFOS (ug/L)	< 0.0030 U	< 0.0040 U
PFOA (ug/L)	< 0.0020 U	< 0.0020 U

DPT-16-19 11/23/2016		
GW Depth Interval:	21 - 25 ft	31 - 35 ft
PFBS (ug/L)	0.17	0.33
PFOS (ug/L)	2.6	0.68
PFOA (ug/L)	0.34	0.93

DPT-16-21 11/28/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	1.1 J	0.16 J
PFOS (ug/L)	12 J	3.2 J
PFOA (ug/L)	15 J	0.74 J

DPT-16-20 11/15/2016		
GW Depth Interval:	16 - 20 ft	26 - 30 ft
PFBS (ug/L)	0.017 J-	< 0.20 UJ
PFOS (ug/L)	0.66 J-	6.8 J-
PFOA (ug/L)	0.15 J-	1.0 J-

DPT-16-31 11/28/2016		
GW Depth Interval:	19 - 23 ft	31 - 35 ft
PFBS (ug/L)	1.1 J	0.086 J
PFOS (ug/L)	42 J	2.0 J
PFOA (ug/L)	28 J	0.34 J

DPT-16-23 11/23/2016		
GW Depth Interval:	21 - 25 ft	31 - 35 ft
PFBS (ug/L)	0.32	0.11
PFOS (ug/L)	0.96	0.27
PFOA (ug/L)	0.84	0.34

PFAS/PFOA Groundwater Concentration Contour

Dashed lines indicate an inferred concentration

- — 0.07 µg/L
- - - 0.07 µg/L
- — 0.02 µg/L
- - - 0.02 µg/L
- — 1.0 µg/L
- - - 1.0 µg/L
- — 2.0 µg/L
- - - 2.0 µg/L
- — 5.0 µg/L
- — 10.0 µg/L

At the time of sampling surface water was not present at SD-16-03 and SD-16-04

Legend

- ⊙ Surface Water and Sediment Sample
- ◉ Soil / GW Sample adjacent to Historic RI
- ○ GW Sample and HPT Survey
- ◉ Soil and GW Sample
- ● Groundwater Sample
- ⊕ Soil Sample, GW Sample, and HTP Survey
- ▭ Former Bay Head Road Annex Facility
- 🟥 Former Burn Pad
- ▭ Former Evaporation Pond
- 🟨 Approximate PFAS Groundwater Plume (>1.0 µg/L)
- 1-ft Contour
- Drainage Features
- ↖ Groundwater Flow Direction

SURFACE WATER ANALYTICAL RESULTS

GROUNDWATER ANALYTICAL RESULTS

Notes:
U indicates value below reporting detection limit
J indicates estimated value
J+ indicates estimated value on the high side
J- indicates estimated value on the low side
0.12 / 0.12 indicates Parent Sample / Duplicate Sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

N

0 37.5 75 150 225 300 Feet

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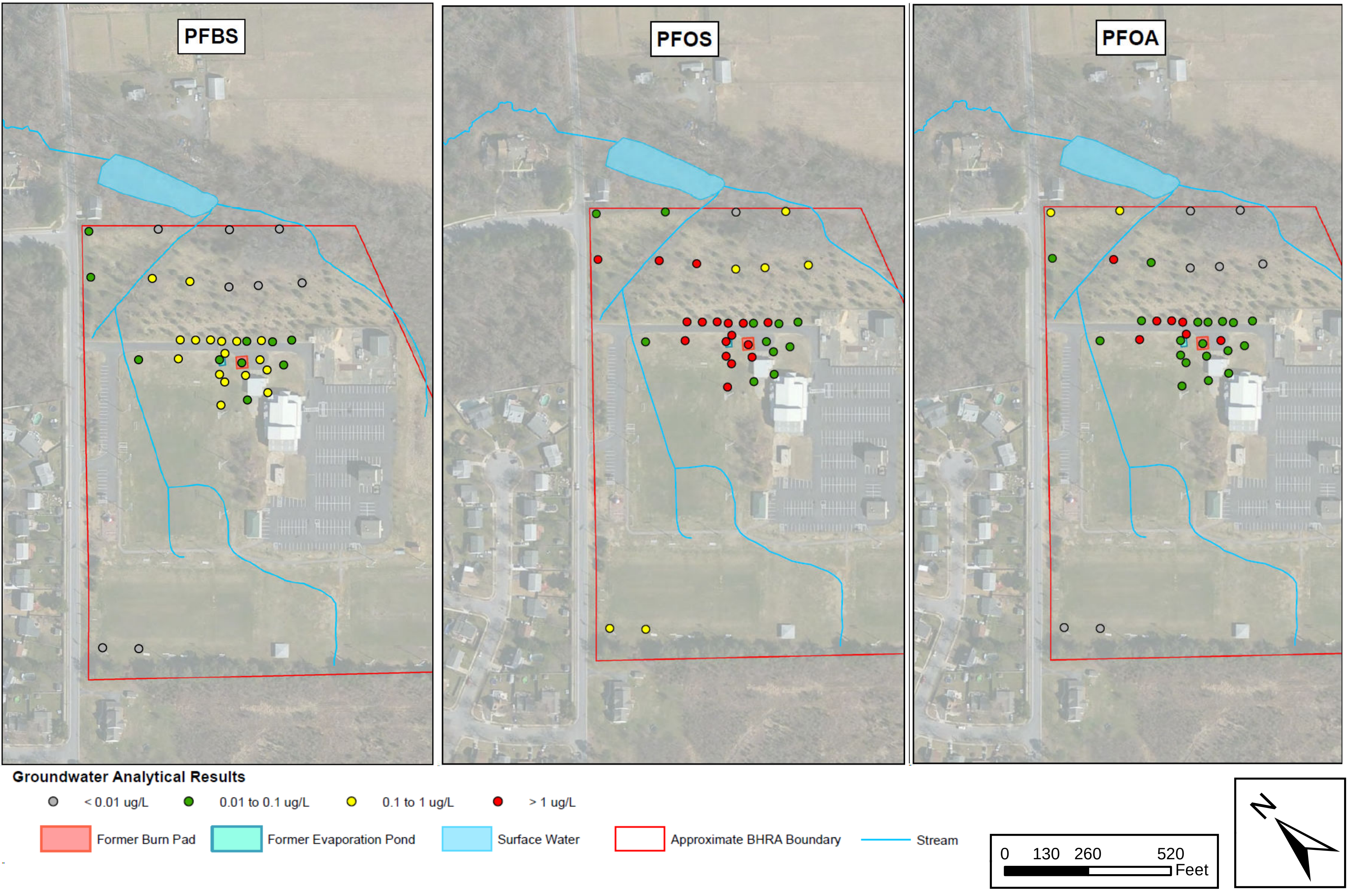
20170206_Fig_2_Groundwater	

Figure 4-2
Groundwater and Surface Water Sampling Results
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005



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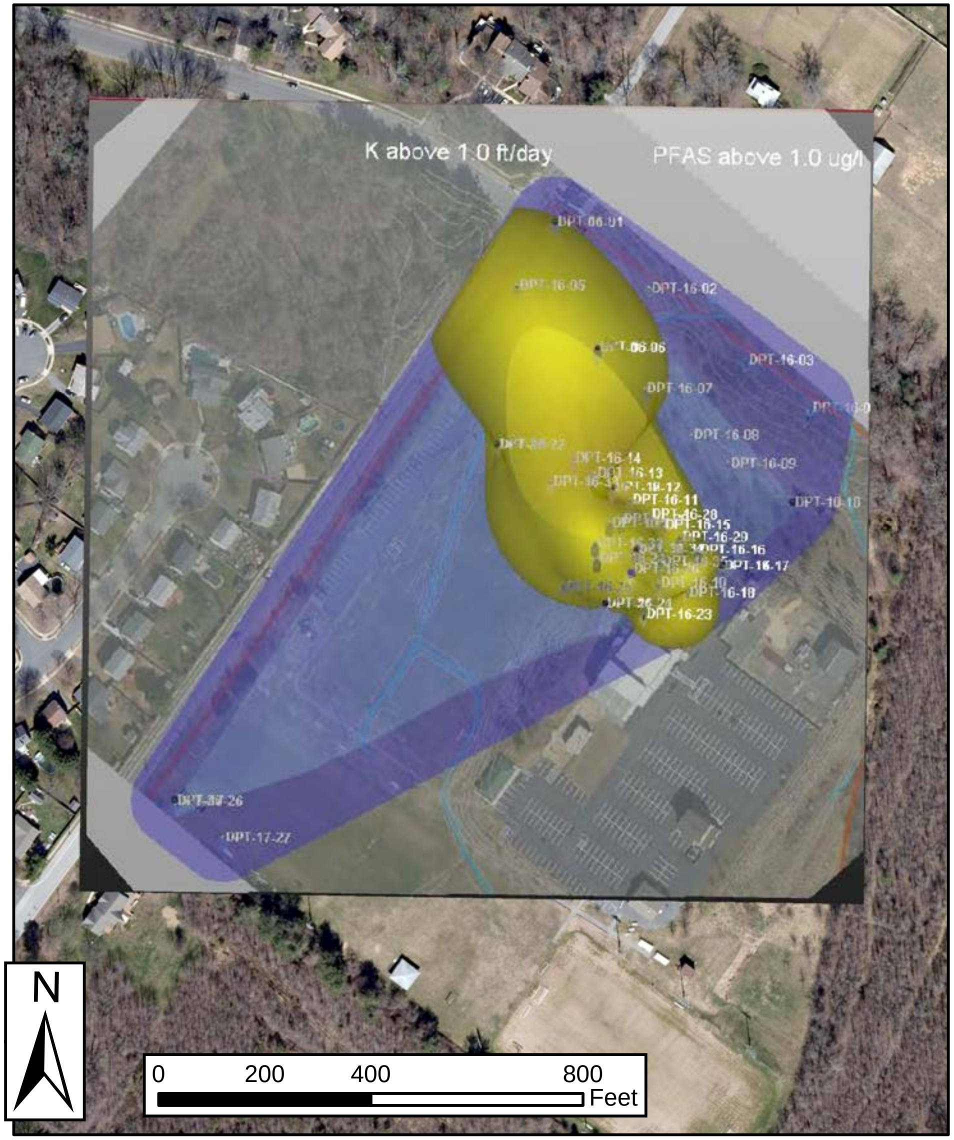
Document Name: Fig_4-3

Figure 4-3
Incremental PFAS Concentrations in Groundwater
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

Plan View



Cross-Sectional View Looking North

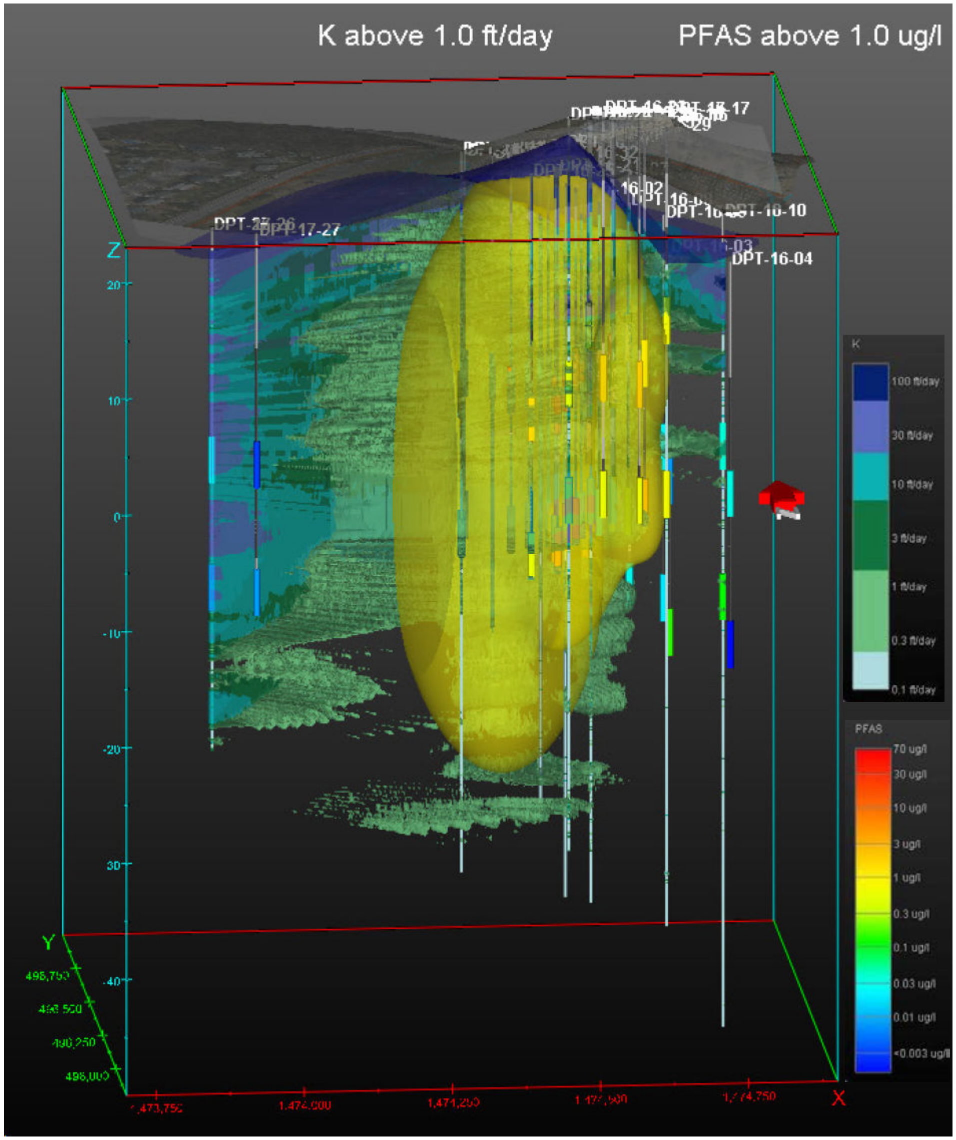


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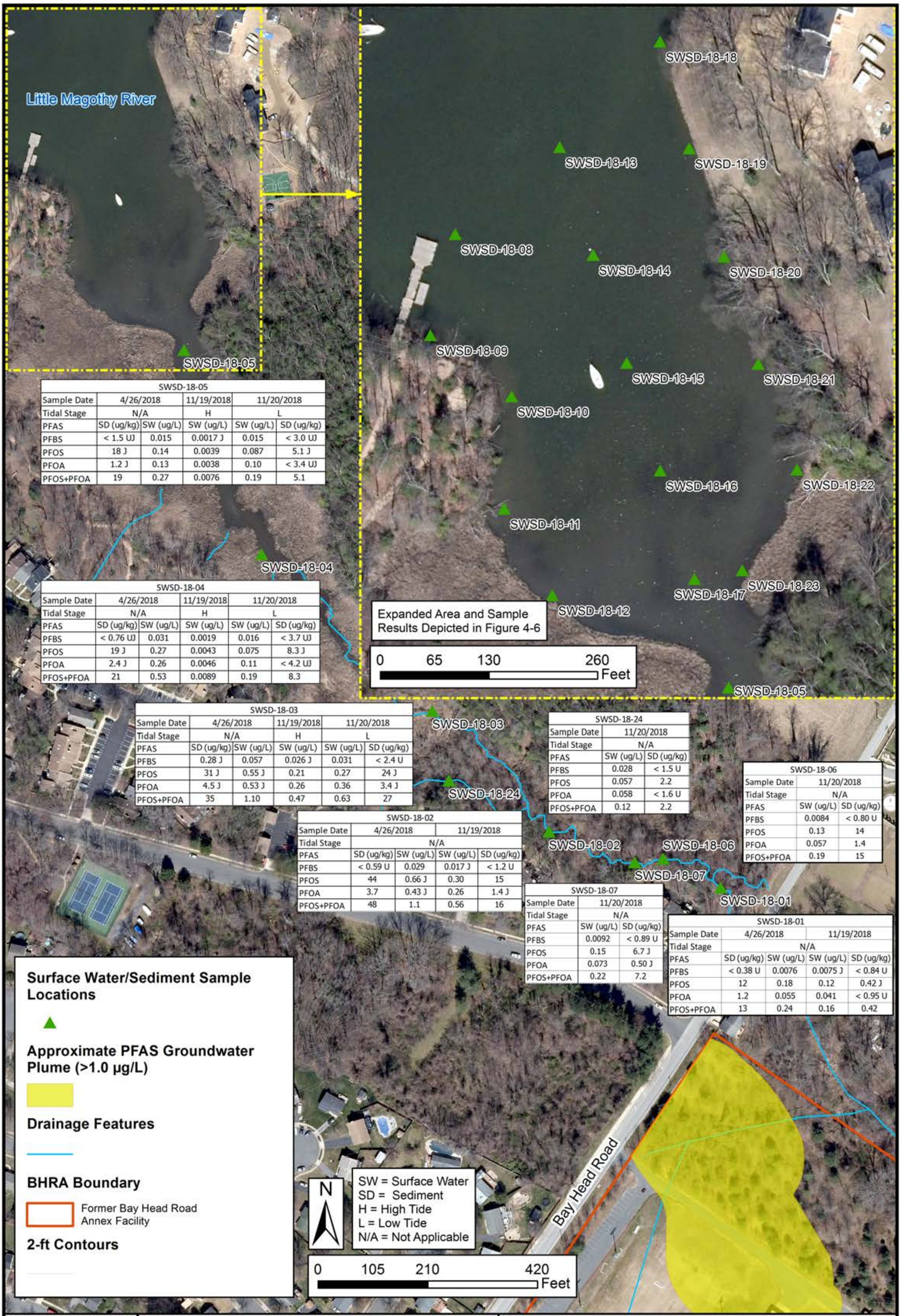
Figure 4-4
Plan and Cross-Sectional View of
EVS Model of the PFAS Plume
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005



SWSD-18-05					
Sample Date	4/26/2018		11/19/2018	11/20/2018	
Tidal Stage	N/A		H	L	
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)	SW (ug/L)	SD (ug/kg)
PFBS	< 1.5 UJ	0.015	0.0017 J	0.015	< 3.0 UJ
PFOS	18 J	0.14	0.0039	0.087	5.1 J
PFOA	1.2 J	0.13	0.0038	0.10	< 3.4 UJ
PFOS+PFOA	19	0.27	0.0076	0.19	5.1

SWSD-18-04					
Sample Date	4/26/2018		11/19/2018	11/20/2018	
Tidal Stage	N/A		H	L	
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)	SW (ug/L)	SD (ug/kg)
PFBS	< 0.76 UJ	0.031	0.0019	0.016	< 3.7 UJ
PFOS	19 J	0.27	0.0043	0.075	8.3 J
PFOA	2.4 J	0.26	0.0046	0.11	< 4.2 UJ
PFOS+PFOA	21	0.53	0.0089	0.19	8.3

SWSD-18-03					
Sample Date	4/26/2018		11/19/2018	11/20/2018	
Tidal Stage	N/A		H	L	
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)	SW (ug/L)	SD (ug/kg)
PFBS	0.28 J	0.057	0.026 J	0.031	< 2.4 U
PFOS	31 J	0.55 J	0.21	0.27	24 J
PFOA	4.5 J	0.53 J	0.26	0.36	3.4 J
PFOS+PFOA	35	1.10	0.47	0.63	27

SWSD-18-24		
Sample Date	11/20/2018	
Tidal Stage	N/A	
PFAS	SW (ug/L)	SD (ug/kg)
PFBS	0.028	< 1.5 U
PFOS	0.057	2.2
PFOA	0.058	< 1.6 U
PFOS+PFOA	0.12	2.2

SWSD-18-06		
Sample Date	11/20/2018	
Tidal Stage	N/A	
PFAS	SW (ug/L)	SD (ug/kg)
PFBS	0.0084	< 0.80 U
PFOS	0.13	14
PFOA	0.057	1.4
PFOS+PFOA	0.19	15

SWSD-18-02				
Sample Date	4/26/2018		11/19/2018	
Tidal Stage	N/A			
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)	SD (ug/kg)
PFBS	< 0.59 U	0.029	0.017 J	< 1.2 U
PFOS	44	0.66 J	0.30	15
PFOA	3.7	0.43 J	0.26	1.4 J
PFOS+PFOA	48	1.1	0.56	16

SWSD-18-07		
Sample Date	11/20/2018	
Tidal Stage	N/A	
PFAS	SW (ug/L)	SD (ug/kg)
PFBS	0.0092	< 0.89 U
PFOS	0.15	6.7 J
PFOA	0.073	0.50 J
PFOS+PFOA	0.22	7.2

SWSD-18-01				
Sample Date	4/26/2018		11/19/2018	
Tidal Stage	N/A			
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)	SD (ug/kg)
PFBS	< 0.38 U	0.0076	0.0075 J	< 0.84 U
PFOS	12	0.18	0.12	0.42 J
PFOA	1.2	0.055	0.041	< 0.95 U
PFOS+PFOA	13	0.24	0.16	0.42

Surface Water/Sediment Sample Locations

▲

Approximate PFAS Groundwater Plume (>1.0 µg/L)

🟨

Drainage Features

BHRA Boundary

▭ Former Bay Head Road Annex Facility

2-ft Contours

SW = Surface Water
SD = Sediment
H = High Tide
L = Low Tide
N/A = Not Applicable

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S. Tjan

DATE
February, 2020

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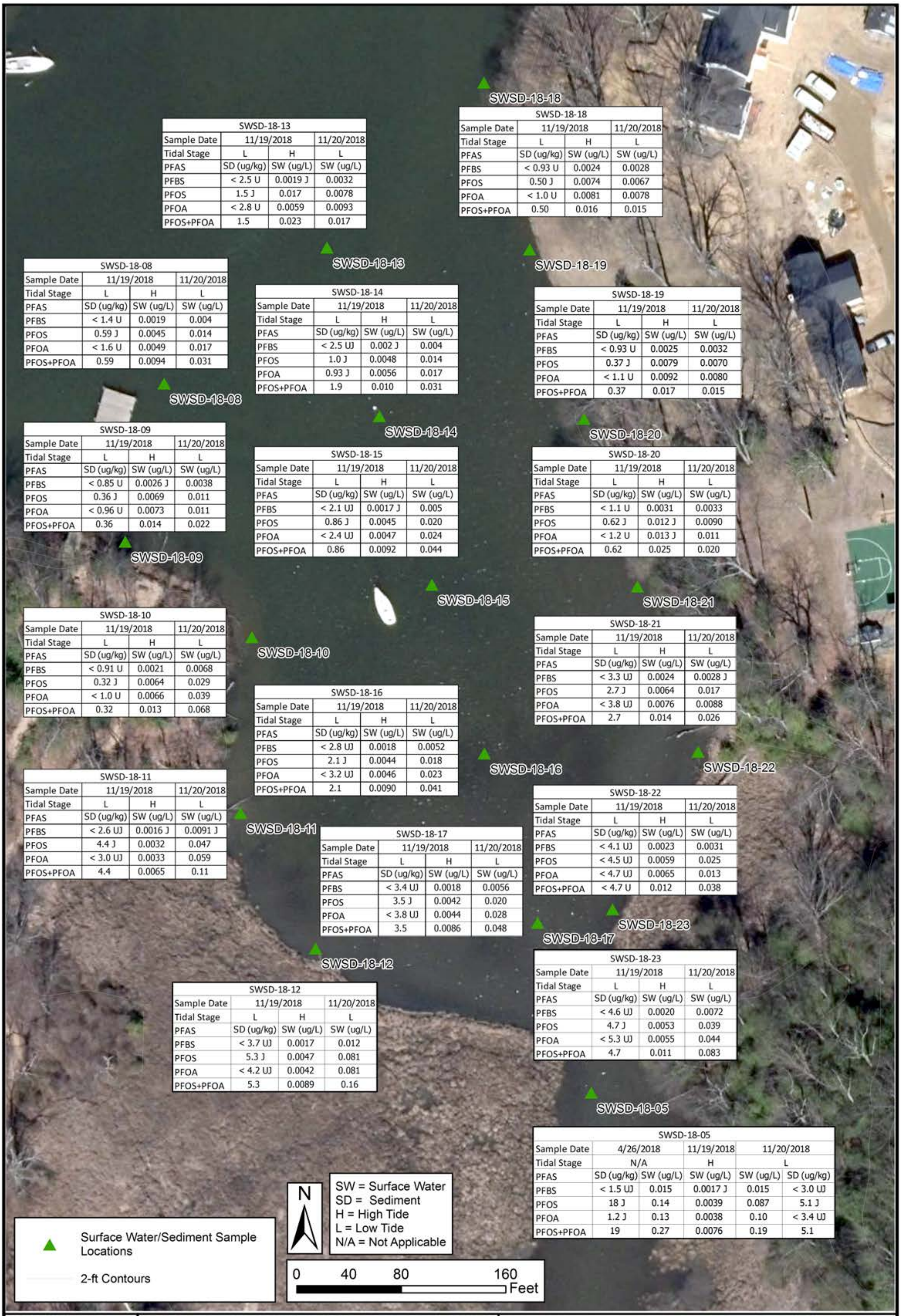
Figure 4-5
Off-Site (West of Bay Head Road)
Sediment and Surface Water Analytical Results
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005



SW = Surface Water
SD = Sediment
H = High Tide
L = Low Tide
N/A = Not Applicable

SWSD-18-18			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 0.93 U	0.0024	0.0028
PFOS	0.50 J	0.0074	0.0067
PFOA	< 1.0 U	0.0081	0.0078
PFOS+PFOA	0.50	0.016	0.015

SWSD-18-13			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 2.5 U	0.0019 J	0.0032
PFOS	1.5 J	0.017	0.0078
PFOA	< 2.8 U	0.0059	0.0093
PFOS+PFOA	1.5	0.023	0.017

SWSD-18-08			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 1.4 U	0.0019	0.004
PFOS	0.59 J	0.0045	0.014
PFOA	< 1.6 U	0.0049	0.017
PFOS+PFOA	0.59	0.0094	0.031

SWSD-18-14			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 2.5 UJ	0.002 J	0.004
PFOS	1.0 J	0.0048	0.014
PFOA	0.93 J	0.0056	0.017
PFOS+PFOA	1.9	0.010	0.031

SWSD-18-19			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 0.93 U	0.0025	0.0032
PFOS	0.37 J	0.0079	0.0070
PFOA	< 1.1 U	0.0092	0.0080
PFOS+PFOA	0.37	0.017	0.015

SWSD-18-09			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 0.85 U	0.0026 J	0.0038
PFOS	0.36 J	0.0069	0.011
PFOA	< 0.96 U	0.0073	0.011
PFOS+PFOA	0.36	0.014	0.022

SWSD-18-15			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 2.1 UJ	0.0017 J	0.005
PFOS	0.86 J	0.0045	0.020
PFOA	< 2.4 UJ	0.0047	0.024
PFOS+PFOA	0.86	0.0092	0.044

SWSD-18-20			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 1.1 U	0.0031	0.0033
PFOS	0.62 J	0.012 J	0.0090
PFOA	< 1.2 U	0.013 J	0.011
PFOS+PFOA	0.62	0.025	0.020

SWSD-18-10			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 0.91 U	0.0021	0.0068
PFOS	0.32 J	0.0064	0.029
PFOA	< 1.0 U	0.0066	0.039
PFOS+PFOA	0.32	0.013	0.068

SWSD-18-21			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 3.3 UJ	0.0024	0.0028 J
PFOS	2.7 J	0.0064	0.017
PFOA	< 3.8 UJ	0.0076	0.0088
PFOS+PFOA	2.7	0.014	0.026

SWSD-18-16			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 2.8 UJ	0.0018	0.0052
PFOS	2.1 J	0.0044	0.018
PFOA	< 3.2 UJ	0.0046	0.023
PFOS+PFOA	2.1	0.0090	0.041

SWSD-18-11			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 2.6 UJ	0.0016 J	0.0091 J
PFOS	4.4 J	0.0032	0.047
PFOA	< 3.0 UJ	0.0033	0.059
PFOS+PFOA	4.4	0.0065	0.11

SWSD-18-22			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 4.1 UJ	0.0023	0.0031
PFOS	< 4.5 UJ	0.0059	0.025
PFOA	< 4.7 UJ	0.0065	0.013
PFOS+PFOA	< 4.7 U	0.012	0.038

SWSD-18-17			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 3.4 UJ	0.0018	0.0056
PFOS	3.5 J	0.0042	0.020
PFOA	< 3.8 UJ	0.0044	0.028
PFOS+PFOA	3.5	0.0086	0.048

SWSD-18-23			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 4.6 UJ	0.0020	0.0072
PFOS	4.7 J	0.0053	0.039
PFOA	< 5.3 UJ	0.0055	0.044
PFOS+PFOA	4.7	0.011	0.083

SWSD-18-12			
Sample Date	11/19/2018		11/20/2018
Tidal Stage	L	H	L
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)
PFBS	< 3.7 UJ	0.0017	0.012
PFOS	5.3 J	0.0047	0.081
PFOA	< 4.2 UJ	0.0042	0.081
PFOS+PFOA	5.3	0.0089	0.16

SWSD-18-05					
Sample Date	4/26/2018		11/19/2018	11/20/2018	
Tidal Stage	N/A		H	L	
PFAS	SD (ug/kg)	SW (ug/L)	SW (ug/L)	SW (ug/L)	SD (ug/kg)
PFBS	< 1.5 UJ	0.015	0.0017 J	0.015	< 3.0 UJ
PFOS	18 J	0.14	0.0039	0.087	5.1 J
PFOA	1.2 J	0.13	0.0038	0.10	< 3.4 UJ
PFOS+PFOA	19	0.27	0.0076	0.19	5.1

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Document Name: Fig. 4-6	

Figure 4-6
Off-Site (West of Bay Head Road)
Sediment and Surface Water Analytical Results
(Expanded Area)
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

Tables

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Table 4-1. Regional Screening Levels Calculated for PFOS, PFOA , PFBS in Groundwater and Soil Using USEPA's RSL Calculator

Chemical	Carcinogenic Slope Factor-Oral (SF) (mg/kg-day)$^{-1}$	Non-Carcinogenic Reference Dose (RfD)(mg/kg-day)	Residential Scenario Screening Levels Calculated Using USEPA RSL Calculator								Industrial/Commercial Composite Worker Screening Levels Calculated Using USEPA RSL Calculator			
			Tap Water (ug/L or ppb)				Soil (mg/kg or ppm)				Soil (mg/kg or ppm)			
			HQ = 0.1	HQ = 1.0	ILCR = 1E-06	ILCR = 1E-04	HQ = 0.1	HQ = 1.0	ILCR = 1E-06	ILCR = 1E-04	HQ = 0.1	HQ = 1.0	ILCR = 1E-06	ILCR = 1E-04
PFOS	NA	2.00E-05	0.04	0.4	NA	NA	0.13	1.3	NA	NA	1.6	16	NA	NA
PFOA	7.00E-02	2.00E-05	0.04	0.4	1.1	111	0.13	1.3	7.8	775	1.6	16	33	3280
PFBS	NA	2.00E-05	40	400	NA	NA	130	1300	NA	NA	1600	16000	NA	NA

HQ = Hazard Quotient

ILCR = Incremental Lifetime Cancer Risk

NA = Not available/applicable

Notes:

- The table represents screening levels based on residential and industrial/commercial worker receptor scenarios for either direct ingestion or groundwater (residential scenario only) or incidental ingestion of contaminated soil (both residential and composite worker scenarios).
- All values were calculated using slope factors or reference doses for PFOS and PFOA published by USEPA Office of Water in support of the Lifetime Health Advisory (LHA), and default exposure assumptions for each potential receptor scenario, contained in USEPA's RSL Calculator on
- Peer reviewed toxicity values considered valid for risk assessment exist for PFBS, and the screening levels may be found in USEPA's RSL table or calculator used to develop them.
- Other potential receptor scenarios (e.g., recreational user, site trespasser, construction worker) are not included in the above table, but could be relevant receptors at a site potentially contaminated with PFOS, PFOA and /or PFBS. These receptors, and their associated exposure scenarios, should be further considered in the scoping phase and completion of the Baseline Human Health Risk Assessment typically completed during an
- The shaded values represent conservative screening levels for PFOSA and PFOA in groundwater or soil that when exceeded should be considered a chemical of potential concern in the risk assessment process and calculations of site-specific risk posed.

Table 4-2. Drinking Water Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex Facility
Annapolis, Maryland

Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
DW-16-01	11/16/2016	DW-16-01-111616	N	< 0.0060 U	< 0.0032 U	< 0.0032 U
DW-16-01	11/16/2016	DW-16-01-111616-DUP	FD	< 0.0060 U	< 0.0032 U	< 0.0032 U
DW-16-02	11/18/2016	DW-16-02-111816	N	< 0.0060 U	< 0.0032 U	< 0.0032 U

Notes: µg/L = micrograms per liter
FD = Field duplicate sample
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Table 4-3. Soil Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex Facility
Annapolis, Maryland

Location Description	Location ID	Collection Date	Interval (ft bgs)	Sample ID	Sample Type Code	PFBS (µg/kg)	PFOS (µg/kg)	PFOA (µg/kg)
On-Site	DPT-16-15	11/2/2016	0 - 1 ft	DPT-16-15-SO-00-01	N	0.14 J	27	0.98
On-Site	DPT-16-15	11/2/2016	0 - 1 ft	DPT-16-15-SO-00-01-DUP	FD	0.12 J	27	0.92
On-Site	DPT-16-15	11/21/2016	14 - 15 ft	DPT-16-15-SO-14-15	N	< 0.37 U	11	0.51 J
On-Site	DPT-16-19	11/22/2016	0 - 1 ft	DPT-16-19-SO-00-01	N	0.18 J	**170**	3.8
On-Site	DPT-16-19	11/22/2016	17 - 17 ft	DPT-16-19-SO-17-18	N	< 0.37 U	6.5	0.37 J
On-Site	DPT-16-20	11/2/2016	0 - 1 ft	DPT-16-20-SO-00-01	N	< 0.33 U	12	0.70
On-Site	DPT-16-20	11/15/2016	16 - 17 ft	DPT-16-20-SO-16-17	N	< 0.37 U	10 J	0.46 J
On-Site	DPT-16-20	11/15/2016	16 - 17 ft	DPT-16-20-SO-16-17-DUP	FD	< 0.36 U	20 J	0.78
On-Site	DPT-16-28	11/2/2016	0 - 1 ft	DPT-16-28-SO-00-01	N	< 0.36 U	8.9	0.27 J
On-Site	DPT-16-28	11/21/2016	14 - 15 ft	DPT-16-28-SO-14-15	N	< 0.35 U	10	0.45 J
On-Site	DPT-16-29	11/2/2016	0 - 1 ft	DPT-16-29-SO-00-01	N	0.19 J	38	1.8
On-Site	DPT-16-29	11/18/2016	14 - 15 ft	DPT-16-29-SO-14-15	N	< 0.37 U	1.5	0.49 J
On-Site	DPT-16-30	11/2/2016	0 - 1 ft	DPT-16-30-SO-00-01	N	0.12 J	20	1.0
On-Site	DPT-16-30	11/21/2016	14 - 15 ft	DPT-16-30-SO-14-15	N	< 0.36 U	57	5.5
On-Site	DPT-16-31	11/2/2016	0 - 1 ft	DPT-16-31-SO-00-01	N	< 0.33 U	5.9	0.26 J
On-Site	DPT-16-31	11/21/2016	14 - 15 ft	DPT-16-31-SO-14-15	N	< 0.36 U	11	0.27 J
On-Site	DPT-16-32	11/2/2016	0 - 1 ft	DPT-16-32-SO-00-01	N	< 0.35 U	10	0.24 J
On-Site	DPT-16-32	11/21/2016	14 - 15 ft	DPT-16-32-SO-14-15	N	< 0.36 U	46	1.1
On-Site	DPT-16-34	11/2/2016	0 - 1 ft	DPT-16-34-SO-00-01	N	< 0.33 U	80	8.9
On-Site	DPT-16-34	11/14/2016	14 - 15 ft	DPT-16-34-SO-14-15	N	< 0.37 U	35	3.2 J+
On-Site	DPT-16-35	11/22/2016	0 - 1 ft	DPT-16-35-SO-00-01	N	0.21 J	28	12
On-Site	DPT-16-35	11/22/2016	19 - 20 ft	DPT-16-35-SO-19-20	N	< 0.36 U	4.0	0.56 J
On-Site	DPT-17-26	1/12/2017	0 - 1 ft	DPT-17-26-SO-00-01	N	< 0.36 U	0.25 J	0.22 J
On-Site	DPT-17-26	1/12/2017	12 - 13 ft	DPT-17-26-SO-12-13	N	< 0.36 U	< 0.36 U	< 0.36 U
On-Site	DPT-17-27	1/12/2017	0 - 1 ft	DPT-17-27-SO-00-01	N	< 0.36 U	< 0.60 U	0.25 J
On-Site	DPT-17-27	1/12/2017	13 - 14 ft	DPT-17-27-SO-13-14	N	< 0.36 U	< 0.36 U	< 0.36 U

Notes: µg/kg = micrograms per kilogram
bgs = Below ground surface
FD = Field duplicate sample
ft = Feet
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Values in **BOLD**: Exceed the PFOS soil Regional Screening Level (RSL) for a Hazard Quotient (HQ) = 0.1 of 130 µg/kg

Table 4-4. Groundwater Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex Facility
Annapolis, Maryland

Location Description	Location ID	Collection Date	Depth to Groundwater (ft bgs)	Interval (ft bgs)	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
On-Site	DPT-16-01	11/14/2016	3.0	17 - 21 ft	DPT-16-01-GW-17-21	N	0.011 J-	**0.98 J-**	**0.062 J-**
On-Site	DPT-16-02	11/11/2016	2.5	6 - 10 ft	DPT-16-02-GW-06-10	N	0.0061 J-	**0.12 J-**	0.033 J-
On-Site	DPT-16-02	11/11/2016	2.5	6 - 10 ft	DPT-16-02-GW-06-10-DUP	FD	0.0059 J-	**0.12 J-**	0.028 J-
On-Site	DPT-16-02	11/11/2016	2.5	17 - 21 ft	DPT-16-02-GW-17-21	N	0.0099 J-	**0.21 J-**	0.036 J-
On-Site	DPT-16-03	11/30/2016	2.0	18 - 22 ft	DPT-16-03-GW-18-22	N	< 0.0019 UJ	0.0071 J-	0.00092 J-
On-Site	DPT-16-03	11/30/2016	2.0	31 - 35 ft	DPT-16-03-GW-31-35	N	< 0.0020 UJ	**0.13 J-**	0.019 J-
On-Site	DPT-16-04	11/30/2016	2.0	18 - 22 ft	DPT-16-04-GW-18-22	N	< 0.0020 UJ	0.027 J-	0.0027 J-
On-Site	DPT-16-04	11/30/2016	2.0	31 - 35 ft	DPT-16-04-GW-31-35	N	< 0.0020 UJ	0.0016 J-	< 0.0020 UJ
On-Site	DPT-16-05	11/14/2016	5.0	17 - 21 ft	DPT-16-05-GW-17-21	N	0.050 J	**2.8 J-**	**0.19 J-**
On-Site	DPT-16-06	12/1/2016	6.0	18 - 22 ft	DPT-16-06-GW-18-22	N	0.20 J-	**2.8 J-**	**1.9 J-**
On-Site	DPT-16-06	12/1/2016	6.0	31 - 35 ft	DPT-16-06-GW-31-35	N	0.28 J-	**2.7 J-**	**1.6 J-**
On-Site	DPT-16-07	12/1/2016	8.0	18 - 22 ft	DPT-16-07-GW-18-22	N	0.17 J-	**1.9 J-**	**0.37 J-**
On-Site	DPT-16-07	12/1/2016	8.0	31 - 35 ft	DPT-16-07-GW-31-35	N	0.18 J-	**3.1 J-**	**1.2 J-**
On-Site	DPT-16-08	12/1/2016	7.5	18 - 22 ft	DPT-16-08-GW-18-22	N	0.0030 J-	0.038 J-	0.0075 J-
On-Site	DPT-16-08	12/1/2016	7.5	31 - 35 ft	DPT-16-08-GW-31-35	N	0.0056 J-	0.022 J-	0.0045 J-
On-Site	DPT-16-09	11/30/2016	7.0	18 - 22 ft	DPT-16-09-GW-18-22	N	0.0043 J-	0.019 J-	0.0045 J-
On-Site	DPT-16-09	11/30/2016	7.0	31 - 35 ft	DPT-16-09-GW-31-35	N	0.0027 J-	0.017 J-	0.0021 J-
On-Site	DPT-16-10	11/30/2016	7.0	18 - 22 ft	DPT-16-10-GW-18-22	N	0.010 J-	0.030 J-	0.0062 J-
On-Site	DPT-16-10	11/30/2016	8.0	31 - 35 ft	DPT-16-10-GW-31-35	N	< 0.0020 UJ	**0.11 J-**	0.014 J-
On-Site	DPT-16-11	12/1/2016	10.0	18 - 22 ft	DPT-16-11-GW-18-22	N	0.18 J-	**6.0 J-**	**2.0 J-**
On-Site	DPT-16-11	12/1/2016	10.0	31 - 35 ft	DPT-16-11-GW-31-35	N	0.080 J-	**0.86 J-**	**0.33 J-**
On-Site	DPT-16-11	12/1/2016	10.0	31 - 35 ft	DPT-16-11-GW-31-35-DUP	FD	0.076 J-	**0.88 J-**	**0.33 J-**
On-Site	DPT-16-12	12/5/2016	10.0	19 - 23 ft	DPT-16-12-GW-19-23	N	0.22	**4.6**	**1.7**
On-Site	DPT-16-12	12/5/2016	10.0	31 - 35 ft	DPT-16-12-GW-31-35	N	0.060	**0.69**	**0.24**
On-Site	DPT-16-13	11/29/2016	9.0	18 - 22 ft	DPT-16-13-GW-18-22	N	0.91 J	**14 J**	**7.0 J**
On-Site	DPT-16-13	11/29/2016	9.0	31 - 35 ft	DPT-16-13-GW-31-35	N	0.060 J	**0.62 J**	**0.31 J**
On-Site	DPT-16-14	12/5/2016	9.0	19 - 23 ft	DPT-16-14-GW-19-23	N	0.15	**6.4**	**1.0**
On-Site	DPT-16-14	12/5/2016	9.0	31 - 35 ft	DPT-16-14-GW-31-35	N	0.20	**5.4**	**0.67**
On-Site	DPT-16-15	11/21/2016	11.0	18 - 22 ft	DPT-16-15-GW-18-22	N	0.54 J-	**12 J-**	**15 J-**
On-Site	DPT-16-15	11/21/2016	11.0	31 - 35 ft	DPT-16-15-GW-31-35	N	0.048 J-	**0.45 J-**	**0.27 J**
On-Site	DPT-16-16	12/5/2016	12.0	19 - 23 ft	DPT-16-16-GW-19-23	N	0.060	**0.88**	**0.22**

Table 4-4. Groundwater Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex Facility
Annapolis, Maryland

Location Description	Location ID	Collection Date	Depth to Groundwater (ft bgs)	Interval (ft bgs)	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
On-Site	DPT-16-16	12/5/2016	12.0	31 - 35 ft	DPT-16-16-GW-31-35	N	0.28	**1.9**	**2.3**
On-Site	DPT-16-17	11/17/2016	13.0	16 - 20 ft	DPT-16-17-GW-16-20	N	0.11	**0.23**	**0.49**
On-Site	DPT-16-17	11/17/2016	13.0	31 - 35 ft	DPT-16-17-GW-31-35	N	0.063	**0.26**	**0.45**
On-Site	DPT-16-18	11/23/2016	12.0	21 - 25 ft	DPT-16-18-GW-21-25	N	0.15	**2.0**	**0.84**
On-Site	DPT-16-18	11/23/2016	12.0	31 - 35 ft	DPT-16-18-GW-31-35	N	0.057	**0.37**	**0.24**
On-Site	DPT-16-18	11/23/2016	12.0	31 - 35 ft	DPT-16-18-GW-31-35-DUP	FD	0.060	**0.38**	**0.25**
On-Site	DPT-16-19	11/23/2016	12.0	21 - 25 ft	DPT-16-19-GW-21-25	N	0.17	**2.6**	**0.34**
On-Site	DPT-16-19	11/23/2016	12.0	31 - 35 ft	DPT-16-19-GW-31-35	N	0.33	**0.68**	**0.93**
On-Site	DPT-16-20	11/15/2016	12.0	16 - 20 ft	DPT-16-20-GW-16-20	N	0.017 J-	**0.66 J-**	**0.15 J-**
On-Site	DPT-16-20	11/15/2016	12.0	26 - 30 ft	DPT-16-20-GW-26-30	N	< 0.20 UJ	**6.8 J-**	**1.0 J-**
On-Site	DPT-16-21	11/28/2016	11.0	19 - 23 ft	DPT-16-21-GW-19-23	N	1.1 J	**12 J**	**15 J**
On-Site	DPT-16-21	11/28/2016	11.0	31 - 35 ft	DPT-16-21-GW-31-35	N	0.16 J	**3.2 J**	**0.74 J**
On-Site	DPT-16-22	12/5/2016	11.0	19 - 23 ft	DPT-16-22-GW-19-23	N	0.070	**0.82**	**0.17**
On-Site	DPT-16-22	12/5/2016	11.0	31 - 35 ft	DPT-16-22-GW-31-35	N	0.29	**0.61**	**0.18**
On-Site	DPT-16-22	12/5/2016	11.0	31 - 35 ft	DPT-16-22-GW-31-35-DUP	FD	0.27	**0.56**	**0.16**
On-Site	DPT-16-23	11/23/2016	11.5	21 - 25 ft	DPT-16-23-GW-21-25	N	0.32	**0.96**	**0.84**
On-Site	DPT-16-23	11/23/2016	11.5	31 - 35 ft	DPT-16-23-GW-31-35	N	0.11	**0.27**	**0.34**
On-Site	DPT-16-24	12/6/2016	11.5	21 - 25 ft	DPT-16-24-GW-21-25	N	0.029	**0.41**	**0.044**
On-Site	DPT-16-24	12/6/2016	11.5	31 - 35 ft	DPT-16-24-GW-31-35	N	0.043	**0.47**	**0.15**
On-Site	DPT-16-25	12/6/2016	11.5	19 - 23 ft	DPT-16-25-GW-19-23	N	0.31	**1.1**	**0.57**
On-Site	DPT-16-25	12/6/2016	11.5	31 - 35 ft	DPT-16-25-GW-31-35	N	0.060	**0.39**	**0.17**
On-Site	DPT-16-28	12/6/2016	11.0	19 - 23 ft	DPT-16-28-GW-19-23	N	0.16	**4.9**	**0.66**
On-Site	DPT-16-28	12/6/2016	11.0	31 - 35 ft	DPT-16-28-GW-31-35	N	0.21	**0.43**	**0.61**
On-Site	DPT-16-29	11/18/2016	11.0	16 - 20 ft	DPT-16-29-GW-16-20	N	0.11	**2.1**	**0.27**
On-Site	DPT-16-29	11/18/2016	11.0	31 - 35 ft	DPT-16-29-GW-31-35	N	0.034	**0.14**	**0.15**
On-Site	DPT-16-30	11/29/2016	11.0	18 - 22 ft	DPT-16-30-GW-18-22	N	0.21 J	**6.6 J**	**1.4 J**
On-Site	DPT-16-30	11/29/2016	11.0	31 - 35 ft	DPT-16-30-GW-31-35	N	0.31 J	**11 J**	**1.4 J**

Table 4-4. Groundwater Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex Facility
Annapolis, Maryland

Location Description	Location ID	Collection Date	Depth to Groundwater (ft bgs)	Interval (ft bgs)	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
On-Site	DPT-16-31	11/28/2016	11.0	19 - 23 ft	DPT-16-31-GW-19-23	N	1.1 J	**42 J**	**28 J**
On-Site	DPT-16-31	11/28/2016	11.0	31 - 35 ft	DPT-16-31-GW-31-35	N	0.086 J	**2.0 J**	**0.34 J**
On-Site	DPT-16-32	11/28/2016	11.0	19 - 23 ft	DPT-16-32-GW-19-23	N	0.14 J	**9.2 J**	**0.68 J**
On-Site	DPT-16-32	11/28/2016	11.0	31 - 35 ft	DPT-16-32-GW-31-35	N	0.12 J	**2.1 J**	**0.65 J**
On-Site	DPT-16-33	12/5/2016	11.0	19 - 23 ft	DPT-16-33-GW-19-23	N	0.23 J	**8.3**	**2.8**
On-Site	DPT-16-33	12/5/2016	11.0	31 - 35 ft	DPT-16-33-GW-31-35	N	0.15	**1.3**	**0.96**
On-Site	DPT-16-34	11/15/2016	11.0	16 - 20 ft	DPT-16-34-GW-16-20	N	0.028 J-	**1.6 J-**	**0.40 J-**
On-Site	DPT-16-34	11/14/2016	11.0	31 - 35 ft	DPT-16-34-GW-31-35	N	0.12 J-	**1.4 J-**	**1.0 J-**
On-Site	DPT-16-35	11/22/2016	11.0	21 - 25 ft	DPT-16-35-GW-21-25	N	0.28 J-	**2.4 J-**	**0.76 J-**
On-Site	DPT-16-35	11/22/2016	11.0	31 - 35 ft	DPT-16-35-GW-31-35	N	0.38 J-	**0.80 J-**	**1.4 J-**
On-Site	DPT-17-26	1/11/2017	13.0	18 - 22 ft	DPT-17-26-GW-18-22	N	0.0011 J	< 0.0083 U	0.0059
On-Site	DPT-17-26	1/11/2017	13.0	29 - 33 ft	DPT-17-26-GW-29-33	N	< 0.0019 U	0.0083	< 0.0024 U
On-Site	DPT-17-27	1/11/2017	13.0	18 - 22 ft	DPT-17-27-GW-18-22	N	< 0.0020 U	< 0.0030 U	< 0.0020 U
On-Site	DPT-17-27	1/11/2017	13.0	29 - 33 ft	DPT-17-27-GW-29-33	N	< 0.0020 U	< 0.0040 U	< 0.0020 U

Notes: µg/L = micrograms per liter
bgs = Below ground surface
FD = Field duplicate sample
ft = Feet
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Values in **BOLD**: Exceed the PFOS or PFOA groundwater Regional Screening Level (RSL) for a Hazard Quotient (HQ) = 0.1 of 0.04 µg/L

Table 4-5. Sediment Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex Facility
Annapolis, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/kg)	PFOS (µg/kg)	PFOA (µg/kg)
On/Near Site (East of Bay Head Road)	SD-16-01	11/2/2016	SWSD-16-01-SD	N	< 0.37 U	1.7	0.23 J
On/Near Site (East of Bay Head Road)	SD-16-02	11/2/2016	SWSD-16-02-SD	N	< 0.69 U	5.1	< 0.69 U
On/Near Site (East of Bay Head Road)	SD-16-02	11/2/2016	SWSD-16-02-SD-DUP	FD	< 0.68 U	4.2	0.23 J
On/Near Site (East of Bay Head Road)	SD-16-03	11/2/2016	SWSD-16-03-SD	N	< 0.63 U	6.6	0.28 J
On/Near Site (East of Bay Head Road)	SD-16-04	11/2/2016	SWSD-16-04-SD	N	< 0.38 U	0.42 J	0.18 J
Off-Site (West of Bay Head Road)	SWSD-18-01	4/26/2018	SWSD-18-01-SD	N	< 0.38 U	12	1.2
Off-Site (West of Bay Head Road)	SWSD-18-01	11/19/2018	SD-18-01	N	< 0.84 U	0.42 J	< 0.95 U
Off-Site (West of Bay Head Road)	SWSD-18-02	4/26/2018	SWSD-18-02-SD	N	< 0.59 U	44	3.7
Off-Site (West of Bay Head Road)	SWSD-18-02	11/19/2018	SD-18-02	N	< 1.2 U	15	1.4 J
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SD	N	0.28 J	31 J	3.7 J
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SD-DUP	FD	< 0.91 UJ	28 J	4.5 J
Off-Site (West of Bay Head Road)	SWSD-18-03	11/20/2018	SD-18-03	N	< 2.4 UJ	24 J	3.4 J
Off-Site (West of Bay Head Road)	SWSD-18-03	11/20/2018	SD-18-03-DUP	FD	< 2.2 UJ	8.9 J	2.3 J
Off-Site (West of Bay Head Road)	SWSD-18-04	4/26/2018	SWSD-18-04-SD	N	< 0.76 UJ	19 J	2.4 J
Off-Site (West of Bay Head Road)	SWSD-18-04	11/20/2018	SD-18-04	N	< 3.7 UJ	8.3 J	< 4.2 UJ
Off-Site (West of Bay Head Road)	SWSD-18-05	4/26/2018	SWSD-18-05-SD	N	< 1.5 UJ	18 J	1.2 J
Off-Site (West of Bay Head Road)	SWSD-18-05	11/19/2018	SD-18-05	N	< 3.0 UJ	5.1 J	< 3.4 UJ
Off-Site (West of Bay Head Road)	SWSD-18-06	11/20/2018	SD-18-06	N	< 0.80 U	14	1.4
Off-Site (West of Bay Head Road)	SWSD-18-07	11/20/2018	SD-18-07	N	< 0.72 U	1.7 J	< 0.81 U
Off-Site (West of Bay Head Road)	SWSD-18-07	11/20/2018	SD-18-07-DUP	FD	< 0.89 U	6.7 J	0.50 J
Off-Site (West of Bay Head Road)	SWSD-18-08	11/19/2018	SD-18-08	N	< 1.4 U	0.59 J	< 1.6 U
Off-Site (West of Bay Head Road)	SWSD-18-09	11/19/2018	SD-18-09	N	< 0.85 U	0.36 J	< 0.96 U
Off-Site (West of Bay Head Road)	SWSD-18-10	11/19/2018	SD-18-10	N	< 0.91 U	0.32 J	< 1.0 U
Off-Site (West of Bay Head Road)	SWSD-18-11	11/19/2018	SD-18-11	N	< 2.6 UJ	4.4 J	< 3.0 UJ
Off-Site (West of Bay Head Road)	SWSD-18-12	11/19/2018	SD-18-12	N	< 3.7 UJ	5.3 J	< 4.2 UJ
Off-Site (West of Bay Head Road)	SWSD-18-13	11/19/2018	SD-18-13	N	< 2.4 UJ	1.5 J	< 2.7 UJ
Off-Site (West of Bay Head Road)	SWSD-18-13	11/19/2018	SD-18-13-DUP	FD	< 2.5 UJ	1.2 J	< 2.8 UJ
Off-Site (West of Bay Head Road)	SWSD-18-14	11/19/2018	SD-18-14	N	< 2.5 UJ	1.0 J	0.93 J
Off-Site (West of Bay Head Road)	SWSD-18-15	11/19/2018	SD-18-15	N	< 2.1 UJ	0.86 J	< 2.4 UJ
Off-Site (West of Bay Head Road)	SWSD-18-16	11/19/2018	SD-18-16	N	< 2.8 UJ	2.1 J	< 3.2 UJ
Off-Site (West of Bay Head Road)	SWSD-18-17	11/19/2018	SD-18-17	N	< 3.4 UJ	3.5 J	< 3.8 UJ
Off-Site (West of Bay Head Road)	SWSD-18-18	11/19/2018	SD-18-18	N	< 0.93 U	0.50 J	< 1.0 U
Off-Site (West of Bay Head Road)	SWSD-18-19	11/19/2018	SD-18-19	N	< 0.93 U	0.37 J	< 1.1 U
Off-Site (West of Bay Head Road)	SWSD-18-20	11/19/2018	SD-18-20	N	< 1.1 U	0.62 J	< 1.2 U

Table 4-5. Sediment Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex Facility
Annapolis, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/kg)	PFOS (µg/kg)	PFOA (µg/kg)
Off-Site (West of Bay Head Road)	SWSD-18-21	11/19/2018	SD-18-21	N	< 3.3 UJ	2.7 J	< 3.8 UJ
Off-Site (West of Bay Head Road)	SWSD-18-22	11/19/2018	SD-18-22	N	< 4.1 UJ	< 4.5 UJ	< 4.7 UJ
Off-Site (West of Bay Head Road)	SWSD-18-23	11/19/2018	SD-18-23	N	< 4.6 UJ	4.7 J	< 5.3 UJ
Off-Site (West of Bay Head Road)	SWSD-18-24	11/20/2018	SD-18-24	N	< 1.5 U	2.2	< 1.6 U

Notes: µg/kg = micrograms per kilogram
FD = Field duplicate sample
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

All sediment samples were collected during the high tidal stage.

Table 4-6. Surface Water Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex Facility
Annapolis, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
On/Near Site (East of Bay Head Road)	SW-16-01	12/5/2016	SW-16-01-SW	N	0.020	0.27	0.023
On/Near Site (East of Bay Head Road)	SW-16-02	12/5/2016	SW-16-02-SW	N	0.0084	0.12	0.042
On/Near Site (East of Bay Head Road)	SW-16-02	12/5/2016	SW-16-02-SW-DUP	FD	0.0089	0.12	0.041
Off-Site (West of Bay Head Road)	SWSD-18-01	4/26/2018	SWSD-18-01-SW	N	0.0076	0.18	0.055
Off-Site (West of Bay Head Road)	SWSD-18-01	11/19/2018	SW-18-01	N	0.0075 J	0.12	0.041
Off-Site (West of Bay Head Road)	SWSD-18-02	4/26/2018	SWSD-18-02-SW	N	0.029	0.66 J	0.43 J
Off-Site (West of Bay Head Road)	SWSD-18-02	11/19/2018	SW-18-02	N	0.017 J	0.3	0.26
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SW	N	0.057	0.4 J	0.49 J
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SW-DUP	FD	0.054	0.55 J	0.53 J
Off-Site (West of Bay Head Road)	SWSD-18-03	11/19/2018	SW-18-03-H	N	0.026 J	0.21	0.26
Off-Site (West of Bay Head Road)	SWSD-18-03	11/20/2018	SW-18-03-L	N	0.031	0.27	0.36
Off-Site (West of Bay Head Road)	SWSD-18-04	4/26/2018	SWSD-18-04-SW	N	0.031	0.27	0.26
Off-Site (West of Bay Head Road)	SWSD-18-04	11/19/2018	SW-18-04-H	N	0.0019	0.0043	0.0046
Off-Site (West of Bay Head Road)	SWSD-18-04	11/20/2018	SW-18-04-L	N	0.016	0.075	0.11
Off-Site (West of Bay Head Road)	SWSD-18-05	4/26/2018	SWSD-18-05-SW	N	0.015	0.14	0.13
Off-Site (West of Bay Head Road)	SWSD-18-05	11/19/2018	SW-18-05-H	N	0.0017 J	0.0039	0.0037
Off-Site (West of Bay Head Road)	SWSD-18-05	11/19/2018	SW-18-05-H-DUP	FD	0.0015 J	0.0035	0.0038
Off-Site (West of Bay Head Road)	SWSD-18-05	11/20/2018	SW-18-05-L	N	0.014	0.087	0.1
Off-Site (West of Bay Head Road)	SWSD-18-05	11/20/2018	SW-18-05-L-DUP	FD	0.015	0.082	0.1
Off-Site (West of Bay Head Road)	SWSD-18-06	11/20/2018	SW-18-06	N	0.0084	0.13	0.057
Off-Site (West of Bay Head Road)	SWSD-18-07	11/20/2018	SW-18-07	N	0.0092	0.15	0.073
Off-Site (West of Bay Head Road)	SWSD-18-08	11/19/2018	SW-18-08-H	N	0.0019	0.0045	0.0049
Off-Site (West of Bay Head Road)	SWSD-18-08	11/20/2018	SW-18-08-L	N	0.0040	0.014	0.017
Off-Site (West of Bay Head Road)	SWSD-18-09	11/19/2018	SW-18-09-H	N	0.0026 J	0.0069	0.0073
Off-Site (West of Bay Head Road)	SWSD-18-09	11/20/2018	SW-18-09-L	N	0.0038	0.011	0.011
Off-Site (West of Bay Head Road)	SWSD-18-10	11/19/2018	SW-18-10-H	N	0.0021	0.0064	0.0066
Off-Site (West of Bay Head Road)	SWSD-18-10	11/20/2018	SW-18-10-L	N	0.0068	0.029	0.039
Off-Site (West of Bay Head Road)	SWSD-18-11	11/19/2018	SW-18-11-H	N	0.0016 J	0.0032	0.0033
Off-Site (West of Bay Head Road)	SWSD-18-11	11/20/2018	SW-18-11-L	N	0.0091 J	0.046	0.059
Off-Site (West of Bay Head Road)	SWSD-18-11	11/20/2018	SW-18-11-L-DUP	FD	0.0091	0.047	0.058
Off-Site (West of Bay Head Road)	SWSD-18-12	11/19/2018	SW-18-12-H	N	0.0017	0.0047	0.0042
Off-Site (West of Bay Head Road)	SWSD-18-12	11/20/2018	SW-18-12-L	N	0.012	0.081	0.081
Off-Site (West of Bay Head Road)	SWSD-18-13	11/19/2018	SW-18-13-H	N	0.0019 J	0.017	0.0059
Off-Site (West of Bay Head Road)	SWSD-18-13	11/20/2018	SW-18-13-L	N	0.0032	0.0078	0.0093
Off-Site (West of Bay Head Road)	SWSD-18-14	11/19/2018	SW-18-14-H	N	0.0020 J	0.0048	0.0056
Off-Site (West of Bay Head Road)	SWSD-18-14	11/20/2018	SW-18-14-L	N	0.0040	0.014	0.017
Off-Site (West of Bay Head Road)	SWSD-18-15	11/19/2018	SW-18-15-H	N	0.0017 J	0.0045	0.0047
Off-Site (West of Bay Head Road)	SWSD-18-15	11/20/2018	SW-18-15-L	N	0.0050	0.02	0.024
Off-Site (West of Bay Head Road)	SWSD-18-15	11/20/2018	SW-18-15-L-DUP	FD	0.0049	0.019	0.024

Table 4-6. Surface Water Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex Facility
Annapolis, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
Off-Site (West of Bay Head Road)	SWSD-18-16	11/19/2018	SW-18-16-H	N	0.0018	0.0044	0.0046
Off-Site (West of Bay Head Road)	SWSD-18-16	11/20/2018	SW-18-16-L	N	0.0052	0.018	0.023
Off-Site (West of Bay Head Road)	SWSD-18-17	11/19/2018	SW-18-17-H	N	0.0018	0.0042	0.0044
Off-Site (West of Bay Head Road)	SWSD-18-17	11/20/2018	SW-18-17-L	N	0.0056	0.02	0.028
Off-Site (West of Bay Head Road)	SWSD-18-18	11/19/2018	SW-18-18-H	N	0.0024	0.0074	0.0081
Off-Site (West of Bay Head Road)	SWSD-18-18	11/20/2018	SW-18-18-L	N	0.0028	0.0067	0.0078
Off-Site (West of Bay Head Road)	SWSD-18-19	11/19/2018	SW-18-19-H	N	0.0025	0.0079	0.0092
Off-Site (West of Bay Head Road)	SWSD-18-19	11/20/2018	SW-18-19-L	N	0.0032	0.0070	0.0080
Off-Site (West of Bay Head Road)	SWSD-18-20	11/19/2018	SW-18-20-H	N	0.0031	0.012 J	0.013 J
Off-Site (West of Bay Head Road)	SWSD-18-20	11/19/2018	SW-18-20-H-DUP	FD	0.0023	0.0065 J	0.0082 J
Off-Site (West of Bay Head Road)	SWSD-18-20	11/20/2018	SW-18-20-L	N	0.0033	0.0090	0.011
Off-Site (West of Bay Head Road)	SWSD-18-21	11/19/2018	SW-18-21-H	N	0.0024	0.0064	0.0076
Off-Site (West of Bay Head Road)	SWSD-18-21	11/20/2018	SW-18-21-L	N	0.0028 J	0.017	0.0088
Off-Site (West of Bay Head Road)	SWSD-18-22	11/19/2018	SW-18-22-H	N	0.0023	0.0059	0.0065
Off-Site (West of Bay Head Road)	SWSD-18-22	11/20/2018	SW-18-22-L	N	0.0031	0.025	0.013
Off-Site (West of Bay Head Road)	SWSD-18-23	11/19/2018	SW-18-23-H	N	0.0020	0.0053	0.0055
Off-Site (West of Bay Head Road)	SWSD-18-23	11/20/2018	SW-18-23-L	N	0.0072	0.039	0.044
Off-Site (West of Bay Head Road)	SWSD-18-24	11/20/2018	SW-18-24	N	0.028	0.057	0.058

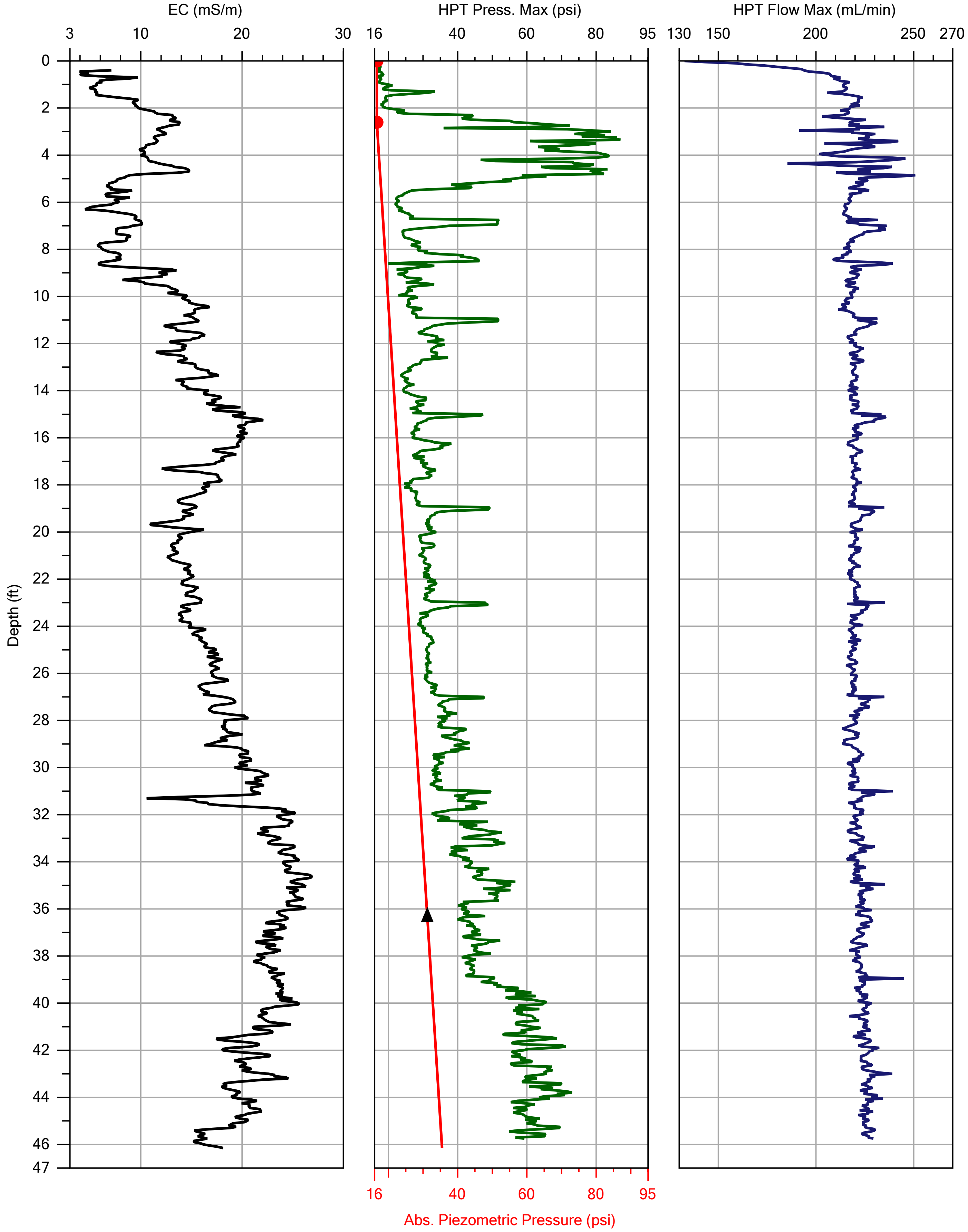
Notes: µg/L = micrograms per liter
FD = Field duplicate sample
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

-H indicates that samples were collected during the high tidal stage.
-L indicates that samples were collected during the low tidal stage.
Locations, SW-18-01, -02, -06, -07 and -24 are considered to be above tidal influence.

Appendices

Appendix A
HPT Data Logs



CASCADE
DRILLING | TECHNICAL SERVICES
EXCELLENCE ON EVERY LEVEL™

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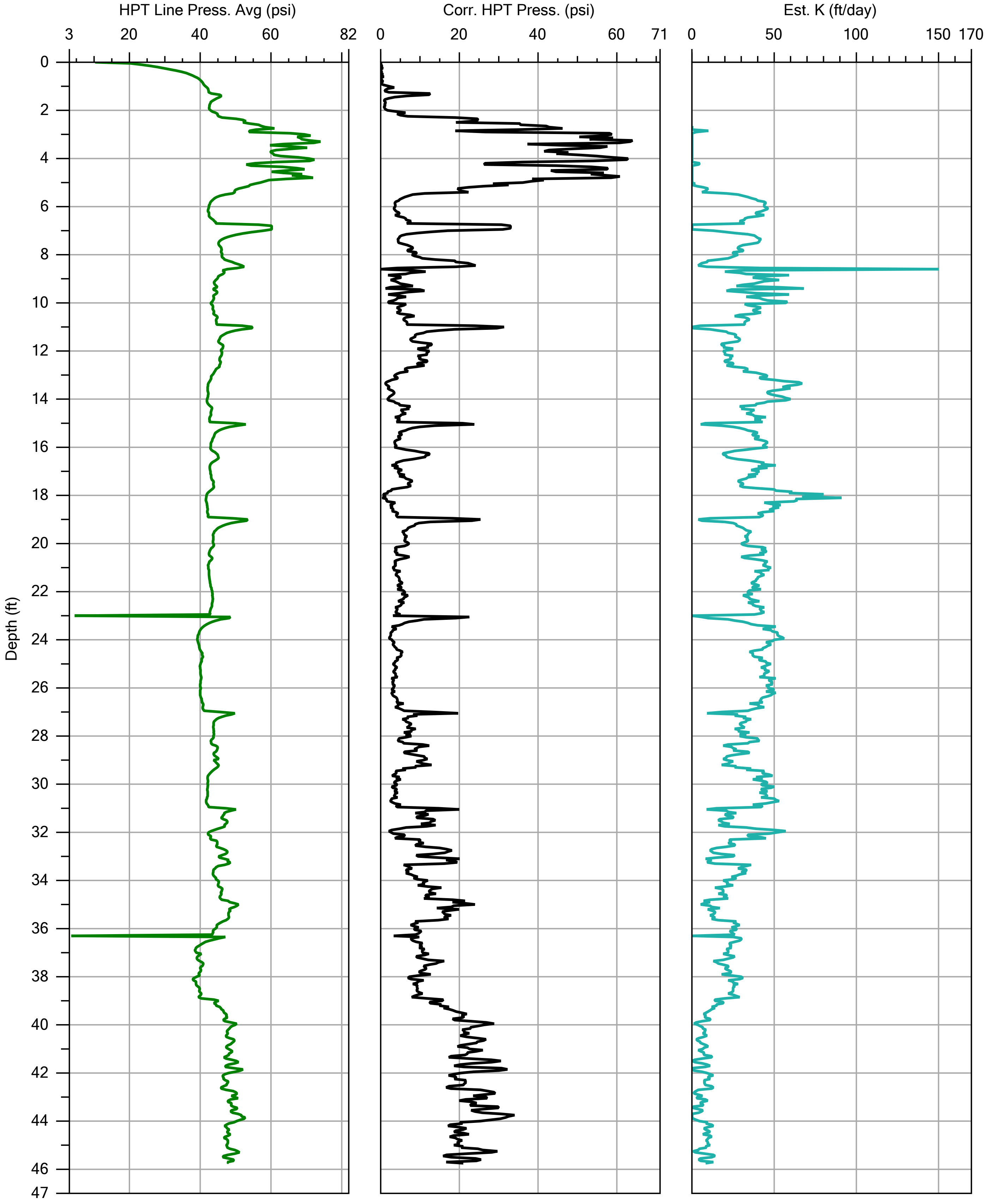
Project ID: 301.16.9002	Client: AECOM	Location:



CASCADE
DRILLING | TECHNICAL SERVICES
EXCELLENCE ON EVERY LEVEL™

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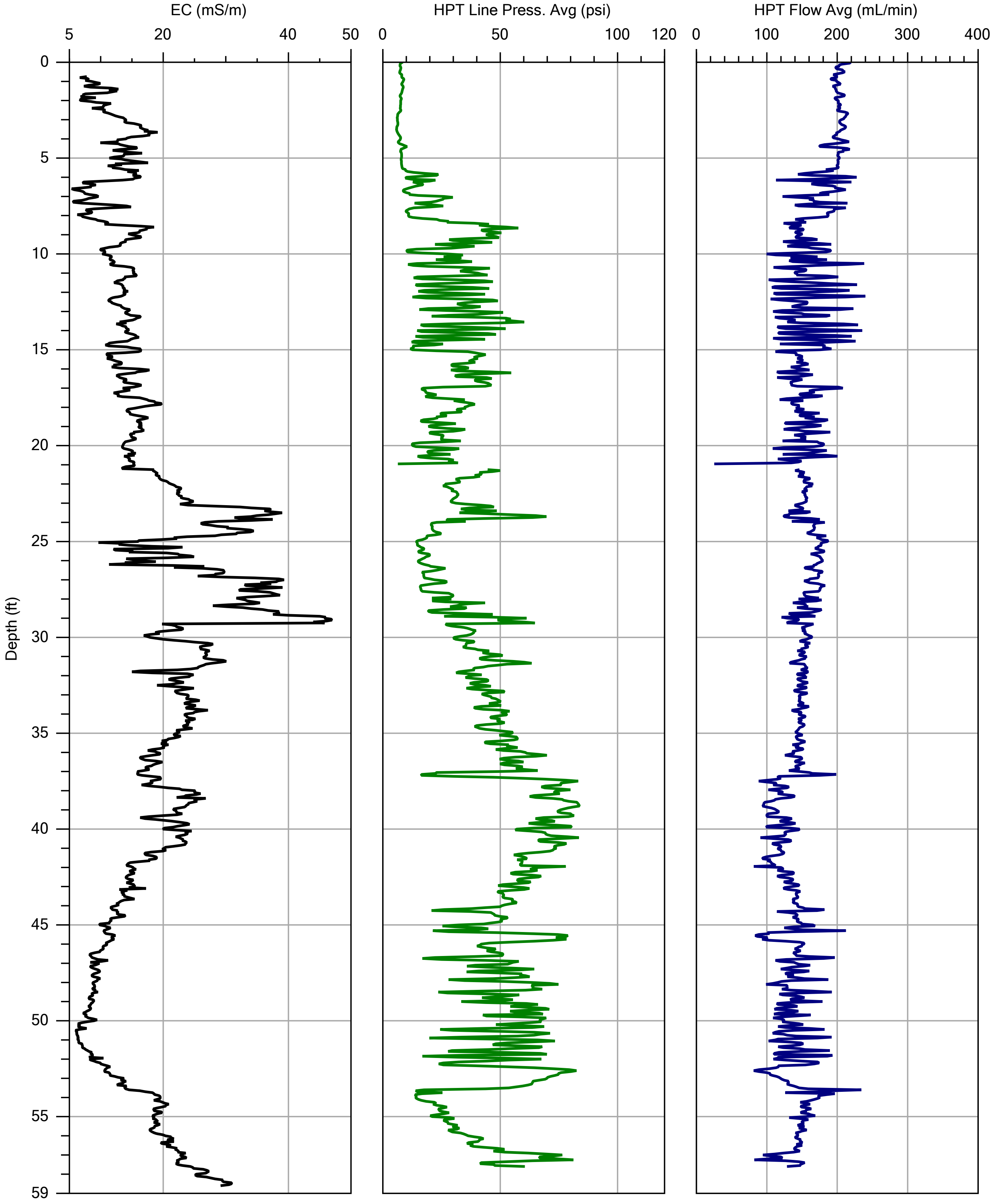

CASCADE
DRILLING | TECHNICAL SERVICES

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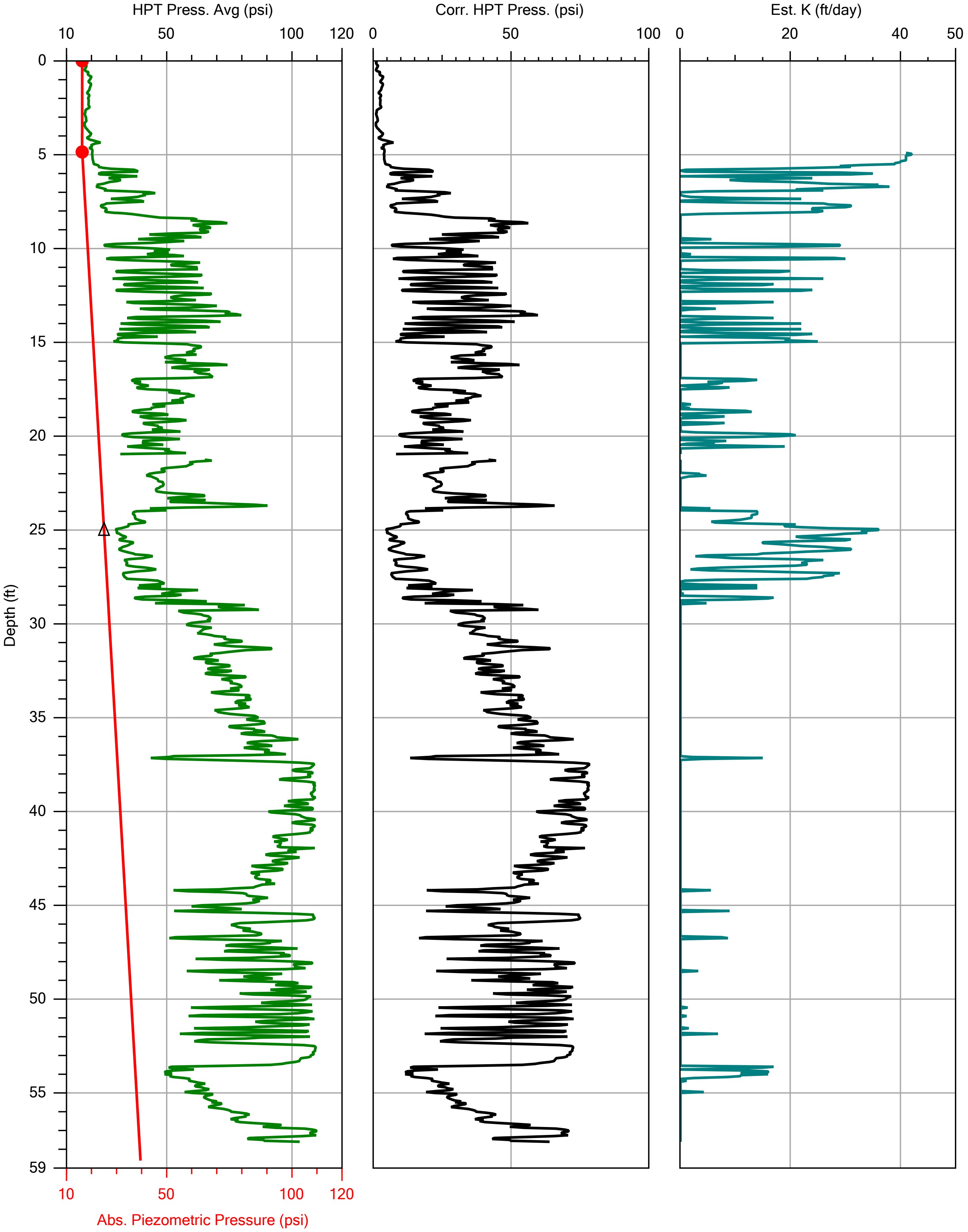

CASCADE
DRILLING | TECHNICAL SERVICES

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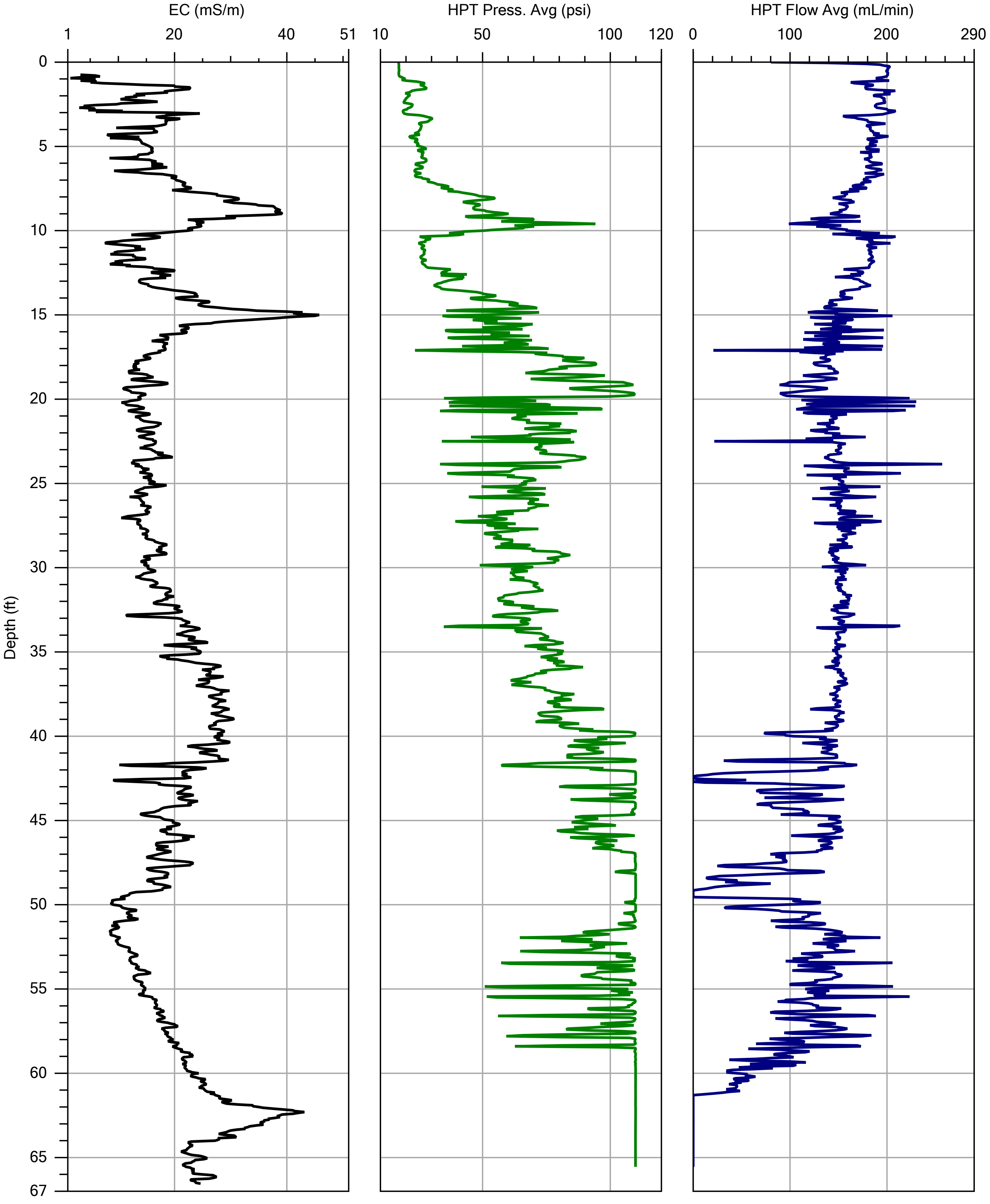

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DRILLING | TECHNICAL SERVICES

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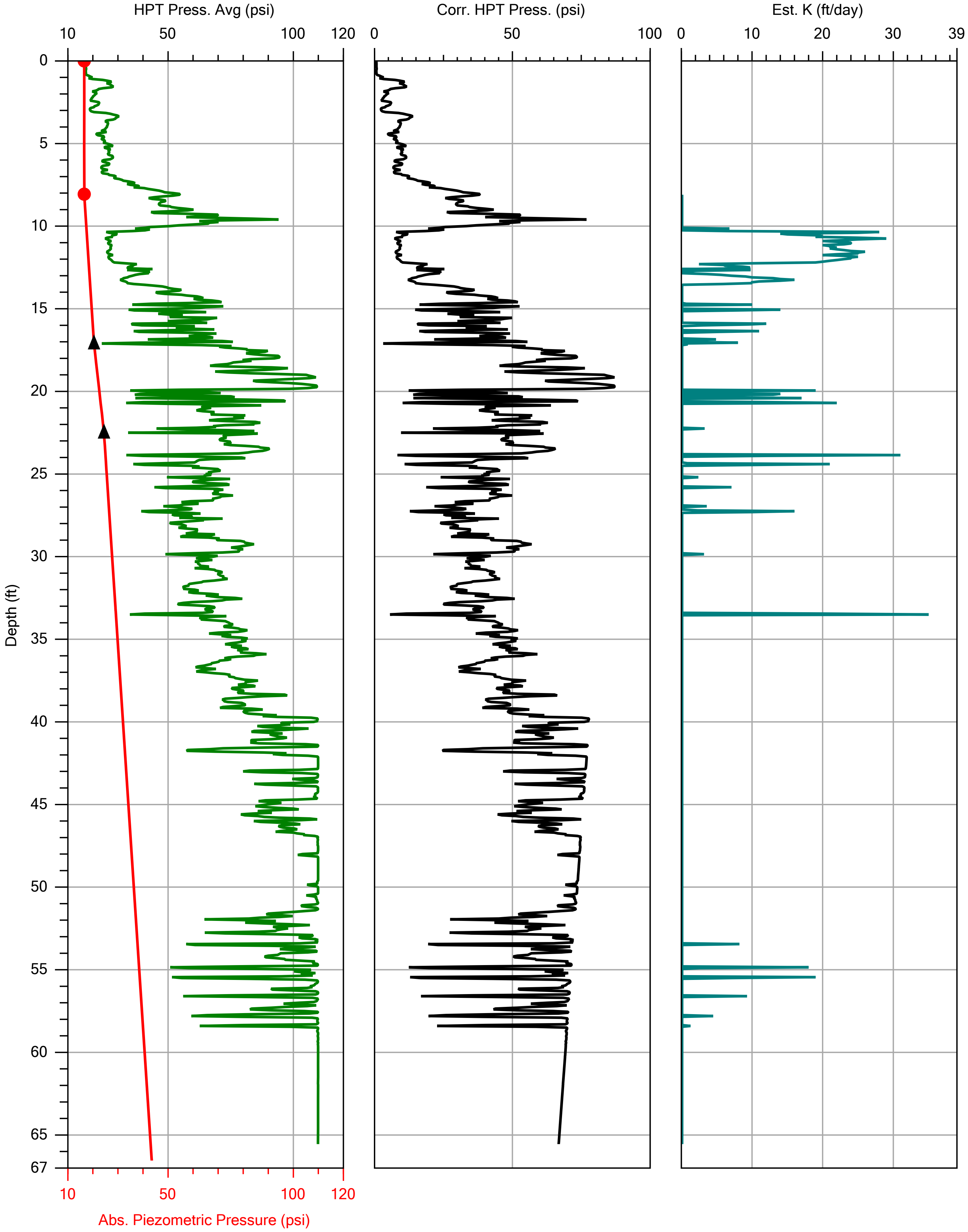

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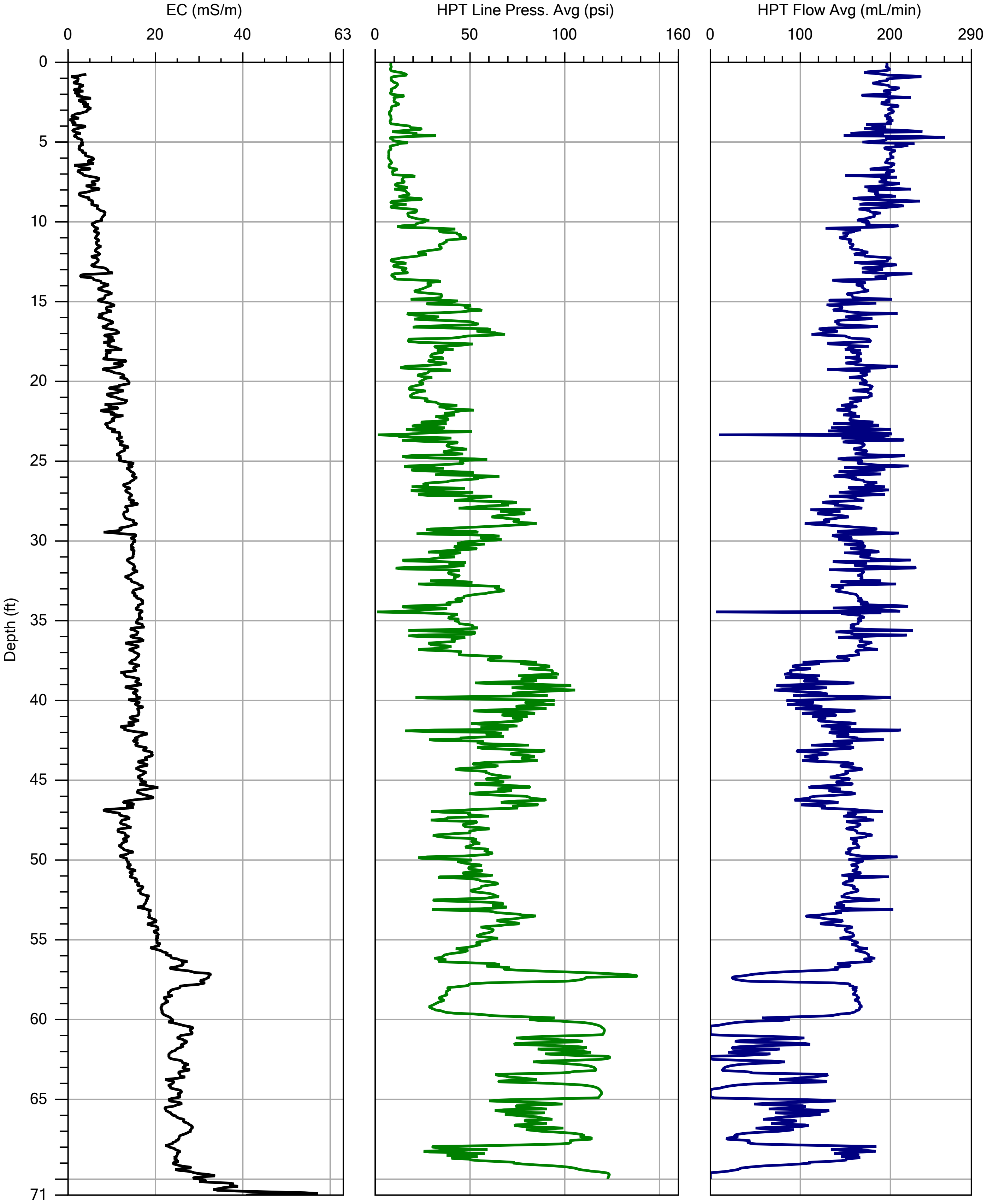

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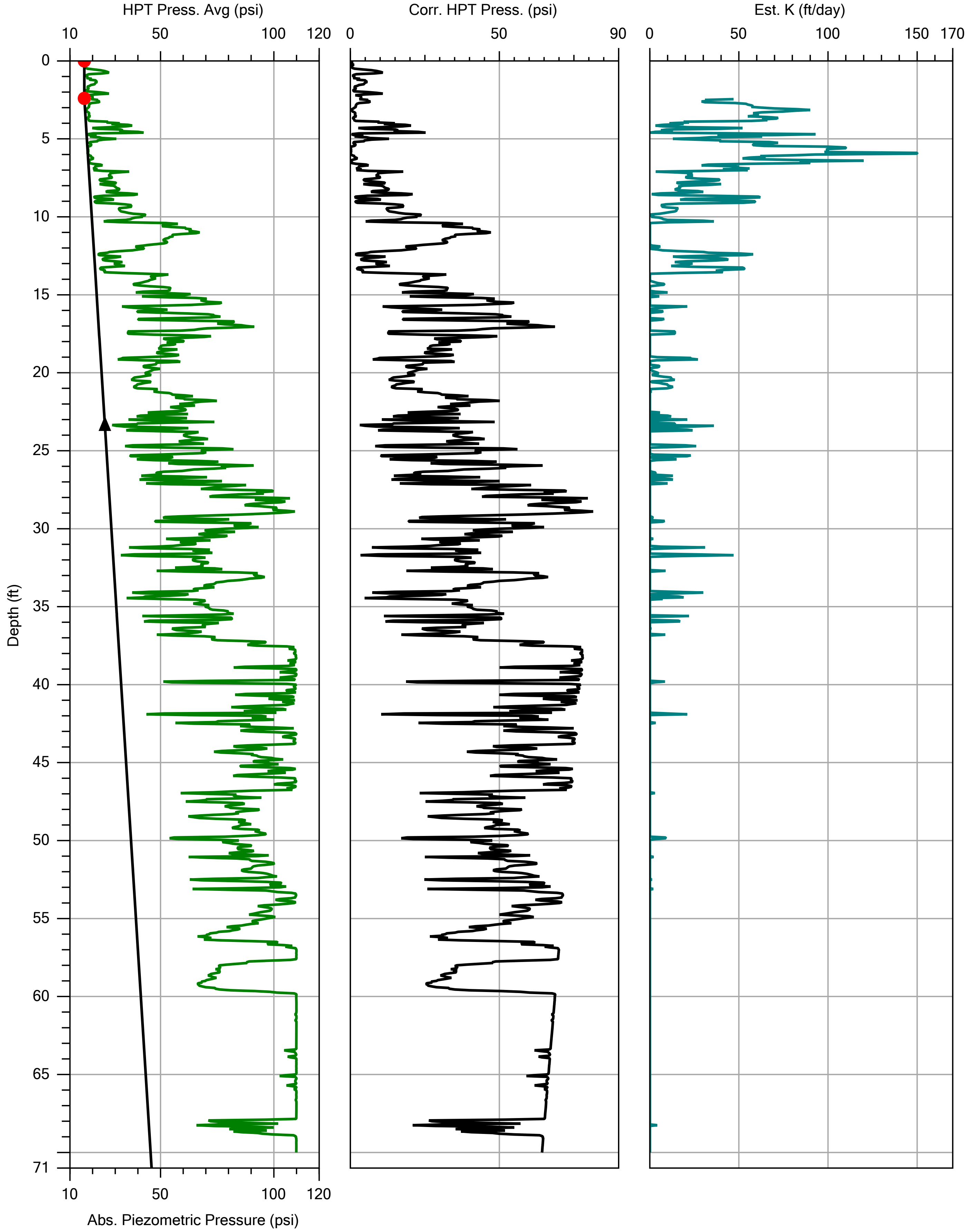

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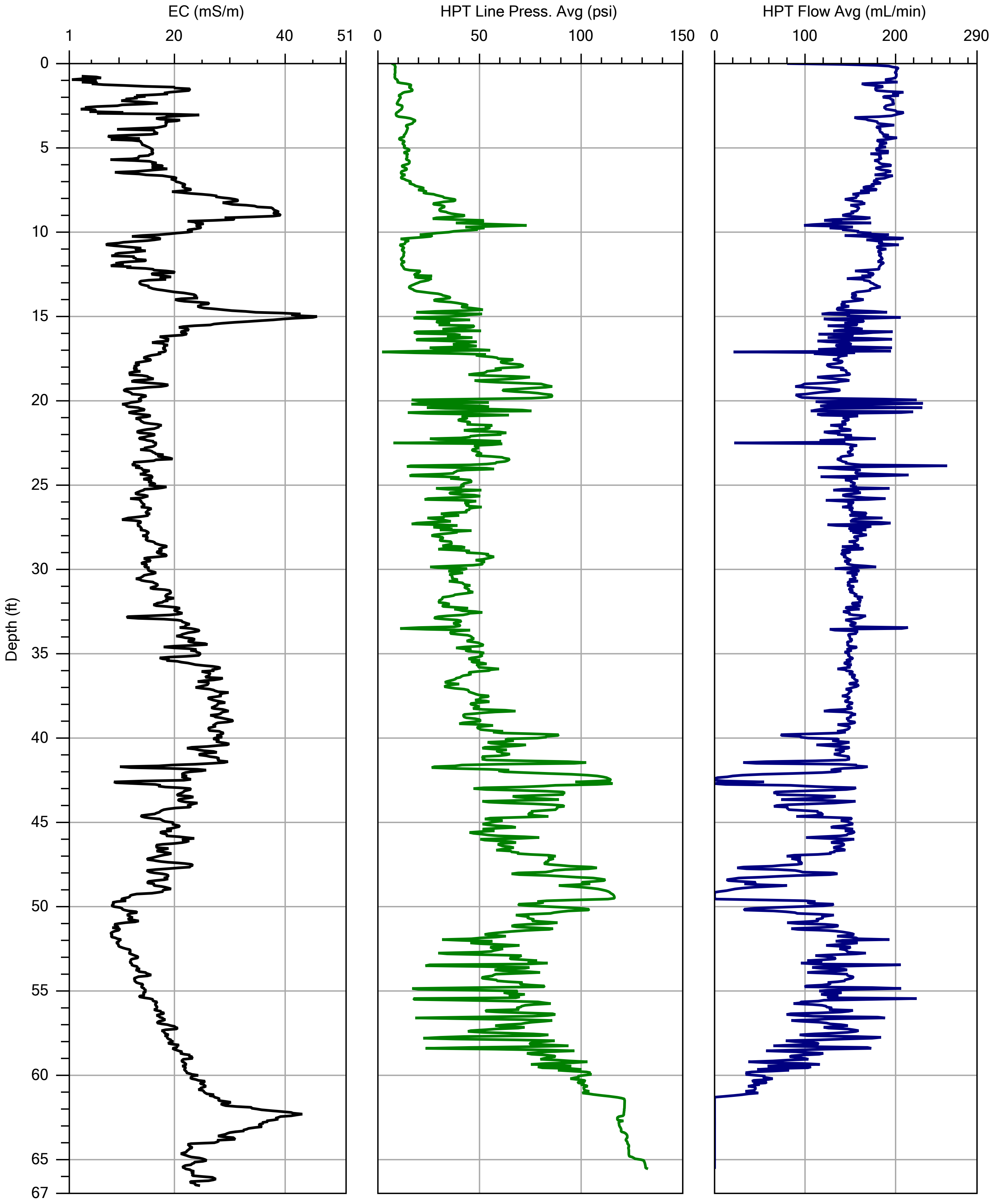

CASCADE
DRILLING | TECHNICAL SERVICES
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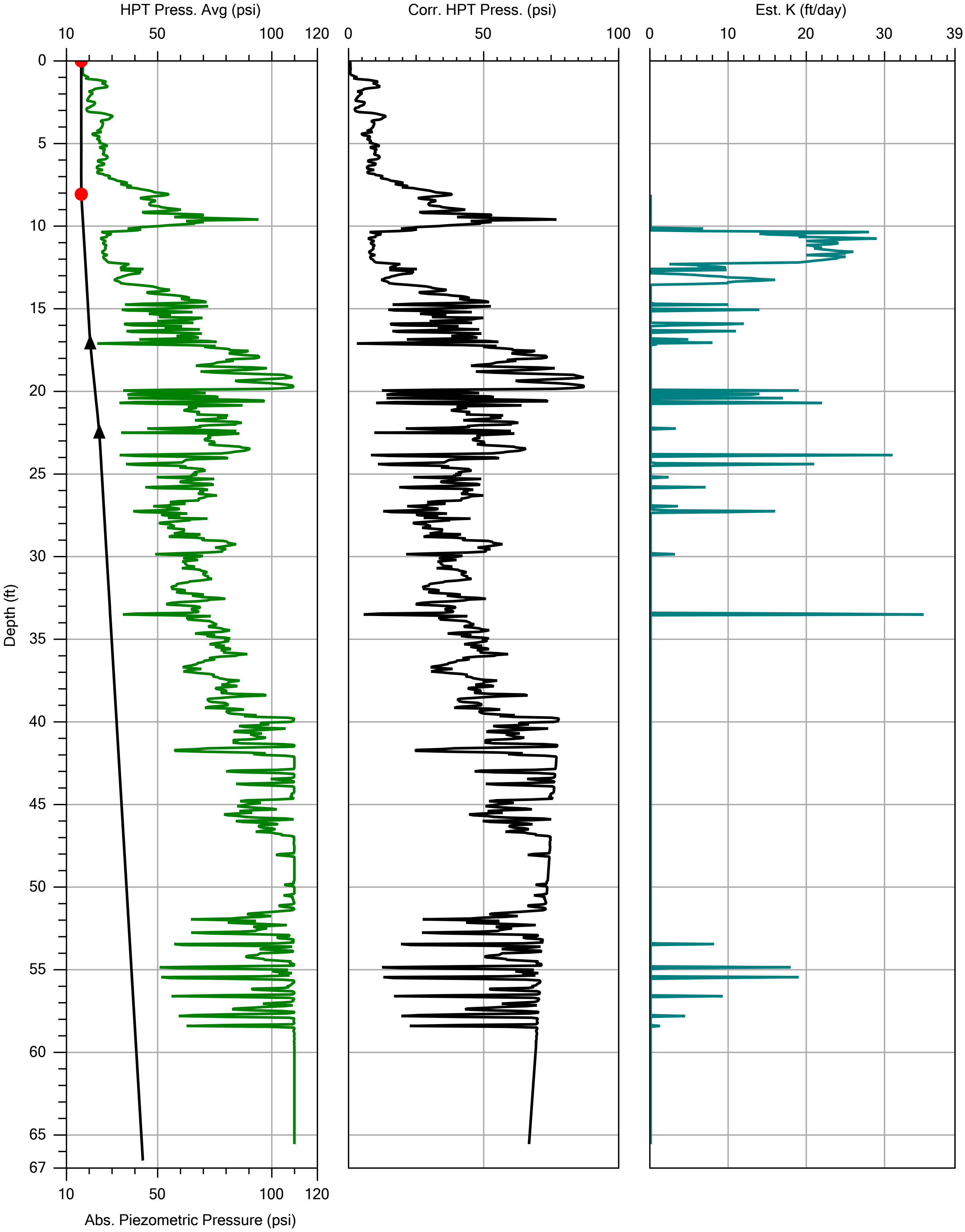

CASCADE DRILLING | TECHNICAL SERVICES EXCELLENCE ON EVERY LEVEL™

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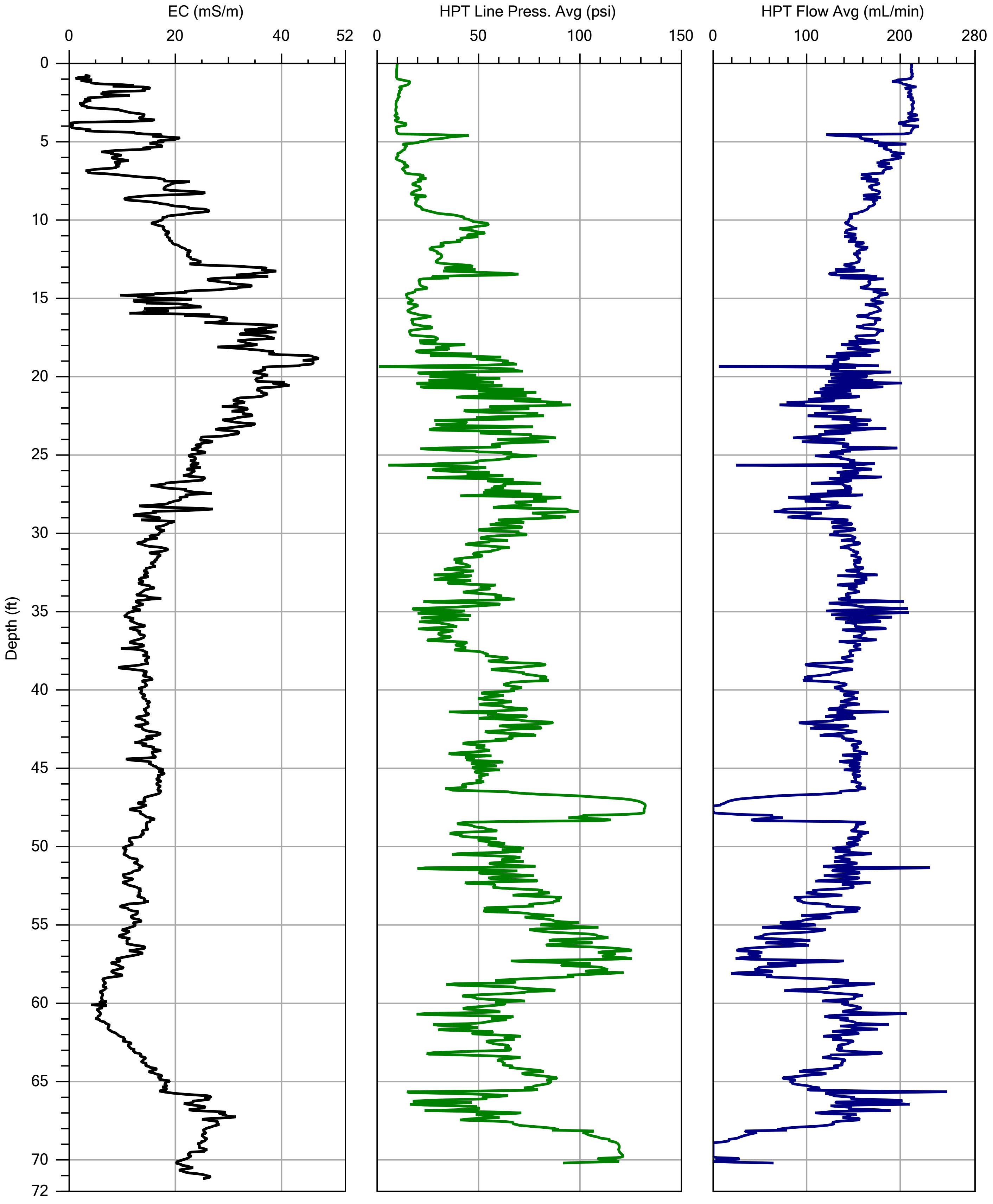

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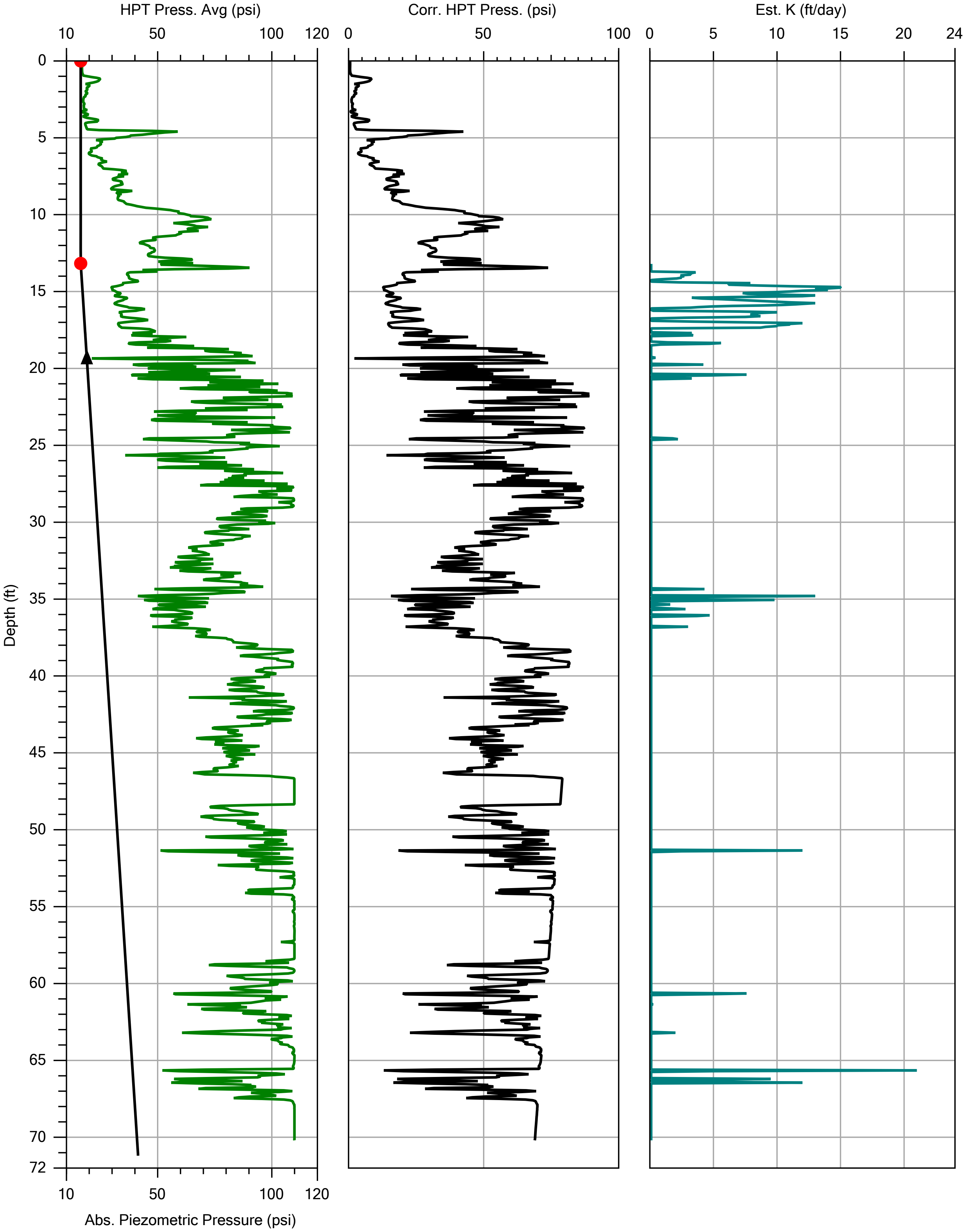

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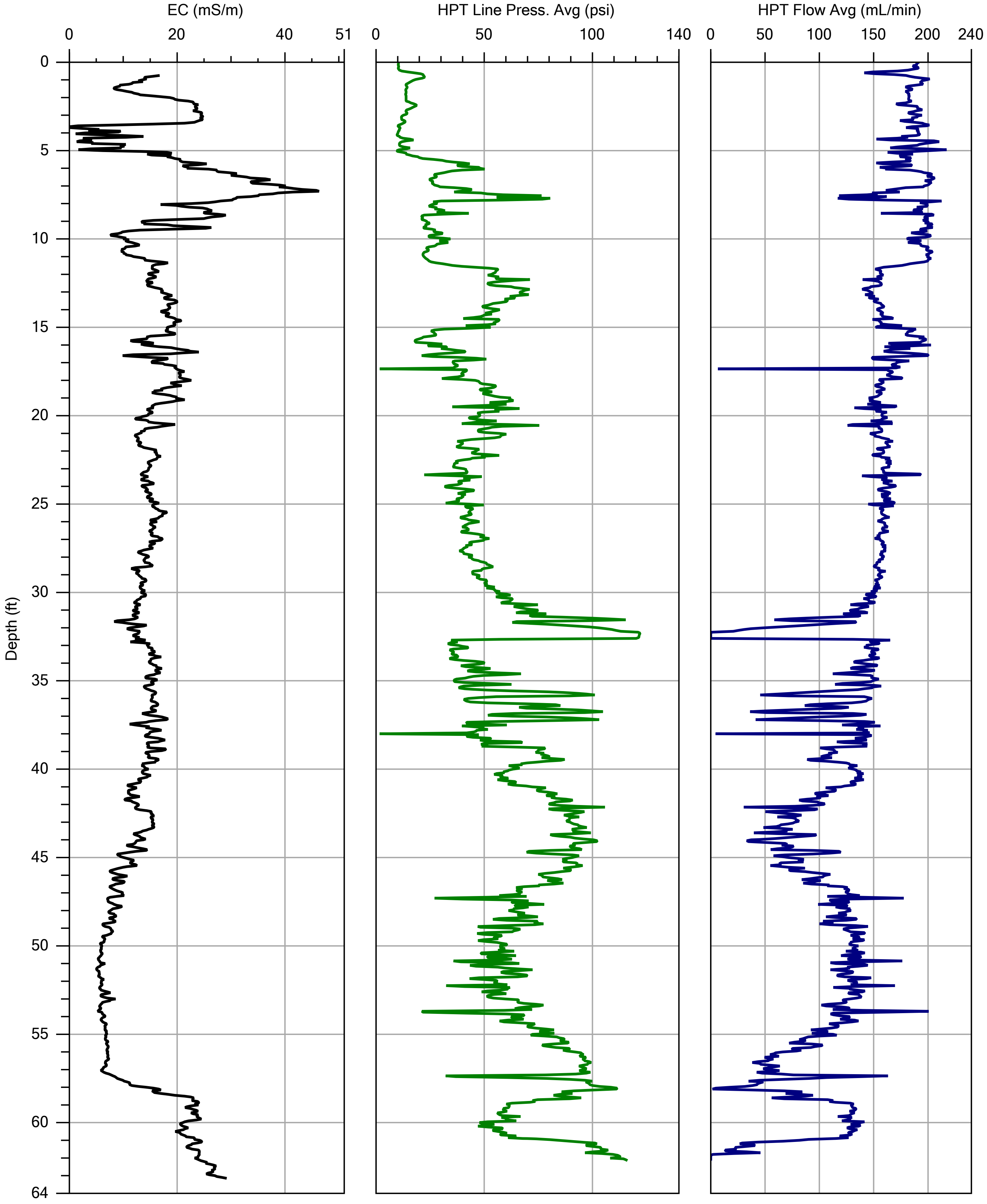

CASCADE
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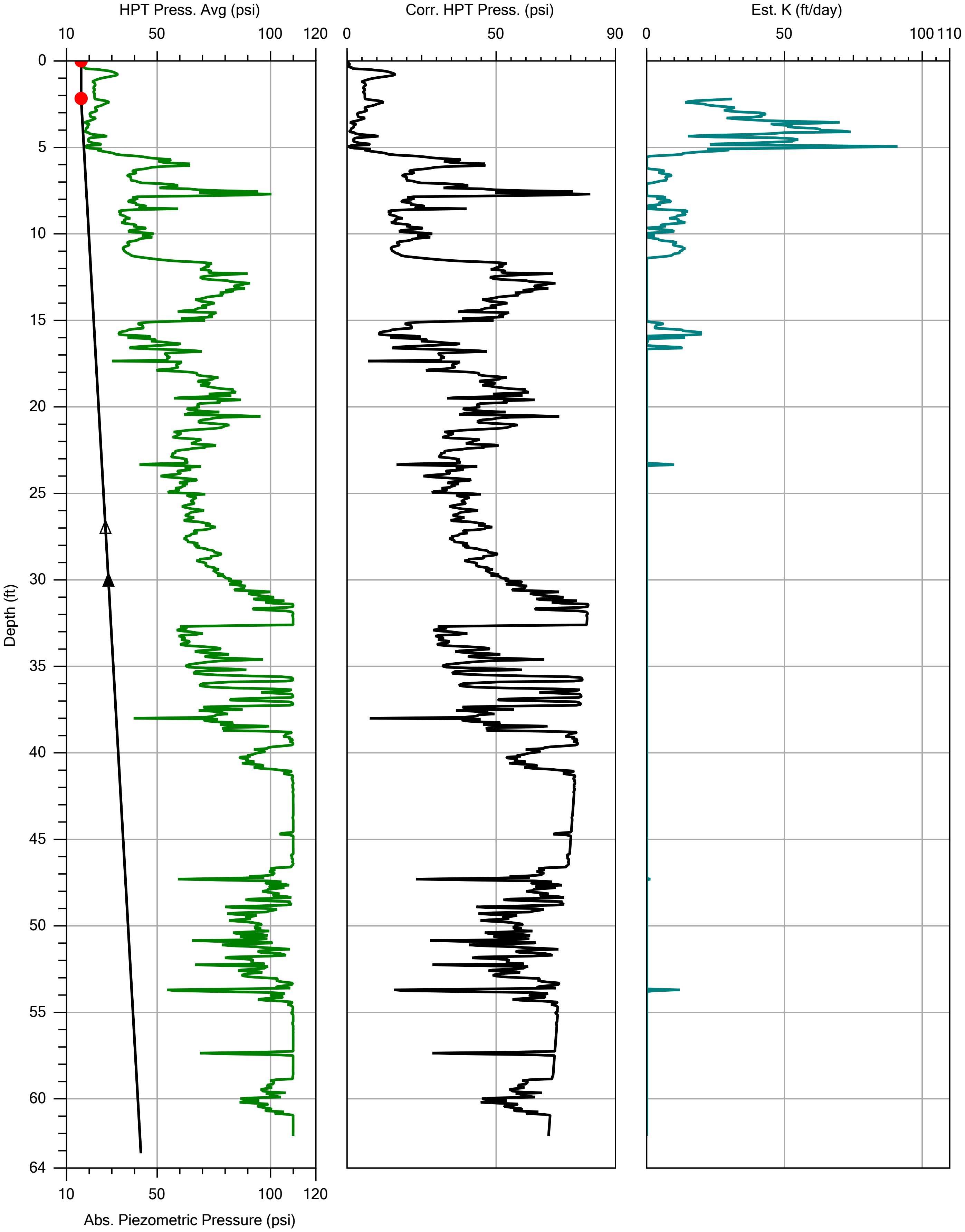

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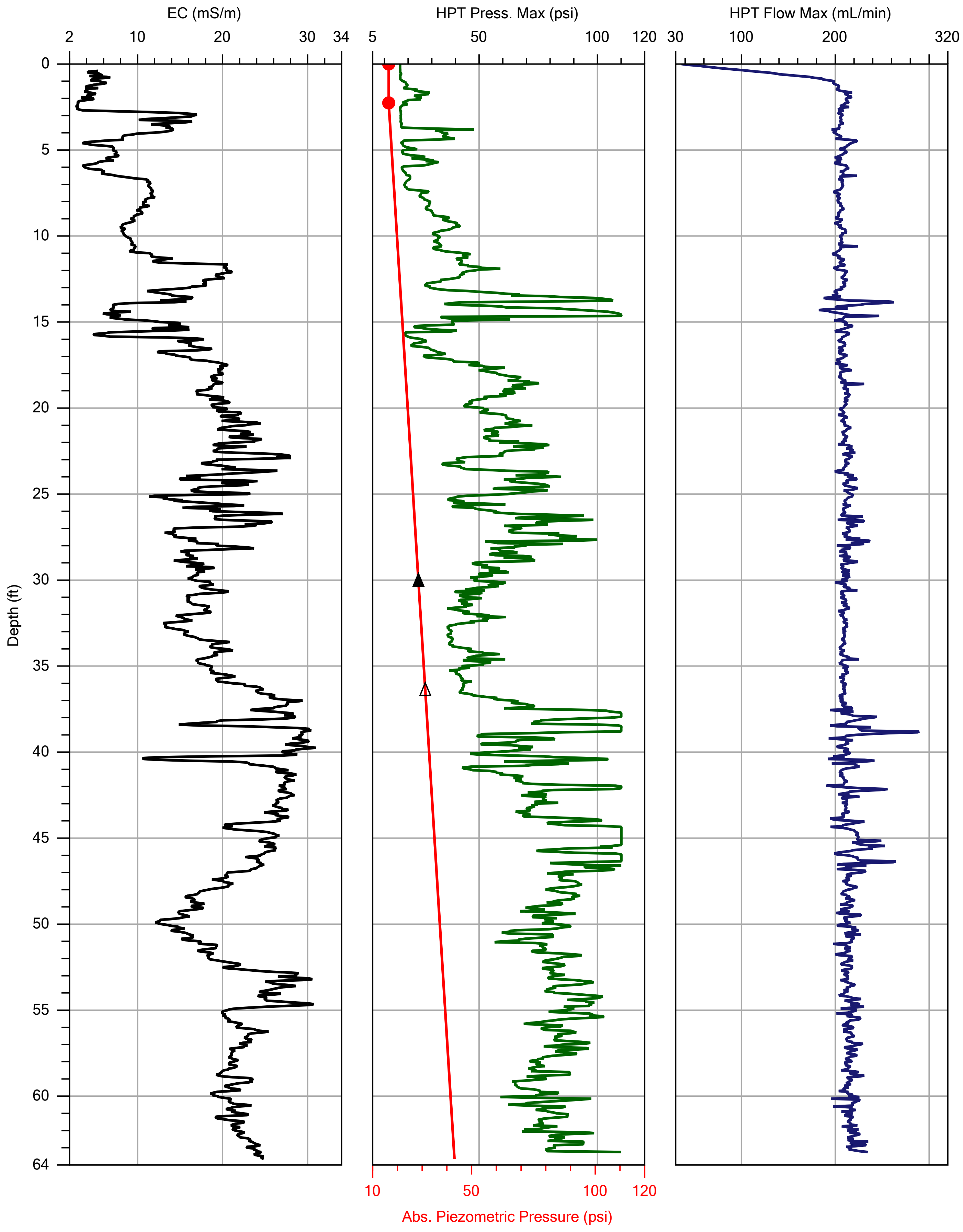

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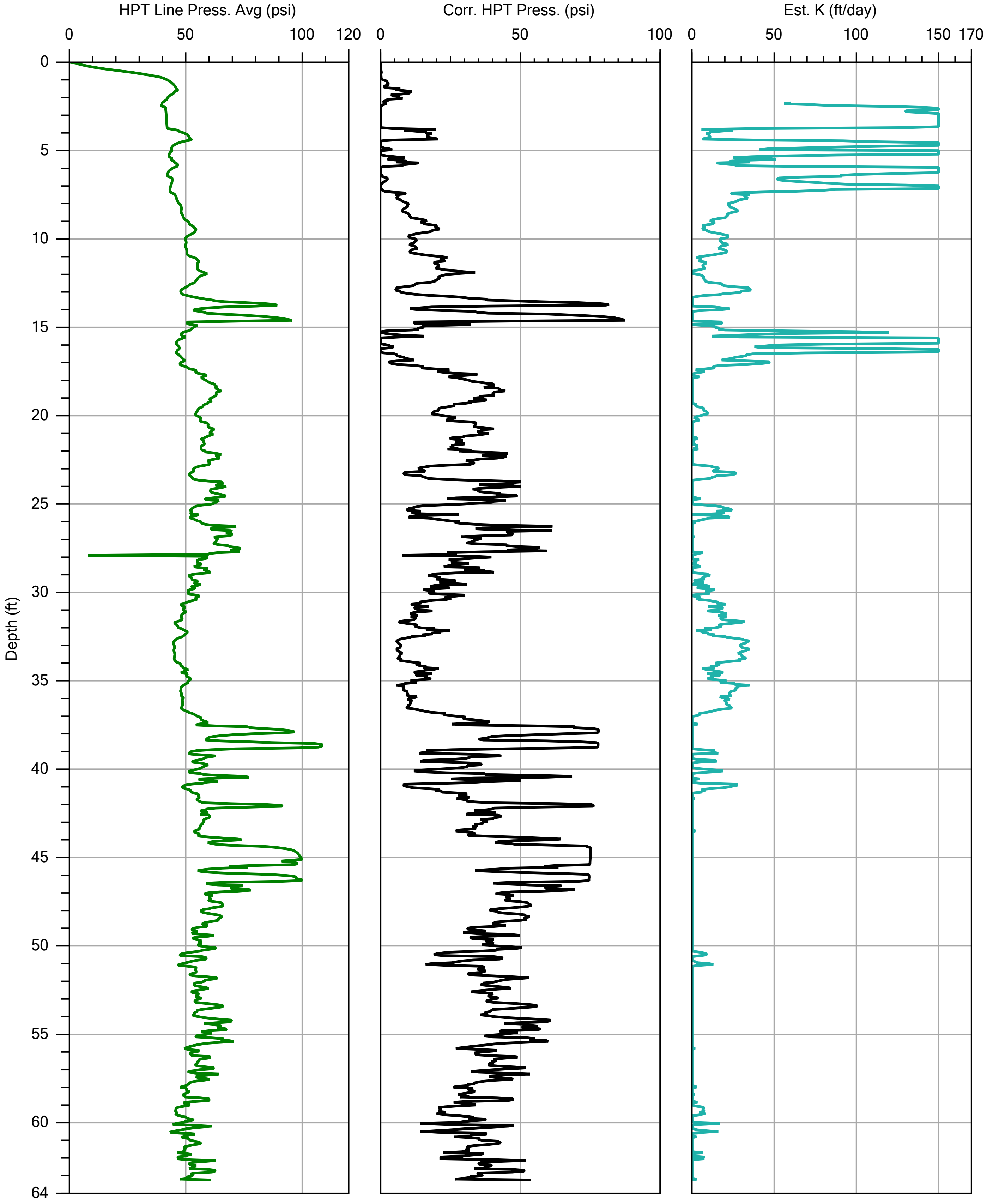

CASCADE DRILLING | TECHNICAL SERVICES EXCELLENCE ON EVERY LEVEL™

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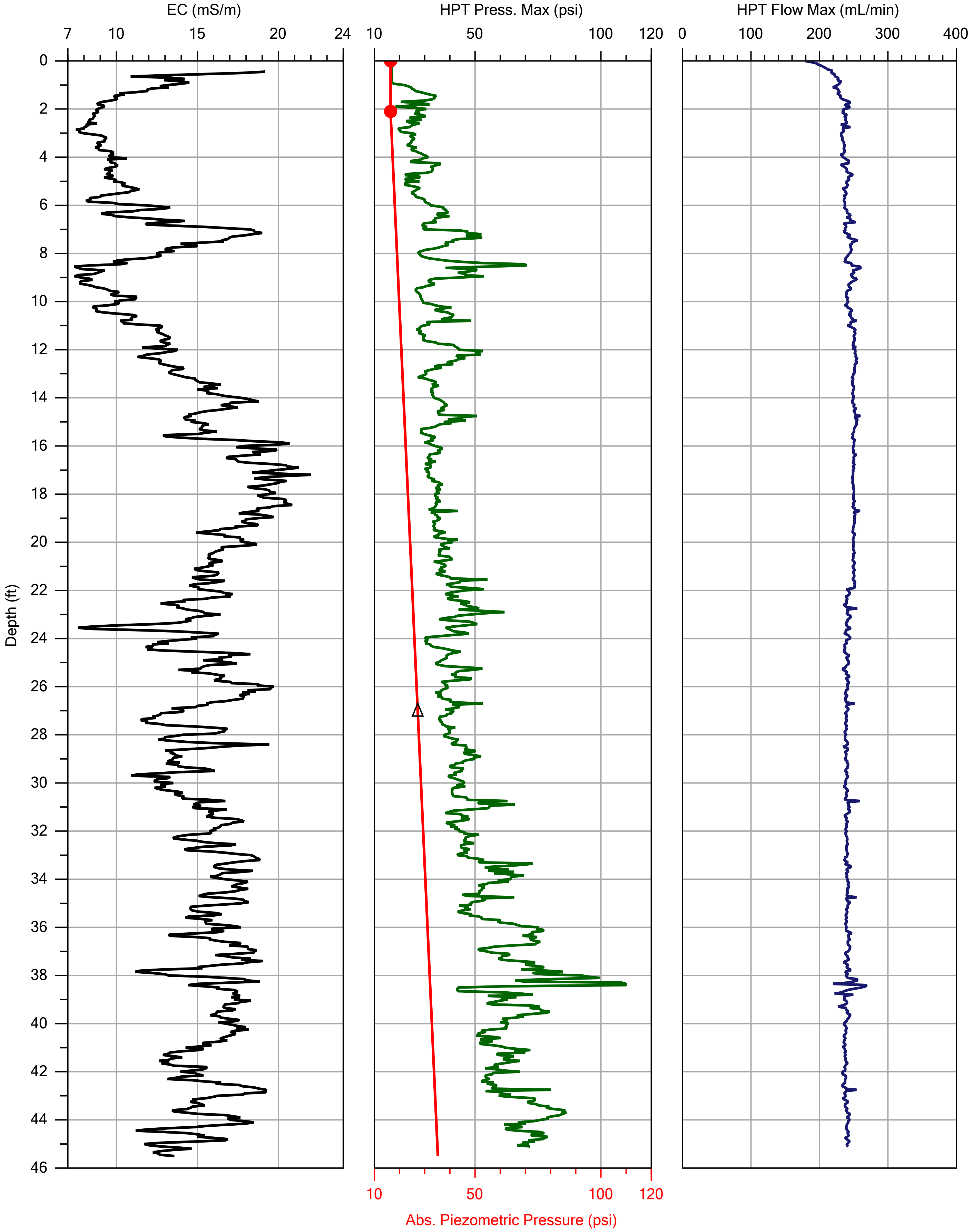

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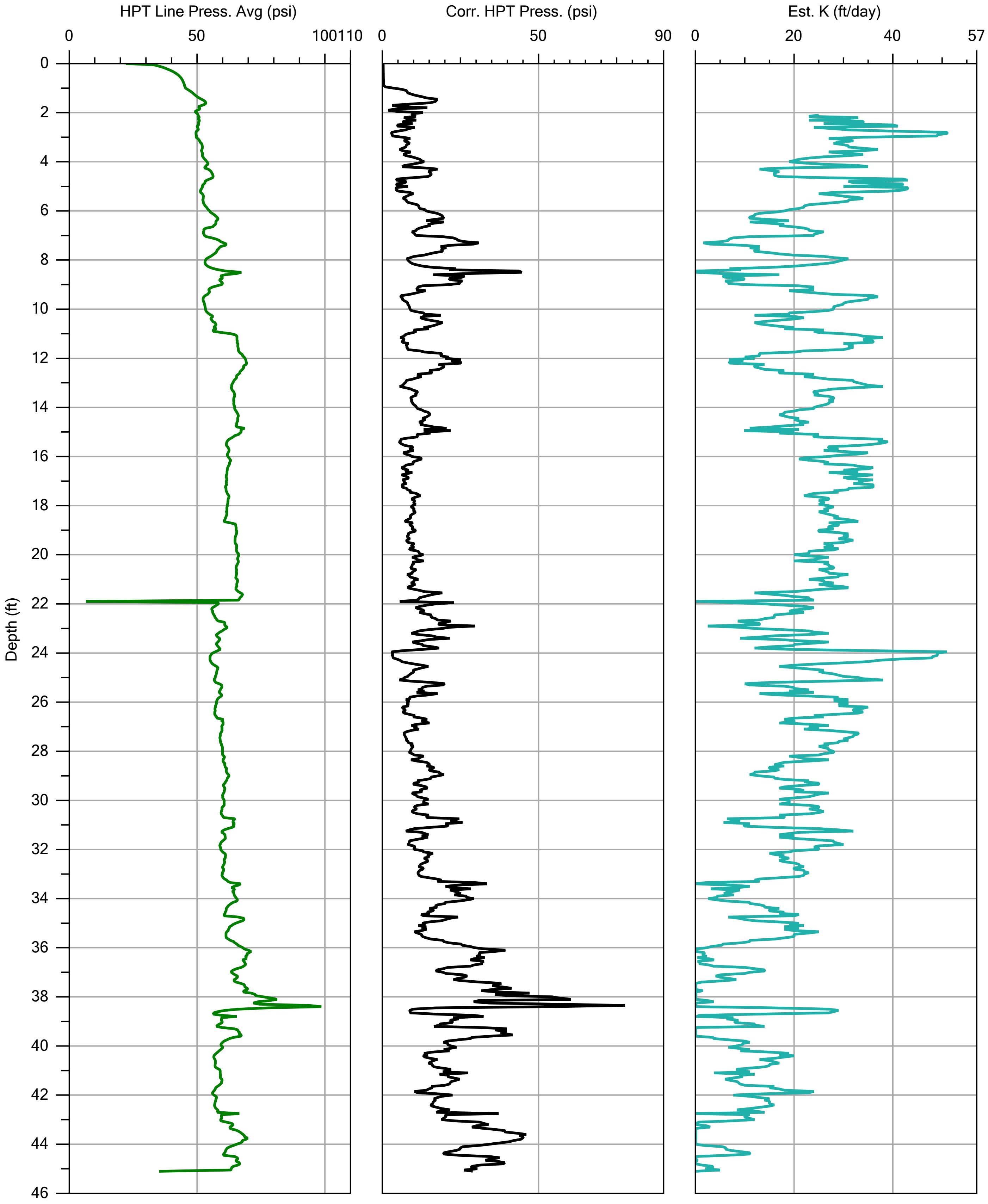

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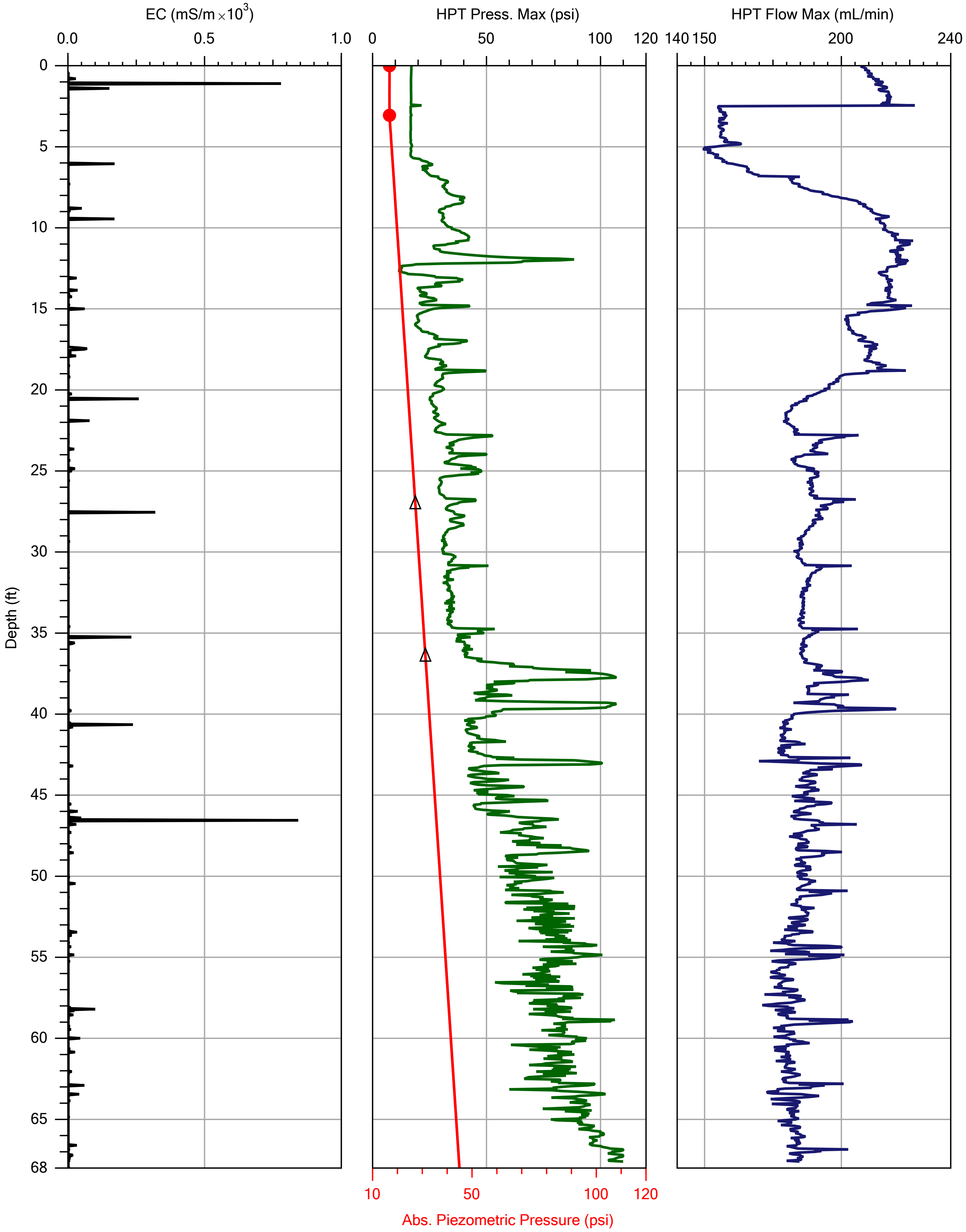

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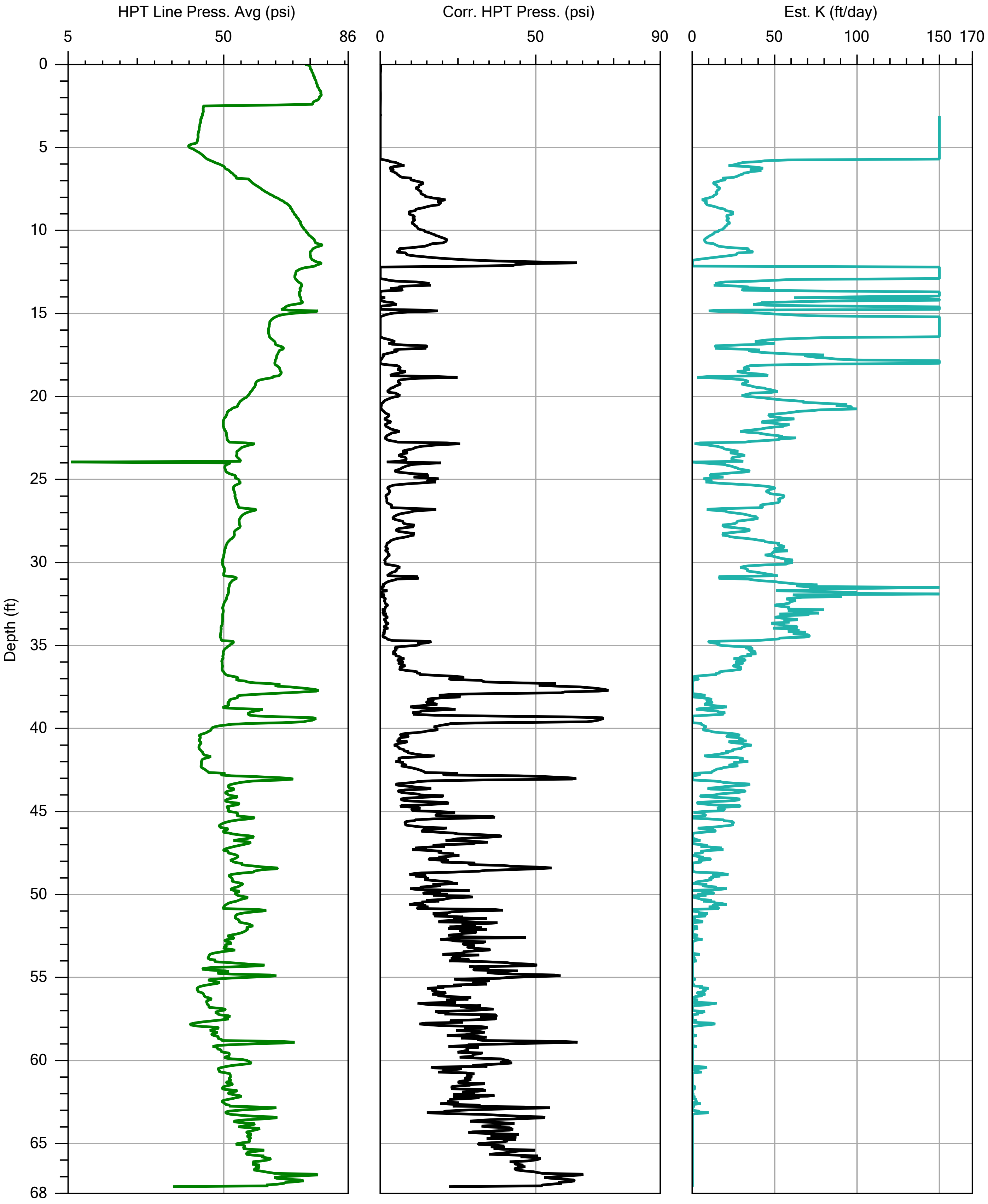

		File: DPT-34.HPT
Company: Cascade Technical Services	Operator: EO	Date: 11/9/2016
Project ID: 301.16.9002	Client: AECOM	Location:

Appendix B
Soil Boring Logs

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Bay Head Rd	Site: Annex	**Hole ID:** DPT-16-15
Project Number: 60444465	Northing:	Total Depth (feet): 25'
Drilling Contractor: Cascade	Easting:	Date / Time Started: 11/21/16 1240
Driller: J. Segreaves	Elevation (feet MSL): Ground:	Date / Time Finished: 11/21/16 1258
Drilling Equipment: Geoprobe 7822DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches):	Weather/Comments:	

Depth (feet)	USCS Description	Log		Samples					Well Diagram	Remarks (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
	See DPT-16-29 lithology				DP			1240		
						①				
5					DP			1242		
						②				
10					DP			1246		
						③				moist
								1250		Collect: DPT-16-15-SO-14-15 1 X 250ml poly
15										

Tracking Codes: 10/19/12, 12:21

USCS Name, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominently coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color**. **Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominently fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**

S# = Sample Number, SD = Sample Depth, ST = Sample Time, A = Analysis.

BZ = Breathing Zone, BG = Background, BH = Borehole, CB = Cuttings Bin

Boring Log
(Continued)

Sheet 2 of 2

Project Name:	Site:	Hole ID: DPT-16-15

Depth (feet)	USCS Description	Log		Samples					Well Diagram	Remarks (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
					DP	④		1253		Increased water noted - will screen 18-22' bgs. collect: DPT-16-15-GW-18-22 @ 1330 2 X 250ml poly unpreserved for PFOA/PFOS/PFBS
20					DP	⑤		1258		
25										DPT-16-15-GW-31-35 @1400
30										

Tracking Codes: 10/19/12, 12:20

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Bay Head Rd	Site: Annapolis	**Hole ID:** DPT-16-19
Project Number: 60444465	Northing:	Total Depth (feet): 20
Drilling Contractor: Cascade	Easting:	Date / Time Started: 11/22/16 1115
Driller: J. Segraves	Elevation (feet MSL): Ground:	Date / Time Finished: 11/22/16
Drilling Equipment: Geoprobe 7822DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches):	Weather/Comments:	

Depth (feet)	USCS Description	Log		Samples					Well Diagram	Remarks (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
					DP			1115		
	As DPT-16-35, rare (<5%) ash or cinder fragments 0-1' bgs									Collect: DPT-16-19-SO-00-01 1 x 250 ml poly PFOA/PFOS/PFBS @1120
						①				
								1120		
5					DP					
	LEAN CLAY WITH SAND					②				
								1123		
10					DP					
						③				
	SANDY SILT							1126		
15										

Tracking Codes: 10/19/12, 12:21

USCS Name, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominently coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color**. **Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominantly fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**
S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.
BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name:		Site:							Hole ID: DPT-16-19	
Depth (feet)	USCS Description	Log		Samples					Well Diagram	Remarks (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
					DP	④		1130		Collect; DPT-16-19-SO-17-18 1 x 250ml poly
20	TD: 20' bgs									
25										
30										

Tracking Codes: 10/19/12, 12:20

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: FBHRA-Annapolis	Site: CTA	**Hole ID:** DPT-16-20
Project Number: 60444465	*Northing:*	Total Depth (feet): 20
Drilling Contractor: Cascade	*Easting:*	Date / Time Started: 11/15/16 0915
Driller: J. Segreaves	Elevation (feet MSL): *Ground:*	Date / Time Finished: 11/15/16 0943
Drilling Equipment: Geoprobe 7822DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches):	Weather/Comments: partly cloudy 55°	

Depth (feet)	USCS Description	Log		Samples					Well Diagram	Remarks (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
	SILT WITH SAND, loose, dry, yellowish red (5YR 4/6) roots upper 0.4', non-cohesive 15% fine sand				DP			0915		
				3.4 / 5.0		①				
	increasing sand to 25%, slightly cohesive							0918		
5					DP					
	LEAN CLAY WITH SAND, soft, dry strong brown (7.5YR 4/6)			3.1 / 5.0		②				
	SILT, med-stiff, dry, brownish yellow (10YR 6/6), low plasticity, micaceous							0921		
10					DP					
	grading to LEAN CLAY, increased plasticity to medium									
				4.0 / 5.0		③				
	SILT WITH SAND, soft, dry, strong brown (7.5YR 4/6) low plasticity 20% fine sand.							0930		
15										

Tracking Codes: 10/19/12, 12:21

<u>USCS Name</u>, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominently coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color**. **Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominently fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**
S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.
BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name: BHRA Annapolis

Site: CTA

Hole ID: DPT-16-20

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted / Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
	SILTY SAND, loose, slightly moist, dark yellowish brown (10YR 4/6) 20% fines, poorly graded fine sand SANDY SILT, medium stiff, dry, reddish brown (5YR 4/4), 35% fine sand			5.0 / 5.0	DP	④		0943		Collect: DPT-16-20-SO-16-17 + DUP PFCs, 2x250ml poly @0945 DPT-16-20-GW-16-20 PFCs, 2x250ml poly @ 1030
20	TD: 20' bgs									DPT-16-20-GW-~~31-35~~ 26-30 MG 2x250ml poly PFCs @ 1105
25										DPT-SO-EB-111516 @ 1100 from acetate liner
30										

RESOLUTION
CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Bay Head Rd Annex	Site:	**Hole ID:** DPT-17-26
Project Number: 60444465	*Northing:*	Total Depth (feet): 25.0'
Drilling Contractor: Cascade	*Easting:*	Date / Time Started: 01/12/17 1010
Driller: J. Segreaves	Elevation (feet MSL): *Ground:*	Date / Time Finished: / 1030
Drilling Equipment: Geoprobe 6620DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches): 2	Weather/Comments:	

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
	SILT, medium stiff, dry				DP	①		1010 1012		DPT-17-26-50-00-01 2X 4oz poly jar @ 1035 PFOA PFOS PFBS
5	SILT WITH SAND, medium stiff, dry, strong brown, 25% fine sand					②		1016		
10	↓					③		1021		DPT-17-26-50-12-13 @ 1050
15										

Tracking Codes: 10/19/12, 12:21

USCS Name, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominently coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color**. **Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominently fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**
S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.
BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

Boring Log (Continued)

Sheet 2 of 2

Project Name:	Site:	**Hole ID:** DPT-17-26

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
					DP	④	NA			
20						⑤		1030		
25										
30										

Tracking Codes: 10/19/12, 12:20

Form: 00-BLANK LOG

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Bay Head Rd Annex	Site:	**Hole ID:** DPT-17-27
Project Number: 60444465	*Northing:*	Total Depth (feet): 25.0'
Drilling Contractor: Cascade	*Easting:*	Date / Time Started:
Driller: J. Segreaves	Elevation (feet MSL): *Ground:*	~~Date / Time Finished:~~ 01/12/17 0935
Drilling Equipment: Geoprobe 6620DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed: 0956
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches): 2	Weather/Comments:	

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted / Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
	SILT, medium stiff, dry 5% fine sand				DP		NA	0935		DPT-17-27-SO-00-01 1 x 4oz poly jar PFOA PFOS PFBS @ 0940
				3.5 / 5.0		①				
								0938		
5										
	SANDY SILT, dense, dry									
				3.0 / 5.0		②				
								0942		
10										
				3.2 / 5.0		③				DPT-17-27-SO-13-14 @ 1000
								0946		
15										

Tracking Codes: 10/19/12, 12:21

USCS Name, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominantly coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color**. **Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominantly fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominantly coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**

S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.
BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name: Former Bay Head Rd Annex

Site:

Hole ID: DPT-17-27

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted / Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
				3.3 / 5.0		④				
20										
				3.3 / 5.0		⑤				
								0956		
25										
30										

Tracking Codes: 10/19/12, 12:20

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Big Bend Rd Annex	Site:	**Hole ID:** DPT-16-28
Project Number: 60444465	*Northing:*	Total Depth (feet):
Drilling Contractor: Cascade	*Easting:*	Date / Time Started: 11/21/16 1145
Driller: J. Segreaves	Elevation (feet MSL): *Ground:*	Date / Time Finished: 11/21/16 1205
Drilling Equipment: Geoprobe 7822DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches):	Weather/Comments:	

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
0	See DPT-16-29 lithology				DP	①		1145		
5					DP	②		1148		
10					DP	③		1150		
15								1154		Collect: DPT-16-28-SO-14-15

USCS Name, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominently coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color**. **Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominently fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**

S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.

BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name:	Site:	**Hole ID:** DPT-16-28

Depth (feet)	USCS Description	Log		Samples					Well Diagram	Remarks (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
					DP	④		1200		
20					DP	⑤		1205		
25										
30										

Tracking Codes: 10/19/12, 12:20

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Bay Head Rd Annex	Site: (CTA)	**Hole ID:** DPT-16-29
Project Number: 60444465	Northing:	Total Depth (feet): 20
Drilling Contractor: Cascade	Easting:	Date / Time Started: 11/18/16 1258
Driller: J. Segreaves	Elevation (feet MSL): Ground:	Date / Time Finished: 11/18/16 1322
Drilling Equipment: Geoprobe 7822DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches):	Weather/Comments: sunny, 65°	

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted / Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
0	SILTY SAND, soft, dry, strong brown (7.5YR 4/6) 30% fines			2.0 / 5.0	DP	①		1258 1300		POOR RECOVERY
5	(7.5YR 5/6) cohesive micaceous LEAN CLAY, stiff, dry, dark yellowish brown (10YR 4/4) medium plasticity			4.4 / 5.0	DP	②		1313		
10	SANDY LEAN CLAY, med-stiff, dry, yellowish red (5YR 4/6) low plasticity 30% fine sand SILTY SAND, medium dense, dry, yellowish red			4.0 / 5.0	DP	③		1316		collect DPT-16-29-SO-14-15 + MS/MSD
15										

USCS Name, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominently coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color.** **Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominently fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**

S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.

BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

Tracking Codes: 10/19/12, 12:21

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name: Former Bay Head Rd Annex Site: (CTA)

Hole ID: DPT-16-29

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted / Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
					DP					
										WET
	POORLY GRADED SAND WITH SILT, medium dense, wet, dark yellowish brown (10YR 4/4) fine sand, 10% fines			4.2 / 5.0		④				Collect: DPT-16-29-GW-16-20 2X 250ml poly unpreserved
								1322		
20	TD: 20' bgs									Collect: DPT-16-29-GW-31-35 2X 250ml poly unpreserved PFOA/PFOS/PFBS 1505
25										
30										

Tracking Codes: 10/19/12, 12:20

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Bay Head Rd Annex - Annapolis	Site:	**Hole ID:** DPT-16-30
Project Number: 60444465	*Northing:*	Total Depth (feet):
Drilling Contractor: Cascade	*Easting:*	Date / Time Started: 11/21/16 1035
Driller: J. Segreares	Elevation (feet MSL): *Ground:*	Date / Time Finished: 1050
Drilling Equipment: Geoprobe 7822DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches):	Weather/Comments:	

Depth (feet)	USCS Description	Log		Samples					Well Diagram	Remarks (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
0–5	See DPT-16-32 lithology			3.3 / 5.0	DP	①		1035 1038		
5–10				3.5 / 5.0	DP	②		1042		
10–15				2.8 / 5.0	DP	③		1046		Collect: DPT-16-30-SO-14-15 1 X 250 ml poly

USCS Name, Consistency/Density (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominently coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color. Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominently fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**

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BZ = Breathing Zone, BG = Background, BH = Borehole, CB = Cuttings Bin

Tracking Codes: 10/19/12, 12:21

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name:

Site:

Hole ID: DPT-16-30

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
					DP					
				2.8 5.0		④				
								1050		
20										
25										
30										

Tracking Codes: 10/19/12, 12:20

Form: 00-BLANK LOG

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Bay Head Rd Site Annex		**Hole ID:** DPT-16-31
Project Number: 60444465	*Northing:*	Total Depth (feet):
Drilling Contractor: Cascade	*Easting:*	Date / Time Started: 11/21/16 1004
Driller: J. Segreaves	Elevation (feet MSL): *Ground:*	Date / Time Finished:
Drilling Equipment: Geoprobe 7822DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: MG	Checked By:
Borehole Diameter (inches):	Weather/Comments:	

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted / Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
	See DPT-16-32 lithology				DP			1004		
				2.7 / 5.0		1				
5								1008		
					DP					
				3.5 / 5.0		2				
10								1010		
					DP					
				3.3 / 5.0		3				
15								1012		Collect: DPT-16-31-SO-14-15

Tracking Codes: 10/19/12, 12:21

USCS Name, **Consistency/Density** (predominantly fine: very soft (n=0-1), soft (n=2-4), medium stiff (n=5-8), stiff (n=9-15), very stiff (n=16-30), hard (n=31+)/predominently coarse: very loose (n=0-4), loose (n=5-10), medium dense (n=11-30), dense (n=31-50), very dense (n=51+)). **Moisture**, (dry, moist, wet). **Color**. **Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominently fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**

S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.

BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name:				Site:				**Hole ID:** DPT-16-31		
Depth (feet)	**USCS Description**	**Log**		**Samples**					**Well Diagram**	**Remarks** (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
				4.0 5.0	DP	④		1015		
20										
25										
30										

Tracking Codes: 10/19/12, 12:20

Form: 00-BLANK LOG

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Bay Head Rd Annex
Site:
Hole ID: DPT-16-32
Project Number: 60444465
Northing:
Total Depth (feet): 20'
Drilling Contractor: Cascade
Easting:
Date / Time Started: 11/21/16 0925
Driller: J. Segrennes
Elevation (feet MSL): Ground:
Date / Time Finished: 11/21/16 0940
Drilling Equipment: Geoprobe 7822DT
▼ Water Depth During Drilling (feet bgs):
Date / Time Completed:
Drilling Method: DP
Logged By: M. Gliuski
Checked By:
Borehole Diameter (inches):
Weather/Comments:

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
	SILT WITH SAND, stiff, dry, dark yellowish brown (10YR 4/4) 20% fine sand				DP			0925		
				4.3/5.0		①				
	LEAN CLAY WITH SAND, stiff, dry, light yellowish brown (2.5Y 6/4), low plasticity 15% fine sand.							0928		
5					DP					
				3.4/5.0		②				
10	SILT WITH SAND, medium stiff dry, strong brown (7.5YR 4/6) 20% fine sand				DP			0932		
				3.1/5.0		③				
15								0936		Collect DPT-16-32-SO-14-15 1x 250ml poly

USCS Name, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominently coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color**. **Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominently fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**
S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.
BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

Tracking Codes: 10/19/12, 12:21

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name:	Site:	**Hole ID:** DPT-16-32

Depth (feet)	USCS Description	Log		Samples					Well Diagram	Remarks (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
	increasing sand to 25%, moist			4.0 5.0	DP	①		0940		
20										
25										
30										

Tracking Codes: 10/19/12, 12:20

Form: 00-BLANK LOG

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: BHRA Annapolis	Site: CTA	**Hole ID:** DPT-16-34
Project Number:	*Northing:*	Total Depth (feet): 25'
Drilling Contractor: Cascade	*Easting:*	Date / Time Started: 11/14/16 1314
Driller: J. Segreaves	Elevation (feet MSL): *Ground:*	Date / Time Finished: 11/14/16 1340
Drilling Equipment: Geoprobe 7822DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches):	Weather/Comments: cloudy 58°	

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted / Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
	SILTY SAND, loose, dry, strong brown (7.5YR 4/6), 25% fines 5% subangular gravel to 20mm				DP			1314		
	grading to SILT WITH SAND, 20% fine sand, cohesive			2.7 5.0		①				
								1316		
5					DP					
	SILT, medium stiff dry, dark yellowish brown (10YR 4/6)			2.8 5.0		②				
	grading to LEAN CLAY, low plasticity.							1319		
10	LEAN CLAY WITH SAND, stiff, dry, dark greenish gray (10Y 4/1), med. plasticity 15% fine sand			2.8 5.0	DP	③				
	SILT WITH SAND, med. stiff, dry strong brown (7.5YR 4/6)							1325		collect: DPT-16-34-SO-14-15
15										

USCS Name, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominently coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color. Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominently fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominently coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**

S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.

BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name: BHRA Annapolis			Site: CTA					Hole ID: DPT-16-34		
Depth (feet)	USCS Description	Log		Samples					Well Diagram	Remarks (list sample numbers here)
		Graphic	USCS or Rock Type	Attempted Recovered	Method	Run Number	PID/FID (ppm)	Time		
					DP					
	SILTY SAND, medium stiff, dry, light olive brown (2.5Y 5/6) 20% fines, cohesive			3.8 5.0		④		1334		
20	grading to SANDY SILT, stiff, moist, strong brown (7.5YR 4/6) with darker red laminations 1-2mm, cohesive			4.4 5.0		⑤		1340		
25	TD: 25' bgs									11/14 1430 collect DPT-16-34-GW-31-35 2X 250ml poly using check valve
30										

Tracking Codes: 10/19/12, 12:20

Form: 00-BLANK LOG

RESOLUTION CONSULTANTS

Boring Log

Sheet 1 of 2

Project Name: Former Bay Head Rd Annex	Site: - Annapolis	**Hole ID:** DPT-16-35
Project Number: 60444465	*Northing:*	Total Depth (feet): 24'
Drilling Contractor: Cascade	*Easting:*	Date / Time Started: 11/22/16 0920
Driller: J. Stgreaves	Elevation (feet MSL): *Ground:*	Date / Time Finished: 11/22/16 0943
Drilling Equipment: Geoprobe 7822DT	▼ Water Depth During Drilling (feet bgs):	Date / Time Completed:
Drilling Method: DP	Logged By: M. Glinski	Checked By:
Borehole Diameter (inches):	Weather/Comments: clear, 35°	

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
	SILT WITH SAND, stiff, dry, yellowish red (5YR 5/8), 20% fine sand				DP			0920		collect: DPT-16-35-SO-00-01 1 x 250 ml poly Unpreserved PFOA/PFOS/PFBS
						①				
5								0924		
	grading to LEAN CLAY WITH SAND, stiff, dry, yellowish red, low to medium plasticity, 20% fine sand.				DP					
						②				
10								0928		
	grading to yellowish brown (10YR 5/6)				DP					
						③				
	SANDY SILT, stiff, dry, 50% red (2.5YR 4/6), 50% light olive brown (2.5Y 5/3)							0931		
15										

Tracking Codes: 10/19/12, 12:21

<u>USCS Name</u>, **Consistency/Density** (predominantly fine: very soft {n=0-1}, soft {n=2-4}, medium stiff {n=5-8}, stiff {n=9-15}, very stiff {n=16-30}, hard {n=31+}/predominantly coarse: very loose {n=0-4}, loose {n=5-10}, medium dense {n=11-30}, dense {n=31-50}, very dense {n=51+}). **Moisture**, (dry, moist, wet). **Color. Gradation** (relative percentages of soil components). **Plasticity/Cohesiveness** (predominantly fine: nonplastic, slightly plastic, low plasticity, medium plasticity, high plasticity)/predominantly coarse: cohesionless, slightly cohesive, cohesive). **Stratification/Structure** (blocky, massive, lensed, etc) (contacts: sharp, gradational) (bedding: horizontal, inclined). **Cementation** (none, weak, moderate, strong). **Other descriptive elements; Geologic Origin**

S# = Sample Number, **SD** = Sample Depth, **ST** = Sample Time, **A** = Analysis.

BZ = Breathing Zone, **BG** = Background, **BH** = Borehole, **CB** = Cuttings Bin

RESOLUTION CONSULTANTS

Boring Log (Continued)

Sheet 2 of 2

Project Name: Former Bay Head Rd. Annex

Site: Annapolis

Hole ID: DPT-16-35

Depth (feet)	USCS Description	Log: Graphic	Log: USCS or Rock Type	Samples: Attempted Recovered	Samples: Method	Samples: Run Number	Samples: PID/FID (ppm)	Samples: Time	Well Diagram	Remarks (list sample numbers here)
					DP	4		0936		Collect DPT-16-35-SO-19-20 1x250ml poly
20					DP	5		0943		DPT-16-35-GW-21-25 2x 250ml poly @ 1010
	TD : 24' bgs									
25										DPT-16-35-GW-31-35 2x 250ml poly @ 1030
30										

Appendix C
Analytical Laboratory Reports (provided on DVD)

Appendix D
Data Validation Reports

Resolution Consultants
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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD
Laboratory:	Accutest Laboratories – Orlando, FL
Job Number:	FA38820
Analyses/Method:	Perfluorinated Compounds (PFCs) by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ EPA Method 537
Validation Level:	Limited
Resolution Consultants Project Number:	60444465-DM.DE
Prepared by:	Paula DiMattei/Resolution Consultants Completed on: 11/30/16
Reviewed by:	Robert Kennedy/Resolution Consultants Completed on: 12/01/16
File Name: FA38820_PFC memo.docx	

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 16, 2016.

Sample ID	Matrix/Sample Type
DW-16-01-111616	Drinking water
DW-16-01-111616-DUP	Field duplicate of DW-16-01-111616
DW-16-01-111616-FRB	Field reagent blank

Data validation activities were conducted with reference to:

- Accutest Laboratories SOP: Standard Operating Procedure for the Extraction of Perfluorinated Alkyl Acids from Potable and Finished Drinking Water Samples for LC/MS/MS Analysis; OP 064.2, Rev. Date: 09/16
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- The project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✓ Data completeness (chain-of-custody (COC)/sample integrity
✓ Holding times/sample preservation
✓ Initial calibration/initial and continuing calibration verification
✓ Laboratory method blanks/field reagent blanks
✓ Surrogate recoveries
✓ Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS) results
✓ Field duplicate results
✓ Internal standard results
✓ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An "NA" indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Qualification of the data was not required on the basis of this data review.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Field Reagent Blanks

Laboratory method blanks and field reagent blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blank or the field reagent blank associated with the samples in this data set.

Surrogate Recoveries

The surrogate recoveries (%Rs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

MS/MSD Results

The MS/MSD %Rs and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

LCS Results

The LCS %Rs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs are reviewed for conformance with the RESCON QC acceptance limit of ≤ 30% [if both results are greater than five times the LOQ] for aqueous matrices. Target compounds were not detected in either sample of the field duplicate pair. Precision is deemed acceptable.

Internal Standard Results

The internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the limit of quantitation (LOQ) but greater than the detection limit (DL) are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Qualification of the data was not required on this basis of this data review.

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD
Laboratory:	Accutest Laboratories – Orlando, FL
Job Number:	FA38917
Analyses/Method:	Perfluorinated Compounds (PFCs) by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ EPA Method 537
Validation Level:	Limited
Resolution Consultants Project Number:	60444465-DM.DE
Prepared by:	Paula DiMattei/Resolution Consultants Completed on: 11/30/16
Reviewed by:	Robert Kennedy/Resolution Consultants Completed on: 12/01/16

File Name: FA38820_PFC memo.docx

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 18, 2016.

Sample ID	Matrix/Sample Type
DW-16-02-111816	Drinking water
DW-16-02-111816-FRB	Field reagent blank

Data validation activities were conducted with reference to:

- Accutest Laboratories SOP: Standard Operating Procedure for the Extraction of Perfluorinated Alkyl Acids from Potable and Finished Drinking Water Samples for LC/MS/MS Analysis; OP 064.2, Rev. Date: 09/16
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- The project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD	
Laboratory:	TestAmerica-West Sacramento, CA	
Job Number:	320-23256-1	
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)	
Validation Level:	Limited	
Resolution Consultants Project Number:	60444465-DM.DE	
Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 12/05/16
Reviewed by:	Robert Kennedy/Resolution Consultants	Completed on: 12/05/16
File Name: J23256-1_PFC memo.docx		

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 2, 2016.

Sample ID	Matrix/Sample Type
DPT-16-15-SO-00-01	Soil
DPT-16-15-SO-00-01-DUP	Field duplicate of DPT-16-15-SO-00-01
DPT-16-20-S0-00-01	Soil
DPT-16-28-S0-00-01	Soil
DPT-16-29-S0-00-01	Soil
DPT-16-30-S0-00-01	Soil
DPT-16-31-S0-00-01	Soil
DPT-16-32-S0-00-01	Soil
DPT-16-34-S0-00-01	Soil
SWSD-16-03SD	Sediment
SWSD-16-04-SD	Sediment
SWSD-16-01-SD	Sediment
SWSD-16-02-SD	Sediment
SWSD-16-02-SD-DUP	Field duplicate of SWSD-16-02-SD
DPT-SO-EB-110216	Equipment blank
SD-EB-110216	Equipment blank

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✓ Data completeness (chain-of-custody (COC)/sample integrity
✓ Holding times/sample preservation
✓ Initial calibration/initial and continuing calibration verification
✓ Laboratory method blanks/equipment blanks
✓ Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓ Field duplicate results
✓ Labeled compound results
✓ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An "NA" indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Qualification of the data was not required on the basis of this data review.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.

- Completeness of analyses was verified by comparing the reported results to the COC requests.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blank or the equipment blank associated with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

LCS/LCSD Results

The LCS %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs are reviewed for conformance with the RESCON QC acceptance limit of $\leq$ 30% [if results are greater than five times the limit of quantitation (LOQ)] and $\leq$ 2x the LOQ [if results are less than five times the LOQ] for aqueous and solid matrices. All field duplicate precision criteria were met.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Qualification of the data was not required on this basis of this data review.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times/sample preservation
✓	Initial calibration/initial and continuing calibration verification
✓	Laboratory method blanks/field reagent blanks
✓	Surrogate recoveries
NA	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS) results
NA	Field duplicate results
✓	Internal standard results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An "NA" indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Qualification of the data was not required on the basis of this data review.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Field Reagent Blanks

Laboratory method blanks and field reagent blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blank or the field reagent blank associated with the sample in this data set.

Surrogate Recoveries

The surrogate recoveries (%Rs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

MS/MSD Results

MS/MSD analyses were not performed on a sample in this data set. Qualification of the data was not required.

LCS Results

The LCS %Rs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate samples were not submitted with this data set. Qualification of the data was not required.

Internal Standard Results

The internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the limit of quantitation (LOQ) but greater than the detection limit (DL) are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Qualification of the data was not required on this basis of this data review.

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD
Laboratory:	TestAmerica-West Sacramento, CA
Job Number:	320-23501-1
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)
Validation Level:	Limited
Resolution Consultants Project Number:	60444465-DM.DE
Prepared by:	Paula DiMattei/Resolution Consultants Completed on: 12/28/16
Reviewed by:	Robert Kennedy/Resolution Consultants Completed on: 12/28/16
File Name: J23501-1_PFC memo.docx	

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 11, 2016.

Sample ID	Matrix/Sample Type
DPT-16-02-GW-06-10	Groundwater
DPT-16-02-GW-06-10-DUP	Field duplicate of DPT-16-02-GW-06-10
DPT-16-02-GW-17-21	Groundwater

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD
Laboratory:	TestAmerica-West Sacramento, CA
Job Number:	320-23542-1
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)
Validation Level:	Limited
Resolution Consultants Project Number:	60444465-DM.DE
Prepared by:	Paula DiMattei/Resolution Consultants Completed on: 12/07/16
Reviewed by:	Robert Kennedy/Resolution Consultants Completed on: 12/19/16
File Name: J23542-1_PFC memo.docx	

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 14, 2016.

Sample ID	Matrix/Sample Type
DPT-16-01-GW-17-21	Groundwater
DPT-16-05-GW-17-21	Groundwater
DPT-16-34-GW-31-35	Groundwater
DPT-16-34-SO-14-15	Soil

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✗	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times/sample preservation
✓	Initial calibration/initial and continuing calibration verification
✓	Laboratory method blanks/equipment blanks
✗	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS) results
NA	Field duplicate results
✓	Labeled compound results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An "NA" indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The laboratory noted in the case narrative that all groundwater samples were decanted to new bottles prior to spiking and extraction because of the presence of excessive amounts of sediment present in the sample bottles. In these cases, the sample bottles are not rinsed as required by the method. Consequently, professional judgment was applied to qualify the positive results for all target compounds as estimated (J-) in these samples indicating a potential loss of target compounds that may have remained in the original sample bottle. Qualified sample results are presented in Table 1.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recovery (%R) and relative percent difference (RPD) results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met except for the nonconformances summarized below. Nonconformances are not noted below if qualification of the data was not required.

Sample ID	Compound	MS/MSD % R	QC Limits
DPT-16-05-GW-17-21	PFBS	161/ok	50-150
Sample ID	**Compound**	**MS/MSD % R**	**QC Limits**
DPT-16-34-SO-14-15	PFOA	179/198	60-140

The parent sample was qualified as follows: (based on NFG 2016)

Criteria	Actions[1]	
	Detected	Not detected
RPD >Upper Acceptance Limit	J	No qualification
%R >Upper Acceptance Limit	J+	No qualification
%R >10% but < Lower Acceptance Limit	J-	UJ
<10%	J-	R
[1]Professional judgment was used to include bias codes as applicable		

Qualified sample results are presented in Table 1.

LCS Results

The LCS %Rs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate samples were not submitted with this data set. Qualification of the data was not required on this basis.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met or qualification of the data was not required.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

It should be noted that the overall bias for a sample result is considered to be indeterminate in cases where the cumulative nonconformances do not show a consistent bias or in cases of the presence of a conflicting high and low bias.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Qualifier Codes and Explanations

Attachment B: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
DPT-16-01-GW-17-21	WG	Perfluorooctanoic Acid (PFOA)	0.062	0.0021	0.0026	µg/L	J-	si
DPT-16-01-GW-17-21	WG	Perfluorobutanesulfonic Acid (PFBS)	0.011	0.0021	0.0026	µg/L	J-	si
DPT-16-01-GW-17-21	WG	Perfluorooctanesulfonic Acid (PFOS)	0.98	0.031	0.042	µg/L	J-	si
DPT-16-05-GW-17-21	WG	Perfluorooctanoic Acid (PFOA)	0.19	0.0019	0.0024	µg/L	J-	si
DPT-16-05-GW-17-21	WG	Perfluorobutanesulfonic Acid (PFBS)	0.050	0.0019	0.0024	µg/L	J	m,si
DPT-16-05-GW-17-21	WG	Perfluorooctanesulfonic Acid (PFOS)	2.8	0.29	0.39	µg/L	J-	si
DPT-16-34-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.12	0.0020	0.0025	µg/L	J-	si
DPT-16-34-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	1.4	0.030	0.039	µg/L	J-	si
DPT-16-34-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	1.0	0.020	0.025	µg/L	J-	si
DPT-16-34-SO-14-15	SO	Perfluorooctanoic Acid (PFOA)	3.2	0.37	0.62	µg/Kg	J+	m

Attachment A

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased high.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased low.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment B

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Labeled compound recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
si	Sample integrity issue
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✗	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times/sample preservation
✓	Initial calibration/initial and continuing calibration verification
✓	Laboratory method blanks/equipment blanks
NA	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓	Field duplicate results
✓	Labeled compound results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An "NA" indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The laboratory noted in the case narrative that all groundwater samples were decanted to new bottles prior to spiking and extraction because of the presence of excessive amounts of sediment present in the sample bottles. In these cases, the sample bottles are not rinsed as required by the method. It was also noted that during sample preparation, the samples turned cloudy white after concentrating the extracts and then adding 400 µl of methanol. Consequently, professional judgment was applied to qualify the positive results for all target compounds in these samples as estimated (J-) indicating a potential loss of target compounds that may have remained in the original sample bottle or might have been impacted during the extract concentration steps. Qualified sample results are presented in Table 1.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met or qualification of the data was not required.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blank associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

MS/MSD analyses were not performed on a sample from this data set. The data were not qualified on this basis.

LCS/LCSD Results

The LCS percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs are reviewed for conformance with the RESCON QC acceptance limit of $\leq$ 30% [if results are greater than five times the limit of quantitation (LOQ)] and $\leq$ 2x the LOQ [if results are less than five times the LOQ] for aqueous matrices. All field duplicate precision criteria were met.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Qualifier Codes and Explanations

Attachment B: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
DPT-16-02-GW-06-10	WG	Perfluorooctanesulfonic Acid (PFOS)	0.12	0.0029	0.0039	µg/L	J-	si
DPT-16-02-GW-06-10	WG	Perfluorooctanoic Acid (PFOA)	0.033	0.0019	0.0024	µg/L	J-	si
DPT-16-02-GW-06-10	WG	Perfluorobutanesulfonic Acid (PFBS)	0.0061	0.0019	0.0024	µg/L	J-	si
DPT-16-02-GW-06-10-DUP	WG	Perfluorooctanesulfonic Acid (PFOS)	0.12	0.0029	0.0039	µg/L	J-	si
DPT-16-02-GW-06-10-DUP	WG	Perfluorooctanoic Acid (PFOA)	0.028	0.0019	0.0024	µg/L	J-	si
DPT-16-02-GW-06-10-DUP	WG	Perfluorobutanesulfonic Acid (PFBS)	0.0059	0.0019	0.0024	µg/L	J-	si
DPT-16-02-GW-17-21	WG	Perfluorooctanesulfonic Acid (PFOS)	0.21	0.0030	0.0039	µg/L	J-	si
DPT-16-02-GW-17-21	WG	Perfluorooctanoic Acid (PFOA)	0.036	0.0020	0.0025	µg/L	J-	si
DPT-16-02-GW-17-21	WG	Perfluorobutanesulfonic Acid (PFBS)	0.0099	0.0020	0.0025	µg/L	J-	si

Attachment A

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased high.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased low.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment B

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Labeled compound recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
si	Sample integrity issue
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD
Laboratory:	TestAmerica-West Sacramento, CA
Job Number:	320-23651-1
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)
Validation Level:	Limited
Resolution Consultants Project Number:	60444465-DM.DE
Prepared by:	Paula DiMattei/Resolution Consultants Completed on: 12/08/16
Reviewed by:	Robert Kennedy/Resolution Consultants Completed on: 12/19/16

File Name: J23651-1_PFC memo.docx

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 14-16, 2016.

Sample ID	Matrix/Sample Type
DPT-16-20-GW-16-20	Groundwater
DPT-16-20-GW-26-30	Groundwater
DPT-16-20-SO-16-17	Soil
DPT-16-20-SO-16-17-DUP	Field duplicate of DPT-16-20-SO-16-17
DPT-16-26-GW-18-22	Groundwater
DPT-16-26-GW-29-33	Groundwater
DPT-16-26-GW-29-33-DUP	Field duplicate of DPT-16-26-GW-29-33
DPT-16-27-GW-18-22	Groundwater
DPT-16-27-GW-29-33	Groundwater
DPT-16-34-GW-16-20	Groundwater
DPT-SO-EB-111516	Equipment blank

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);

Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD
Laboratory:	TestAmerica-West Sacramento, CA
Job Number:	320-23718-1
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)
Validation Level:	Limited
Resolution Consultants Project Number:	60444465-DM.DE
Prepared by:	Paula DiMattei/Resolution Consultants Completed on: 12/13/16
Reviewed by:	Robert Kennedy/Resolution Consultants Completed on: 12/14/16

File Name: J23718-1_PFC memo.docx

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 17-18, 2016.

Sample ID	Matrix/Sample Type
DPT-16-17-GW-16-20	Groundwater
DPT-16-17-GW-31-35	Groundwater
DPT-16-29-GW-16-20	Groundwater
DPT-16-29-GW-31-35	Groundwater
DPT-16-29-SO-14-15	Soil

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times/sample preservation
✓	Initial calibration/initial and continuing calibration verification
✓	Laboratory method blanks/equipment blanks
✓	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
NA	Field duplicate results
✓	Labeled compound results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An "NA" indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Qualification of the data was not required.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

LCS/LCSD Results

The LCS/LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

A field duplicate pair was not submitted with this data set. Data were not qualified on this basis.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Qualification of the data was not required.

- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✗	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times/sample preservation
✓	Initial calibration/initial and continuing calibration verification
✓	Laboratory method blanks/equipment blanks
NA	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✗	Field duplicate results
✓	Labeled compound results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An “NA” indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The laboratory noted in the case narrative that all groundwater samples were decanted to new bottles prior to spiking and extraction because of the presence of excessive amounts of sediment present in the sample bottles. In these cases, the sample bottles are not rinsed as required by the method. Consequently, professional judgment was applied to qualify the positive and nondetect results for all target compounds in these samples as estimated (J-/UJ) indicating a potential loss of target compounds that may have remained in the original sample bottle. Qualified sample results are presented in Table 1.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blanks or equipment blank associated with the samples in this data set.

MS/MSD Results

MS/MSD analyses were not performed on a sample from this data set. The data were not qualified on this basis.

LCS/LCSD Results

The LCS percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs are reviewed for conformance with the RESCON QC acceptance limit of $\leq$ 30% [if results are greater than five times the limit of quantitation (LOQ)] and $\leq$ 2x the LOQ [if results are less than five times the LOQ] for aqueous matrices. All field duplicate precision criteria were met with the following exceptions.

Compound	LOQ	DPT-16-20-SO-16-17 (µg/Kg)	DPT-16-20-SO-16-17-DUP (µg/Kg)	RPD
PFOS	0.61	10	20	67

Compound	LOQ	DPT-16-26-GW-29-33 (µg/L)	DPT-16-26-GW-29-33-DUP (µg/L)	RPD
PFOS	0.0040	0.080	0.053	41

Data qualification was as follows:

Actions: (Resolution Consultants professional judgment was used)

Criteria		Action	
		Detected	**Nondetected**
Sample and duplicate are nondetect results	RPD Not calculable (NC)	No	No qualification
Sample and duplicate results ≥5xLOQ	RPD >30 (aqueous and solids)	J	Not Applicable
Sample and duplicate results <5xLOQ	Absolute difference ≤ 2x LOQ (aqueous and solids)	J	Not Applicable
If sample or duplicate result is >5x LOQ and the other is not detected	NC	J	UJ

Qualified sample results are shown in Table 1.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

It should be noted that the overall bias for a sample result is considered to be indeterminate in cases where the cumulative nonconformances do not show a consistent bias or in cases of the presence of a conflicting high and low bias.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Qualifier Codes and Explanations

Attachment B: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
DPT-16-20-GW-16-20	WG	Perfluorooctanesulfonic Acid (PFOS)	0.66	0.030	0.040	µg/L	J-	si
DPT-16-20-GW-16-20	WG	Perfluorooctanoic Acid (PFOA)	0.15	0.020	0.025	µg/L	J-	si
DPT-16-20-GW-16-20	WG	Perfluorobutanesulfonic Acid (PFBS)	0.017	0.020	0.025	µg/L	J-	si
DPT-16-20-GW-26-30	WG	Perfluorooctanesulfonic Acid (PFOS)	6.8	0.30	0.40	µg/L	J-	si
DPT-16-20-GW-26-30	WG	Perfluorooctanoic Acid (PFOA)	1.0	0.20	0.25	µg/L	J-	si
DPT-16-20-GW-26-30	WG	Perfluorobutanesulfonic Acid (PFBS)		0.20	0.25	µg/L	UJ	si
DPT-16-20-SO-16-17	SO	Perfluorooctanesulfonic Acid (PFOS)	10	0.37	0.61	µg/Kg	J	fd
DPT-16-20-SO-16-17-DUP	SO	Perfluorooctanesulfonic Acid (PFOS)	20	0.36	0.59	µg/Kg	J	fd
DPT-16-26-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	0.038	0.0029	0.0039	µg/L	J-	si
DPT-16-26-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	0.0073	0.0020	0.0025	µg/L	J-	si
DPT-16-26-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.0010	0.0020	0.0025	µg/L	J-	si
DPT-16-26-GW-29-33	WG	Perfluorooctanesulfonic Acid (PFOS)	0.080	0.0030	0.0040	µg/L	J	fd,si
DPT-16-26-GW-29-33	WG	Perfluorooctanoic Acid (PFOA)	0.0050	0.0020	0.0025	µg/L	J-	si
DPT-16-26-GW-29-33	WG	Perfluorobutanesulfonic Acid (PFBS)	0.0010	0.0020	0.0025	µg/L	J-	si
DPT-16-26-GW-29-33-DUP	WG	Perfluorooctanesulfonic Acid (PFOS)	0.053	0.0030	0.0040	µg/L	J	fd,si
DPT-16-26-GW-29-33-DUP	WG	Perfluorooctanoic Acid (PFOA)	0.0031	0.0020	0.0025	µg/L	J-	si
DPT-16-26-GW-29-33-DUP	WG	Perfluorobutanesulfonic Acid (PFBS)		0.0020	0.0025	µg/L	UJ	si
DPT-16-27-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	0.026	0.0030	0.0040	µg/L	J-	si
DPT-16-27-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	0.0017	0.0020	0.0025	µg/L	J-	si
DPT-16-27-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)		0.0020	0.0025	µg/L	UJ	si
DPT-16-27-GW-29-33	WG	Perfluorooctanesulfonic Acid (PFOS)	0.015	0.0030	0.0040	µg/L	J-	si
DPT-16-27-GW-29-33	WG	Perfluorooctanoic Acid (PFOA)	0.0022	0.0020	0.0025	µg/L	J-	si
DPT-16-27-GW-29-33	WG	Perfluorobutanesulfonic Acid (PFBS)		0.0020	0.0025	µg/L	UJ	si
DPT-16-34-GW-16-20	WG	Perfluorooctanesulfonic Acid (PFOS)	1.6	0.030	0.039	µg/L	J-	si
DPT-16-34-GW-16-20	WG	Perfluorooctanoic Acid (PFOA)	0.40	0.020	0.025	µg/L	J-	si
DPT-16-34-GW-16-20	WG	Perfluorobutanesulfonic Acid (PFBS)	0.028	0.020	0.025	µg/L	J-	si

Attachment A

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased high.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased low.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment B

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Labeled compound recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
si	Sample integrity issue
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

RESOLUTION CONSULTANTS

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD
Laboratory:	TestAmerica-West Sacramento, CA
Job Number:	320-23783-1
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)
Validation Level:	Limited
Resolution Consultants Project Number:	60444465-DM.DE
Prepared by:	Paula DiMattei/Resolution Consultants Completed on: 12/13/16
Reviewed by:	Robert Kennedy/Resolution Consultants Completed on: 12/13/16

File Name: J23783-1_PFC memo.docx

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 21-22, 2016.

Sample ID	Matrix/Sample Type
DPT-16-15-GW-18-22	Groundwater
DPT-16-15-GW-31-35	Groundwater
DPT-16-15-SO-14-15	Soil
DPT-16-19-SO-00-01	Soil
DPT-16-19-SO-17-18	Soil
DPT-16-28-SO-14-15	Soil
DPT-16-30-SO-14-15	Soil
DPT-16-31-SO-14-15	Soil
DPT-16-32-SO-14-15	Soil
DPT-16-35-GW-21-25	Groundwater
DPT-16-35-GW-31-35	Groundwater
DPT-16-35-SO-00-01	Soil
DPT-16-35-SO-19-20	Soil

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD	
Laboratory:	TestAmerica-West Sacramento, CA	
Job Number:	320-23830-1	
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)	
Validation Level:	Limited	
Resolution Consultants Project Number:	60444465-DM.DE	
Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 12/28/16
Reviewed by:	Robert Kennedy /Resolution Consultants	Completed on: 12/28/16
File Name: J23830-1_PFC memo.docx		

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 23, 2016.

Sample ID	Matrix/Sample Type
DPT-16-18-GW-21-25	Groundwater
DPT-16-18-GW-31-35	Groundwater
DPT-16-18-GW-31-35-DUP	Field duplicate of DPT-16-18-GW-31-35
DPT-16-19-GW-21-25	Groundwater
DPT-16-19-GW-31-35	Groundwater
DPT-16-23-GW-21-25	Groundwater
DPT-16-23-GW-31-35	Groundwater
DPT-GW-EB-112316	Equipment blank

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✓ Data completeness (chain-of-custody (COC)/sample integrity
✓ Holding times/sample preservation
✓ Initial calibration/initial and continuing calibration verification
✓ Laboratory method blanks/equipment blanks
✓ Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓ Field duplicate results
✓ Labeled compound results
✓ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An "NA" indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Qualification of the data was not required on the basis of this data review.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blank or the equipment blank associated with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met or qualification of the data was not required.

LCS/LCSD Results

The LCS %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs are reviewed for conformance with the RESCON QC acceptance limit of $\leq$ 30% [if results are greater than five times the limit of quantitation (LOQ)] and $\leq$ 2x the LOQ [if results are less than five times the LOQ] for aqueous and solid matrices. All field duplicate precision criteria were met.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Qualification of the data was not required on this basis of this data review.

- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✗	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times/sample preservation
✓	Initial calibration/initial and continuing calibration verification
✓	Laboratory method blanks/equipment blanks
NA	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
NA	Field duplicate results
✗	Labeled compound results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An “NA” indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The laboratory noted that the sample container label for sample 320-23783-10 identified the sample as DPT-16-**22**-SO-14-15 while the COC identified this sample as DPT-16-**28**-SO-14-15. The sample ID listed on the COC was used to identify this sample.

The laboratory noted in the case narrative that all groundwater samples were decanted to new bottles prior to spiking and extraction because of the presence of excessive amounts of sediment present in the sample bottles. In these cases, the sample bottles are not rinsed as required by the method. Consequently, professional judgment was applied to qualify the positive results for all target compounds in these samples as estimated (J-) indicating a potential loss of target compounds that may have remained in the original sample bottle. Qualified sample results are presented in Table 1.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met or qualification of the data was not required.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

MS/MSD analyses were not performed on a sample from this data set. The data were not qualified on this basis.

LCS/LCSD Results

The LCS/LCSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

A field duplicate pair was not submitted with this data set. Data were not qualified on this basis.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met except for the labeled compound results summarized below.

Sample ID	Labeled Compound	% Recovery	QC Limits
DPT-16-15-GW-31-35	$13C_4$-PFOA	22	25-150

Samples were qualified as follows:

Actions: (Based on NFG 2011)

Criteria	Actions	
	Detected	Not detected
%R > Upper Acceptance Limit	J	UJ
%R >10% but < Lower Acceptance Limit	J	UJ
%R <10%	See below	
<10% and S/N >10:1	J	R
<10% and S/N <10:1	R	R

Qualified sample results are presented in Table 1.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Qualifier Codes and Explanations

Attachment B: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
DPT-16-15-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	12	0.30	0.40	µg/L	J-	si
DPT-16-15-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	15	0.20	0.25	µg/L	J-	si
DPT-16-15-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.54	0.20	0.25	µg/L	J-	si
DPT-16-15-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.27	0.0020	0.0025	µg/L	J	lc,si
DPT-16-15-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.048	0.0020	0.0025	µg/L	J-	si
DPT-16-15-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	0.45	0.031	0.041	µg/L	J-	si
DPT-16-35-GW-21-25	WG	Perfluorobutanesulfonic Acid (PFBS)	0.28	0.0020	0.0025	µg/L	J-	si
DPT-16-35-GW-21-25	WG	Perfluorooctanesulfonic Acid (PFOS)	2.4	0.030	0.040	µg/L	J-	si
DPT-16-35-GW-21-25	WG	Perfluorooctanoic Acid (PFOA)	0.76	0.020	0.025	µg/L	J-	si
DPT-16-35-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	0.80	0.030	0.040	µg/L	J-	si
DPT-16-35-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	1.4	0.020	0.025	µg/L	J-	si
DPT-16-35-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.38	0.020	0.025	µg/L	J-	si

Attachment A

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased high.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased low.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment B

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Labeled compound recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
si	Sample integrity issue
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD	
Laboratory:	TestAmerica-West Sacramento, CA	
Job Number:	320-23890-1	
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)	
Validation Level:	Limited	
Resolution Consultants Project Number:	60444465-DM.DE	
Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 12/22/16
Reviewed by:	Robert Kennedy/Resolution Consultants	Completed on: 12/22/16
File Name: J23890-1_PFC memo.docx		

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 28-29, 2016.

Sample ID	Matrix/Sample Type
DPT-16-13-GW-18-22	Groundwater
DPT-16-13-GW-31-35	Groundwater
DPT-16-21-GW-19-23	Groundwater
DPT-16-21-GW-31-35	Groundwater
DPT-16-30-GW-18-22	Groundwater
DPT-16-30-GW-31-35	Groundwater
DPT-16-31-GW-19-23	Groundwater
DPT-16-31-GW-31-35	Groundwater
DPT-16-32-GW-19-23	Groundwater
DPT-16-32-GW-31-35	Groundwater

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD	
Laboratory:	TestAmerica-West Sacramento, CA	
Job Number:	320-23998-1	
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)	
Validation Level:	Limited	
Resolution Consultants Project Number:	60444465-DM.DE	
Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 1/9/2017
Reviewed by:	Robert Kennedy/Resolution Consultants	Completed on: 1/9/2017
File Name: J23998-1_PFC memo.docx		

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on November 30, 2016 and December 1, 2016.

Sample ID	Matrix/Sample Type
DPT-16-03-GW-18-22	Groundwater
DPT-16-03-GW-31-35	Groundwater
DPT-16-04-GW-18-22	Groundwater
DPT-16-04-GW-31-35	Groundwater
DPT-16-06-GW-18-22	Groundwater
DPT-16-06-GW-31-35	Groundwater
DPT-16-07-GW-18-22	Groundwater
DPT-16-07-GW-31-35	Groundwater
DPT-16-08-GW-18-22	Groundwater
DPT-16-08-GW-31-35	Groundwater
DPT-16-09-GW-18-22	Groundwater
DPT-16-09-GW-31-35	Groundwater
DPT-16-10-GW-18-22	Groundwater
DPT-16-10-GW-31-35	Groundwater
DPT-16-11-GW-18-22	Groundwater
DPT-16-11-GW-31-35	Groundwater
DPT-16-11-GW-31-35-DUP	Field Duplicate of DPT-16-11-GW-31-35

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✗ Data completeness (chain-of-custody (COC)/sample integrity
✓ Holding times/sample preservation
✓ Initial calibration/initial and continuing calibration verification
✓ Laboratory method blanks/equipment blanks
✓ Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓ Field duplicate results
✓ Labeled compound results
✓ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An “NA” indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.

- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The laboratory noted in the case narrative that all groundwater samples were decanted to new bottles prior to spiking and extraction because of the excessive amounts of sediment present in the sample bottles. In these cases, the sample bottles are not rinsed as required by the method. Consequently, professional judgment was applied to qualify the positive and nondetect results for all target compounds in these samples as estimated (J-/UJ) indicating a potential loss of target compounds that may have remained in the original sample bottle. Qualified sample results are presented in Table 1.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met or qualification of the data was not required.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met or qualification of the data was not required.

LCS/LCSD Results

The LCS/LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs are reviewed for conformance with the RESCON QC acceptance limit of $\leq$ 30% [if results are greater than five times the limit of quantitation (LOQ)] and $\leq$ 2x the LOQ [if results are less than five times the LOQ] for aqueous and solid matrices. All field duplicate precision criteria were met.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met or qualification of the data was not required.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Qualifier Codes and Explanations

Attachment B: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
DPT-16-03-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	0.0071	0.0029	0.0039	µg/L	J-	si
DPT-16-03-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	0.00092	0.0019	0.0024	µg/L	J-	si
DPT-16-03-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)		0.0019	0.0024	µg/L	UJ	si
DPT-16-03-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	0.13	0.0030	0.0039	µg/L	J-	si
DPT-16-03-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.019	0.0020	0.0025	µg/L	J-	si
DPT-16-03-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)		0.0020	0.0025	µg/L	UJ	si
DPT-16-04-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	0.027	0.0029	0.0039	µg/L	J-	si
DPT-16-04-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	0.0027	0.0020	0.0025	µg/L	J-	si
DPT-16-04-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)		0.0020	0.0025	µg/L	UJ	si
DPT-16-04-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	0.0016	0.0030	0.0040	µg/L	J-	si
DPT-16-04-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)		0.0020	0.0025	µg/L	UJ	si
DPT-16-04-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)		0.0020	0.0025	µg/L	UJ	si
DPT-16-06-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.20	0.0019	0.0024	µg/L	J-	si
DPT-16-06-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	2.8	0.029	0.039	µg/L	J-	si
DPT-16-06-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	1.9	0.019	0.024	µg/L	J-	si
DPT-16-06-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	2.7	0.031	0.041	µg/L	J-	si
DPT-16-06-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	1.6	0.021	0.026	µg/L	J-	si
DPT-16-06-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.28	0.021	0.026	µg/L	J-	si
DPT-16-07-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	0.37	0.0020	0.0025	µg/L	J-	si
DPT-16-07-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.17	0.0020	0.0025	µg/L	J-	si
DPT-16-07-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	1.9	0.030	0.040	µg/L	J-	si
DPT-16-07-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.18	0.0020	0.0025	µg/L	J-	si
DPT-16-07-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	3.1	0.030	0.040	µg/L	J-	si
DPT-16-07-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	1.2	0.020	0.025	µg/L	J-	si
DPT-16-08-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	0.038	0.0030	0.0040	µg/L	J-	si
DPT-16-08-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	0.0075	0.0020	0.0025	µg/L	J-	si
DPT-16-08-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.0030	0.0020	0.0025	µg/L	J-	si
DPT-16-08-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	0.022	0.0029	0.0039	µg/L	J-	si
DPT-16-08-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.0045	0.0019	0.0024	µg/L	J-	si
DPT-16-08-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.0056	0.0019	0.0024	µg/L	J-	si
DPT-16-09-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	0.019	0.0029	0.0039	µg/L	J-	si
DPT-16-09-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	0.0045	0.0019	0.0024	µg/L	J-	si
DPT-16-09-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.0043	0.0019	0.0024	µg/L	J-	si
DPT-16-09-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	0.017	0.0029	0.0038	µg/L	J-	si
DPT-16-09-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.0021	0.0019	0.0024	µg/L	J-	si
DPT-16-09-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.0027	0.0019	0.0024	µg/L	J-	si
DPT-16-10-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	0.030	0.0029	0.0038	µg/L	J-	si
DPT-16-10-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	0.0062	0.0019	0.0024	µg/L	J-	si
DPT-16-10-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.010	0.0019	0.0024	µg/L	J-	si
DPT-16-10-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	0.11	0.0030	0.0040	µg/L	J-	si
DPT-16-10-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.014	0.0020	0.0025	µg/L	J-	si
DPT-16-10-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)		0.0020	0.0025	µg/L	UJ	si
DPT-16-11-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.18	0.0019	0.0024	µg/L	J-	si
DPT-16-11-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	6.0	0.29	0.38	µg/L	J-	si
DPT-16-11-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	2.0	0.19	0.24	µg/L	J-	si
DPT-16-11-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.33	0.0020	0.0025	µg/L	J-	si
DPT-16-11-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.080	0.0020	0.0025	µg/L	J-	si
DPT-16-11-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	0.86	0.030	0.040	µg/L	J-	si
DPT-16-11-GW-31-35-DUP	WG	Perfluorooctanoic Acid (PFOA)	0.33	0.0020	0.0025	µg/L	J-	si
DPT-16-11-GW-31-35-DUP	WG	Perfluorobutanesulfonic Acid (PFBS)	0.076	0.0020	0.0025	µg/L	J-	si
DPT-16-11-GW-31-35-DUP	WG	Perfluorooctanesulfonic Acid (PFOS)	0.88	0.029	0.039	µg/L	J-	si

Attachment A

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased high.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased low.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment B

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Labeled compound recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
si	Sample integrity issue
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✗	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times/sample preservation
✓	Initial calibration/initial and continuing calibration verification
✓	Laboratory method blanks/equipment blanks
NA	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
NA	Field duplicate results
✗	Labeled compound results
✗	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An “NA” indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The laboratory noted in the case narrative that all groundwater samples were decanted to new bottles prior to spiking and extraction because of the excessive amounts of sediment present in the sample bottles. In these cases, the sample bottles are not rinsed as required by the method. Consequently, professional judgment was applied to qualify the positive results for all target compounds in these samples as estimated

(J-) indicating a potential loss of target compounds that may have remained in the original sample bottle. Qualified sample results are presented in Table 1.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met or qualification of the data was not required.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

MS/MSD analyses were not performed on a sample from this data set. The data were not qualified on this basis.

LCS/LCSD Results

The LCS/LCSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

A field duplicate pair was not submitted with this data set. Data were not qualified on this basis.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met except for the labeled compound results summarized below.

Sample ID	Labeled Compound	% Recovery	QC Limits
DPT-16-30-GW-31-35 DL	$13C_4$-PFOA	163	25-150
DPt-16-31-GW-19-23 DL	18O2-PFHxS	154	25-150

Samples were qualified as follows:

Actions: (Based on NFG 2011)

Criteria	Actions	
	Detected	**Not detected**
%R > Upper Acceptance Limit	J	UJ
%R >10% but < Lower Acceptance Limit	J	UJ
%R <10%	See below	
<10% and S/N >10:1	J	R
<10% and S/N <10:1	R	R

Qualified sample results are presented in Table 1.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

Sample DPT-16-31-GW-19-23 was analyzed at a 100x dilution; however, PFOS still exceeded the calibration range. The PFOS in this sample did not saturate the instrument detector, therefore, the result was reported from the 100x dilution and was qualified as estimated (J) since the calibration range was exceeded. Qualified sample results are presented in Table 1.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Qualifier Codes and Explanations

Attachment B: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
DPT-16-13-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	14	0.15	0.20	µg/L	J-	si
DPT-16-13-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	7.0	0.099	0.12	µg/L	J-	si
DPT-16-13-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.91	0.099	0.12	µg/L	J-	si
DPT-16-13-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.31	0.0020	0.0025	µg/L	J-	si
DPT-16-13-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.060	0.0020	0.0025	µg/L	J-	si
DPT-16-13-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	0.62	0.031	0.041	µg/L	J-	si
DPT-16-21-GW-19-23	WG	Perfluorooctanesulfonic Acid (PFOS)	12	0.15	0.20	µg/L	J-	si
DPT-16-21-GW-19-23	WG	Perfluorooctanoic Acid (PFOA)	15	0.10	0.13	µg/L	J-	si
DPT-16-21-GW-19-23	WG	Perfluorobutanesulfonic Acid (PFBS)	1.1	0.10	0.13	µg/L	J-	si
DPT-16-21-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.16	0.0020	0.0025	µg/L	J-	si
DPT-16-21-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	3.2	0.031	0.041	µg/L	J-	si
DPT-16-21-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.74	0.020	0.025	µg/L	J-	si
DPT-16-30-GW-18-22	WG	Perfluorobutanesulfonic Acid (PFBS)	0.21	0.0021	0.0026	µg/L	J-	si
DPT-16-30-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)	6.6	0.078	0.10	µg/L	J-	si
DPT-16-30-GW-18-22	WG	Perfluorooctanoic Acid (PFOA)	1.4	0.052	0.065	µg/L	J-	si
DPT-16-30-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.31	0.0020	0.0025	µg/L	J-	si
DPT-16-30-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	11	0.15	0.20	µg/L	J-	si
DPT-16-30-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	1.4	0.10	0.13	µg/L	J	lc,si
DPT-16-31-GW-19-23	WG	Perfluorooctanesulfonic Acid (PFOS)	42	0.30	0.40	µg/L	J	si,q
DPT-16-31-GW-19-23	WG	Perfluorooctanoic Acid (PFOA)	28	0.20	0.25	µg/L	J-	si
DPT-16-31-GW-19-23	WG	Perfluorobutanesulfonic Acid (PFBS)	1.1	0.20	0.25	µg/L	J	lc,si
DPT-16-31-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.34	0.0021	0.0026	µg/L	J-	si
DPT-16-31-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.086	0.0021	0.0026	µg/L	J-	si
DPT-16-31-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	2.0	0.031	0.041	µg/L	J-	si
DPT-16-32-GW-19-23	WG	Perfluorobutanesulfonic Acid (PFBS)	0.14	0.0020	0.0025	µg/L	J-	si
DPT-16-32-GW-19-23	WG	Perfluorooctanesulfonic Acid (PFOS)	9.2	0.076	0.10	µg/L	J-	si
DPT-16-32-GW-19-23	WG	Perfluorooctanoic Acid (PFOA)	0.68	0.051	0.063	µg/L	J-	si
DPT-16-32-GW-31-35	WG	Perfluorobutanesulfonic Acid (PFBS)	0.12	0.0020	0.0026	µg/L	J-	si
DPT-16-32-GW-31-35	WG	Perfluorooctanesulfonic Acid (PFOS)	2.1	0.031	0.041	µg/L	J-	si
DPT-16-32-GW-31-35	WG	Perfluorooctanoic Acid (PFOA)	0.65	0.020	0.026	µg/L	J-	si

Attachment A

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased high.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased low.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment B

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Labeled compound recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
si	Sample integrity issue
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

RESOLUTION CONSULTANTS

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD
Laboratory:	TestAmerica-West Sacramento, CA
Job Number:	320-24060-1
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)
Validation Level:	Limited
Resolution Consultants Project Number:	60444465-DM.DE
Prepared by:	Paula DiMattei/Resolution Consultants Completed on: 1/5/2017
Reviewed by:	Robert Kennedy/Resolution Consultants Completed on: 1/6/2017

File Name: J24060-1_PFC memo.docx

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on December 5-6, 2016.

Sample ID	Matrix/Sample Type
DPT-16-12-GW-19-23	Groundwater
DPT-16-12-GW-31-35	Groundwater
DPT-16-14-GW-19-23	Groundwater
DPT-16-14-GW-31-35	Groundwater
DPT-16-16-GW-19-23	Groundwater
DPT-16-16-GW-31-35	Groundwater
DPT-16-22-GW-19-23	Groundwater
DPT-16-22-GW-31-35	Groundwater
DPT-16-22-GW-31-35-DUP	Field duplicate of DPT-16-22-GW-31-35
DPT-16-24-GW-21-25	Groundwater
DPT-16-24-GW-31-35	Groundwater
DPT-16-25-GW-19-23	Groundwater
DPT-16-25-GW-31-35	Groundwater
DPT-16-28-GW-19-23	Groundwater
DPT-16-28-GW-31-35	Groundwater
DPT-16-33-GW-19-23	Groundwater
DPT-16-33-GW-31-35	Groundwater
SW-16-01-SW	Surface Water
SW-16-02-SW	Surface Water

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Data Validation Report

Project: Former Bay Head Road Annex- Annapolis, MD

Laboratory: TestAmerica-West Sacramento, CA

Job Number: 320-24961-1

Analyses/Method: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)

Validation Level: Limited

Resolution Consultants Project Number: 60444465-DM.DE

Prepared by: Paula DiMattei/Resolution Consultants Completed on: 1/19/2017

Reviewed by: Robert Kennedy/Resolution Consultants Completed on:1 /19/2017

File Name: J24060-1_PFC memo.docx

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on December 5-6, 2016.

Sample ID	Matrix/Sample Type
DPT-17-26-GW-18-22	Groundwater
DPT-17-26-GW-29-33	Groundwater
DPT-17-27-GW-18-22	Groundwater
DPT-17-27-GW-29-33	Groundwater
DPT-GW-EB-26-22	Equipment blank
DPT-GW-EB-26-33	Equipment blank
DPT-GW-EB-27-22	Equipment blank
DPT-GW-EB-27-33	Equipment blank
DPT-TB-011117	Trip blank

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and

- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✓ Data completeness (chain-of-custody (COC)/sample integrity
✓ Holding times/sample preservation
✓ Initial calibration/initial and continuing calibration verification
✗ Laboratory method blanks/equipment blanks
NA Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
NA Field duplicate results
✓ Labeled compound results
✓ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An “NA” indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Select data points were qualified as negated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment rinsate blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Data validation qualifications for individual samples are based on the maximum contaminant concentration detected in all associated blanks. Blank contamination is not discussed if qualification of the data was not required. The following table summarizes the contamination detected and the associated samples.

Blank ID	Compound	Concentration (µg/L)	Associated Samples
DPT-GW-EB-26-22	PFOS	0.020	DPT-17-26-GW-18-22
DPT-GW-EB-26-33	PFOA	0.00090 J	DPT-17-26-GW-29-33
DPT-GW-EB-27-33	PFOS	0.0074	DPT-17-27-GW-29-33

Samples were qualified as follows:

Actions: Based on NFG 2016

Blank Result	Sample Result	Actions
<LOQ	Not detected	No qualification
	< LOQ	Qualify sample result as U at the LOQ
	≥ LOQ	Use professional judgment
≥LOQ	< LOQ	Qualify sample result as U at the LOQ
	≥ LOQ but <blank result	Qualify sample result as U at the result concentration.
	≥ LOQ but ≥blank result	Use professional judgment

Qualified sample results are presented in Table 1.

MS/MSD Results

MS/MSD analyses were not performed on a sample from this data set. The data were not qualified on this basis.

LCS/LCSD Results

The LCS/LCSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate samples were not submitted with this data set. The data were not qualified on this basis.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met or qualification of the data was not required.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Qualifier Codes and Explanations

Attachment B: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
DPT-17-26-GW-18-22	WG	Perfluorooctanesulfonic Acid (PFOS)		0.0083	0.0083	µg/L	U	be
DPT-17-26-GW-29-33	WG	Perfluorooctanoic Acid (PFOA)		0.0024	0.0024	µg/L	U	be
DPT-17-27-GW-29-33	WG	Perfluorooctanesulfonic Acid (PFOS)		0.0040	0.0040	µg/L	U	be

Attachment A

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased high.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased low.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment B

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Labeled compound recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
si	Sample integrity issue
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

Sample ID	Matrix/Sample Type
SW-16-02-SW-DUP	Field Duplicate of SW-16-02-SW

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times/sample preservation
✓	Initial calibration/initial and continuing calibration verification
✓	Laboratory method blanks/equipment blanks
NA	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓	Field duplicate results
✓	Labeled compound results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An “NA” indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Qualification of the data was not required.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All samples were extracted 4-5 days beyond the 7-day extraction holding time that is stipulated in the SAP. Professional judgment was used to take no actions due to the stability of the target compounds in aqueous samples and since the samples were extracted within the laboratory's current holding time criterion of 14-days from sample collection. The data are not adversely impacted.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory method blank associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

MS/MSD analyses were not performed on a sample from this data set. The data were not qualified on this basis.

LCS/LCSD Results

The LCS/LCSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs are reviewed for conformance with the RESCON QC acceptance limit of ≤ 30% [if results are greater than five times the limit of quantitation (LOQ)] and ≤ 2x the LOQ [if results are less than five times the LOQ] for aqueous and solid matrices. All field duplicate precision criteria were met.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met or qualification of the data was not required.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Qualification of the data was not required on the basis of this review.

RESOLUTION
CONSULTANTS

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD	
Laboratory:	TestAmerica-West Sacramento, CA	
Job Number:	320-24995-1	
Analyses/Method:	Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/ Revision 1.4 (August 2015)	
Validation Level:	Limited	
Resolution Consultants Project Number:	60444465-DM.DE	
Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 1/24/2017
Reviewed by:	Robert Kennedy/Resolution Consultants	Completed on: 1/25/2017

File Name: J24995-1_PFC memo.docx

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on January 12, 2017.

Sample ID	Matrix/Sample Type
DPT-SO-EB-26	Equipment blank
DPT-SO-EB-27	Equipment blank
DPT-17-27-SO-00-01	Soil
DPT-17-27-SO-13-14	Soil
DPT-17-26-SO-00-01	Soil
DPT-17-26-SO-12-13	Soil

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissues by Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)/Revision 1.4 (August 2015);
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (September 2016);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0 (DoD, July 2013); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

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Data Validation Report

Project:	Former Bay Head Road Annex- Annapolis, MD
Laboratory:	TestAmerica-West Sacramento, CA
Job Number:	320-38602
Analyses/Method:	Per- and Polyfluorinated Substances (PFAS) in Water, Soils, Sediments and Tissue [Method PFAS by LC//MS/MS Compliant with QSM 5.1 Table B-15]/Lab SOP No. WS-LC-0025, Rev 2.9 (11/22/2017)
Validation Level:	Limited
Resolution Consultants Project Number:	60444465-SA.DM
Prepared by:	Paula DiMattei/Resolution Consultants Completed on:5/29/2018
Reviewed by:	Robert Kennedy/Resolution Consultants Completed on: 5/29/2018

File Name: J38602 PFAS memo.docx

SUMMARY

The samples listed below were collected by Resolution Consultants from the Former Bay Head Road Annex site in Annapolis, MD on April 26, 2018.

Sample ID	Matrix/Sample Type
SWSD-18-01-SD	Sediment
SWSD-18-02-SD	Sediment
SWSD-18-03-SD	Sediment
SWSD-18-04-SD	Sediment
SWSD-18-05-SD	Sediment
SWSD-18-03-SD-DUP	Field duplicate of SWSD-18-03-SD
SD-EB 042618	Sediment Equipment blank
SWSD-18-01-SW	Surface water
SWSD-18-02-SW	Surface water
SWSD-18-03-SW	Surface water
SWSD-18-04-SW	Surface water
SWSD-18-05-SW	Surface water
SWSD-18-03-SW-DUP	Field duplicate of SWSD-18-03-SW

Data validation activities were conducted with reference to:

- TestAmerica-West Sacramento SOP: Per- and Polyfluorinated Substances (PFAS) in Water, Soils, Sediments and Tissue [Method PFAS by LC//MS/MS Compliant with QSM 5.1 Table B-15, Lab SOP No. WS-LC-0025, Rev 2.9 (11/22/2017);

- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (January 2017);
- USEPA Contract Laboratory Program National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016)
- Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017); and
- the project-specific Sampling and Analysis Plan.

In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✓ Data completeness (chain-of-custody (COC)/sample integrity
✓ Holding times/sample preservation
✓ Initial calibration/initial and continuing calibration verification
✗ Laboratory method blanks/equipment blanks
✗ Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS) results
✗ Field duplicate results
✗ Extracted internal standard results
✗ Injection internal standard results
✗ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An “NA” indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. It should be noted that the data were reviewed for compliance with the requirements listed in Table B-15 of the QSM 5.1. Select data points were qualified as estimated or negated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the quality control (QC) acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) QC acceptance criteria were met.

All QC acceptance criteria were met or qualification of the data was not required.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment rinsate blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Data validation qualifications for individual samples are based on the maximum contaminant concentration detected in all associated blanks. Blank contamination is not discussed if qualification of the data was not required. The following table summarizes the contamination detected and the associated samples.

Blank ID	Compound	Concentration (ng/L)	Associated Samples
MB 320-220815/1-A	PFOA	5.27	All aqueous samples

Samples were qualified as follows:

Actions: (Based on NFG 2017)

Blank Type	Blank Result	Sample Result	Action
Method or Field	Detect	Non-detect	No qualification
	< LOQ	< LOQ	Report at LOQ and qualify as non-detect (U)
		≥ LOQ	Use professional judgment
	≥ LOQ	< LOQ	Report at LOQ and qualify as non-detect (U)
		≥ LOQ but < Blank Result	Report at sample result and qualify as non-detect (U) or as unusable (R)
		≥ LOQ and ≥ Blank Result	Use professional judgment
	Gross contamination	Detect	Report at sample result and qualify as unusable (R)

Qualified sample results are presented in Table 1. Professional judgment was applied to take no actions in cases where the sample result for PFOA was greater than the LOQ and greater than the blank concentration.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. The following table summarizes the nonconformances.

Sample ID	Compound	MS %R	MSD %R	QC Limits
SWSD-18-03-SD	PFOS	ok	47	69-131
SWSD-10-03-SW	PFHpA	138	159	80-113

Samples were qualified as follows:

Actions: (Based on NFG 2017)

	MS/MSD %Rs			MS/MSD RPD
Qualify results	**<10% R**	**10%R to Lower Limit**	**>Upper Limit**	**> QC Limit**
Detected Results	J-	J-	J+	J
Non-Detected Results	R	UJ	Accept	Accept
Notes: Qualifications should be applied to the affected compound in the unspiked sample only unless all data appear to be impacted. If the sample result is > 4x the spike added concentration, no action is taken based on RESCON professional judgment. As noted in E.4 of the NFG, considerations include the actions noted above but are not limited to these actions. Therefore, RESCON professional judgment is applied to include bias codes.				

Qualified sample results are summarized in Table 1.

LCS Results

The LCS %Rs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs are reviewed for conformance with the Resolution Consultants' QC acceptance limit of ≤ 30% as stipulated in the project-specific SAP [if results are greater than five times the limit of quantitation (LOQ)] and ≤ 2x the LOQ [if results are less than five times the LOQ] for aqueous and solid matrices. The following table summarizes the nonconformances.

Compound	QL	SWSD-18-03-SW (ng/L)	SWSD-18-03-SW DUP (ng/L)	RPD
PFOS	40	400	550	32

Actions: (Based on RESCON professional judgment)

Criteria	RPD	Action	
		Detect	**Nondetect**
Sample and duplicate are nondetect results	Not calculable (NC)	No qualification	No qualification

Criteria	RPD	Action	
		Detect	Nondetect
Sample and duplicate results <LOQ	Not applicable	No qualification	No qualification
Sample and duplicate results ≥5xLOQ	>30% Aqueous >30% Solid	J	Not Applicable
Sample and duplicate results are >LOQ and <5xLOQ	Absolute difference is >2xLOQ	J	Not Applicable
If sample or duplicate result is >5xLOQ and the other is not detected	NC	J	UJ
If sample or duplicate result is <LOQ and the other is not detected	NC	No qualification	No qualification

Qualified sample results are summarized in Table 1.

Extracted Internal Standard Results

The extracted internal standard (IS) results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met except for the extracted IS results tabulated below.

Sample ID	Extracted IS	% Recovery	QC Limits	Associated Compounds
SWSD-18-05-SD	13C2-PFTeDA	41	50-150	PFTeDA
SWSD-18-04-SW	13C2-PFTeDA	39	50-150	PFTeDA
SWSD-18-05-SW	13C2-PFTeDA	42	50-150	PFTeDA

Samples were qualified as follows:

Actions: (based on NFG 2016):

Criteria	Actions[1]	
	Detected	Nondetected
%R > Upper Acceptance Limit	J	UJ
%R >10% but < Lower Acceptance Limit	J	UJ
%R <10%	See below	
<10% and S/N >10:1	J	R
<10% and S/N <10:1	R	R
[1] The PFAS method is performed using isotope dilution technique; therefore, professional judgment was applied and bias codes were not included in data qualification.		

Qualified sample results are summarized in Table 1.

Injection Internal Standard Results

The injection IS results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met except for the injection IS results tabulated below.

Sample ID	Injection IS	% Recovery	QC Limits	Affected Compounds
SWSD-18-02-SW DL	13C2-PFOA	10	50-150	PFOS, PFOA, PFHxS
SWSD-18-03-SW DL	13C2-PFOA	10	50-150	PFOS, PFHxA, PFOA, PFHxS
SWSD-18-04-SW DL	13C2-PFOA	22	50-150	PFHxS
SWSD-18-05-SW DL	13C2-PFOA	24	50-150	PFHxS
SWSD-18-03-SW-DUP DL	13C2-PFOA	11	50-150	PFOS, PFHxA, PFOA, PFHxS

In the absence of specified data validation guidance, professional judgment was applied to qualify the affected sample results tabulated above as estimated (J).

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

The percent solids data were reviewed to ensure that the NFG specified criteria of >30% were met. All percent solids criteria were met with the following exceptions: SWSD-18-03-SD (21.8%), SWSD-18-04-SD (23.6%), SWSD-18-05-SD (11.7%), SWSD-18-05-SD (11.7%), and SWSD-18-03-SD-DUP (19.5%).

Samples were qualified as follows:

Actions: (Based on NFG 2017)

Criteria	Action	
	Detects	Non-detects
%Solids < 10.0%	Use professional judgment	Use professional judgment
10.0% ≤%Solids < 30.0%	Use professional judgment	Use professional judgment

Professional judgment was applied to qualify the positive and nondetect results as estimated (UJ) when percent solids results were <30%. Qualified sample results are summarized in Table 1.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Qualifier Codes and Explanation
Attachment B: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-EB042618	WQ	Perfluorooctanoic Acid (PFOA)		3.8	1.7	ng/L	U	bl
SWSD-18-01-SD	SE	Perfluorooctanesulfonic Acid (PFOS)	12	1.1	2.1	µg/Kg	J	x
SWSD-18-01-SD	SE	Perfluoroundecanoic Acid (PFUnA)		0.43	0.64	µg/Kg	UJ	x
SWSD-18-01-SD	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		2.1	4.3	µg/Kg	UJ	x
SWSD-18-01-SD	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		2.1	4.3	µg/Kg	UJ	x
SWSD-18-01-SD	SE	Perfluorohexanoic Acid (PFHxA)		0.43	0.64	µg/Kg	UJ	x
SWSD-18-01-SD	SE	Perfluorododecanoic Acid (PFDoA)		0.43	0.64	µg/Kg	UJ	x
SWSD-18-01-SD	SE	Perfluorooctanoic Acid (PFOA)	1.2	0.43	0.64	µg/Kg	J	x
SWSD-18-01-SD	SE	Perfluorodecanoic Acid (PFDA)		0.43	0.64	µg/Kg	UJ	x
SWSD-18-01-SD	SE	Perfluorohexanesulfonic Acid (PFHxS)	6.3	0.43	0.64	µg/Kg	J	x
SWSD-18-01-SD	SE	Perfluorobutanesulfonic Acid (PFBS)		0.38	0.85	µg/Kg	UJ	x
SWSD-18-01-SD	SE	Perfluoroheptanoic Acid (PFHpA)		0.43	0.64	µg/Kg	UJ	x
SWSD-18-01-SD	SE	Perfluorononanoic Acid (PFNA)		0.43	0.64	µg/Kg	UJ	x
SWSD-18-01-SD	SE	Perfluorotetradecanoic Acid (PFTA)		0.64	0.85	µg/Kg	UJ	x
SWSD-18-01-SD	SE	Perfluorotridecanoic Acid (PFTrDA)		0.43	0.64	µg/Kg	UJ	x
SWSD-18-02-SD	SE	Perfluorooctanesulfonic Acid (PFOS)	44	1.7	3.3	µg/Kg	J	x
SWSD-18-02-SD	SE	Perfluoroundecanoic Acid (PFUnA)		0.66	0.99	µg/Kg	UJ	x
SWSD-18-02-SD	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		3.3	6.6	µg/Kg	UJ	x
SWSD-18-02-SD	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		3.3	6.6	µg/Kg	UJ	x
SWSD-18-02-SD	SE	Perfluorohexanoic Acid (PFHxA)	1.3	0.66	0.99	µg/Kg	J	x
SWSD-18-02-SD	SE	Perfluorododecanoic Acid (PFDoA)		0.66	0.99	µg/Kg	UJ	x
SWSD-18-02-SD	SE	Perfluorooctanoic Acid (PFOA)	3.7	0.66	0.99	µg/Kg	J	x
SWSD-18-02-SD	SE	Perfluorodecanoic Acid (PFDA)		0.66	0.99	µg/Kg	UJ	x
SWSD-18-02-SD	SE	Perfluorohexanesulfonic Acid (PFHxS)	10	0.66	0.99	µg/Kg	J	x
SWSD-18-02-SD	SE	Perfluorobutanesulfonic Acid (PFBS)		0.59	1.3	µg/Kg	UJ	x
SWSD-18-02-SD	SE	Perfluoroheptanoic Acid (PFHpA)	0.32	0.66	0.99	µg/Kg	J	x
SWSD-18-02-SD	SE	Perfluorononanoic Acid (PFNA)		0.66	0.99	µg/Kg	UJ	x
SWSD-18-02-SD	SE	Perfluorotetradecanoic Acid (PFTA)		0.99	1.3	µg/Kg	UJ	x
SWSD-18-02-SD	SE	Perfluorotridecanoic Acid (PFTrDA)		0.66	0.99	µg/Kg	UJ	x
SWSD-18-02-SW	WS	Perfluorooctanesulfonic Acid (PFOS)	660	30	40	ng/L	J	i
SWSD-18-02-SW	WS	Perfluorooctanoic Acid (PFOA)	430	15	20	ng/L	J	i
SWSD-18-02-SW	WS	Perfluorohexanesulfonic Acid (PFHxS)	1100	9.9	20	ng/L	J	i
SWSD-18-03-SD	SE	Perfluorooctanesulfonic Acid (PFOS)	31	2.3	4.6	µg/Kg	J	m,x
SWSD-18-03-SD	SE	Perfluoroundecanoic Acid (PFUnA)	0.70	0.92	1.4	µg/Kg	J	x
SWSD-18-03-SD	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		4.6	9.2	µg/Kg	UJ	x
SWSD-18-03-SD	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		4.6	9.2	µg/Kg	UJ	x
SWSD-18-03-SD	SE	Perfluorohexanoic Acid (PFHxA)	2.3	0.92	1.4	µg/Kg	J	x
SWSD-18-03-SD	SE	Perfluorododecanoic Acid (PFDoA)	0.46	0.92	1.4	µg/Kg	J	x
SWSD-18-03-SD	SE	Perfluorooctanoic Acid (PFOA)	3.7	0.92	1.4	µg/Kg	J	x
SWSD-18-03-SD	SE	Perfluorodecanoic Acid (PFDA)		0.92	1.4	µg/Kg	UJ	x
SWSD-18-03-SD	SE	Perfluorohexanesulfonic Acid (PFHxS)	17	0.92	1.4	µg/Kg	J	x
SWSD-18-03-SD	SE	Perfluorobutanesulfonic Acid (PFBS)	0.28	0.82	1.8	µg/Kg	J	x
SWSD-18-03-SD	SE	Perfluoroheptanoic Acid (PFHpA)		0.92	1.4	µg/Kg	UJ	x
SWSD-18-03-SD	SE	Perfluorononanoic Acid (PFNA)		0.92	1.4	µg/Kg	UJ	x
SWSD-18-03-SD	SE	Perfluorotetradecanoic Acid (PFTA)		1.4	1.8	µg/Kg	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SWSD-18-03-SD	SE	Perfluorotridecanoic Acid (PFTrDA)		0.92	1.4	µg/Kg	UJ	x
SWSD-18-03-SD-DUP	SE	Perfluorooctanesulfonic Acid (PFOS)	28	2.5	5.0	µg/Kg	J	x
SWSD-18-03-SD-DUP	SE	Perfluoroundecanoic Acid (PFUnA)	0.56	1.0	1.5	µg/Kg	J	x
SWSD-18-03-SD-DUP	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		5.0	10	µg/Kg	UJ	x
SWSD-18-03-SD-DUP	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		5.0	10	µg/Kg	UJ	x
SWSD-18-03-SD-DUP	SE	Perfluorohexanoic Acid (PFHxA)	2.3	1.0	1.5	µg/Kg	J	x
SWSD-18-03-SD-DUP	SE	Perfluorododecanoic Acid (PFDoA)		1.0	1.5	µg/Kg	UJ	x
SWSD-18-03-SD-DUP	SE	Perfluorooctanoic Acid (PFOA)	4.5	1.0	1.5	µg/Kg	J	x
SWSD-18-03-SD-DUP	SE	Perfluorodecanoic Acid (PFDA)		1.0	1.5	µg/Kg	UJ	x
SWSD-18-03-SD-DUP	SE	Perfluorohexanesulfonic Acid (PFHxS)	17	1.0	1.5	µg/Kg	J	x
SWSD-18-03-SD-DUP	SE	Perfluorobutanesulfonic Acid (PFBS)		0.91	2.0	µg/Kg	UJ	x
SWSD-18-03-SD-DUP	SE	Perfluoroheptanoic Acid (PFHpA)		1.0	1.5	µg/Kg	UJ	x
SWSD-18-03-SD-DUP	SE	Perfluorononanoic Acid (PFNA)		1.0	1.5	µg/Kg	UJ	x
SWSD-18-03-SD-DUP	SE	Perfluorotetradecanoic Acid (PFTA)		1.5	2.0	µg/Kg	UJ	x
SWSD-18-03-SD-DUP	SE	Perfluorotridecanoic Acid (PFTrDA)		1.0	1.5	µg/Kg	UJ	x
SWSD-18-03-SW	WS	Perfluoroheptanoic Acid (PFHpA)	43	1.5	2.0	ng/L	J+	m
SWSD-18-03-SW	WS	Perfluorooctanesulfonic Acid (PFOS)	400	30	40	ng/L	J	fd,i
SWSD-18-03-SW	WS	Perfluorohexanoic Acid (PFHxA)	520	9.9	20	ng/L	J	i
SWSD-18-03-SW	WS	Perfluorooctanoic Acid (PFOA)	490	15	20	ng/L	J	i
SWSD-18-03-SW	WS	Perfluorohexanesulfonic Acid (PFHxS)	1800	9.9	20	ng/L	J	i
SWSD-18-03-SW-DUP	WS	Perfluorooctanesulfonic Acid (PFOS)	550	29	39	ng/L	J	fd,i
SWSD-18-03-SW-DUP	WS	Perfluorohexanoic Acid (PFHxA)	520	9.8	20	ng/L	J	i
SWSD-18-03-SW-DUP	WS	Perfluorooctanoic Acid (PFOA)	530	15	20	ng/L	J	i
SWSD-18-03-SW-DUP	WS	Perfluorohexanesulfonic Acid (PFHxS)	1800	9.8	20	ng/L	J	i
SWSD-18-04-SD	SE	Perfluorooctanesulfonic Acid (PFOS)	19	2.1	4.2	µg/Kg	J	x
SWSD-18-04-SD	SE	Perfluoroundecanoic Acid (PFUnA)	1.4	0.84	1.3	µg/Kg	J	x
SWSD-18-04-SD	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		4.2	8.4	µg/Kg	UJ	x
SWSD-18-04-SD	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		4.2	8.4	µg/Kg	UJ	x
SWSD-18-04-SD	SE	Perfluorohexanoic Acid (PFHxA)	1.3	0.84	1.3	µg/Kg	J	x
SWSD-18-04-SD	SE	Perfluorododecanoic Acid (PFDoA)	0.54	0.84	1.3	µg/Kg	J	x
SWSD-18-04-SD	SE	Perfluorooctanoic Acid (PFOA)	2.4	0.84	1.3	µg/Kg	J	x
SWSD-18-04-SD	SE	Perfluorodecanoic Acid (PFDA)		0.84	1.3	µg/Kg	UJ	x
SWSD-18-04-SD	SE	Perfluorohexanesulfonic Acid (PFHxS)	18	0.84	1.3	µg/Kg	J	x
SWSD-18-04-SD	SE	Perfluorobutanesulfonic Acid (PFBS)		0.76	1.7	µg/Kg	UJ	x
SWSD-18-04-SD	SE	Perfluoroheptanoic Acid (PFHpA)		0.84	1.3	µg/Kg	UJ	x
SWSD-18-04-SD	SE	Perfluorononanoic Acid (PFNA)		0.84	1.3	µg/Kg	UJ	x
SWSD-18-04-SD	SE	Perfluorotetradecanoic Acid (PFTA)		1.3	1.7	µg/Kg	UJ	x
SWSD-18-04-SD	SE	Perfluorotridecanoic Acid (PFTrDA)	0.48	0.84	1.3	µg/Kg	J	x
SWSD-18-04-SW	WS	Perfluorotetradecanoic Acid (PFTA)		3.0	4.0	ng/L	UJ	lc
SWSD-18-04-SW	WS	Perfluorohexanesulfonic Acid (PFHxS)	940	5.1	10	ng/L	J	i
SWSD-18-05-SD	SE	Perfluorooctanesulfonic Acid (PFOS)	18	4.2	8.3	µg/Kg	J	x
SWSD-18-05-SD	SE	Perfluoroundecanoic Acid (PFUnA)	5.7	1.7	2.5	µg/Kg	J	x
SWSD-18-05-SD	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		8.3	17	µg/Kg	UJ	x
SWSD-18-05-SD	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		8.3	17	µg/Kg	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SWSD-18-05-SD	SE	Perfluorohexanoic Acid (PFHxA)		1.7	2.5	µg/Kg	UJ	x
SWSD-18-05-SD	SE	Perfluorododecanoic Acid (PFDoA)	1.8	1.7	2.5	µg/Kg	J	x
SWSD-18-05-SD	SE	Perfluorooctanoic Acid (PFOA)	1.2	1.7	2.5	µg/Kg	J	x
SWSD-18-05-SD	SE	Perfluorodecanoic Acid (PFDA)	1.6	1.7	2.5	µg/Kg	J	x
SWSD-18-05-SD	SE	Perfluorohexanesulfonic Acid (PFHxS)	4.8	1.7	2.5	µg/Kg	J	x
SWSD-18-05-SD	SE	Perfluorobutanesulfonic Acid (PFBS)		1.5	3.3	µg/Kg	UJ	x
SWSD-18-05-SD	SE	Perfluoroheptanoic Acid (PFHpA)		1.7	2.5	µg/Kg	UJ	x
SWSD-18-05-SD	SE	Perfluorononanoic Acid (PFNA)		1.7	2.5	µg/Kg	UJ	x
SWSD-18-05-SD	SE	Perfluorotetradecanoic Acid (PFTA)		2.5	3.3	µg/Kg	UJ	lc,x
SWSD-18-05-SD	SE	Perfluorotridecanoic Acid (PFTrDA)	1.2	1.7	2.5	µg/Kg	J	x
SWSD-18-05-SW	WS	Perfluorotetradecanoic Acid (PFTA)		3.0	4.0	ng/L	UJ	lc
SWSD-18-05-SW	WS	Perfluorohexanesulfonic Acid (PFHxS)	420	5.0	10	ng/L	J	i

Attachment A

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased high.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased low.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment B

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

REVIEW ELEMENTS

The data were evaluated based on the following review elements (where applicable to the method):

✓ Data completeness (chain-of-custody (COC)/sample integrity
✓ Holding times/sample preservation
✓ Initial calibration/initial and continuing calibration verification
✗ Laboratory method blanks/equipment blanks
✓ Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
NA Field duplicate results
✓ Labeled compound results
✓ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An "NA" indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as reported and may be used for decision making purposes. Select data points were qualified as negated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (chain-of-custody (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

Holding Times/Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD) or correlation coefficient (r) or coefficient of determination (r^2) method acceptance criteria were met;
- the initial calibration verification standard (ICV) percent recovery acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and method percent difference or percent drift (%D) criteria were met.

All QC acceptance criteria were met.

Laboratory Method Blanks/Equipment Blanks

Laboratory method blanks and equipment rinsate blanks are evaluated as to whether there are contaminants detected above the detection limit (DL). Data validation qualifications for individual samples are based on the maximum contaminant concentration detected in all associated blanks. Blank contamination is not discussed if qualification of the data was not required. The following table summarizes the contamination detected and the associated samples.

Blank ID	Compound	Concentration (µg/L)	Associated Samples
DPT-SO-EB-27	PFOS	0.0011 J	DPT-17-27-SO-00-01 DPT-17-27-SO-13-14

Samples were qualified as follows:

Actions: Based on NFG 2016

Blank Result	Sample Result	Actions
<LOQ	Not detected	No qualification
	< LOQ	Qualify sample result as U at the LOQ
	≥ LOQ	Use professional judgment
≥LOQ	< LOQ	Qualify sample result as U at the LOQ
	≥ LOQ but <blank result	Qualify sample result as U at the result concentration.
	≥ LOQ but ≥blank result	Use professional judgment

Qualified sample results are presented in Table 1.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

LCS/LCSD Results

The LCS/LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate samples were not submitted with this data set. The data were not qualified on this basis.

Labeled Compound Results

The labeled compound results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

If applicable, compounds detected at concentrations less than the LOQ but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Qualifier Codes and Explanations

Attachment B: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
DPT-17-27-SO-00-01	SO	Perfluorooctanesulfonic Acid (PFOS)		0.60	0.60	µg/Kg	U	be

Attachment A

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased high.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample and is potentially biased low.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment B

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Labeled compound recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
si	Sample integrity issue
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

RESOLUTION CONSULTANTS

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK08
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM

Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 01/22/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK08 PFAS 14 analytes memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 19, 2018 and November 20, 2018.

Sample ID	Matrix/Sample Type
SD-18-03-DUP	Field Duplicate of SD-18-03
SD-18-07-DUP	Field Duplicate of SD-18-07
SD-18-01	Sediment
SD-18-02	Sediment
SD-18-03	Sediment
SD-18-04	Sediment
SD-18-05	Sediment
SD-18-06	Sediment
SD-18-07	Sediment
SD-18-08	Sediment

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK10
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM
Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 01/24/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK10 PFAS 10 additional memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 19, 2018 and November 20, 2018.

Sample ID	Matrix/Sample Type
SD-18-03-DUP	Field Duplicate of SD-18-03
SD-18-07-DUP	Field Duplicate of SD-18-07
SD-18-01	Sediment
SD-18-02	Sediment
SD-18-03	Sediment
SD-18-04	Sediment
SD-18-05	Sediment
SD-18-06	Sediment
SD-18-07	Sediment
SD-18-08	Sediment

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Solids by Method 537 version 1.1 Modified Using LCS/MS/MS (2017);
- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓ Data completeness (chain-of-custody (COC)/sample integrity
✓ Holding times and sample preservation
✓ Initial calibration/continuing calibration verification
✓ Laboratory blanks/equipment blanks
✓ Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS) results
✓ Field duplicate results
✓ Extracted internal standard results
✓ Injection internal standard results
✗ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for 10 additional PFAS compounds not included in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

LCS Results

The LCS %Rs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of $\leq$ 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and $\leq$ 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

All field duplicate precision criteria were met.

Extracted Internal Standard Results

The extracted internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This “J” qualifier is retained during data validation.

Percent Solids

The percent solids data were reviewed to ensure that the NFG specified criteria were met.

Nonconformances are summarized in Attachment A in Table A-1. Samples were qualified as follows:

Actions: (Based on NFG 2017)

Criteria	**Action**	
	Detects	**Non-detects**
%Solids < 10.0%	Use professional judgment	Use professional judgment
10.0% ≤%Solids < 30.0%	Use professional judgment	Use professional judgment
%Solids ≥ 30.0%	No qualification	No qualification

Professional judgment was applied to qualify affected positive and nondetect results as estimated (J/UJ) with an indeterminate bias. Qualified sample results are summarized in Table 1.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-03	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		2.9	3.1	ng/g	UJ	x
SD-18-03	SE	6:2 Fluorotelomer Sulfonate		7.5	7.8	ng/g	UJ	x
SD-18-03	SE	8:2 Fluorotelomer Sulfonate		7.5	7.8	ng/g	UJ	x
SD-18-03	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		2.6	3.9	ng/g	UJ	x
SD-18-03	SE	Perfluoro-1-pentanesulfonate (PFPeS)		2.5	3.5	ng/g	UJ	x
SD-18-03	SE	Perfluorobutanoic Acid (PFBA)		2.7	3.1	ng/g	UJ	x
SD-18-03	SE	Perfluorodecanesulfonic Acid (PFDS)		7.8	9.8	ng/g	UJ	x
SD-18-03	SE	Perfluoroheptanesulfonic acid (PFHpS)		2.6	3.1	ng/g	UJ	x
SD-18-03	SE	Perfluorooctane Sulfonamide (PFOSA)		2.7	3.1	ng/g	UJ	x
SD-18-03	SE	Perfluoropentanoic Acid (PFPA)		2.7	3.1	ng/g	UJ	x
SD-18-03-DUP	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		2.8	3.0	ng/g	UJ	x
SD-18-03-DUP	SE	6:2 Fluorotelomer Sulfonate		7.0	7.4	ng/g	UJ	x
SD-18-03-DUP	SE	8:2 Fluorotelomer Sulfonate		7.0	7.4	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		2.4	3.7	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluoro-1-pentanesulfonate (PFPeS)		2.4	3.3	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluorobutanoic Acid (PFBA)		2.5	3.0	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluorodecanesulfonic Acid (PFDS)		7.4	9.2	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluoroheptanesulfonic acid (PFHpS)		2.4	3.0	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-03-DUP	SE	Perfluorooctane Sulfonamide (PFOSA)		2.5	3.0	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluoropentanoic Acid (PFPA)		2.5	3.0	ng/g	UJ	x
SD-18-04	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		4.7	5.0	ng/g	UJ	x
SD-18-04	SE	6:2 Fluorotelomer Sulfonate		12	12	ng/g	UJ	x
SD-18-04	SE	8:2 Fluorotelomer Sulfonate		12	12	ng/g	UJ	x
SD-18-04	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		4.0	6.2	ng/g	UJ	x
SD-18-04	SE	Perfluoro-1-pentanesulfonate (PFPeS)		4.0	5.6	ng/g	UJ	x
SD-18-04	SE	Perfluorobutanoic Acid (PFBA)		4.2	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluorodecanesulfonic Acid (PFDS)		12	16	ng/g	UJ	x
SD-18-04	SE	Perfluoroheptanesulfonic acid (PFHpS)		4.0	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluorooctane Sulfonamide (PFOSA)		4.2	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluoropentanoic Acid (PFPA)		4.2	5.0	ng/g	UJ	x
SD-18-05	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		3.8	4.0	ng/g	UJ	x
SD-18-05	SE	6:2 Fluorotelomer Sulfonate		9.5	10	ng/g	UJ	x
SD-18-05	SE	8:2 Fluorotelomer Sulfonate		9.5	10	ng/g	UJ	x
SD-18-05	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		3.3	5.0	ng/g	UJ	x
SD-18-05	SE	Perfluoro-1-pentanesulfonate (PFPeS)		3.2	4.5	ng/g	UJ	x
SD-18-05	SE	Perfluorobutanoic Acid (PFBA)		3.4	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluorodecanesulfonic Acid (PFDS)		10	13	ng/g	UJ	x
SD-18-05	SE	Perfluoroheptanesulfonic acid (PFHpS)		3.3	4.0	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-05	SE	Perfluorooctane Sulfonamide (PFOSA)		3.4	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluoropentanoic Acid (PFPA)		3.4	4.0	ng/g	UJ	x

Attachment A

Nonconformance Summary Tables

Table A-1 - Percent Solids

Sample ID	Percent Solids (%)	Status
SD-18-03	24.5	<30%
SD-18-03-DUP	25.5	<30%
SD-18-04	15.2	<30%
SD-18-05	18.1	<30%

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK11
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM

Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 01/24/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK11 PFAS additional memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 19, 2018 and November 20, 2018.

Sample ID	Matrix/Sample Type
SD-18-13-DUP	Field Duplicate of SD-18-13
SD-18-09	Sediment
SD-18-10	Sediment
SD-18-11	Sediment
SD-18-12	Sediment
SD-18-13	Sediment
SD-18-14	Sediment
SD-18-15	Sediment
SD-18-16	Sediment
SD-18-17	Sediment
SD-18-18	Sediment
SD-18-19	Sediment
SD-18-20	Sediment
SD-18-21	Sediment
SD-18-22	Sediment
SD-18-23	Sediment
SD-18-24	Sediment

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Solids by Method 537 version 1.1 Modified Using LCS/MS/MS (2017);
- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times and sample preservation
✓	Initial calibration/continuing calibration verification
✓	Laboratory blanks/equipment blanks
✓	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS) results
✓	Field duplicate results
✓	Extracted internal standard results
✓	Injection internal standard results
✗	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

<u>Data Completeness (COC)/Sample Integrity</u>

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for 10 additional PFAS compounds not included in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with QC acceptance criteria. All QC acceptance criteria were met.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

LCS Results

The LCS %Rs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of $\leq$ 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and $\leq$ 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

All field duplicate precision criteria were met.

Extracted Internal Standard Results

The extracted internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

Percent Solids

The percent solids data were reviewed to ensure that the NFG specified criteria were met.

Nonconformances are summarized in Attachment A in Table A-1. Samples were qualified as follows:

Actions: (Based on NFG 2017)

Criteria	**Action**	
	Detects	**Non-detects**
%Solids < 10.0%	Use professional judgment	Use professional judgment
10.0% ≤%Solids < 30.0%	Use professional judgment	Use professional judgment
%Solids ≥ 30.0%	No qualification	No qualification

Professional judgment was applied to qualify affected positive and nondetect results as estimated (J/UJ) with an indeterminate bias. Qualified sample results are summarized in Table 1.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-11	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		3.3	3.5	ng/g	UJ	x
SD-18-11	SE	6:2 Fluorotelomer Sulfonate		8.3	8.7	ng/g	UJ	x
SD-18-11	SE	8:2 Fluorotelomer Sulfonate		8.3	8.7	ng/g	UJ	x
SD-18-11	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		2.8	4.3	ng/g	UJ	x
SD-18-11	SE	Perfluoro-1-pentanesulfonate (PFPeS)		2.8	3.9	ng/g	UJ	x
SD-18-11	SE	Perfluorobutanoic Acid (PFBA)		3.0	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluorodecanesulfonic Acid (PFDS)		8.7	11	ng/g	UJ	x
SD-18-11	SE	Perfluoroheptanesulfonic acid (PFHpS)		2.8	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluorooctane Sulfonamide (PFOSA)		3.0	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluoropentanoic Acid (PFPA)		3.0	3.5	ng/g	UJ	x
SD-18-12	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		4.7	5.0	ng/g	UJ	x
SD-18-12	SE	6:2 Fluorotelomer Sulfonate		12	12	ng/g	UJ	x
SD-18-12	SE	8:2 Fluorotelomer Sulfonate		12	12	ng/g	UJ	x
SD-18-12	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		4.0	6.2	ng/g	UJ	x
SD-18-12	SE	Perfluoro-1-pentanesulfonate (PFPeS)		4.0	5.6	ng/g	UJ	x
SD-18-12	SE	Perfluorobutanoic Acid (PFBA)		4.2	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluorodecanesulfonic Acid (PFDS)		12	16	ng/g	UJ	x
SD-18-12	SE	Perfluoroheptanesulfonic acid (PFHpS)		4.0	5.0	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-12	SE	Perfluorooctane Sulfonamide (PFOSA)		4.2	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluoropentanoic Acid (PFPA)		4.2	5.0	ng/g	UJ	x
SD-18-13	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		3.0	3.2	ng/g	UJ	x
SD-18-13	SE	6:2 Fluorotelomer Sulfonate		7.6	8.1	ng/g	UJ	x
SD-18-13	SE	8:2 Fluorotelomer Sulfonate		7.6	8.1	ng/g	UJ	x
SD-18-13	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		2.6	4.0	ng/g	UJ	x
SD-18-13	SE	Perfluoro-1-pentanesulfonate (PFPeS)		2.6	3.6	ng/g	UJ	x
SD-18-13	SE	Perfluorobutanoic Acid (PFBA)		2.7	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluorodecanesulfonic Acid (PFDS)		8.1	10	ng/g	UJ	x
SD-18-13	SE	Perfluoroheptanesulfonic acid (PFHpS)		2.6	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluorooctane Sulfonamide (PFOSA)		2.7	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluoropentanoic Acid (PFPA)		2.7	3.2	ng/g	UJ	x
SD-18-13-DUP	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		3.1	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	6:2 Fluorotelomer Sulfonate		7.9	8.3	ng/g	UJ	x
SD-18-13-DUP	SE	8:2 Fluorotelomer Sulfonate		7.9	8.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		2.7	4.2	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluoro-1-pentanesulfonate (PFPeS)		2.7	3.7	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorobutanoic Acid (PFBA)		2.8	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorodecanesulfonic Acid (PFDS)		8.3	10	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluoroheptanesulfonic acid (PFHpS)		2.7	3.3	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-13-DUP	SE	Perfluorooctane Sulfonamide (PFOSA)		2.8	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluoropentanoic Acid (PFPA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		3.1	3.3	ng/g	UJ	x
SD-18-14	SE	6:2 Fluorotelomer Sulfonate		7.9	8.3	ng/g	UJ	x
SD-18-14	SE	8:2 Fluorotelomer Sulfonate		7.9	8.3	ng/g	UJ	x
SD-18-14	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		2.7	4.2	ng/g	UJ	x
SD-18-14	SE	Perfluoro-1-pentanesulfonate (PFPeS)		2.7	3.8	ng/g	UJ	x
SD-18-14	SE	Perfluorobutanoic Acid (PFBA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluorodecanesulfonic Acid (PFDS)		8.3	10	ng/g	UJ	x
SD-18-14	SE	Perfluoroheptanesulfonic acid (PFHpS)		2.7	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluorooctane Sulfonamide (PFOSA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluoropentanoic Acid (PFPA)		2.8	3.3	ng/g	UJ	x
SD-18-15	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		2.6	2.8	ng/g	UJ	x
SD-18-15	SE	6:2 Fluorotelomer Sulfonate		6.7	7.1	ng/g	UJ	x
SD-18-15	SE	8:2 Fluorotelomer Sulfonate		6.7	7.1	ng/g	UJ	x
SD-18-15	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		2.3	3.5	ng/g	UJ	x
SD-18-15	SE	Perfluoro-1-pentanesulfonate (PFPeS)		2.3	3.2	ng/g	UJ	x
SD-18-15	SE	Perfluorobutanoic Acid (PFBA)		2.4	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluorodecanesulfonic Acid (PFDS)		7.1	8.8	ng/g	UJ	x
SD-18-15	SE	Perfluoroheptanesulfonic acid (PFHpS)		2.3	2.8	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-15	SE	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluoropentanoic Acid (PFPA)		2.4	2.8	ng/g	UJ	x
SD-18-16	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		3.6	3.8	ng/g	UJ	x
SD-18-16	SE	6:2 Fluorotelomer Sulfonate		9.0	9.5	ng/g	UJ	x
SD-18-16	SE	8:2 Fluorotelomer Sulfonate		9.0	9.5	ng/g	UJ	x
SD-18-16	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		3.1	4.7	ng/g	UJ	x
SD-18-16	SE	Perfluoro-1-pentanesulfonate (PFPeS)		3.0	4.3	ng/g	UJ	x
SD-18-16	SE	Perfluorobutanoic Acid (PFBA)		3.2	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluorodecanesulfonic Acid (PFDS)		9.5	12	ng/g	UJ	x
SD-18-16	SE	Perfluoroheptanesulfonic acid (PFHpS)		3.1	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluorooctane Sulfonamide (PFOSA)		3.2	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluoropentanoic Acid (PFPA)		3.2	3.8	ng/g	UJ	x
SD-18-17	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		4.2	4.5	ng/g	UJ	x
SD-18-17	SE	6:2 Fluorotelomer Sulfonate		11	11	ng/g	UJ	x
SD-18-17	SE	8:2 Fluorotelomer Sulfonate		11	11	ng/g	UJ	x
SD-18-17	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		3.6	5.6	ng/g	UJ	x
SD-18-17	SE	Perfluoro-1-pentanesulfonate (PFPeS)		3.6	5.1	ng/g	UJ	x
SD-18-17	SE	Perfluorobutanoic Acid (PFBA)		3.8	4.5	ng/g	UJ	x
SD-18-17	SE	Perfluorodecanesulfonic Acid (PFDS)		11	14	ng/g	UJ	x
SD-18-17	SE	Perfluoroheptanesulfonic acid (PFHpS)		3.6	4.5	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-17	SE	Perfluorooctane Sulfonamide (PFOSA)		3.8	4.5	ng/g	UJ	x
SD-18-17	SE	Perfluoropentanoic Acid (PFPA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		4.2	4.5	ng/g	UJ	x
SD-18-21	SE	6:2 Fluorotelomer Sulfonate		11	11	ng/g	UJ	x
SD-18-21	SE	8:2 Fluorotelomer Sulfonate		11	11	ng/g	UJ	x
SD-18-21	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		3.6	5.6	ng/g	UJ	x
SD-18-21	SE	Perfluoro-1-pentanesulfonate (PFPeS)		3.6	5.0	ng/g	UJ	x
SD-18-21	SE	Perfluorobutanoic Acid (PFBA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluorodecanesulfonic Acid (PFDS)		11	14	ng/g	UJ	x
SD-18-21	SE	Perfluoroheptanesulfonic acid (PFHpS)		3.6	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluorooctane Sulfonamide (PFOSA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluoropentanoic Acid (PFPA)		3.8	4.5	ng/g	UJ	x
SD-18-22	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		5.2	5.5	ng/g	UJ	x
SD-18-22	SE	6:2 Fluorotelomer Sulfonate		13	14	ng/g	UJ	x
SD-18-22	SE	8:2 Fluorotelomer Sulfonate		13	14	ng/g	UJ	x
SD-18-22	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		4.5	6.9	ng/g	UJ	x
SD-18-22	SE	Perfluoro-1-pentanesulfonate (PFPeS)		4.4	6.2	ng/g	UJ	x
SD-18-22	SE	Perfluorobutanoic Acid (PFBA)		4.7	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluorodecanesulfonic Acid (PFDS)		14	17	ng/g	UJ	x
SD-18-22	SE	Perfluoroheptanesulfonic acid (PFHpS)		4.5	5.5	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-22	SE	Perfluorooctane Sulfonamide (PFOSA)		4.7	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluoropentanoic Acid (PFPA)		4.7	5.5	ng/g	UJ	x
SD-18-23	SE	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		5.8	6.2	ng/g	UJ	x
SD-18-23	SE	6:2 Fluorotelomer Sulfonate		15	15	ng/g	UJ	x
SD-18-23	SE	8:2 Fluorotelomer Sulfonate		15	15	ng/g	UJ	x
SD-18-23	SE	Perfluoro-1-nonanesulfonic acid (PFNS)		5.0	7.7	ng/g	UJ	x
SD-18-23	SE	Perfluoro-1-pentanesulfonate (PFPeS)		4.9	7.0	ng/g	UJ	x
SD-18-23	SE	Perfluorobutanoic Acid (PFBA)		5.3	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluorodecanesulfonic Acid (PFDS)		15	19	ng/g	UJ	x
SD-18-23	SE	Perfluoroheptanesulfonic acid (PFHpS)		5.0	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluorooctane Sulfonamide (PFOSA)		5.3	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluoropentanoic Acid (PFPA)		5.3	6.2	ng/g	UJ	x

Attachment A

Nonconformance Summary Tables

Table A-1 - Percent Solids

Sample ID	Percent Solids (%)	Status
SD-18-11	20.9	<30%
SD-18-12	15.5	<30%
SD-18-13	23	<30%
SD-18-13-DUP	23.8	<30%
SD-18-14	23.3	<30%
SD-18-15	26.5	<30%
SD-18-16	20.3	<30%
SD-18-17	16.5	<30%
SD-18-21	16.6	<30%
SD-18-22	13.6	<30%
SD-18-23	12.2	<30%

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

RESOLUTION CONSULTANTS

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK15
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM
Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 01/31/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK15 PFAS 10 additional memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 19, 2018.

Sample ID	Matrix/Sample Type
SW-18-05-H-DUP	Field Duplicate of SW-18-05-H
SW-18-01-H	Surface water
SW-18-02-H	Surface water
SW-18-03-H	Surface water
SW-18-04-H	Surface water
SW-18-05-H	Surface water
SW-18-08-H	Surface water
SW-18-09-H	Surface water
SW-18-10-H	Surface water
SW-18-11-H	Surface water
SW-18-12-H	Surface water
SW-18-13-H	Surface water
SW-18-14-H	Surface water
SW-18-15-H	Surface water
SW-18-16-H	Surface water
SW-18-17-H	Surface water

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Aqueous samples by Method 537 version 1.1 Modified Using LCS/MS/MS (2018;
- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓ Data completeness (chain-of-custody (COC)/sample integrity
✗ Holding times and sample preservation
✓ Initial calibration/continuing calibration verification
✓ Laboratory blanks/equipment blanks
✗ Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓ Field duplicate results
✗ Extracted internal standard results
✓ Injection internal standard results
✓ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for 10 additional PFAS compounds not included in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Select samples were re-extracted outside of the 7-day extraction holding time stipulated in the project specific SAP in order to confirm the extracted standard recovery nonconformances. The recovery of 13C8-PFOSA in the initial analysis of sample SW-18-01-H fell below 10% and was improved and >10% in the re-extraction analysis. Consequently, the result from the reanalysis was chosen to be reported in order to avoid rejection of data. All other sample results were reported from the initial analysis which was extracted and analyzed within holding time.

A reference method for the analysis of PFAS compounds using isotope dilution does not exist; therefore, there is no method established holding time criterion. The laboratory standard operating procedure (SOP) indicates that the extraction holding time for aqueous samples is 14 days from sample collection. Consequently, professional judgment was used to take data validation actions based on the SOP established extraction holding time criterion.

The 14-day extraction holding time was exceeded by two days for the re-extraction analysis of sample SW-18-01-H. The positive result for PFOSA reported from the reextraction analysis was qualified as estimated (J).

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met or qualification of the data was not required.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria.

Nonconformances are summarized in Attachment A in Table A-1. Samples were qualified as follows:

Actions: (Based on NFG 2017)

Qualify results	**MS/MSD %Rs**			**MS/MSD RPD**
	<10% R	**10%R to Lower Limit**	**>Upper Limit**	**> QC Limit**
Detected Results	J-	J-	J+	J
Non-Detected Results	R	UJ	Accept	Accept
[1]Criteria from **Table B-15, QSM 5.1**: Use in-house laboratory QC limits for LCS %R if not specified. RPD ≤ 30%				
Notes: Qualifications should be applied to the affected compound in the unspiked sample only unless all data appear to be impacted. If the sample result is > 4x the spike added concentration, no action is taken based on Resolution Consultants' professional judgment. As noted in E.4 of the NFG, considerations include the actions noted above but are not limited to these actions. Therefore, Resolution Consultants' professional judgment is applied to include bias codes.				

Qualified sample results are summarized in Table 1.

LCS/LSD Results

The LCS and LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of ≤ 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and ≤ 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

All field duplicate precision criteria were met.

Extracted Internal Standard Results

The extracted internal standard (ES) results were reviewed for conformance with the QC acceptance criteria.

The nonconforming ES results were confirmed through re-extraction by the laboratory. In all cases, the detected results in the original analysis were comparable to those in the re-extracted samples. The laboratory chose to report the original analyses which were performed within holding time since the sample results were comparable to the re-extraction analysis and recoveries for one or more ES were still outside of the QC acceptance limits in the re-extraction analyses. The original results were reported with the following exception. The %R for 13C8-PFOSA was improved and >10% in the re-extraction analysis of sample SW-18-01-H. Consequently, the PFOSA result was reported from the re-extraction analysis of this sample in order to avoid rejection of this result if reported from the original analysis.

Nonconformances are summarized in Attachment A in Table A-2. It should be noted that only the nonconformances affecting the sample results which were selected for reporting are summarized in this table.

Samples were qualified as follows:

Actions: (Based on NFG 2016)

Criteria	**Actions[1]**	
	Detected	**Nondetected**
%R > Upper Acceptance Limit	J	UJ
%R >10% but < Lower Acceptance Limit	J	UJ
%R <10%	See below	
<10% and S/N >10:1	J	R
<10% and S/N <10:1	R	R

[1] The PFAS method is performed using isotope dilution technique; therefore, professional judgment was applied and bias codes were not included in data qualification.

Qualified sample results are summarized in Table 1.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This “J” qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SW-18-01-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-01-H	WS	Perfluoro-1-pentanesulfonate (PFPeS)	6.3	0.91	1.7	ng/L	J	lc
SW-18-01-H	WS	Perfluorooctane Sulfonamide (PFOSA)	1.7	2.4	2.5	ng/L	J	lc
SW-18-01-H	WS	Perfluoropentanoic Acid (PFPA)	8.0	4.0	5.0	ng/L	J	lc
SW-18-02-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-02-H	WS	Perfluoro-1-pentanesulfonate (PFPeS)	16	0.92	1.7	ng/L	J	lc
SW-18-02-H	WS	Perfluorooctane Sulfonamide (PFOSA)	3.0	2.4	2.5	ng/L	J	lc
SW-18-03-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.5	ng/L	UJ	lc
SW-18-03-H	WS	Perfluorooctane Sulfonamide (PFOSA)	1.5	2.4	2.5	ng/L	J	lc
SW-18-04-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-04-H	WS	Perfluoro-1-pentanesulfonate (PFPeS)	0.46	0.91	1.7	ng/L	J	lc
SW-18-04-H	WS	Perfluorooctane Sulfonamide (PFOSA)	0.83	2.4	2.5	ng/L	J	lc
SW-18-05-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-05-H	WS	Perfluorodecanesulfonic Acid (PFDS)		1.9	2.5	ng/L	UJ	m
SW-18-05-H	WS	Perfluorooctane Sulfonamide (PFOSA)	0.90	2.4	2.5	ng/L	J	lc
SW-18-05-H-DUP	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.4	ng/L	UJ	lc
SW-18-05-H-DUP	WS	Perfluorooctane Sulfonamide (PFOSA)	1.1	2.4	2.4	ng/L	J	lc
SW-18-08-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate		1.6	2.5	ng/L	UJ	lc

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
		(4:2 FTS)						
SW-18-08-H	WS	Perfluorooctane Sulfonamide (PFOSA)	0.93	2.4	2.5	ng/L	J	lc
SW-18-09-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-09-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-10-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.5	2.5	ng/L	UJ	lc
SW-18-11-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-11-H	WS	Perfluorooctane Sulfonamide (PFOSA)	0.91	2.5	2.5	ng/L	J	lc
SW-18-12-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.5	ng/L	UJ	lc
SW-18-12-H	WS	Perfluorooctane Sulfonamide (PFOSA)	0.97	2.4	2.5	ng/L	J	lc
SW-18-13-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-13-H	WS	Perfluoro-1-pentanesulfonate (PFPeS)	0.55	0.93	1.7	ng/L	J	lc
SW-18-13-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.5	2.5	ng/L	UJ	lc
SW-18-13-H	WS	Perfluoropentanoic Acid (PFPA)	2.2	4.1	5.1	ng/L	J	lc
SW-18-14-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.5	ng/L	UJ	lc
SW-18-14-H	WS	Perfluoro-1-pentanesulfonate (PFPeS)	0.44	0.90	1.6	ng/L	J	lc
SW-18-14-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-14-H	WS	Perfluoropentanoic Acid (PFPA)	2.2	3.9	4.9	ng/L	J	lc
SW-18-15-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-15-H	WS	Perfluoro-1-pentanesulfonate (PFPeS)	0.39	0.91	1.7	ng/L	J	lc
SW-18-15-H	WS	Perfluorooctane Sulfonamide (PFOSA)	0.97	2.4	2.5	ng/L	J	lc
SW-18-15-H	WS	Perfluoropentanoic Acid	2.2	4.0	5.0	ng/L	J	lc

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
		(PFPA)						
SW-18-16-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-16-H	WS	8:2 Fluorotelomer Sulfonate		1.7	2.5	ng/L	UJ	lc
SW-18-16-H	WS	Perfluorooctane Sulfonamide (PFOSA)	0.88	2.4	2.5	ng/L	J	h,lc
SW-18-17-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-17-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc

Attachment A

Nonconformance Summary Tables

Table A-1 - MS/MSD Results

Sample ID	Compound	MS % Recovery	MSD % Recovery	Lower Limit	Upper Limit	RPD	RPD Limit
SW-18-05-H	Perfluorodecanesulfonic Acid (PFDS)	62	58	70	130	ok	30

Table A-2- Extracted Internal Standards

Sample ID	Extracted Standard	Recovery	Lower Limit	Upper Limit
SW-18-01-H RE	13C8-PFOSA	19	50	150
SW-18-01-H	13C2-4:2FTS	203	50	150
	13C3-PFBS	176	50	150
	13C5 PFPeA	163	50	150
SW-18-02-H	13C2-4:2FTS	200	50	150
	13C3-PFBS	151	50	150
	13C8-PFOSA	12	50	150
SW-18-03-H	13C2-4:2FTS	156	50	150
	13C8-PFOSA	10	50	150
SW-18-04-H	13C2-4:2FTS	176	50	150
	13C3-PFBS	152	50	150
	13C8-PFOSA	14	50	150
SW-18-05-H	13C2-4:2FTS	165	50	150
	13C8-PFOSA	20	50	150
SW-18-05-H-DUP	13C8-PFOSA	10	50	150
	13C2-4:2FTS	153	50	150
SW-18-08-H	13C2-4:2FTS	181	50	150
	13C8-PFOSA	9	50	150
SW-18-09-H	13C2-4:2FTS	186	50	150
	13C8-PFOSA	14	50	150
SW-18-10-H	13C8-PFOSA	12	50	150
SW-18-11-H	13C2-4:2FTS	161	50	150
	13C8-PFOSA	13	50	150
SW-18-12-H	13C2-4:2FTS	188	50	150
	13C8-PFOSA	11	50	150
SW-18-13-H	13C2-4:2FTS	171	50	150
	13C3-PFBS	159	50	150
	13C5 PFPeA	155	50	150
	13C8-PFOSA	12	50	150
SW-18-14-H	13C2-4:2FTS	186	50	150

Sample ID	Extracted Standard	Recovery	Lower Limit	Upper Limit
	13C3-PFBS	170	50	150
	13C5 PFPeA	161	50	150
	13C8-PFOSA	10	50	150
SW-18-15-H	13C2-4:2FTS	153	50	150
	13C3-PFBS	160	50	150
	13C5 PFPeA	152	50	150
	13C8-PFOSA	8	50	150
SW-18-16-H	13C2-8:2FTS	49	50	150
	13C8-PFOSA	8	50	150
	13C2-4:2FTS	168	50	150
SW-18-17-H	13C8-PFOSA	12	50	150
	13C2-4:2FTS	176	50	150

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK16
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM

Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 02/04/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK16 PFAS 10 additional memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 19, 2018 and November 20, 2018.

Sample ID	Matrix/Sample Type
SW-18-20-H-DUP	Field Duplicate of SW-18-20-H
SW-18-06	Surface water
SW-18-07	Surface water
SW-18-18-H	Surface water
SW-18-19-H	Surface water
SW-18-20-H	Surface water
SW-18-21-H	Surface water
SW-18-22-H	Surface water
SW-18-23-H	Surface water
SW-18-24	Surface water

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Aqueous samples by Method 537 version 1.1 Modified Using LCS/MS/MS (2018);

- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✗	Holding times and sample preservation
✓	Initial calibration/continuing calibration verification
✓	Laboratory blanks/equipment blanks
✗	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓	Field duplicate results
✗	Extracted internal standard results
✓	Injection internal standard results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for 10 additional PFAS compounds not included in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Select samples were re-extracted outside of the 7-day extraction holding time stipulated in the project specific SAP in order to confirm the extracted standard recovery nonconformances. The recovery of 13C8-PFOSA in the initial analysis of sample SW-18-24 fell below 10% and was improved and >10% in the re-extraction analysis. Consequently, the result from the reanalysis was chosen to be reported in order to avoid rejection of data. All other sample results were reported from the initial analysis which was extracted and analyzed within holding time.

A reference method for the analysis of PFAS compounds using isotope dilution does not exist; therefore, there is no method established holding time criterion. The laboratory standard operating procedure (SOP) indicates that the extraction holding time for aqueous samples is 14 days from sample collection. Consequently, professional judgment was used to take data validation actions based on the SOP established extraction holding time criterion.

The 14-day extraction holding time was exceeded by two days for the re-extraction analysis of sample SW-18-24. The positive result for PFOSA reported from the reextraction analysis was qualified as estimated (J).

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met or qualification of the data was not required.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria.

Nonconformances are summarized in Attachment A in Table A-1. Samples were qualified as follows:

Actions: (Based on NFG 2017)

	MS/MSD %Rs			**MS/MSD RPD**
Qualify results	**<10% R**	**10%R to Lower Limit**	**>Upper Limit**	**> QC Limit**
Detected Results	J-	J-	J+	J
Non-Detected Results	R	UJ	Accept	Accept
[1]Criteria from **Table B-15, QSM 5.1**: Use in-house laboratory QC limits for LCS %R if not specified. RPD ≤ 30%				
Notes: Qualifications should be applied to the affected compound in the unspiked sample only unless all data appear to be impacted. If the sample result is > 4x the spike added concentration, no action is taken based on Resolution Consultants' professional judgment. As noted in E.4 of the NFG, considerations include the actions noted above but are not limited to these actions. Therefore, Resolution Consultants' professional judgment is applied to include bias codes.				

Qualified sample results are summarized in Table 1.

LCS/LSD Results

The LCS and LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of ≤ 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and ≤ 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

All field duplicate precision criteria were met.

Extracted Internal Standard Results

The extracted internal standard (ES) results were reviewed for conformance with the QC acceptance criteria.

The nonconforming ES results were confirmed through re-extraction by the laboratory. In all cases, the detected results in the original analysis were comparable to those in the re-extracted samples. The laboratory chose to report the original analyses which were performed within holding time since the sample results were comparable to the re-extraction analysis and recoveries for one or more ES were still outside of the QC acceptance limits in the re-extraction analyses. The original results were reported with the following exception. The %R for 13C8-PFOSA was improved and >10% in the re-extraction analysis of sample SW-18-24. Consequently, the PFOSA result was reported from the re-extraction analysis of this sample in order to avoid rejection of this result if reported from the original analysis.

Nonconformances are summarized in Attachment A in Table A-2. It should be noted that only the nonconformances affecting the sample results which were selected for reporting are summarized in this table.

Samples were qualified as follows:

Actions: (Based on NFG 2016)

Criteria	Actions[1]	
	Detected	**Nondetected**
%R > Upper Acceptance Limit	J	UJ
%R >10% but < Lower Acceptance Limit	J	UJ
%R <10%	See below	
<10% and S/N >10:1	J	R
<10% and S/N <10:1	R	R

[1] The PFAS method is performed using isotope dilution technique; therefore, professional judgment was applied and bias codes were not included in data qualification.

Qualified sample results are summarized in Table 1.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SW-18-06	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-06	WS	Perfluorooctane Sulfonamide (PFOSA)	3.4	2.5	2.5	ng/L	J	lc
SW-18-07	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-07	WS	Perfluorooctane Sulfonamide (PFOSA)	1.5	2.4	2.5	ng/L	J	lc
SW-18-18-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-18-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-19-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-19-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-20-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-20-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-20-H	WS	Perfluoropentanoic Acid (PFPA)	3.7	4.0	5.0	ng/L	J-	m
SW-18-20-H-DUP	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-20-H-DUP	WS	Perfluorooctane Sulfonamide (PFOSA)		2.5	2.5	ng/L	UJ	lc
SW-18-21-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-21-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-22-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-22-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-23-H	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SW-18-23-H	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-24	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-24	WS	Perfluorooctane Sulfonamide (PFOSA)	6.8	2.4	2.5	ng/L	J	h,lc

Attachment A

Nonconformance Summary Tables

Table A-1 - MS/MSD Results

Sample ID	Compound	MS % Recovery	MSD % Recovery	Lower Limit	Upper Limit	RPD	RPD Limit
SW-18-20-H	Perfluoropentanoic Acid (PFPA)	67	66	70	130	0	30

Table A-2 – Extracted Standard Results

Sample ID	Extracted Standard	Recovery	Lower Limit	Upper Limit
SW-18-18-H	13C2-4:2FTS	175	50	150
	13C8-PFOSA	16	50	150
SW-18-19-H	13C2-4:2FTS	197	50	150
	13C8-PFOSA	20	50	150
SW-18-20-H	13C2-4:2FTS	179	50	150
	13C8-PFOSA	18	50	150
SW-18-20-H-DUP	13C2-4:2FTS	193	50	150
	13C8-PFOSA	15	50	150
SW-18-21-H	13C2-4:2FTS	191	50	150
	13C8-PFOSA	37	50	150
SW-18-22-H	13C2-4:2FTS	159	50	150
	13C8-PFOSA	18	50	150
SW-18-23-H	13C2-4:2FTS	194	50	150
	13C8-PFOSA	31	50	150
SW-18-24 RE	13C8-PFOSA	14	50	150
SW-18-24	13C2-4:2FTS	181	50	150
SW-18-06	13C2-4:2FTS	205	50	150
	13C8-PFOSA	46	50	150
SW-18-07	13C2-4:2FTS	203	50	150
	13C8-PFOSA	19	50	150

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK17
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM

Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 02/04/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK17 PFAS 10 additional memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 20, 2018.

Sample ID	Matrix/Sample Type
EB-112018	Equipment blank
SW-18-05-L-DUP	Field Duplicate of SW-18-05-L
SW-18-11-L-DUP	Field Duplicate of SW-18-11-L
SW-18-15-L-DUP	Field Duplicate of SW-18-15-L
SW-18-03-L	Surface water
SW-18-04-L	Surface water
SW-18-05-L	Surface water
SW-18-08-L	Surface water
SW-18-09-L	Surface water
SW-18-10-L	Surface water
SW-18-11-L	Surface water
SW-18-12-L	Surface water
SW-18-13-L	Surface water
SW-18-14-L	Surface water
SW-18-15-L	Surface water
SW-18-16-L	Surface water
SW-18-17-L	Surface water
SW-18-18-L	Surface water
SW-18-19-L	Surface water

Sample ID	Matrix/Sample Type
SW-18-20-L	Surface water
SW-18-21-L	Surface water
SW-18-22-L	Surface water
SW-18-23-L	Surface water

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Aqueous samples by Method 537 version 1.1 Modified Using LCS/MS/MS (2018);
- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✗	Holding times and sample preservation
✓	Initial calibration/continuing calibration verification
✓	Laboratory blanks/equipment blanks
✓	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓	Field duplicate results
✗	Extracted internal standard results
✓	Injection internal standard results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated or rejected due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for 10 additional PFAS compounds not included in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Select samples were re-extracted outside of the 7-day extraction holding time stipulated in the project specific SAP in order to confirm the extracted standard recovery nonconformances. The recovery of 13C8-PFOSA in the initial analysis of samples SW-18-05-L-DUP, SW-18-09-L, SW-18-10-L, SW-18-14-L, SW-18-15-L-DUP, SW-18-18-L, SW-18-20-L and SW-18-23-L fell below 10% and was improved and >10% in the re-extraction analysis. Consequently, the result from the reanalysis was chosen to be reported in order to avoid rejection of data. All other sample results were reported from the initial analysis which was extracted and analyzed within holding time.

A reference method for the analysis of PFAS compounds using isotope dilution does not exist; therefore, there is no method established holding time criterion. The laboratory standard operating procedure (SOP) indicates that the extraction holding time for aqueous samples is 14 days from sample collection. Consequently, professional judgment was used to take data validation actions based on the SOP established extraction holding time criterion.

The 14-day extraction holding time was exceeded by two days for the re-extraction analysis of sample SW-18-23-L. The nondetect result for PFOSA reported from the reextraction analysis was qualified as estimated (UJ).

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met or qualification of the data was not required.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks or equipment blanks associated with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

LCS/LSD Results

The LCS and LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of $\leq$ 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and $\leq$ 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

All field duplicate precision criteria were met.

Extracted Internal Standard Results

The extracted internal standard (ES) results were reviewed for conformance with the QC acceptance criteria.

The nonconforming ES results were confirmed through re-extraction by the laboratory. In all cases, the detected results in the original analysis were comparable to those in the re-extracted samples. The laboratory chose to report the original analyses which were performed within holding time since the sample results were comparable to the re-extraction analysis and recoveries for one or more ES were still outside of the QC acceptance limits in the re-extraction analyses. The original results were reported with the following exceptions. The %R for 13C8-PFOSA was improved and >10% in the re-extraction analysis of samples SW-18-05-L-DUP, SW-18-09-L, SW-18-10-L, SW-18-14-L, SW-18-15-L-DUP, SW-18-18-L, SW-18-20-L and SW-18-23-L Consequently, the PFOSA result was reported from the re-extraction analysis of these samples in order to avoid rejection of this result if reported from the original analysis.

The %R for 13C8-PFOSA was <10% in the original and re-extraction analysis for samples SW-18-13-L and SW-18-15-L. The PFOSA results in these samples were qualified as rejected (R) and are not usable for project decisions.

Nonconformances are summarized in Attachment A in Table A-1. It should be noted that only the nonconformances affecting the sample results which were selected for reporting are summarized in this table.

Actions: (Based on NFG 2016)

Criteria	Actions[1]	
	Detected	Nondetected
%R > Upper Acceptance Limit	J	UJ
%R >10% but < Lower Acceptance Limit	J	UJ
%R <10%	See below	
<10% and S/N >10:1	J	R
<10% and S/N <10:1	R	R
[1]The PFAS method is performed using isotope dilution technique; therefore, professional judgment was applied and bias codes were not included in data qualification.		

Qualified sample results are summarized in Table 1.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SW-18-03-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.9	2.9	ng/L	UJ	lc
SW-18-03-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.8	2.9	ng/L	UJ	lc
SW-18-04-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.9	2.8	ng/L	UJ	lc
SW-18-04-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.7	2.8	ng/L	UJ	lc
SW-18-05-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.5	ng/L	UJ	lc
SW-18-05-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-05-L-DUP	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.4	ng/L	UJ	lc
SW-18-05-L-DUP	WS	Perfluorooctane Sulfonamide (PFOSA)	1.1	2.4	2.4	ng/L	J	lc
SW-18-08-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-08-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-09-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-09-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.4	ng/L	UJ	lc
SW-18-10-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.5	ng/L	UJ	lc
SW-18-10-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.5	2.6	ng/L	UJ	lc
SW-18-11-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.9	2.8	ng/L	UJ	lc
SW-18-11-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.7	2.8	ng/L	UJ	lc
SW-18-11-L-DUP	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.9	2.9	ng/L	UJ	lc
SW-18-11-L-DUP	WS	Perfluorooctane Sulfonamide (PFOSA)		2.8	2.9	ng/L	UJ	lc
SW-18-12-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.9	2.8	ng/L	UJ	lc
SW-18-12-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.7	2.8	ng/L	UJ	lc
SW-18-13-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-13-L	WS	Perfluorooctane Sulfonamide			2.5	ng/L	R	lc

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
		(PFOSA)						
SW-18-14-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-14-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-15-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-15-L	WS	6:2 Fluorotelomer Sulfonate	1.0	1.7	2.5	ng/L	J	lc
SW-18-15-L	WS	Perfluorooctane Sulfonamide (PFOSA)			2.5	ng/L	R	lc
SW-18-15-L-DUP	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.5	ng/L	UJ	lc
SW-18-15-L-DUP	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-16-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-16-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-17-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-17-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-18-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.5	ng/L	UJ	lc
SW-18-18-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-19-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.5	ng/L	UJ	lc
SW-18-19-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-20-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.4	ng/L	UJ	lc
SW-18-20-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.4	ng/L	UJ	lc
SW-18-21-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.9	2.8	ng/L	UJ	lc
SW-18-21-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.7	2.8	ng/L	UJ	lc
SW-18-22-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.7	2.5	ng/L	UJ	lc
SW-18-22-L	WS	Perfluorooctane Sulfonamide (PFOSA)		2.4	2.5	ng/L	UJ	lc
SW-18-23-L	WS	1H,1H,2H,2H-perfluorohexane sulfonate (4:2 FTS)		1.6	2.4	ng/L	UJ	lc
SW-18-23-L	WS	Perfluorooctane Sulfonamide		2.4	2.5	ng/L	UJ	h,lc

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
		(PFOSA)						

Attachment A

Nonconformance Summary Tables

Table A-1-Extracted Standard Results

Sample ID	Extracted Standard	% Recovery	Lower Limit	Upper Limit
SW-18-03-L	13C8-PFOSA	38	50	150
	13C2-4:2FTS	183	50	150
SW-18-04-L	13C2-4:2FTS	189	50	150
	13C8-PFOSA	47	50	150
SW-18-05-L	13C2-4:2FTS	197	50	150
SW-18-05-L	13C8-PFOSA	35	50	150
SW-18-05-L-DUP	13C2-4:2FTS	203	50	150
SW-18-05-L-DUP RE	13C8-PFOSA	6	50	150
SW-18-08-L	13C2-4:2FTS	204	50	150
	13C8-PFOSA	12	50	150
SW-18-09-L	13C2-4:2FTS	213	50	150
SW-18-09-L RE	13C8-PFOSA	12	50	150
SW-18-10-L	13C2-4:2FTS	210	50	150
SW-18-10-L RE	13C8-PFOSA	20	50	150
SW-18-11-L	13C8-PFOSA	30	50	150
	13C2-4:2FTS	226	50	150
SW-18-11-L-DUP	13C2-4:2FTS	200	50	150
	13C8-PFOSA	31	50	150
SW-18-12-L	13C2-4:2FTS	204	50	150
	13C8-PFOSA	48	50	150
SW-18-13-L	13C2-4:2FTS	214	50	150
	13C8-PFOSA	2	50	150
SW-18-14-L	13C2-4:2FTS	190	50	150
SW-18-14-L RE	13C8-PFOSA	35	50	150
SW-18-15-L	13C2-4:2FTS	211	50	150
	13C2_6:2FTS	152	50	150
	13C8-PFOSA	2	50	150
SW-18-15-L-DUP	13C2-4:2FTS	196	50	150
SW-18-15-L-DUP RE	13C8-PFOSA	45	50	150
SW-18-16-L	13C2-4:2FTS	199	50	150
	13C8-PFOSA	16	50	150
SW-18-17-L	13C2-4:2FTS	188	50	150
	13C8-PFOSA	14	50	150
SW-18-18-L	13C2-4:2FTS	189	50	150
SW-18-18-L RE	13C8-PFOSA	21	50	150
SW-18-19-L	13C2-4:2FTS	194	50	150

Sample ID	Extracted Standard	% Recovery	Lower Limit	Upper Limit
	13C8-PFOSA	22	50	150
SW-18-20-L	13C2-4:2FTS	182	50	150
SW-18-20-L RE	13C8-PFOSA	15	50	150
SW-18-21-L	13C2-4:2FTS	215	50	150
	13C8-PFOSA	44	50	150
SW-18-22-L	13C2-4:2FTS	184	50	150
	13C8-PFOSA	15	50	150
SW-18-23-L	13C2-4:2FTS	202	50	150
SW-18-23-L RE	13C8-PFOSA	32	50	150

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Solids by Method 537 version 1.1 Modified Using LCS/MS/MS (2017);
- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times and sample preservation
✓	Initial calibration/continuing calibration verification
✓	Laboratory blanks/equipment blanks
✗	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✗	Field duplicate results
✓	Extracted internal standard results
✓	Injection internal standard results
✗	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for the 14 target compounds noted in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with QC acceptance criteria.

All QC acceptance criteria were met with the following exception. Sample SD-18-02 exceeded the 14-day extraction holding time stipulated in the project specific SAP by one day. A reference method for the analysis of PFAS compounds using isotope dilution does not exist; therefore, there is no method established holding time criterion. The laboratory standard operating procedure (SOP) indicates that the extraction holding time for solid samples is 28 days from sample collection. Consequently, professional judgment was used to accept the data without qualification since this sample met the SOP established extraction holding time criterion.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria.

Nonconformances are summarized in Attachment A in Table A-1. Samples were qualified as follows:

Actions: (Based on NFG 2017)

Qualify results	**MS/MSD %Rs**			**MS/MSD RPD**
	<10% R	**10%R to Lower Limit**	**>Upper Limit**	**> QC Limit**
Detected Results	J-	J-	J+	J
Non-Detected Results	R	UJ	Accept	Accept
[1]Criteria from **Table B-15, QSM 5.1**: Use in-house laboratory QC limits for LCS %R if not specified. RPD < 30%				
Notes: Qualifications should be applied to the affected compound in the unspiked sample only unless all data appear to be impacted. If the sample result is > 4x the spike added concentration, no action is taken based on Resolution Consultants' professional judgment. As noted in E.4 of the NFG, considerations include the actions noted above but are not limited to these actions. Therefore, Resolution Consultants' professional judgment is applied to include bias codes.				

Qualified sample results are summarized in Table 1.

LCS/LSD Results

The LCS and LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of < 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and < 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

Nonconformances are summarized in Attachment A in Table A-2. Samples were qualified as follows:

Actions: (Based on Resolution Consultants' professional judgment)

Criteria	**RPD**	**Action[1]**	
		Detect	**Nondetect**
Sample and duplicate are nondetect results	Not calculable (NC)	No qualification	No qualification

Criteria	RPD	Action[1]	
		Detect	Nondetect
Sample and duplicate results <LOQ	Not applicable	No qualification	No qualification
Sample and duplicate results ≥5x LOQ	>30% Aqueous >50% All other sample types	J	Not Applicable
Sample and duplicate results are > LOQ and < 5x QL	>60% Aqueous >100% All other sample types	J	Not Applicable
If sample or duplicate result is >5x LOQ and the other is not detec5ted	NC	J	UJ
If sample or duplicate result is < LOQ and the other is not detected	NC	No qualification	No qualification

[1] Resolution Consultants' professional judgement is used to determine the actions applied to sample results when the sample results do not fall into the scenarios described in this table.

Qualified sample results are summarized in Table 1.

Extracted Internal Standard Results

The extracted internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

Percent Solids

The percent solids data were reviewed to ensure that the NFG specified criteria were met. The percent solids content was >30% for all samples with the following exceptions: SD-18-03 (24.5%), SD-18-03-DUP (25.5%), SD-18-04 (15.2%) and SD-18-05 (18.1%).

Samples were qualified as follows:

Actions: (Based on NFG 2017)

Criteria	Action	
	Detects	Non-detects
%Solids < 10.0%	Use professional judgment	Use professional judgment
10.0% ≤%Solids < 30.0%	Use professional judgment	Use professional judgment
%Solids ≥ 30.0%	No qualification	No qualification

Professional judgment was applied to qualify affected positive and nondetect results as estimated (J/UJ) with an indeterminate bias. Qualified sample results are summarized in Table 1.

It should be noted that in instances of multiple nonconformances, the bias is considered indeterminate in cases where a conflicting low and high bias exists or when a result does not exhibit a consistent bias for all nonconformances. These results have an overall qualification of estimated (J).

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-03	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		7.8	12	ng/g	UJ	x
SD-18-03	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		7.8	12	ng/g	UJ	x
SD-18-03	SE	Perfluorobutanesulfonic Acid (PFBS)		2.4	3.1	ng/g	UJ	x
SD-18-03	SE	Perfluorodecanoic Acid (PFDA)		2.7	3.9	ng/g	UJ	x
SD-18-03	SE	Perfluorododecanoic Acid (PFDoA)		2.7	3.1	ng/g	UJ	x
SD-18-03	SE	Perfluoroheptanoic Acid (PFHpA)		2.7	3.1	ng/g	UJ	x
SD-18-03	SE	Perfluorohexanesulfonic Acid (PFHxS)	12	2.5	3.1	ng/g	J	m,x
SD-18-03	SE	Perfluorohexanoic Acid (PFHxA)	1.3	2.7	3.1	ng/g	J	x
SD-18-03	SE	Perfluorononanoic Acid (PFNA)		2.7	3.1	ng/g	UJ	x
SD-18-03	SE	Perfluorooctanesulfonic Acid (PFOS)	24	2.6	3.1	ng/g	J	fd,x
SD-18-03	SE	Perfluorooctanoic Acid (PFOA)	3.4	2.7	3.1	ng/g	J	x
SD-18-03	SE	Perfluorotetradecanoic Acid (PFTA)		2.7	3.1	ng/g	UJ	x
SD-18-03	SE	Perfluorotridecanoic Acid (PFTrDA)		2.7	3.1	ng/g	UJ	x
SD-18-03	SE	Perfluoroundecanoic Acid (PFUnA)		2.7	3.1	ng/g	UJ	x
SD-18-03-DUP	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		7.4	11	ng/g	UJ	x
SD-18-03-DUP	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		7.4	11	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluorobutanesulfonic Acid (PFBS)		2.2	3.0	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluorodecanoic Acid (PFDA)		2.5	3.7	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluorododecanoic Acid (PFDoA)		2.5	3.0	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluoroheptanoic Acid (PFHpA)		2.5	3.0	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluorohexanesulfonic	7.1	2.4	3.0	ng/g	J	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
		Acid (PFHxS)						
SD-18-03-DUP	SE	Perfluorohexanoic Acid (PFHxA)	1.2	2.5	3.0	ng/g	J	x
SD-18-03-DUP	SE	Perfluorononanoic Acid (PFNA)		2.5	3.0	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluorooctanesulfonic Acid (PFOS)	8.9	2.4	3.0	ng/g	J	fd,x
SD-18-03-DUP	SE	Perfluorooctanoic Acid (PFOA)	2.3	2.5	3.0	ng/g	J	x
SD-18-03-DUP	SE	Perfluorotetradecanoic Acid (PFTA)		2.5	3.0	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluorotridecanoic Acid (PFTrDA)		2.5	3.0	ng/g	UJ	x
SD-18-03-DUP	SE	Perfluoroundecanoic Acid (PFUnA)		2.5	3.0	ng/g	UJ	x
SD-18-04	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		12	19	ng/g	UJ	x
SD-18-04	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		12	19	ng/g	UJ	x
SD-18-04	SE	Perfluorobutanesulfonic Acid (PFBS)		3.7	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluorodecanoic Acid (PFDA)		4.2	6.2	ng/g	UJ	x
SD-18-04	SE	Perfluorododecanoic Acid (PFDoA)		4.2	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluoroheptanoic Acid (PFHpA)		4.2	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluorohexanesulfonic Acid (PFHxS)	3.5	4.0	5.0	ng/g	J	x
SD-18-04	SE	Perfluorohexanoic Acid (PFHxA)		4.2	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluorononanoic Acid (PFNA)		4.2	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluorooctanesulfonic Acid (PFOS)	8.3	4.0	5.0	ng/g	J	x
SD-18-04	SE	Perfluorooctanoic Acid (PFOA)		4.2	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluorotetradecanoic Acid (PFTA)		4.2	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluorotridecanoic Acid (PFTrDA)		4.2	5.0	ng/g	UJ	x
SD-18-04	SE	Perfluoroundecanoic Acid (PFUnA)		4.2	5.0	ng/g	UJ	x
SD-18-05	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		10	15	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-05	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		10	15	ng/g	UJ	x
SD-18-05	SE	Perfluorobutanesulfonic Acid (PFBS)		3.0	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluorodecanoic Acid (PFDA)		3.4	5.0	ng/g	UJ	x
SD-18-05	SE	Perfluorododecanoic Acid (PFDoA)		3.4	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluoroheptanoic Acid (PFHpA)		3.4	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluorohexanesulfonic Acid (PFHxS)	2.8	3.2	4.0	ng/g	J	x
SD-18-05	SE	Perfluorohexanoic Acid (PFHxA)		3.4	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluorononanoic Acid (PFNA)		3.4	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluorooctanesulfonic Acid (PFOS)	5.1	3.3	4.0	ng/g	J	x
SD-18-05	SE	Perfluorooctanoic Acid (PFOA)		3.4	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluorotetradecanoic Acid (PFTA)		3.4	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluorotridecanoic Acid (PFTrDA)		3.4	4.0	ng/g	UJ	x
SD-18-05	SE	Perfluoroundecanoic Acid (PFUnA)		3.4	4.0	ng/g	UJ	x
SD-18-07	SE	Perfluorohexanesulfonic Acid (PFHxS)	0.28	0.77	0.96	ng/g	J	fd
SD-18-07	SE	Perfluorooctanesulfonic Acid (PFOS)	1.7	0.78	0.96	ng/g	J	fd
SD-18-07-DUP	SE	Perfluorohexanesulfonic Acid (PFHxS)	1.4	0.95	1.2	ng/g	J	fd
SD-18-07-DUP	SE	Perfluorooctanesulfonic Acid (PFOS)	6.7	0.96	1.2	ng/g	J	fd

Attachment A

Nonconformance Summary Tables

Table A-1 - MS/MSD Results

Sample ID	Compound	MS % Recovery	MSD % Recovery	Lower Limit	Upper Limit	RPD	RPD Limit
SD-18-03	Perfluorohexanesulfonic Acid (PFHxS)	49	71	70	130	8	30

Table A-2 - Field Duplicates

Sample ID	Duplicate ID	Compound	Sample Result	Qual	Duplicate Result	Qual	LOQ	Units	RPD
SD-18-07	SD-18-07-DUP	Perfluorooctanesulfonic Acid (PFOS)	1.7		6.7		0.96	ng/g	119
SD-18-03	SD-18-03-DUP	Perfluorooctanesulfonic Acid (PFOS)	24		8.9		3.1	ng/g	91.8
SD-18-07	SD-18-07-DUP	Perfluorohexanesulfonic Acid (PFHxS)	0.28	J	1.4		0.96	ng/g	133.3

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK09
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM

Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 01/23/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK09 PFAS 14 analytes memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 19, 2018 and November 20, 2018.

Sample ID	Matrix/Sample Type
SD-18-13-DUP	Field Duplicate of SD-18-13
SD-18-09	Sediment
SD-18-10	Sediment
SD-18-11	Sediment
SD-18-12	Sediment
SD-18-13	Sediment
SD-18-14	Sediment
SD-18-15	Sediment
SD-18-16	Sediment
SD-18-17	Sediment
SD-18-18	Sediment
SD-18-19	Sediment
SD-18-20	Sediment
SD-18-21	Sediment
SD-18-22	Sediment
SD-18-23	Sediment
SD-18-24	Sediment

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Solids by Method 537 version 1.1 Modified Using LCS/MS/MS (2017);
- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓ Data completeness (chain-of-custody (COC)/sample integrity
✓ Holding times and sample preservation
✓ Initial calibration/continuing calibration verification
✓ Laboratory blanks/equipment blanks
✓ Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓ Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓ Field duplicate results
✓ Extracted internal standard results
✓ Injection internal standard results
✗ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for the 14 target compounds noted in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with QC acceptance criteria.

All QC acceptance criteria were met with the following exception. Sample SD-18-24 exceeded the 14-day extraction holding time stipulated in the project specific SAP by one day. A reference method for the analysis of PFAS compounds using isotope dilution does not exist; therefore, there is no method established holding time criterion. The laboratory standard operating procedure (SOP) indicates that the extraction holding time for solid samples is 28 days from sample collection. Consequently, professional judgment was used to accept the data without qualification since this sample met the SOP established extraction holding time criterion.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

LCS/LSD Results

The LCS and LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of ≤ 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and ≤ 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

All field duplicate precision criteria were met.

Extracted Internal Standard Results

The extracted internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This “J” qualifier is retained during data validation.

Percent Solids

The percent solids data were reviewed to ensure that the NFG specified criteria were met.

Nonconformances are summarized in Attachment A in Table A-1. Samples were qualified as follows:

Actions: (Based on NFG 2017)

Criteria	**Action**	
	Detects	**Non-detects**
%Solids < 10.0%	Use professional judgment	Use professional judgment
10.0% ≤%Solids < 30.0%	Use professional judgment	Use professional judgment
%Solids ≥ 30.0%	No qualification	No qualification

Professional judgment was applied to qualify affected positive and nondetect results as estimated (J/UJ) with an indeterminate bias. Qualified sample results are summarized in Table 1.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-11	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		8.7	13	ng/g	UJ	x
SD-18-11	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		8.7	13	ng/g	UJ	x
SD-18-11	SE	Perfluorobutanesulfonic Acid (PFBS)		2.6	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluorodecanoic Acid (PFDA)		3.0	4.3	ng/g	UJ	x
SD-18-11	SE	Perfluorododecanoic Acid (PFDoA)		3.0	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluoroheptanoic Acid (PFHpA)		3.0	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluorohexanesulfonic Acid (PFHxS)	1.4	2.8	3.5	ng/g	J	x
SD-18-11	SE	Perfluorohexanoic Acid (PFHxA)		3.0	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluorononanoic Acid (PFNA)		3.0	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluorooctanesulfonic Acid (PFOS)	4.4	2.8	3.5	ng/g	J	x
SD-18-11	SE	Perfluorooctanoic Acid (PFOA)		3.0	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluorotetradecanoic Acid (PFTA)		3.0	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluorotridecanoic Acid (PFTrDA)		3.0	3.5	ng/g	UJ	x
SD-18-11	SE	Perfluoroundecanoic Acid (PFUnA)		3.0	3.5	ng/g	UJ	x
SD-18-12	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		12	19	ng/g	UJ	x
SD-18-12	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		12	19	ng/g	UJ	x
SD-18-12	SE	Perfluorobutanesulfonic Acid (PFBS)		3.7	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluorodecanoic Acid (PFDA)		4.2	6.2	ng/g	UJ	x
SD-18-12	SE	Perfluorododecanoic Acid (PFDoA)		4.2	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluoroheptanoic Acid (PFHpA)		4.2	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluorohexanesulfonic Acid (PFHxS)	1.6	4.0	5.0	ng/g	J	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-12	SE	Perfluorohexanoic Acid (PFHxA)		4.2	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluorononanoic Acid (PFNA)		4.2	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluorooctanesulfonic Acid (PFOS)	5.3	4.0	5.0	ng/g	J	x
SD-18-12	SE	Perfluorooctanoic Acid (PFOA)		4.2	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluorotetradecanoic Acid (PFTA)		4.2	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluorotridecanoic Acid (PFTrDA)		4.2	5.0	ng/g	UJ	x
SD-18-12	SE	Perfluoroundecanoic Acid (PFUnA)	1.3	4.2	5.0	ng/g	J	x
SD-18-13	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		8.1	12	ng/g	UJ	x
SD-18-13	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		8.1	12	ng/g	UJ	x
SD-18-13	SE	Perfluorobutanesulfonic Acid (PFBS)		2.4	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluorodecanoic Acid (PFDA)		2.7	4.0	ng/g	UJ	x
SD-18-13	SE	Perfluorododecanoic Acid (PFDoA)		2.7	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluoroheptanoic Acid (PFHpA)		2.7	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluorohexanesulfonic Acid (PFHxS)		2.6	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluorohexanoic Acid (PFHxA)		2.7	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluorononanoic Acid (PFNA)		2.7	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluorooctanesulfonic Acid (PFOS)	1.5	2.6	3.2	ng/g	J	x
SD-18-13	SE	Perfluorooctanoic Acid (PFOA)		2.7	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluorotetradecanoic Acid (PFTA)		2.7	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluorotridecanoic Acid (PFTrDA)		2.7	3.2	ng/g	UJ	x
SD-18-13	SE	Perfluoroundecanoic Acid (PFUnA)		2.7	3.2	ng/g	UJ	x
SD-18-13-DUP	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		8.3	12	ng/g	UJ	x
SD-18-13-DUP	SE	N-Methyl Perfluorooctane		8.3	12	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
		Sulfonamidoacetic Acid						
SD-18-13-DUP	SE	Perfluorobutanesulfonic Acid (PFBS)		2.5	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorodecanoic Acid (PFDA)		2.8	4.2	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorododecanoic Acid (PFDoA)		2.8	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluoroheptanoic Acid (PFHpA)		2.8	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorohexanesulfonic Acid (PFHxS)		2.7	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorohexanoic Acid (PFHxA)		2.8	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorononanoic Acid (PFNA)		2.8	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorooctanesulfonic Acid (PFOS)	1.2	2.7	3.3	ng/g	J	x
SD-18-13-DUP	SE	Perfluorooctanoic Acid (PFOA)		2.8	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorotetradecanoic Acid (PFTA)		2.8	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluorotridecanoic Acid (PFTrDA)		2.8	3.3	ng/g	UJ	x
SD-18-13-DUP	SE	Perfluoroundecanoic Acid (PFUnA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		8.3	13	ng/g	UJ	x
SD-18-14	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		8.3	13	ng/g	UJ	x
SD-18-14	SE	Perfluorobutanesulfonic Acid (PFBS)		2.5	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluorodecanoic Acid (PFDA)		2.8	4.2	ng/g	UJ	x
SD-18-14	SE	Perfluorododecanoic Acid (PFDoA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluoroheptanoic Acid (PFHpA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluorohexanesulfonic Acid (PFHxS)		2.7	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluorohexanoic Acid (PFHxA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluorononanoic Acid (PFNA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluorooctanesulfonic Acid (PFOS)	1.0	2.7	3.3	ng/g	J	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-14	SE	Perfluorooctanoic Acid (PFOA)	0.93	2.8	3.3	ng/g	J	x
SD-18-14	SE	Perfluorotetradecanoic Acid (PFTA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluorotridecanoic Acid (PFTrDA)		2.8	3.3	ng/g	UJ	x
SD-18-14	SE	Perfluoroundecanoic Acid (PFUnA)		2.8	3.3	ng/g	UJ	x
SD-18-15	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		7.1	11	ng/g	UJ	x
SD-18-15	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		7.1	11	ng/g	UJ	x
SD-18-15	SE	Perfluorobutanesulfonic Acid (PFBS)		2.1	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluorodecanoic Acid (PFDA)		2.4	3.5	ng/g	UJ	x
SD-18-15	SE	Perfluorododecanoic Acid (PFDoA)		2.4	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluoroheptanoic Acid (PFHpA)		2.4	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluorohexanesulfonic Acid (PFHxS)		2.3	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluorohexanoic Acid (PFHxA)		2.4	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluorononanoic Acid (PFNA)		2.4	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluorooctanesulfonic Acid (PFOS)	0.86	2.3	2.8	ng/g	J	x
SD-18-15	SE	Perfluorooctanoic Acid (PFOA)		2.4	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluorotetradecanoic Acid (PFTA)		2.4	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluorotridecanoic Acid (PFTrDA)		2.4	2.8	ng/g	UJ	x
SD-18-15	SE	Perfluoroundecanoic Acid (PFUnA)		2.4	2.8	ng/g	UJ	x
SD-18-16	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		9.5	14	ng/g	UJ	x
SD-18-16	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		9.5	14	ng/g	UJ	x
SD-18-16	SE	Perfluorobutanesulfonic Acid (PFBS)		2.8	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluorodecanoic Acid (PFDA)		3.2	4.7	ng/g	UJ	x
SD-18-16	SE	Perfluorododecanoic		3.2	3.8	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
		Acid (PFDoA)						
SD-18-16	SE	Perfluoroheptanoic Acid (PFHpA)		3.2	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluorohexanesulfonic Acid (PFHxS)	1.6	3.0	3.8	ng/g	J	x
SD-18-16	SE	Perfluorohexanoic Acid (PFHxA)		3.2	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluorononanoic Acid (PFNA)		3.2	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluorooctanesulfonic Acid (PFOS)	2.1	3.1	3.8	ng/g	J	x
SD-18-16	SE	Perfluorooctanoic Acid (PFOA)		3.2	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluorotetradecanoic Acid (PFTA)		3.2	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluorotridecanoic Acid (PFTrDA)		3.2	3.8	ng/g	UJ	x
SD-18-16	SE	Perfluoroundecanoic Acid (PFUnA)		3.2	3.8	ng/g	UJ	x
SD-18-17	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		11	17	ng/g	UJ	x
SD-18-17	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		11	17	ng/g	UJ	x
SD-18-17	SE	Perfluorobutanesulfonic Acid (PFBS)		3.4	4.5	ng/g	UJ	x
SD-18-17	SE	Perfluorodecanoic Acid (PFDA)		3.8	5.6	ng/g	UJ	x
SD-18-17	SE	Perfluorododecanoic Acid (PFDoA)		3.8	4.5	ng/g	UJ	x
SD-18-17	SE	Perfluoroheptanoic Acid (PFHpA)		3.8	4.5	ng/g	UJ	x
SD-18-17	SE	Perfluorohexanesulfonic Acid (PFHxS)	2.8	3.6	4.5	ng/g	J	x
SD-18-17	SE	Perfluorohexanoic Acid (PFHxA)		3.8	4.5	ng/g	UJ	x
SD-18-17	SE	Perfluorononanoic Acid (PFNA)		3.8	4.5	ng/g	UJ	x
SD-18-17	SE	Perfluorooctanesulfonic Acid (PFOS)	3.5	3.6	4.5	ng/g	J	x
SD-18-17	SE	Perfluorooctanoic Acid (PFOA)		3.8	4.5	ng/g	UJ	x
SD-18-17	SE	Perfluorotetradecanoic Acid (PFTA)		3.8	4.5	ng/g	UJ	x
SD-18-17	SE	Perfluorotridecanoic Acid (PFTrDA)		3.8	4.5	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SD-18-17	SE	Perfluoroundecanoic Acid (PFUnA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		11	17	ng/g	UJ	x
SD-18-21	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		11	17	ng/g	UJ	x
SD-18-21	SE	Perfluorobutanesulfonic Acid (PFBS)		3.3	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluorodecanoic Acid (PFDA)		3.8	5.6	ng/g	UJ	x
SD-18-21	SE	Perfluorododecanoic Acid (PFDoA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluoroheptanoic Acid (PFHpA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluorohexanesulfonic Acid (PFHxS)		3.6	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluorohexanoic Acid (PFHxA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluorononanoic Acid (PFNA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluorooctanesulfonic Acid (PFOS)	2.7	3.6	4.5	ng/g	J	x
SD-18-21	SE	Perfluorooctanoic Acid (PFOA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluorotetradecanoic Acid (PFTA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluorotridecanoic Acid (PFTrDA)		3.8	4.5	ng/g	UJ	x
SD-18-21	SE	Perfluoroundecanoic Acid (PFUnA)		3.8	4.5	ng/g	UJ	x
SD-18-22	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		14	21	ng/g	UJ	x
SD-18-22	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		14	21	ng/g	UJ	x
SD-18-22	SE	Perfluorobutanesulfonic Acid (PFBS)		4.1	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluorodecanoic Acid (PFDA)		4.7	6.9	ng/g	UJ	x
SD-18-22	SE	Perfluorododecanoic Acid (PFDoA)		4.7	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluoroheptanoic Acid (PFHpA)		4.7	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluorohexanesulfonic Acid (PFHxS)		4.4	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluorohexanoic Acid		4.7	5.5	ng/g	UJ	x

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
		(PFHxA)						
SD-18-22	SE	Perfluorononanoic Acid (PFNA)		4.7	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluorooctanesulfonic Acid (PFOS)		4.5	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluorooctanoic Acid (PFOA)		4.7	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluorotetradecanoic Acid (PFTA)		4.7	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluorotridecanoic Acid (PFTrDA)		4.7	5.5	ng/g	UJ	x
SD-18-22	SE	Perfluoroundecanoic Acid (PFUnA)		4.7	5.5	ng/g	UJ	x
SD-18-23	SE	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		15	23	ng/g	UJ	x
SD-18-23	SE	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		15	23	ng/g	UJ	x
SD-18-23	SE	Perfluorobutanesulfonic Acid (PFBS)		4.6	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluorodecanoic Acid (PFDA)		5.3	7.7	ng/g	UJ	x
SD-18-23	SE	Perfluorododecanoic Acid (PFDoA)		5.3	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluoroheptanoic Acid (PFHpA)		5.3	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluorohexanesulfonic Acid (PFHxS)	1.7	4.9	6.2	ng/g	J	x
SD-18-23	SE	Perfluorohexanoic Acid (PFHxA)		5.3	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluorononanoic Acid (PFNA)		5.3	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluorooctanesulfonic Acid (PFOS)	4.7	5.0	6.2	ng/g	J	x
SD-18-23	SE	Perfluorooctanoic Acid (PFOA)		5.3	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluorotetradecanoic Acid (PFTA)		5.3	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluorotridecanoic Acid (PFTrDA)		5.3	6.2	ng/g	UJ	x
SD-18-23	SE	Perfluoroundecanoic Acid (PFUnA)		5.3	6.2	ng/g	UJ	x

Attachment A

Nonconformance Summary Tables

Table A-1 - Percent Solids

Sample ID	Percent Solids (%)	Status
SD-18-11	20.9	<30%
SD-18-12	15.5	<30%
SD-18-13	23	<30%
SD-18-13-DUP	23.8	<30%
SD-18-14	23.3	<30%
SD-18-15	26.5	<30%
SD-18-16	20.3	<30%
SD-18-17	16.5	<30%
SD-18-21	16.6	<30%
SD-18-22	13.6	<30%
SD-18-23	12.2	<30%

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK12
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM

Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 01/29/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK12 PFAS 14 analytes memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 19, 2018.

Sample ID	Matrix/Sample Type
SW-18-05-H-DUP	Field Duplicate of SW-18-05-H
SW-18-01-H	Surface water
SW-18-02-H	Surface water
SW-18-03-H	Surface water
SW-18-04-H	Surface water
SW-18-05-H	Surface water
SW-18-08-H	Surface water
SW-18-09-H	Surface water
SW-18-10-H	Surface water
SW-18-11-H	Surface water
SW-18-12-H	Surface water
SW-18-13-H	Surface water
SW-18-14-H	Surface water
SW-18-15-H	Surface water
SW-18-16-H	Surface water
SW-18-17-H	Surface water

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Aqueous samples by Method 537 version 1.1 Modified Using LCS/MS/MS (2018);
- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✗	Holding times and sample preservation
✓	Initial calibration/continuing calibration verification
✓	Laboratory blanks/equipment blanks
✓	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓	Field duplicate results
✗	Extracted internal standard results
✓	Injection internal standard results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for the 14 target compounds noted in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with QC acceptance criteria.

Select samples were re-extracted outside of the 7-day extraction holding time stipulated in the project specific SAP in order to confirm the extracted standard recovery nonconformances. The recovery of 13C2-PFTeDA in the initial analysis of select samples [SW-18-01-H, SW-18-10-H, SW-18-11-H, SW-18-12-H, SW-18-13H, SW-18-14-H, SW-18-15-H, and SW-18-16-H fell below 10% and was improved or met the QC acceptance limits in the re-extraction analysis. Consequently, the result from the reanalysis was chosen to be reported in order to avoid rejection of these data. All other sample results were reported from the initial analysis which was extracted and analyzed within holding time.

A reference method for the analysis of PFAS compounds using isotope dilution does not exist; therefore, there is no method established holding time criterion. The laboratory standard operating procedure (SOP) indicates that the extraction holding time for aqueous samples is 14 days from sample collection. Consequently, professional judgment was used to take data validation actions based on the SOP established extraction holding time criterion.

The 14-day extraction holding time was exceeded by two days for the re-extraction analysis of samples SW-18-01-H, SW-18-10-H, SW-18-11-H, SW-18-12-H, SW-18-13H, SW-18-14-H, SW-18-15-H, and SW-18-16-H. The nondetect results for PFTeDA reported from these analyses were qualified as estimated (UJ).

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the signal to noise (S/N) ratio and ion abundance ratio (if applicable to the review) QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and

- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

LCS/LSD Results

The LCS and LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of ≤ 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and ≤ 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

All field duplicate precision criteria were met.

Extracted Internal Standard Results

The extracted internal standard results were reviewed for conformance with the QC acceptance criteria.

Nonconformances are summarized in Attachment A in Table A-1. Samples were qualified as follows:

Actions: (Based on NFG 2016)

Criteria	Actions[1]	
	Detected	Nondetected
%R > Upper Acceptance Limit	J	UJ
%R >10% but < Lower Acceptance Limit	J	UJ
%R <10%	See below	
<10% and S/N >10:1	J	R
<10% and S/N <10:1	R	R

<table>
<tr><th rowspan="2">Criteria</th><th colspan="2">Actions[1]</th></tr>
<tr><th>Detected</th><th>Nondetected</th></tr>
<tr><td colspan="3">[1]The PFAS method is performed using isotope dilution technique; therefore, professional judgment was applied and bias codes were not included in data qualification.</td></tr>
</table>

Qualified sample results are summarized in Table 1.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This "J" qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SW-18-01-H	WS	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-01-H	WS	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-01-H	WS	Perfluorobutanesulfonic Acid (PFBS)	7.5	0.91	1.7	ng/L	J	lc
SW-18-01-H	WS	Perfluorododecanoic Acid (PFDoA)		1.0	1.7	ng/L	UJ	lc
SW-18-01-H	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	h,lc
SW-18-01-H	WS	Perfluorotridecanoic Acid (PFTrDA)		1.0	1.7	ng/L	UJ	lc
SW-18-01-H	WS	Perfluoroundecanoic Acid (PFUnA)		1.0	1.7	ng/L	UJ	lc
SW-18-02-H	WS	Perfluorobutanesulfonic Acid (PFBS)	17	0.92	1.7	ng/L	J	lc
SW-18-03-H	WS	Perfluorobutanesulfonic Acid (PFBS)	26	0.90	1.6	ng/L	J	lc
SW-18-03-H	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.6	ng/L	UJ	lc
SW-18-04-H	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.7	ng/L	UJ	lc
SW-18-05-H	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc
SW-18-05-H-DUP	WS	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.4	ng/L	UJ	lc
SW-18-05-H-DUP	WS	Perfluorododecanoic Acid (PFDoA)		0.98	1.6	ng/L	UJ	lc
SW-18-05-H-DUP	WS	Perfluorotetradecanoic Acid (PFTA)		0.98	1.6	ng/L	UJ	lc
SW-18-05-H-DUP	WS	Perfluorotridecanoic Acid (PFTrDA)		0.98	1.6	ng/L	UJ	lc
SW-18-08-H	WS	Perfluorotetradecanoic Acid (PFTA)		0.98	1.6	ng/L	UJ	lc
SW-18-09-H	WS	Perfluorobutanesulfonic Acid (PFBS)	2.6	0.91	1.7	ng/L	J	lc
SW-18-09-H	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc
SW-18-10-H	WS	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-10-H	WS	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-10-H	WS	Perfluorododecanoic Acid (PFDoA)		1.0	1.7	ng/L	UJ	lc
SW-18-10-H	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.7	ng/L	UJ	h
SW-18-10-H	WS	Perfluorotridecanoic Acid (PFTrDA)		1.0	1.7	ng/L	UJ	lc
SW-18-10-H	WS	Perfluoroundecanoic Acid (PFUnA)		1.0	1.7	ng/L	UJ	lc
SW-18-11-H	WS	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SW-18-11-H	WS	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-11-H	WS	Perfluorododecanoic Acid (PFDoA)		1.0	1.7	ng/L	UJ	lc
SW-18-11-H	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	h,lc
SW-18-11-H	WS	Perfluorotridecanoic Acid (PFTrDA)		1.0	1.7	ng/L	UJ	lc
SW-18-11-H	WS	Perfluoroundecanoic Acid (PFUnA)		1.0	1.7	ng/L	UJ	lc
SW-18-12-H	WS	n-ethyl perfluorooctane sulfonamidoacetic acid		2.0	2.5	ng/L	UJ	lc
SW-18-12-H	WS	n-methyl perfluorooctane sulfonamidoacetic acid		2.0	2.5	ng/L	UJ	lc
SW-18-12-H	WS	Perfluorododecanoic Acid (PFDoA)		0.99	1.6	ng/L	UJ	lc
SW-18-12-H	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.6	ng/L	UJ	h
SW-18-12-H	WS	Perfluorotridecanoic Acid (PFTrDA)		0.99	1.6	ng/L	UJ	lc
SW-18-12-H	WS	Perfluoroundecanoic Acid (PFUnA)		0.99	1.6	ng/L	UJ	lc
SW-18-13-H	WS	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-13-H	WS	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-13-H	WS	Perfluorobutanesulfonic Acid (PFBS)	1.9	0.93	1.7	ng/L	J	lc
SW-18-13-H	WS	Perfluorododecanoic Acid (PFDoA)		1.0	1.7	ng/L	UJ	lc
SW-18-13-H	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	h,lc
SW-18-13-H	WS	Perfluorotridecanoic Acid (PFTrDA)		1.0	1.7	ng/L	UJ	lc
SW-18-14-H	WS	n-ethyl perfluorooctane sulfonamidoacetic acid		2.0	2.5	ng/L	UJ	lc
SW-18-14-H	WS	Perfluorobutanesulfonic Acid (PFBS)	2.0	0.90	1.6	ng/L	J	lc
SW-18-14-H	WS	Perfluorododecanoic Acid (PFDoA)		0.98	1.6	ng/L	UJ	lc
SW-18-14-H	WS	Perfluorotetradecanoic Acid (PFTA)		0.98	1.6	ng/L	UJ	h,lc
SW-18-14-H	WS	Perfluorotridecanoic Acid (PFTrDA)		0.98	1.6	ng/L	UJ	lc
SW-18-15-H	WS	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-15-H	WS	N-Methyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-15-H	WS	Perfluorobutanesulfonic Acid (PFBS)	1.7	0.91	1.7	ng/L	J	lc
SW-18-15-H	WS	Perfluorododecanoic Acid (PFDoA)		1.0	1.7	ng/L	UJ	lc
SW-18-15-H	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	h
SW-18-15-H	WS	Perfluorotridecanoic Acid (PFTrDA)		1.0	1.7	ng/L	UJ	lc
SW-18-15-H	WS	Perfluoroundecanoic Acid (PFUnA)		1.0	1.7	ng/L	UJ	lc
SW-18-16-H	WS	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid		2.0	2.5	ng/L	UJ	lc
SW-18-16-H	WS	N-Methyl Perfluorooctane		2.0	2.5	ng/L	UJ	lc

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
		Sulfonamidoacetic Acid						
SW-18-16-H	WS	Perfluorododecanoic Acid (PFDoA)		1.0	1.7	ng/L	UJ	lc
SW-18-16-H	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.7	ng/L	UJ	h
SW-18-16-H	WS	Perfluorotridecanoic Acid (PFTrDA)		1.0	1.7	ng/L	UJ	lc
SW-18-16-H	WS	Perfluoroundecanoic Acid (PFUnA)		1.0	1.7	ng/L	UJ	lc
SW-18-17-H	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc

Attachment A

Nonconformance Summary Tables

Table A-1 Extracted Internal Standards

Sample ID	Extracted Internal Standards	% Recovery	Lower Limit	Upper Limit
SW-18-01-H	13C2-PFDOA	26	50	150
	13C3-PFBS	169	50	150
	13C7-PFUnDA	45	50	150
	D3-MEFOSAA	47	50	150
	D5-ETFOSAA	27	50	150
SW-18-01-H RE	13C2-PFTEDA	38	50	150
SW-18-02-H	13C3-PFBS	155	50	150
SW-18-03-H	13C2-PFTEDA	23	50	150
	13C3-PFBS	154	50	150
SW-18-04-H	13C2-PFTEDA	34	50	150
SW-18-05-H	13C2-PFTEDA	27	50	150
SW-18-05-H-DUP	13C2-PFDOA	35	50	150
	13C2-PFTEDA	11	50	150
	D5-ETFOSAA	35	50	150
SW-18-08-H	13C2-PFTEDA	30	50	150
SW-18-09-H	13C2-PFTEDA	17	50	150
	13C3-PFBS	153	50	150
SW-18-10-H	13C2-PFDOA	17	50	150
	13C7-PFUnDA	34	50	150
	D3-MEFOSAA	34	50	150
	D5-ETFOSAA	17	50	150
SW-18-11-H	13C2-PFDOA	26	50	150
	13C7-PFUnDA	43	50	150
	D3-MEFOSAA	47	50	150
	D5-ETFOSAA	29	50	150
SW-18-11-H RE	13C2-PFTEDA	34	50	150
SW-18-12-H	13C2-PFDOA	28	50	150
	13C7-PFUnDA	46	50	150
	D3-MEFOSAA	49	50	150
	D5-ETFOSAA	31	50	150
SW-18-13-H	13C2-PFDOA	30	50	150
	13C3-PFBS	163	50	150
	D3-MEFOSAA	47	50	150
	D5-ETFOSAA	27	50	150
SW-18-13-H RE	13C2-PFTEDA	48	50	150

Sample ID	Extracted Internal Standards	% Recovery	Lower Limit	Upper Limit
SW-18-14-H	13C2-PFDOA	30	50	150
	13C3-PFBS	169	50	150
	D5-ETFOSAA	27	50	150
SW-18-14-H RE	13C2-PFTEDA	38	50	150
SW-18-15-H	13C2-PFDOA	16	50	150
	13C3-PFBS	156	50	150
	13C7-PFUnDA	33	50	150
	D3-MEFOSAA	34	50	150
	D5-ETFOSAA	17	50	150
SW-18-16-H	13C2-PFDOA	19	50	150
	13C7-PFUnDA	34	50	150
	D3-MEFOSAA	38	50	150
	D5-ETFOSAA	23	50	150
SW-18-17-H	13C2-PFTEDA	29	50	150

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK13
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM

Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 01/29/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK13 PFAS 14 analytes memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 19, 2018 and November 20, 2018.

Sample ID	Matrix/Sample Type
SW-18-20-H-DUP	Field Duplicate of SW-18-20-H
SW-18-06	Surface water
SW-18-07	Surface water
SW-18-18-H	Surface water
SW-18-19-H	Surface water
SW-18-20-H	Surface water
SW-18-21-H	Surface water
SW-18-22-H	Surface water
SW-18-23-H	Surface water
SW-18-24	Surface water

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Aqueous samples by Method 537 version 1.1 Modified Using LCS/MS/MS (2018);
- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times and sample preservation
✓	Initial calibration/continuing calibration verification
✓	Laboratory blanks/equipment blanks
✗	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✗	Field duplicate results
✗	Extracted internal standard results
✓	Injection internal standard results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for the 14 target compounds noted in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with QC acceptance criteria.

All QC acceptance criteria were met with the following exceptions. Samples SW-18-23-H, SW-18-22-H, SW-18-21-H, SW-18-20-H-DUP, SW-18-20-H, SW-18-19-H and SW-18-18-H exceeded the 7-day extraction holding time stipulated in the project specific SAP by one day. A reference method for the analysis of PFAS compounds using isotope dilution does not exist; therefore, there is no method established holding time criterion. The laboratory standard operating procedure (SOP) indicates that the extraction holding time for aqueous samples is 14 days from sample collection. Consequently, professional judgment was used to accept the data without qualification since this sample met the SOP established extraction holding time criterion.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks associated with the samples in this data set. An equipment blank was not submitted with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria.

Nonconformances are summarized in Attachment A in Table A-1. Samples were qualified as follows:

Actions: (Based on NFG 2017)

Qualify results	MS/MSD %Rs			MS/MSD RPD
	<10% R	**10%R to Lower Limit**	**>Upper Limit**	**> QC Limit**
Detected Results	J-	J-	J+	J
Non-Detected Results	R	UJ	Accept	Accept
[1]Criteria from **Table B-15, QSM 5.1**: Use in-house laboratory QC limits for LCS %R if not specified. RPD < 30%				
Notes: Qualifications should be applied to the affected compound in the unspiked sample only unless all data appear to be impacted. If the sample result is > 4x the spike added concentration, no action is taken based on Resolution Consultants' professional judgment. As noted in E.4 of the NFG, considerations include the actions noted above but are not limited to these actions. Therefore, Resolution Consultants' professional judgment is applied to include bias codes.				

Qualified sample results are summarized in Table 1.

LCS/LSD Results

The LCS and LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of < 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and < 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

Nonconformances are summarized in Attachment A in Table A-2. Samples were qualified as follows:

Actions: (Based on Resolution Consultants' professional judgment)

Criteria	RPD	Action[1]	
		Detect	Nondetect
Sample and duplicate are nondetect results	Not calculable (NC)	No qualification	No qualification
Sample and duplicate results <LOQ	Not applicable	No qualification	No qualification
Sample and duplicate results $\geq$5x LOQ	>30% Aqueous >50% All other sample types	J	Not Applicable
Sample and duplicate results are > LOQ and < 5x QL	>60% Aqueous >100% All other sample types	J	Not Applicable
If sample or duplicate result is >5x LOQ and the other is not detec5ted	NC	J	UJ
If sample or duplicate result is < LOQ and the other is not detected	NC	No qualification	No qualification
[1] Resolution Consultants' professional judgement is used to determine the actions applied to sample results when the sample results do not fall into the scenarios described in this table.			

Qualified sample results are summarized in Table 1.

Extracted Internal Standard Results

The extracted internal standard results were reviewed for conformance with the QC acceptance criteria.

Nonconformances are summarized in Attachment A in Table A-3. Samples were qualified as follows:

Actions: (Based on NFG 2016)

Criteria	Actions[1]	
	Detected	Nondetected
%R > Upper Acceptance Limit	J	UJ
%R >10% but < Lower Acceptance Limit	J	UJ
%R <10%	See below	
<10% and S/N >10:1	J	R
<10% and S/N <10:1	R	R
[1]The PFAS method is performed using isotope dilution technique; therefore, professional judgment was applied and bias codes were not included in data qualification.		

Qualified sample results are summarized in Table 1.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This “J” qualifier is retained during data validation.

It should be noted that in instances of multiple nonconformances, the bias is considered indeterminate in cases where a conflicting low and high bias exists or when a result does not exhibit a consistent bias for all nonconformances. These results have an overall qualification of estimated (J).

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SW-18-07	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.7	ng/L	UJ	lc
SW-18-20-H	WS	Perfluorohexanesulfonic Acid (PFHxS)	43	0.92	1.7	ng/L	J	fd
SW-18-20-H	WS	Perfluorohexanoic Acid (PFHxA)	11	1.0	1.7	ng/L	J	fd,m
SW-18-20-H	WS	Perfluorooctanesulfonic Acid (PFOS)	12	1.0	1.7	ng/L	J	fd,m
SW-18-20-H	WS	Perfluorooctanoic Acid (PFOA)	13	1.0	1.7	ng/L	J	fd,m
SW-18-20-H	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc
SW-18-20-H-DUP	WS	Perfluorohexanesulfonic Acid (PFHxS)	23	0.93	1.7	ng/L	J	fd
SW-18-20-H-DUP	WS	Perfluorohexanoic Acid (PFHxA)	7.1	1.0	1.7	ng/L	J	fd
SW-18-20-H-DUP	WS	Perfluorooctanesulfonic Acid (PFOS)	6.5	1.0	1.7	ng/L	J	fd
SW-18-20-H-DUP	WS	Perfluorooctanoic Acid (PFOA)	8.2	1.0	1.7	ng/L	J	fd
SW-18-20-H-DUP	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc
SW-18-21-H	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc
SW-18-23-H	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.7	ng/L	UJ	lc
SW-18-24	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc

Attachment A

Nonconformance Summary Tables

Table A-1 - MS/MSD Results

Sample ID	Compound	MS % Recovery	MSD % Recovery	Lower Limit	Upper Limit	RPD	RPD Limit
SW-18-20-H	Perfluorooctanoic Acid (PFOA)	-32	-21	76	136	ok	30
	Perfluorohexanoic Acid (PFHxA)	25	27	77	132	ok	30
	Perfluorooctanesulfonic Acid (PFOS)	-28	-21	67	134	ok	30

Table A-2 - Field Duplicates

Sample ID	Duplicate ID	Compound	Sample Result	Qual	Duplicate Result	Qual	LOQ	Units	RPD
SW-18-20-H	SW-18-20-H-DUP	Perfluorohexanesulfonic Acid (PFHxS)	43		23		1.7	ng/L	60.6
SW-18-20-H	SW-18-20-H-DUP	Perfluorooctanoic Acid (PFOA)	13		8.2		1.7	ng/L	45.3
SW-18-20-H	SW-18-20-H-DUP	Perfluorohexanoic Acid (PFHxA)	11		7.1		1.7	ng/L	43.1
SW-18-20-H	SW-18-20-H-DUP	Perfluorooctanesulfonic Acid (PFOS)	12		6.5		1.7	ng/L	59.5

Table A-3 - Extracted Internal Standards

Sample ID	Extracted Internal Standards	% Recovery	Lower Limit	Upper Limit
SW-18-07	13C2-PFTEDA	45	50	150
SW-18-20-H	13C2-PFTEDA	48	50	150
SW-18-20-H-DUP	13C2-PFTEDA	49	50	150
SW-18-21-H	13C2-PFTEDA	47	50	150
SW-18-23-H	13C2-PFTEDA	45	50	150
SW-18-24	13C2-PFTEDA	40	50	150

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

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Data Validation Report

Project:	Little Magothy River Swimming/Wading Risk Evaluation
Laboratory:	Eurofins Lancaster Laboratories Environmental, Lancaster, PA
Service Request:	TAK14
Analyses/Method:	PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15/ PFAS Isotope Dilution Method
Validation Level:	Stage 2B
Resolution Consultants Project Number:	60444465.SA.DM

Prepared by:	Paula DiMattei/Resolution Consultants	Completed on: 01/30/2019
Reviewed by:	Elissa McDonagh/Resolution Consultants	File Name: TAK14 PFAS 14 analytes memo

SUMMARY

The samples listed below were collected by Resolution Consultants from the Little Magothy River site on November 20, 2018.

Sample ID	Matrix/Sample Type
EB-112018	Equipment blank
SW-18-05-L-DUP	Field Duplicate of SW-18-05-L
SW-18-11-L-DUP	Field Duplicate of SW-18-11-L
SW-18-15-L-DUP	Field Duplicate of SW-18-15-L
SW-18-03-L	Surface water
SW-18-04-L	Surface water
SW-18-05-L	Surface water
SW-18-08-L	Surface water
SW-18-09-L	Surface water
SW-18-10-L	Surface water
SW-18-11-L	Surface water
SW-18-12-L	Surface water
SW-18-13-L	Surface water
SW-18-14-L	Surface water
SW-18-15-L	Surface water
SW-18-16-L	Surface water
SW-18-17-L	Surface water
SW-18-18-L	Surface water
SW-18-19-L	Surface water

Sample ID	Matrix/Sample Type
SW-18-20-L	Surface water
SW-18-21-L	Surface water
SW-18-22-L	Surface water
SW-18-23-L	Surface water

Data validation activities were conducted with reference to:

- Laboratory SOP: Polyfluorinated Alkyl Substances (PFAS) in Aqueous samples by Method 537 version 1.1 Modified Using LCS/MS/MS (2018);
- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (January 2017);
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (April 2016);
- Table B-15 from the Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1 (DoD, 2017);
- Project-specific Sampling and Analysis Plan; and the
- laboratory quality control (QC) limits

The National Functional Guidelines were modified to accommodate the non-CLP methodologies. In the absence of method-specific information, laboratory QC limits, project-specific requirements and/or Resolution Consultants' professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓	Data completeness (chain-of-custody (COC)/sample integrity
✓	Holding times and sample preservation
✓	Initial calibration/continuing calibration verification
✓	Laboratory blanks/equipment blanks
✓	Matrix spike (MS) and/or matrix spike duplicate (MSD) results
✓	Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) results
✓	Field duplicate results
✗	Extracted internal standard results
✓	Injection internal standard results
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. An NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. The symbol (✗) indicates that a QC nonconformance resulted in the qualification of data. Any QC nonconformance that resulted in the qualification of data is discussed below. In addition, nonconformances or other issues that were noted during validation, but did not result in qualification of data, may be discussed for informational purposes only.

The data appear valid as qualified and may be used for decision making purposes. Select data points were qualified as estimated due to nonconformances of certain QC criteria (see discussion below). Qualified sample results are presented in Table 1.

RESULTS

Data Completeness (COC)/Sample Integrity

The data package was reviewed and found to meet acceptance criteria for completeness:

- The COCs were reviewed for completeness of information relevant to the samples and requested analyses, and for signatures indicating transfer of sample custody.
- The laboratory sample login sheet(s) were reviewed for issues potentially affecting sample integrity, including the condition of sample containers upon receipt at the laboratory.
- Completeness of analyses was verified by comparing the reported results to the COC requests.

The samples in this SDG were analyzed for the 14 target compounds noted in EPA Method 537.1.1 (September 2009).

Holding Times and Sample Preservation

Sample preservation and preparation/analysis holding times were reviewed for conformance with QC acceptance criteria.

All QC acceptance criteria were met with the following exception. Samples SW-18-09-L, SW-18-18-L and SW-18-20-L exceeded the 7-day extraction holding time stipulated in the project specific SAP by seven days. A reference method for the analysis of PFAS compounds using isotope dilution does not exist; therefore, there is no method established holding time criterion. The laboratory standard operating procedure (SOP) indicates that the extraction holding time for aqueous samples is 14 days from sample collection. Consequently, professional judgment was used to accept the data without qualification since this sample met the SOP established extraction holding time criterion.

Initial Calibration/Initial and Continuing Calibration Verification

Calibration data were reviewed for conformance with the QC acceptance criteria to ensure that:

- the initial calibration (ICAL) percent relative standard deviation (%RSD), correlation coefficient (r) or coefficient of determination (r^2) QC acceptance criteria were met;
- the recalculation of the initial calibration standards QC acceptance criteria were met;
- the initial calibration verification standard (ICV) QC acceptance criteria were met;
- the instrument sensitivity check (ISC) QC acceptance criteria were met; and
- the continuing calibration verification standard (CCV) frequency and percent recovery (%R) QC acceptance criteria were met.

All QC acceptance criteria were met.

Laboratory Blanks/Equipment Blanks

Laboratory instrument blank, laboratory method blank, and equipment rinsate blank results are evaluated as to whether there are contaminants detected above the detection limit (DL). Target compounds were not detected in the laboratory blanks or equipment blank associated with the samples in this data set.

MS/MSD Results

The MS/MSD percent recoveries (%Rs) and relative percent differences (RPDs) were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met or qualification of the data was not required.

LCS/LSD Results

The LCS and LCSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Field Duplicate Results

Field duplicate RPDs were reviewed for conformance with the Resolution Consultants' QC acceptance criteria of ≤ 50% [if one or both results were greater than five times the limit of quantitation (LOQ)] for solid matrices and ≤ 30% [if one or both results were greater than five times the limit of quantitation (LOQ)] for aqueous matrices.

All field duplicate precision criteria were met.

Extracted Internal Standard Results

The extracted internal standard results were reviewed for conformance with the QC acceptance criteria.

Nonconformances are summarized in Attachment A in Table A-1. Samples were qualified as follows:

Actions: (Based on NFG 2016)

Criteria	Actions[1]	
	Detected	Nondetected
%R > Upper Acceptance Limit	J	UJ
%R >10% but < Lower Acceptance Limit	J	UJ
%R <10%	See below	
<10% and S/N >10:1	J	R
<10% and S/N <10:1	R	R

[1] The PFAS method is performed using isotope dilution technique; therefore, professional judgment was applied and bias codes were not included in data qualification.

Qualified sample results are summarized in Table 1.

Injection Internal Standard Results

The injection internal standard results were reviewed for conformance with the QC acceptance criteria. All QC acceptance criteria were met.

Sample Results/Reporting Issues

All sample results detected at concentrations less than the lowest calibration standard but greater than the DL are qualified by the laboratory as estimated (J). This “J” qualifier is retained during data validation.

QUALIFICATION ACTIONS

Sample results qualified as a result of validation actions are summarized in Table 1. All actions are described above.

ATTACHMENTS

Attachment A: Nonconformance Summary Tables

Attachment B: Qualifier Codes and Explanations

Attachment C: Reason Codes and Explanations

Table 1 - Data Validation Summary of Qualified Data

Sample ID	Matrix	Compound	Result	LOD	LOQ	Units	Validation Qualifiers	Validation Reason
SW-18-05-L	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.6	ng/L	UJ	lc
SW-18-05-L-DUP	WS	Perfluorotetradecanoic Acid (PFTA)		0.98	1.6	ng/L	UJ	lc
SW-18-08-L	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc
SW-18-10-L	WS	Perfluorotetradecanoic Acid (PFTA)		0.98	1.6	ng/L	UJ	lc
SW-18-11-L	WS	Perfluorobutanesulfonic Acid (PFBS)	9.1	1.0	1.9	ng/L	J	lc
SW-18-14-L	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc
SW-18-15-L-DUP	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.6	ng/L	UJ	lc
SW-18-16-L	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc
SW-18-17-L	WS	Perfluorotetradecanoic Acid (PFTA)		0.99	1.7	ng/L	UJ	lc
SW-18-21-L	WS	Perfluorobutanesulfonic Acid (PFBS)	2.8	1.0	1.9	ng/L	J	lc
SW-18-22-L	WS	Perfluorotetradecanoic Acid (PFTA)		1.0	1.7	ng/L	UJ	lc
SW-18-23-L	WS	Perfluorotetradecanoic Acid (PFTA)		0.98	1.6	ng/L	UJ	lc

Attachment A

Nonconformance Summary Tables

Table A-1 - Extracted Internal Standards

Sample ID	Extracted Internal Standards	% Recovery	Lower Limit	Upper Limit
SW-18-05-L	13C2-PFTEDA	46	50	150
SW-18-05-L-DUP	13C2-PFTEDA	45	50	150
SW-18-08-L	13C2-PFTEDA	43	50	150
SW-18-10-L	13C2-PFTEDA	42	50	150
SW-18-11-L	13C3-PFBS	152	50	150
SW-18-14-L	13C2-PFTEDA	38	50	150
SW-18-15-L-DUP	13C2-PFTEDA	44	50	150
SW-18-16-L	13C2-PFTEDA	48	50	150
SW-18-17-L	13C2-PFTEDA	44	50	150
SW-18-21-L	13C3-PFBS	151	50	150
SW-18-22-L	13C2-PFTEDA	45	50	150
SW-18-23-L	13C2-PFTEDA	38	50	150

Attachment B

Qualifier Codes and Explanations

Qualifier	Explanation
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential low bias.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with a potential high bias.
JN	The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Attachment C

Reason Codes and Explanations

Reason Code	Explanation
be	Equipment blank contamination
bf	Field blank contamination
bl	Laboratory blank contamination
c	Calibration issue
cl	Clean-up standard recovery
d	Reporting limit raised due to chromatographic interference
fd	Field duplicate RPDs
h	Holding times
i	Internal standard areas (including recovery standards)
k	Estimated Maximum Possible Concentration (EMPC)
l	LCS or OPR recoveries
lc	Extracted internal standard recovery
ld	Laboratory duplicate RPDs
lp	Laboratory control sample/laboratory control sample duplicate RPDs
m	Matrix spike recovery
md	Matrix spike/matrix spike duplicate RPDs
nb	Negative laboratory blank contamination
p	Chemical preservation issue
r	Dual column RPD
q	Quantitation issue
s	Surrogate recovery
su	Ion suppression
t	Temperature preservation issue
x	Percent solids
y	Serial dilution results
z	ICS results

Appendix E
Human Health Risk Assessment

APPENDIX E
HUMAN HEALTH RISK ASSESSMENT

Former Bay Head Road Annex IR Program Site 1
Former Naval Surface Warfare Center
Carderock Division
Annapolis Detachment
Annapolis, Maryland

Final

Prepared for:

Department of the Navy
Naval Facilities Engineering Command, Washington
1314 Harwood Street SE
Washington Navy Yard, DC 20374-5018

July 2020

APPENDIX E
HUMAN HEALTH RISK ASSESSMENT

Former Bay Head Road Annex IR Program Site 1
Former Naval Surface Warfare Center
Carderock Division
Annapolis Detachment
Annapolis, Maryland

Final

Prepared for:

Department of the Navy
Naval Facilities Engineering Command, Washington
1314 Harwood Street SE
Washington Navy Yard, DC 20374-5018

Prepared by:

1155 Elm Street, Suite 401
Manchester, NH 03101

Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-17-D-1800, CTO N4008018F4822

July 2020

CONTENTS

FIGURES

TABLES*

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* Tables 1 through 10 (human health risk assessment tables) follow the numbering scheme required by USEPA's Risk Assessment Guidance for Superfund (RAGS) Part D guidance document. Where tables are not required, there may be gaps in table numbers (e.g., Table 8).

ATTACHMENTS

LIST OF ACRONYMS AND ABBREVIATIONS

%	Percent
>	greater than
ABS_{GI}	fraction of contaminant absorbed in gastrointestinal tract
ADAF	age-dependent adjustment factor
ADD	average daily dose
AFFF	aqueous film forming foam
BHRA	Bay Head Road Annex
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
COPC	chemical of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CTA	Children’s Theatre of Annapolis
CTE	central tendency exposure
DOD	Department of Defense
DON	Department of Navy
DPT	direct-push technology
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
FBP	Former Burn Pad
ft bgs	feet below ground surface
HHRA	human health risk assessment
HI	hazard index
HPT	hydraulic profiling tool
HQ	hazard quotient
IC	institutional control
IRIS	Integrated Risk Information System
KM	Kaplan-Meier
K_{OW}	octanol-water partition coefficient
K_P	dermal permeability coefficient
LADD	lifetime average daily dose
LOD	limit of detection
MDE	Maryland Department of the Environment

mg/kg-day	milligram per kilogram per day
NAVFAC	Naval Facilities Engineering Command
NCOPC	not a chemical of potential concern
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PPRTV	Provisional Peer-Reviewed Toxicity Values
PVC	polyvinyl chloride
RAGS	Risk Assessment Guidance for Superfund
RfD	reference dose
RfD_{ABS}	absorbed reference dose
RfD_{O}	oral reference dose
RI	remedial investigation
RME	reasonable maximum exposure
RSL	Regional Screening Level
SAP	sampling and analysis plan
SF_{ABS}	absorbed slope factor
SF_{O}	oral slope factor
U.S.	United States
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
UU/UE	unlimited use/unrestricted exposure
µg/L	microgram per liter
µg/kg	microgram per kilogram

EXECUTIVE SUMMARY

This human health risk assessment (HHRA) report is presented as an appendix to the Phase I Remedial Investigation (RI) Report for the Former Bay Head Road Annex (BHRA) (site) in Annapolis, Maryland. The primary objective of the HHRA is to evaluate the potential risk/hazard to human receptors associated with exposure to per- and polyfluoroalkyl substances (PFAS) (specifically perfluorooctane sulfonate [PFOS], perfluorooctanoic acid [PFOA], and perfluorobutanesulfonic acid [PFBS]) present in soil, groundwater, drinking water, sediment, and surface water attributable to past operations at the site. The HHRA was conducted in accordance with the United States (U.S.) Navy and U.S. Environmental Protection Agency's (USEPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) risk assessment guidance and policies, as applicable, and as referenced throughout this appendix.

HHRA Dataset

The dataset evaluated in the HHRA is as follows:

- The HHRA soil dataset included results from surface soil samples collected from 0 to 1 feet (ft) below ground surface (bgs) and subsurface soil samples collected from a 1 ft depth interval between 12 and 20 ft bgs, from 12 on-site locations sampled during the November 2016 and/or January 2017 sampling events.
- The HHRA groundwater dataset included results from grab groundwater samples collected from 35 locations across the site during the November/December 2016 and January 2017 sampling events.
- The HHRA drinking water dataset included results from drinking water samples collected from 2 permanent shallow wells, via cold-water spigots, at residential properties within one-half mile of the site during the November 2016 sampling event.
- The HHRA sediment dataset included results for sediment samples collected from 4 locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016, and from 24 locations at downgradient off-site locations to the north of the site (off-site, west of Bay Head Road) in April and/or November 2018.
- The HHRA surface water dataset included results for surface water samples collected from 2 locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016, and from 24 locations at downgradient off-site locations to the north of the site (off-site, west of Bay Head Road), including 5 locations along the creek in April 2018 and 24 locations along the creek and within the bay in November 2018.

Receptors and Exposure Scenarios Evaluated

The HHRA evaluated potentially complete exposure pathways for the following human receptors identified based on current and reasonable future land-use scenarios in accordance with the conceptual site model (CSM):

- Current/future recreational user (adult/child)
- Current/future outdoor (commercial/industrial) worker
- Future construction/excavation/utility worker
- Hypothetical future on-site resident (adult/child)

The above receptors may be exposed to soil (all receptors) and/or sediment (recreational user) via incidental ingestion and dermal contact; and groundwater via incidental ingestion (workers) or ingestion as drinking water (hypothetical future resident). The inhalation exposure pathway was not quantitatively assessed for PFAS due to the absence of currently recommended toxicity values by USEPA, and dermal contact with PFAS in groundwater was not quantitatively evaluated in accordance with the approach used by USEPA (2019a) due to the limited dermal absorption of PFAS in water through human skin.

There are currently no residents located on the site and there are no plans for residential use of the site in the future. Current institutional controls (IC) restrict use of the property to non-residential development (DON, 2001b). In addition, groundwater underlying site is not used for drinking water. The site and immediate vicinity are connected to the Anne Arundel County Public Water system and the county and state regulations prohibit the installation of water supply wells. Therefore, groundwater was not evaluated for potable use by commercial/industrial receptors in the HHRA. However, a residential exposure scenario, including the use of groundwater under a potable/household use scenario, was evaluated in the HHRA as a conservative measure of hypothetical future site use to represent an unlimited use/unrestricted exposure (UU/UE) scenario and provide information for decision-making purposes. Evaluation of groundwater under a residential scenario is also protective of potable use by commercial/industrial receptors.

There are two shallow private residential drinking water wells located within one-half mile hydraulically down- or side-gradient of the site. The analytical results associated with drinking water samples from these wells indicated non-detect levels of PFAS compounds. Thus, indicating that off-site exposure through drinking water is currently not complete.

Tier I Screening Evaluation

The Tier I Screening (i.e., chemical of potential concern [COPC] selection) step of the HHRA was conducted using a two-tiered screening process, including a comparison of the maximum detected concentration of chemicals within each medium and exposure point to generic (Tier IA) screening levels (available for soil and groundwater) and site-specific (Tier IB) screening levels (derived for soil, groundwater, sediment, and surface water). Human health screening levels for PFAS were selected based the most currently available USEPA (2019a) and DOD (2019) guidance. The site-specific (Tier IB) screening levels were developed using site-specific information to be protective of current and potential future use exposure scenarios, in accordance with the site CSM. Chemicals detected at concentrations above the screening levels were further evaluated in the Tier II site-specific risk evaluation for the associated media, receptor/exposure scenario, and exposure point.

The results of the Tier I screening evaluation are as follows:

- No soil or groundwater COPCs were identified for the on-site outdoor (commercial/industrial) worker or construction/excavation/utility worker exposure scenarios. Therefore, these scenarios do not pose an unacceptable risk/hazard and were not further evaluated in the Tier II HHRA;
- No soil, sediment, or surface water COPCs were identified for the recreational user; therefore, exposure to soil, sediment, or surface water by this receptor does not pose an unacceptable risk/hazard and was not further evaluated in the Tier II HHRA;
- PFOS was selected as a surface soil and combined surface and subsurface soil COPC for further evaluation of a hypothetical future on-site residential exposure scenario;

– PFOS and PFOA were selected as groundwater COPCs for further evaluation of a hypothetical future on-site residential exposure scenario (which is also protective of potable use of groundwater by commercial/industrial receptors).

Tier II Baseline HHRA

The Tier II HHRA performed a quantitative estimation of potential risk/hazard to current and potential future human receptors for which COPCs were identified in the Tier I screening evaluation. A reasonable maximum exposure (RME) scenario and a central tendency exposure (CTE) scenario were evaluated.

Potential risks/hazards were estimated based on exposure point concentrations (EPCs) of COPCs in soil and groundwater. For soil, EPCs were defined as the 95 percent (%) upper confidence limit (UCL) on the arithmetic mean concentration within the associated depth interval (i.e., surface soil; and combined surface and subsurface soil). Groundwater EPCs were defined as the 95% UCL concentration from locations identified as being within the core of the plume (i.e., area of the site with the highest groundwater concentrations), in accordance with USEPA guidance (2014b).

The cumulative potential excess lifetime cancer risk (ELCR) and noncancer hazard index (HI) (per target endpoint) for each exposure scenario were evaluated in comparison to USEPA's CERCLA target risk range of 10^{-6} to 10^{-4} for potential carcinogens and target HI of 1 for non-carcinogens. Cumulative potential ELCR's were also discussed in comparison to the Maryland Department of the Environment's target ELCR of 1 x 10^{-5} (MDE, 2019). For each associated exposure scenario (i.e., RME/CTE/receptor/medium) with a potential risk/HI above USEPA target levels, chemicals of concern (COCs) were defined as COPCs with an individual ELCR greater than (>) 10^{-6} or HI > 1.

HHRA Conclusions

Summaries of the potential ELCR and HI results associated with the hypothetical future on-site residential exposure scenario are presented in **Tables ES-1 and ES-2**, respectively, as follows**.**

Table ES-1. Summary of Potential ELCR Associated with a Hypothetical Future On-Site Residential Exposure Scenario:

	Surface Soil		**Combined Surface and Subsurface Soil**		**Groundwater**		**Cumulative ELCR (Soil and Groundwater)**
Scenario/ COPC	**EPC (µg/kg)**	**ELCR**	**EPC (µg/kg)**	**ELCR**	**EPC (µg/L)**	**ELCR**	
RME Scenario:							
PFOS	108	N/A	47	N/A	9.68	N/A	N/A
PFOA	NCOPC	NCOPC	NCOPC	NCOPC	8.74	8E-06	8E-06
						Cumulative ELCR:	**8E-06**
CTE Scenario:							
PFOS	108	N/A	47	N/A	9.68	N/A	N/A
PFOA	NCOPC	NCOPC	NCOPC	NCOPC	8.74	3E-06	3E-06
						Cumulative ELCR:	**3E-06**

NCOPC - Not identified as a COPC based on the Tier I screening evaluation.
N/A - Not applicable; cancer toxicity value not available for PFOA.

Table ES-2. Summary of Potential Noncancer HI Associated with a Hypothetical Future On-Site Residential Exposure Scenario:

Scenario/ COPC	Surface Soil		Combined Surface and Subsurface Soil		Groundwater		Total HI (Soil and Groundwater)
	EPC (µg/kg)	HI	EPC (µg/kg)	HI	EPC (µg/L)	HI	
RME Scenario:							
PFOS	108	0.09	47	0.04	9.68	24	24
PFOA	NCOPC	NCOPC	NCOPC	NCOPC	8.74	22	22
Total HI (rounded to one significant figure):							**50**
CTE Scenario:							
PFOS	108	0.03	47	0.01	9.68	15	15
PFOA	NCOPC	NCOPC	NCOPC	NCOPC	8.74	14	14
Total HI (rounded to one significant figure):							**30**

NCOPC - Not identified as a COPC based on the Tier I screening evaluation.

In summary, the conclusions of the HHRA indicate that for the hypothetical future on-site residential exposure scenario, the potential cumulative ELCR is within USEPA’s target ELCR range of 10^{-6} to 10^{-4}, and is also less than MDE’s target ELCR of 1×10^{-5}. However, the HI is greater than the USEPA target HI of 1, and is primarily driven by the potential ingestion/consumption of site groundwater as a drinking water source if used in the future. PFOS and PFOA were identified as site-related COCs in groundwater for a hypothetical future use scenario in which groundwater underlying the site is used as a source of drinking water or other potable use. Lastly, based on the Tier I and Tier II screening, no soil COCs were identified based on all the exposure scenarios evaluated, including the hypothetical future on-site residential scenario.

1. INTRODUCTION

This appendix presents a human health risk assessment (HHRA) conducted for the Former Bay Head Road Annex (BHRA) facility in Annapolis, Maryland (site). The HHRA was conducted as part of the Phase I Remedial Investigation (RI) report, which is being submitted on behalf of the Naval Facilities Engineering Command (NAVFAC) Washington, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62742-17-D-1800, Contract Task Order (CTO) F4822. The scope of this HHRA is limited to per- and polyfluoroalkyl substances (PFAS) (specifically perfluorooctane sulfonate [PFOS], perfluorooctanoic acid [PFOA], and perfluorobutanesulfonic acid [PFBS]) in soil, groundwater, drinking water, sediment, and surface water.

The history and description of the site is detailed in Section 1 of the RI report. The site location map is presented on **Figure 1**.

1.1 OBJECTIVES

The primary objective of the HHRA is to evaluate whether exposure to PFAS concentrations in soil, groundwater, drinking water, sediment, and surface water attributable to past operations at the Former BHRA facility may pose a risk/hazard to human health above USEPA target levels. The HHRA performs a quantitative estimation of potential risk/hazard to current and potential future human receptors that may come in contact with PFAS in soil, groundwater, drinking water, sediment, and surface water.

1.2 HHRA APPROACH

The HHRA was conducted in accordance with the United States (U.S.) Navy and U.S. Environmental Protection Agency's (USEPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) risk assessment guidance and policies, as applicable, and as referenced throughout this appendix. Guidance documentation includes, but is not limited to, the following:

- *Navy Policy for Conducting Human Health Risk Assessments Under the Environmental Restoration Program* (DON, 2001a)
- *Department of the Navy Environmental Restoration Program Manual* (DON, 2018)
- *U.S. Navy Human Health Risk Assessment Guidance* (DON, 2008)
- *Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual* (Parts A, B, D, E) (USEPA, 1989; 1991; 2001; 2004)
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA, 2002a)
- *Human Health Toxicity Values in Superfund Risk Assessments* (USEPA, 2003)
- *Exposure Factors Handbook* (USEPA, 2011)
- *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors* (USEPA, 2014a)
- *Determining Groundwater Exposure Point Concentrations, Supplemental Guidance* (USEPA, 2014b)

Pursuant to the *Navy Policy for Conducting Human Health Risk Assessments Under the Environmental Restoration Program* (DON, 2001a), the determination of human health risk at a site is clearly prescribed to ensure sufficient resources are allocated for the protection of human health. The Navy Policy for conducting HHRAs identifies a three-tiered approach that may be implemented in its entirety depending on the level and magnitude of incremental risk or hazard that is determined in prior tiers. The following sections describe the tiers followed for this HHRA.

1.2.1 Tier IA – Human Health Risk-Based Screening Evaluation

The Tier IA includes the following:

- Identify and summarize relevant datasets.
- Refine the conceptual site model (CSM) for potentially complete exposure pathways for both current and future land uses.
- Identify chemicals of potential concern (COPCs) for further quantitative evaluation in the site-specific risk-based screening evaluation (Tier IB).

1.2.2 Tier IB – Site-Specific Human Health Risk-Based Screening Evaluation

The Tier IB includes the following:

- Develop site-specific risk-based screening levels for potentially complete exposure pathways for both current and future land uses.
- Identify COPCs for further quantitative evaluation in the site-specific risk assessment (Tier II).

1.2.3 Tier II – Baseline Human Health Risk Assessment

The Tier II includes the following:

- **Data Evaluation and Reduction**: Conducted in Tier IA.
- **Exposure Assessment**: Includes re-evaluation of the CSM, if appropriate and necessary, and identification of potential receptors, pathways, and intake factors for both current and future land uses.
- **Toxicity Assessment**: Includes the hazard identification and dose-response assessment processes in which it is determined whether exposure to a chemical can cause an adverse health effect in humans; and where toxicity values and chemical-specific values for carcinogenic and noncarcinogenic COPCs are identified.
- **Risk Characterization**: Integrates the toxicity and exposure assessments to estimate the potential risk associated with COPCs at the site and identifies risk drivers/risk-based chemicals of concern (COCs) above target risk/hazard levels.
- **Uncertainty Analysis**: Discusses the uncertainty associated with all aspects of the HHRA or limitations that may have a significant impact on the outcome of the HHRA due to an underestimation or overestimation of risk.

Section 2 presents the data evaluation; Section 3 presents the Tier IA/B risk-based screening evaluation; Section 4 presents the Tier II baseline HHRA; and Section 5 presents a description of uncertainties. The HHRA summary conclusions are presented in Section 6.

2. ANALYTICAL DATA SUMMARY

This section summarizes the available environmental data (soil, groundwater, drinking water, sediment, and surface water) and discusses how the analytical data were compiled and summarized for evaluation in the HHRA. Sampling was conducted on and in the vicinity of the site during multiple stages of investigation. A brief summary of the sampling events is provided in this section. Further details on the sampling events performed as part of each phase of site investigation and the nature and extent of PFAS in site media are provided in Sections 3 and 4 of the RI report, respectively.

2.1 SUMMARY OF ANALYTICAL DATA EVALUATED IN THE HHRA

A brief description of the environmental data evaluated in the HHRA is provided below by media. Summary tables of analytical data evaluated in the HHRA are presented in **Attachment A**. This HHRA evaluates the three PFAS compounds with published toxicity values from USEPA's hierarchy of sources of dose-response values (discussed in Section 4.3), which include PFOS, PFOA, and PFBS. Additional PFAS compounds were analyzed in groundwater, drinking water, sediment, and surface water. However, due to a lack of currently recommended toxicity values by USEPA, these compounds are not evaluated or further discussed in this HHRA report.

2.1.1 Soil

Focused soil sampling was conducted during the Stage 2 on-site RI activities from November 2016 through January 2017 to determine the extent of PFAS in soil in the vicinity of potential PFAS source areas. Twenty-six (26) soil samples, including 2 field duplicates, were collected from 12 locations on the site and analyzed for PFAS. At each location, a surface soil sample was collected from 0 to 1 feet (ft) below ground surface (bgs), and a subsurface soil sample was collected from a 1 ft interval between 12 and 20 ft bgs. Sample/field duplicate pairs were combined and treated as one sample result for evaluation in the HHRA, as further discussed in Section 2.2. Therefore, 24 soil sample/field duplicate pairs were evaluated in the HHRA.

Soil data were grouped as follows for evaluation in the HHRA: (1) surface soil (0 to 1 ft bgs); and combined surface and subsurface soil (0 to 20 ft bgs). Human contact with soil deeper than 10 to 15 ft bgs is not likely to occur. However, since subsurface soil samples were not collected shallower than or equal to 15 ft bgs at some locations, the deeper subsurface soil samples were used to represent the shallower subsurface soil interval. A summary of soil samples and the analytical soil data evaluated in the HHRA are presented in **Attachment A, Table A-1**. The soil sample locations are presented on **Figure 2**.

2.1.2 Groundwater

Seventy-two (72) groundwater samples, including 4 field duplicates, were collected from 35 locations on the site during the November/December 2016 and January 2017 sampling events and analyzed for PFAS. Grab groundwater samples were collected in the overburden from two different 4-ft depth intervals at 33 of the 35 direct-push technology (DPT) boring locations (only one sample was collected at DPT-16-01 and -05) based on hydraulic profiling tool (HPT) data for soil particle size and hydraulic conductivity using a GeoProbe® Screen Point 16 Groundwater Sampler or temporary polyvinyl chloride (PVC) well points with 5-foot slotted screen. None of the DPT borings encountered bedrock. A summary of groundwater samples and analytical data evaluated in the HHRA are presented in **Attachment A, Table A-2**. The groundwater sample locations are presented on **Figure 2**.

2.1.3 Drinking Water

Three (3) drinking water samples, including one field duplicate, were collected from 2 permanent shallow wells, via cold-water spigots, located at residential properties within one-half mile of the site during the November 2016 sampling event. The depth of private well DW-16-01 is 55 to 60 ft bgs; and the depth of private well DW-16-02 is approximately 40 to 50 ft bgs (Resolution, 2016b). A summary of drinking water samples and analytical data evaluated in the HHRA are presented in **Attachment A, Table A-3.**

2.1.4 Sediment

Sediment samples were collected during multiple phases of site investigation in 2016 and 2018. Five (5) sediment samples, including one field duplicate, were collected from 4 locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016. In addition, 33 sediment samples, including 4 field duplicates, were collected at downgradient off-site locations to the north of the site within the creek (5 locations sampled in both April and November 2018) and the bay (19 locations sampled in November 2018) (off-site, west of Bay Head Road).

A summary of sediment samples and analytical data evaluated in the HHRA are presented in **Attachment A, Table A-4.** The sediment sample locations are presented on **Figures 2 and 3**.

2.1.5 Surface Water

Three (3) surface water samples, including one field duplicate, were collected from 2 locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016. In addition, a total of 54 surface water samples, including 6 field duplicates, were collected from 24 downgradient off-site locations to the north of the site within the creek and the bay (off-site, west of Bay Head Road) in April and/or November 2018. During the April 2018 sampling event, 6 samples, including 1 field duplicate, were collected from 5 of the 24 downgradient off-site locations. During the November 2018 sampling event, 27 samples, including 3 field duplicates, were collected from all 24 locations during the low tidal stage and 21 samples, including 2 field duplicates, were collected from 19 of the 24 locations during the high tidal stage. (The 5 locations not sampled during the high tidal stage were above tidal influence).

A summary of surface water samples and analytical data evaluated in the HHRA are presented in **Attachment A, Table A-5.** The surface water sample locations are presented on **Figures 2 and 3**.

2.2 DATA ANALYSIS

Soil, groundwater, drinking water, sediment and surface water samples were collected in accordance with the sampling procedures and methodologies, and analytical methods presented in the Tier II Sampling and Analysis Plan (SAP) (Resolution, 2016a) and in the additional PFAS testing technical memorandum (Resolution, 2018) prepared for the project.

While the focused soil and groundwater investigation conducted as part of this Phase I RI verifies the PFAS source area associated with the FBP, PFAS have not been fully delineated in soil, as further discussed in the RI report. Therefore, this contributes uncertainty to the HHRA. In accordance with the SAP, groundwater samples were collected as grab samples using DPT. Due to their construction, grab samples are likely to have more turbidity-entrained soil particulates than a monitoring well sample would have, potentially biasing groundwater results high. Grab groundwater samples were proposed in this Phase I RI for screening purposes to guide the installation of monitoring wells (location, screen length and depth intervals) during later phases of the RI. While the HHRA evaluates the existing soil and groundwater data, these uncertainties are noted, further discussed in the uncertainty analysis, and have been considered while making recommendations for further site investigation.

All analytical soil, groundwater, drinking water, sediment, and surface water data were evaluated, validated, and qualified prior to use in the risk assessment. A “Stage 2A” level data validation was completed on all PFAS compounds. Data validation included a comparison of the site data to corresponding blank (laboratory, field, equipment, and trip) concentration data. Estimated concentrations are those generated from samples containing PFAS above the detection limit, but below the limit of quantitation. These concentrations were “J” qualified and were used in the HHRA without modification. For groundwater samples, the majority of the “J” qualified results were qualified as “J-“, indicating the analyte was positively detected in the sample, but the reported value is an approximate concentration, potentially biased low.

Non-detect concentrations are those generated from samples that did not contain PFAS at or above the detection limit. Non-detects were flagged with “U” or “UJ,” and the result was considered a non-detect value in the HHRA. All analytical data were found to be of acceptable quality and appropriate for use as qualified in the HHRA without limitations. No analytical results were rejected during the data validation process. Further details on data validation are provided in the ‘Summary of the Data Validation and a Quality Assurance Based Data Usability Assessment’, and data validation memos for all stages of the RI, which are included as Appendix D to the RI Report.

The reporting limits associated with all soil, groundwater, drinking water, sediment, and surface water sample analytical results are less than the associated risk-based screening levels described in Section 3.2.1; thus, they are appropriate for meeting data quality objectives in the HHRA being conducted as part of this Phase I RI.

2.3 DATA TREATMENT

Analytical data for surface soil, combined surface and subsurface soil, groundwater, sediment, and surface water were separately compiled into summary statistics as discussed below. PFAS were not detected in any drinking water samples. Therefore, drinking water was not further evaluated in the HHRA. For each chemical detected at least once within a medium/sample type/depth interval, the summary statistics include frequency of detection, range of detection limits, range of detected concentrations, and location of maximum detected result. The following guidance documents were used to develop the summary statistics:

- U.S. Navy Human Health Risk Assessment Guidance (DON, 2008)
- Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual, Parts A and D (USEPA, 1989; 2001)

For sample locations in which a duplicate sample was also collected, the duplicate sample results were processed for use in the calculation of summary statistics. Duplicates were resolved as follows: (1) where both the sample and the duplicate results are not detected, the resulting value is the maximum limit of detection (LOD); (2) where both the sample and the duplicate result are detected, the resulting value is the maximum of the detected results; and (3) where one of the pair is reported as not detected and the other is detected, the detected concentration is used.

3. TIER I HUMAN HEALTH RISK BASED SCREENING EVALUATION

3.1 CONCEPTUAL SITE MODEL

A summary of the current and potential future land-use and the potential human receptors is provided in this section. Further details on the site description, history, geology/hydrogeology, potential sources of contamination, nature and extent of contamination, and fate and transport mechanisms are discussed in Sections 1 through 5 of the RI Report.

The focus of the Phase I RI was to investigate the presence of PFAS associated with historical operations at the Former Burn Pad (FBP) located in the north central area of the former BHRA. Activities at the BHRA included fire testing and fire suppression research conducted in the vicinity of the FBP. The primary sources of PFAS soil and groundwater impacts at the BHRA include surface releases from historical fire/burn-testing operations entailing the use of PFAS containing aqueous film forming foam (AFFF) in the fire suppression system and apparent application at the FBP and associated evaporation pond. Potential secondary sources include PFAS-impacted soil/sediment erosion and overland stormwater runoff within site drainage features (grass-lined swales that discharge to the drainage feature to the north of the site). The regrading of PFAS-impacted soils during redevelopment of the site is also a possible secondary source of PFAS.

The site consists of a tract of land approximately 23.8 acres in size located on the peninsula between the Magothy and Severn rivers, and is less than two miles from the Chesapeake Bay. Residential areas to the north and west surround the site. U.S. Routes 50 and 301 are located south of the site with undeveloped land, residential areas, and Sandy Point State Park to the east. Current land use at the property is for recreational purposes as a public park called Bay Head Park, athletic fields, as well as the Children's Theatre of Annapolis (CTA), which currently has two permanent employees. Based on the Record of Decision issued in March 2001 (Navy, 2001b), there are deed restrictions consisting of institutional controls (ICs) prohibiting future residential development of the site. Future use of the site is anticipated to remain recreational and commercial.

The site and immediate vicinity are connected to the Anne Arundel County Public Water system, and county and state regulations prohibit the installation of water supply wells. However, there are two shallow private residential drinking water wells located hydraulically down- or side-gradient of the site. The depth of private well DW-16-01 is 55 to 60 ft bgs; and the depth of private well DW-16-02 is approximately 40 to 50 ft bgs (Resolution, 2016b). The analytical results associated with drinking water samples from these wells indicated non-detect levels of PFAS.

To the north of the site is a creek that drains from the site into the Little Magothy River. At the point at which the creek drains into the river is a bay area (depicted on **Figure 3**).

Potentially complete human exposure scenarios based on the current and reasonable potential future uses of the property are as follows:

- Current on-site outdoor (commercial/industrial) workers may be exposed to surface soil while performing outdoor maintenance, landscaping, or other similar activities. Current on-site outdoor (commercial/industrial) workers are not assumed to contact groundwater since there are currently no on-site water supply wells present on-site.
- Future on-site outdoor (commercial/industrial) workers may be exposed to combined surface and subsurface soil, assuming soils become mixed during potential future redevelopment activities, while performing outdoor maintenance, landscaping, or other similar activities. On-site (commercial/industrial) outdoor workers are conservatively assumed to have

potential contact with groundwater during irrigation or other similar non-potable activities, under a hypothetical scenario in which irrigation wells are installed on-site. On-site outdoor (commercial/industrial) workers are not assumed to use groundwater for potable purposes. The evaluation of groundwater under a hypothetical future residential scenario (discussed below) is also protective of potable use by commercial/industrial receptors.

- Current recreational users (adults and children) may be exposed to surface soil on-site while walking, picnicking, and playing on athletic fields. Current recreational users may also be exposed to sediment and surface water within the on-site and off-site areas while wading in the creek or wading/swimming in the bay of the river.
- Future recreational users (adults and children) may be exposed to combined surface and subsurface soil on-site (assuming soils become mixed during potential future redevelopment activities) while walking, picnicking, and playing. Exposure to sediment and surface water within the on-site and off-site areas may also occur while wading in the creek or wading/swimming in the bay of the river.
- Future construction/excavation/utility workers may access the site while performing construction activities in the case of redevelopment or addition of structures on-site, soil excavation, and/or utility repair, etc. During these activities, a future construction/excavation/utility worker may be exposed to combined surface and subsurface soil in addition to shallow groundwater (at depths between 0 to 15 ft bgs) within an excavation trench.
- Residential use is not a reasonable, anticipated future use of the site due to the deed restrictions consisting of institutional controls prohibiting future residential development. However, for purposes of the HHRA, an unlimited use/unrestricted exposure (UU/UE) scenario was conservatively evaluated for informational purposes. This UU/UE scenario assumes that a hypothetical future resident (adult/child) may contact site surface soil or combined surface and subsurface soil, and groundwater (used for potable/household use).

Human receptors may be exposed to soil and sediment via incidental ingestion and dermal contact; and groundwater via incidental ingestion (worker scenarios) or ingestion (hypothetical future residential scenario). The inhalation exposure pathway was not quantitatively assessed for PFAS due to the absence of USEPA-approved toxicity values. Dermal contact with PFAS in groundwater was also not quantitatively evaluated, in accordance with the approach utilized in USEPA's Regional Screening Level (RSL) calculator (USEPA, 2019a).

The human health CSM for the site is depicted in **Figure 4**. The potential exposure points, exposure pathways, and potentially exposed receptors are also presented in **Table 1**. A detailed discussion of the receptors and exposure scenarios for which COPCs were identified for evaluation in the Tier II HHRA, as a result of the Tier I A/B screening, is provided in Section 4.2 (Exposure Assessment).

3.2 IDENTIFICATION OF COPCS

The Tier I evaluation includes identification of COPCs based on a comparison of the maximum detected concentration, following treatment of duplicates as discussed in Section 2.2, of PFAS compounds within each exposure point to the screening levels for each medium listed below. PFAS compounds detected at concentrations above the screening levels were further evaluated in the Tier II site-specific risk evaluation. PFAS compounds that were not detected in a particular medium or were detected at concentrations below the screening levels were eliminated from being COPCs for the associated receptor and were not evaluated further. No COPCs were eliminated due to a low frequency of detection for this evaluation.

The COPC selection was conducted using a two-tiered screening process, including a comparison to generic (Tier IA) screening levels (available for soil and groundwater) and site-specific (Tier IB) screening levels (derived for soil, groundwater, sediment, and surface water). Human health screening levels for PFAS were selected based on the most currently available USEPA and DOD guidance, as referenced in the following section. The site-specific (Tier IB) screening levels were developed using site-specific information to be protective of current and potential future use exposure scenarios, in accordance with the CSM discussed in Section 3.1. A summary of site-specific inputs used to develop Tier IB screening levels is provided in **Attachment B**.

3.2.1 Screening Levels

Published USEPA human health screening levels for PFOS and PFOA are not available (USEPA, 2019a). Therefore, risk-based screening levels for PFOS and PFOA were calculated using the USEPA RSL Calculator (USEPA, 2019a) in accordance with DOD guidance on investigation of PFAS (DOD, 2019). The chronic oral reference dose (RfD) for PFOS and PFOA (2×10^{-5} milligram of chemical per kilogram of body weight per day [mg/kg-day]), published by USEPA (2016b and c) and the oral cancer slope factor (CSF) for PFOA (7×10^{-2} per mg/kg-day), published by USEPA (2016c), were utilized in the calculation of soil, groundwater, sediment, and surface water screening levels. These toxicity values are included in the USEPA's RSL calculator (USEPA, 2019a) and are currently recommended by DOD for use in the evaluation of PFAS (DOD, 2019).

USEPA residential soil, commercial/industrial soil, and tap water RSLs for PFBS are available and were used for Tier 1A screening levels (USEPA, 2019a), in accordance with DOD guidance on investigation of PFAS (DOD, 2019). Tier 1B screening levels were calculated using the RSL calculator (USEPA, 2019a). The chronic oral RfD (2×10^{-2} mg/kg-day) and the subchronic oral RfD (2×10^{-1} mg/kg-day) for PFBS, published by USEPA (2014c), were utilized in the calculation of Tier 1B screening levels protective of the recreational user exposure scenario. These toxicity values are included in the USEPA's RSL calculator (USEPA, 2019a) and are currently recommended by DOD for use in the evaluation of PFAS (DOD, 2019).

Screening levels for all media are based on a target risk level of 1×10^{-6} (PFOA only) and a target hazard quotient (HQ) of 0.1 (to account for potential cumulative effects of multiple chemicals acting on the same target organ) (for PFOS, PFOA, and PFBS).

Further details of the Tier IA and Tier IB screening levels used to select COPCs are discussed per media below.

Soil

Tier IA soil screening levels for PFOS and PFOA were calculated for a residential and commercial/industrial worker exposure scenario, utilizing USEPA default exposure assumptions (USEPA, 2014a), as applicable. For PFBS, Tier IA soil screening levels protective of residential and commercial/industrial worker exposure scenarios are equal to the USEPA RSLs for residential soil and industrial soil (USEPA, 2019a), respectively.

Tier IB soil screening levels were developed for the following site-specific exposure scenarios based on current and/or potential future use of the site described in the CSM Section (Section 3.1):

- Recreational user (child [0 to 6 years] and adult] – Assumes exposure to soil may occur for 2 days per week for 26 weeks (6 warmer months) of the year while walking, picnicking, and playing on athletic fields, based on professional judgement. The rate of potential soil ingestion and area of the body exposed to soil is conservatively assumed to equal that of a default residential exposure scenario;

- On-site outdoor (commercial/industrial) worker – Consistent with a default/full-time worker exposure scenario, this scenario assumes exposure to soil may occur for 250 days per year for 25 years while performing outdoor maintenance, landscaping, or other similar activities on a full-time basis;
- Construction/excavation/utility worker – Assumes exposure to soil may occur for 250 days per year for a 1-year construction project while performing construction activities, soil excavation, utility repairs, and/or other soil intrusive activities.

The detailed exposure assumptions on which the Tier IB screening levels are based are presented in **Attachment B**. The generic (Tier IA) soil screening levels for a commercial/industrial worker scenario are considered appropriate to represent a site-specific on-site outdoor (commercial/industrial) worker exposure scenario. Therefore, the Tier IA and Tier IB soil screening levels for this exposure scenario are equal. **Table 2.1 (surface soil) and Table 2.2 (combined surface and subsurface soil)** present the COPC selection for soil, including the Tier IA and Tier IB soil screening levels.

Groundwater

For PFOS and PFOA, the Tier IA groundwater screening levels are equal to the lower of the following:

- USEPA's Lifetime Drinking Water Health Advisory for PFOS and PFOA of (0.07 microgram per liter [μg/L]), as individual compounds and the combined PFOS + PFOA concentration (USEPA, 2016b and c);
- USEPA tap water RSLs calculated for PFOS and PFOA using USEPA's RSL Calculator (USEPA, 2019a), in accordance with DOD guidance on investigation of PFAS (DOD, 2019).

For PFBS, the tap water RSLs are the Tier 1A groundwater screening levels, in accordance with DOD guidance on investigation of PFAS (DOD, 2019).

Tier IB groundwater screening levels were developed for the following site-specific exposure scenarios based on current and/or potential future use of the site described in the CSM Section (Section 3.1):

- On-site outdoor (commercial/industrial) worker – Assumes exposure to groundwater may occur for 150 days per year for 25 years during use of groundwater for non-potable purposes, such as irrigation. This exposure scenario conservatively assumes exposure to site groundwater may occur via incidental ingestion for up to 3 days per week for 50 weeks of the year;
- Construction/excavation/utility worker – Assumes exposure to groundwater in an excavation trench may occur 125 days per year for a 1-year construction project while performing construction activities, soil excavation, utility repairs, and/or other intrusive activities. This scenario assumes that a worker may come in contact with water for 50% of their time spent on-site, based on professional judgement.

The detailed exposure assumptions on which the Tier IB screening levels are based are presented in **Attachment B**. **Table 2.3** presents the COPC selection for groundwater, including the Tier IA and Tier IB groundwater screening levels.

Sediment

Published USEPA human health sediment screening levels are not available. Therefore, Tier IB sediment screening levels were developed for the PFAS chemicals detected in sediment. The sediment screening levels were calculated using the USEPA RSL Calculator (USEPA, 2019a) for the recreational user (child [0 to 6 years] and adult) using conservative inputs protective of a site-specific current/future exposure scenario. Sediment exposure is assumed to occur via incidental ingestion and dermal contact for 2 days per week for 26 weeks (6 warmer months) of the year while wading in the creek or wading/swimming in the bay of the river, based on professional judgement. The exposure assumptions on which the Tier IB screening levels are based are presented in **Attachment B**. **Table 2.4** presents the COPC selection for sediment, including the Tier IB sediment screening levels.

Surface Water

Published USEPA human health surface water screening levels are also not available. Therefore, Tier IB surface water screening levels were developed for the chemicals detected in surface water. The surface water screening levels were calculated using the USEPA RSL Calculator (USEPA, 2019a) for the recreational user (child [0 to 6 years] and adult) using conservative inputs protective of a site-specific current/future exposure scenario. Surface water exposure is assumed to occur via incidental ingestion for 2 days per week for 26 weeks (6 warmer months) of the year while wading in the creek or wading/swimming in the bay of the river, based on professional judgement. The exposure assumptions on which the Tier IB screening levels are based are presented in **Attachment B**. **Table 2.5** presents the COPC selection for surface water, including the Tier IB surface water screening levels.

3.2.2 COPC Selection Results

The COPC selection discussed in this section is presented in the data summary tables for each medium (**Tables 2.1 through 2.5**). The following COPCs were identified per media/dataset:

Soil

PFOS was detected in both surface soil and combined surface and subsurface soil samples at concentrations greater than the Tier IA soil screening level protective of a residential exposure scenario. Although a residential scenario is not a current or reasonable future use scenario for the site, PFOS was selected as a COPC in surface soil and in combined surface and subsurface soil for further evaluation of a hypothetical future on-site residential exposure scenario for informational purposes.

PFAS were not detected at concentrations in surface soil or combined surface and subsurface soil greater than the Tier IA/Tier IB screening levels for an on-site outdoor (commercial/industrial) worker, recreational user, or construction/excavation/utility worker exposure scenario. Therefore, no soil COPCs were selected for further evaluation of these exposure scenarios in the Tier II HHRA.

Groundwater

PFOS and PFOA were detected in groundwater at concentrations greater than the Tier IA groundwater screening levels protective of a residential exposure scenario, including the use of groundwater as drinking water. Although a residential scenario is not a current or reasonable future use scenario and potable water is supplied by the city, PFOS and PFOA were selected as groundwater COPCs for further evaluation of a hypothetical future on-site residential exposure scenario for informational purposes.

PFAS were not detected at concentrations in groundwater greater than the Tier IB screening levels for an on-site outdoor (commercial/industrial) worker scenario or a construction/ excavation/utility worker scenario, which include potential groundwater exposures via non-potable uses. Therefore, no groundwater COPCs were selected for further evaluation of these exposure scenarios in the Tier II HHRA.

Sediment

PFAS were not detected at concentrations in sediment greater than the Tier IB screening levels for a recreational user. Therefore, no sediment COPCs were selected for further evaluation in the HHRA.

Surface Water

PFAS were not detected at concentrations in surface water greater than the Tier IB screening levels for a recreational user. Therefore, no surface water COPCs were selected for further evaluation in the Tier II HHRA.

4. TIER II BASELINE HUMAN HEALTH RISK ASSESSMENT

The Tier II HHRA quantitatively evaluated potential exposure to site COPCs, including PFOS in soil and PFOS and PFOA in groundwater for the associated receptors and exposure pathways identified in **Table 1** and discussed in Section 3.1. Soil and groundwater COPCs were only identified for the hypothetical future on-site residential exposure scenario. Therefore, the other exposure scenarios, including an on-site outdoor (commercial/industrial) worker, recreational user (adult/child), and construction/ utility/excavation worker, were not further evaluated in the Tier II HHRA and do not pose a health risk greater than USEPA target risk/HQ levels.

4.1 DETERMINATION OF EXPOSURE POINT CONCENTRATIONS

To evaluate the magnitude of potential human exposures, the concentration of each COPC in each exposure medium/exposure point that receptors may contact over the exposure period is estimated. An estimate of this concentration is referred to as an exposure point concentration (EPC). EPCs for evaluation of the reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios for each dataset described in Section 2.1 were calculated as described below.

4.1.1 Soil

PFOS was identified as a surface soil and combined surface and subsurface soil COPC for further evaluation of a hypothetical future on-site residential exposure scenario. The soil EPCs for PFOS are equal to the 95 percent (%) upper confidence limit (UCL) on the arithmetic mean concentration for both the RME and CTE scenarios. USEPA’s ProUCL Version 5.1.002 software (USEPA, 2016a) was utilized to calculate the Kaplan-Meier (KM) Mean and the 95% UCL for COPCs identified in soil and groundwater samples following the COPC selection. The ProUCL outputs for soil and groundwater samples are provided in **Attachment C.** The surface soil EPC is presented in **Table 3.1.RME/CTE** and the combined surface and subsurface soil EPC is presented in **Table 3.2.RME/CTE.**

4.1.2 Groundwater

PFOS and PFOA were identified as groundwater COPCs for further evaluation of a hypothetical future on-site residential exposure scenario. USEPA guidance recommends that groundwater EPCs be derived using data from wells identified as being within the core of the plume (USEPA, 2014b). Groundwater data were further reviewed to identify samples within the core of the plume, in accordance with USEPA guidance (2014b). The core of the plume was identified as the area containing the locations with the highest detected concentrations of PFOS and PFOA in groundwater (defined in this HHRA as having a PFOA and/or PFOS concentration equal to or greater than 100 times the groundwater screening level, discussed in Section 3.2.1). This area, referred to as “core of the groundwater plume”, is the half-acre area surrounding the FBP and former evaporation pond, as depicted on **Figure 5**. The sample locations within this area are indicated on **Table 3.2.RME/CTE**.

Groundwater EPCs were calculated for the higher concentration area. Groundwater EPCs are equal to the 95% UCL (calculated as described in Section 2.2) for both the RME and CTE scenarios. The groundwater EPCs are presented in **Table 3.3.RME/CTE**.

4.2 EXPOSURE ASSESSMENT

The purpose of the exposure assessment is the quantification of the extent, frequency, and duration of actual or potential exposure to chemicals by pathways relevant to the site and activities of the potential receptors. As part of the exposure assessment, current and potential future exposure pathways were determined through the identified populations which may potentially be exposed to COPCs at the site.

An exposure pathway describes the course a chemical follows while moving through environmental media to the receptor. An exposure pathway may consist of a mechanism of release of chemicals to an environmental medium (e.g., soil), an exposure route (e.g., ingestion), and a receptor (e.g., construction worker). An exposure pathway is considered complete when contact by a receptor with impacted media may occur under current site conditions or in the future. USEPA (1989, 1991) guidance requires that plausible exposures under both current and future land use scenarios be evaluated in an HHRA. **Table 1** presents a summary of the current and potential future exposure routes quantitatively and/or qualitatively evaluated in the HHRA as well as the human receptors. Several of the human receptors listed on **Table 1** (on-site outdoor (commercial/industrial) worker, recreational user, and construction/excavation/utility worker) do not have COPCs identified in the Tier IA/IB screening step. Therefore, only the hypothetical future on-site residential exposure scenario, for which PFOS was identified as a soil COPC, and PFOS and PFOA were identified as groundwater COPCs, were further evaluated in the Tier II HHRA.

4.2.1 Hypothetical Future On-Site Resident

There are currently no residents located on the site and ICs are in place restricting future use at the facility to non-residential. Therefore, residential use is not a reasonable, anticipated future use of the site. In addition, groundwater underlying site is not used for drinking water and drinking water is supplied to the site by the Anne Arundel County Public Water system. Private residential drinking water wells located hydraulically down- or side-gradient of the site (DW-16-01 and DW-16-02) reported non-detect levels of PFAS. However, a residential adult/child exposure scenario, including the use of site groundwater under a potable/household use scenario, was evaluated in the HHRA as a conservative measure of hypothetical future site use to represent an UU/UE scenario and provide information for decision-making purposes. Future re-development associated with the conversion to future residential use could result in mixing of surface and subsurface soils. Therefore, the hypothetical future resident is assumed to contact surface soil or a combination of surface and subsurface soil. The Tier II HHRA evaluated a hypothetical future on-site resident (adult/child) for the following exposure pathways:

- Exposure to surface soil (undisturbed scenario) through incidental ingestion and dermal contact;
- Exposure to combined surface and subsurface soil (disturbed scenario) through incidental ingestion and dermal contact; and
- Exposure to groundwater through ingestion of drinking water.

The exposure factors used for evaluation of a hypothetical future on-site resident in the HHRA are presented in **Tables 4.1.RME/CTE (soil) and 4.2.RME/CTE (groundwater)**. The assumed exposure factors are consistent with USEPA’s standard default exposure factors for a residential exposure scenario (2014a; 2019a).

4.2.2 Calculation of Dose

The purpose of the exposure assessment is to identify exposure equations to be used in the HHRA and to document assumptions made for each parameter used in these equations. USEPA guidance documents used in this exposure assessment include the Risk Assessment Guidance for Superfund (RAGS), Part A (USEPA, 1989); Exposure Factors Handbook (USEPA, 2011); Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002a); RAGS Part E (Supplemental Guidance for Dermal Risk Assessment) (USEPA, 2004); and Supplemental Guidance: Update of Standard Default Exposure Factors (USEPA, 2014a).

Equations are presented for the calculation of chronic daily intake values for the ingestion and dermal contact pathways of exposure. The equations are used for calculating a lifetime average daily dose (LADD) relevant to cancer risk (i.e., cancer intake) or for calculating an average daily dose (ADD) relevant to noncancer hazard (i.e., noncancer intake). The medium-specific equations used for the calculation of carcinogenic and noncarcinogenic intakes of the COPCs are presented in **Tables 4.1.RME/CTE (soil) and 4.2.RME/CTE (groundwater)**, along with the exposure parameters used for evaluation of the hypothetical future on-site residential exposure scenario in the Tier II HHRA. In the calculation of oral and dermal dose associated with PFOS in soil, absorption adjustment factors of 1 and 0.1, respectively, were used in accordance with the values utilized in the USEPA RSL Calculator (USEPA, 2019a).

4.3 TOXICITY ASSESSMENT

The toxicity assessment was conducted in accordance with USEPA guidance and considers chronic (long-term) exposures for carcinogenic and noncarcinogenic COPCs. No COPCs were identified for sub-chronic (short-term) exposure scenarios (i.e., construction worker). The USEPA's guidance regarding the hierarchy of sources of human health dose-response values in risk assessment was followed (USEPA, 2003; 2019a). There are no toxicity values associated with exposure to PFOA or PFOS available from Tier 1 (USEPA's Integrated Risk Information System (IRIS) [USEPA, 2019b]) or Tier 2 (USEPA Provisional Peer-Reviewed Toxicity Values (PPRTV) [USEPA, 2019c]) sources of human health dose-response values (USEPA 2003; 2019a). Therefore, toxicity values published by the USEPA Office of Water (USEPA, 2016b and c) were utilized in this HHRA, in accordance with DOD guidance on investigation of PFAS in CERCLA HHRAs (DOD, 2019) and as utilized in the USEPA RSL calculator (USEPA, 2019a). These toxicity values are further discussed in the following sections.

4.3.1 Toxicity Information for Noncarcinogenic Effects

Systemic toxic effects other than cancer can be associated with exposures to chemicals. RfDs for oral exposures are the toxicity values that are used to evaluate the potential of developing noncarcinogenic effects because of exposure to potentially toxic chemicals. RfDs have been developed on the premise that there are protective mechanisms that must be overcome before an appreciable risk of adverse health effects is manifested during a defined exposure period. It is assumed that there is a threshold dose that must be exceeded before adverse effects can occur. USEPA's Office of Water's estimated chronic oral RfD for PFOS and PFOA are 2×10^{-5} mg/kg-day (USEPA, 2016b and 2016c).

Chemicals classified as carcinogens may also produce other systemic effects. These chemicals were also evaluated for potential noncarcinogenic toxic effects and were included in the determination of chronic toxicity HQs, which characterize noncancer hazards. Carcinogenic effects, however, are usually manifested at levels that are significantly lower than those associated with systemic toxic effects; thus, cancer is usually the predominant adverse effect for chemicals that may elicit carcinogenic and noncarcinogenic responses.

Table 5.1 summarizes the oral noncarcinogenic toxicity values (i.e., RfDs) and the corresponding critical effects for PFOS and PFOA.

4.3.2 Toxicity Information for Carcinogenic Effects

The potential for human carcinogenic effects is evaluated based on the chemical-specific CSF values along with the weight-of-evidence classification (categories A through E) of the USEPA. The CSF values are the toxicity values that quantitatively define the dose-response relationship of a known or suspected carcinogen. The CSF value is a mathematical extrapolation of the slope of the dose-response curve from high doses administered to animals (or the exposures observed in epidemiological studies) to the low doses commonly experienced in the environment. The USEPA has developed CSFs for chemicals classified as carcinogens based on the premise that there is no threshold (i.e., there is no level of exposure below which there is no risk of a carcinogenic effect).

USEPA's *Guidelines for Carcinogen Risk Assessment* (USEPA, 2005) classifies human carcinogenic potential as "known/likely," "cannot be determined," and "not likely" to replace the weight of evidence categories A through E. The guidelines also acknowledge that the mode of action of a carcinogen may involve both threshold and non-threshold mechanisms.

Evidence for the carcinogenicity of PFOA is considered suggestive because only one species has been evaluated, the tumor response occurred primarily in males, and there is only one study with available/applicable dose-response data. USEPA (2005) generally does not attempt a dose-response assessment or recommend a CSF for use in quantitative assessment where suggestive evidence is identified (USEPA, 2016c). However, a CSF of 0.07 per mg/kg-day was calculated by USEPA (2016c) to determine whether the Lifetime Drinking Water Health Advisory for PFOA derived based on noncancer effects (0.07 µg/L) would be protective for a cancer endpoint as well. It was determined that the Health Advisory (and other risk-based screening levels) derived based on the noncancer endpoint are protective of the cancer endpoint. USEPA's most recent update to the RSL calculator (USEPA, 2019a) utilizes this oral CSF for PFOA, and its use in performing CERCLA HHRAs is endorsed by DOD (DOD, 2019). Therefore, it was also utilized in this HHRA.

USEPA has not calculated a CSF for PFOS because the weight of evidence for the carcinogenicity of PFOS to humans is too limited to support a quantitative assessment.

Table 6.1 summarizes the oral carcinogenic toxicity values (i.e., CSFs) and the corresponding weight-of-evidence classifications.

4.3.3 Adjustment of Toxicity Factors

No RfDs or CSFs are available for evaluating dermal exposure. Therefore, carcinogenic and noncarcinogenic risks associated with dermal exposure may be evaluated using an oral CSF or RfD adjusted such that the toxicity value is appropriate for the dermal pathway. As detailed by USEPA (2004), for purposes of evaluating dermal exposure, it is generally necessary to adjust an oral toxicity factor (i.e., RfD or CSF) from an administered (i.e., applied) dose to an absorbed (i.e., internal) dose. The fraction of PFOA/PFOS absorbed in the gastrointestinal tract in the critical toxicity study is not known, therefore, the oral RfD was utilized for evaluation of the dermal exposure route for PFOS in soil, consistent with the approach used in the USEPA RSL Calculator (USEPA, 2019a).

4.4 RISK CHARACTERIZATION

Risk characterization combines estimates of exposure with toxicity data to develop estimates of the probability that an adverse effect will occur under the specified conditions of exposure. The risk characterization was divided into three phases: (1) risk estimation, (2) risk description, and (3) uncertainty analysis.

Risk estimation is undertaken by combining the toxicity factors and exposure assessment equations to calculate estimates of risks. Noncarcinogenic risks are reported as a pathway-specific HI, which is the sum of individual COPC HQs for that pathway. Only HQs from COPCs that affect the same target organ are summed to generate HIs. The target organ for both PFOS and PFOA is the developmental system; therefore, HQs for PFOS and PFOA are summed to estimate the HI. Estimates of carcinogenic risks are reported as excess lifetime cancer risks (ELCRs). Current practice considers carcinogenic risks to be additive when assessing exposure to a mixture of hazardous substances. However, as discussed in Section 4.3.2, PFOA is the only COPC for which an ELCR is being quantitatively assessed in this HHRA. Risk description entails several discussions, including the relative contributions of individual exposure pathways to the total potential risk for each medium. The significance of the risk estimates are relative to risk management criteria set forth in USEPA policy. The uncertainty analysis describes and quantifies, where possible, the impact of data uncertainty and variability, exposure assumptions, and toxicity values on estimates of potential risk.

4.4.1 Estimation of Potential Risk

Noncancer hazard is estimated by means of a HQ. To calculate noncarcinogenic HQs, the ADDs, calculated as described in Section 4.2.2 were divided by the RfDs as follows:

$$HQ = ADD / RfD$$

The sum of this ratio for all chemicals within an exposure point and pathway that have the same target organ or type of toxicity is termed the pathway HI. The HI is useful as a reference point for gauging potential effects of environmental exposures to complex mixtures. In general, HIs that are less than 1 are not of regulatory concern; however, a HI of greater than 1 does not automatically indicate that an adverse effect will occur and should not automatically be interpreted as posing an unacceptable risk to the exposed population.

The total pathway HI for each exposure point was calculated by summing the HQs for PFOS and PFOA. Total HIs for each receptor by medium were calculated by summing the total HIs across pathways within the media (e.g., summing dermal and ingestion soil risk estimates). Total HIs are presented per media and exposure pathway in **Tables 7.1.RME and 7.1.CTE**. Receptor-specific HIs per target organ are presented in **Tables 9.1.RME, 9.1.CTE, 9.2.RME, and 9.2.CTE**.

USEPA uses a target HI per target organ of 1 (USEPA 1991).

The potential cancer risk of each receptor is estimated for each medium by means of an ELCR. USEPA (1991) states that where the cumulative incremental current or future potential ELCR to an individual is less than 10^{-4}, action generally is not warranted unless there are adverse environmental impacts. Maryland Department for the Environment (MDE) utilizes a target cumulative ELCR of 1×10^{-5}. To calculate the ELCR, the chemical- and pathway-specific LADDs calculated as described in Section 4.2.2 were multiplied by CSFs as follows:

$$ELCR = CSF \times LADD$$

The resulting value represents the incremental upper-bound probability that an individual could develop cancer over his or her lifetime due to exposure to potential carcinogens under the conditions specified in the exposure scenario. For example, carcinogenic risk levels of 10^{-6} and 10^{-4} represent an incremental chance of one-in-one-million and one-in-ten-thousand, respectively, that an individual could contract cancer over a lifetime.

The potential cancer risk for each pathway (e.g., the soil ingestion pathway) was calculated by summing the potential risks from each COPC at each exposure point within the pathway, while receptor risks for each medium were calculated by summing ELCRs for each pathway within the medium (e.g., the soil incidental ingestion and dermal contact pathways). Pathway ELCRs are calculated in **Tables 7.1.RME and 7.1.CTE**. Total potential ELCRs are presented per media and exposure pathway in **Tables 9.1.RME, 9.1.CTE, 9.2.RME, and 9.2.CTE**.

Table 11 provides a summary of potential ELCRs and noncarcinogenic HIs for the hypothetical future on-site residential exposure scenario. Potential ELCRs and HIs above USEPA target levels are identified to facilitate risk management decisions. The potential ELCRs presented on **Table 11** do not exceed MDE's target risk level. **Table 11** also lists the chemicals identified as risk drivers/COCs for each exposure scenario in which the total potential ELCR or total potential HI are above USEPA target levels (i.e., total ELCR greater than (>) 10^{-4}, and total HI > 1 per target endpoint). For each associated exposure scenario (i.e., RME/CTE/receptor/medium) with a potential risk/HI above USEPA target levels, risk drivers/COCs were defined as COPCs with an individual ELCR > 10^{-6} or HI > 1.

4.4.2 Risk Description

Soil and groundwater COPCs were only identified for a hypothetical future on-site residential exposure scenario, which is being evaluated to represent a UU/UE scenario for informational purposes. No COPCs were identified for other current/future receptors/exposure scenarios, including an on-site outdoor (commercial/industrial) worker, recreational user (adult/child), and construction/utility/excavation worker; therefore, the associated health risks for these other potential scenarios are less than USEPA target risk/HQ levels.

This subsection summarizes the human health risks potentially posed to a hypothetical future on-site resident associated with exposure to site soil and groundwater. Individual chemical-specific potential carcinogenic risks are expressed as probabilities of developing cancer (i.e., ELCRs), while noncarcinogenic hazards are expressed as HIs. Total potential ELCRs and HIs were calculated for the hypothetical future on-site resident by summing the ELCR/HI associated with each media-specific exposure scenario.

Description of HI Estimates

HI estimates represent the potential risk of health effects other than cancer from exposure to COPCs at the site. Target organ-specific HIs were evaluated as to whether they exceed risk management criteria. The total potential HIs for the hypothetical future on-site resident scenario based on exposure to site soil (i.e., surface soil or combined surface and subsurface soil) and groundwater are presented in **Tables 9.1.RME/CTE (surface soil and groundwater) and 9.2.RME/CTE (combined surface and subsurface soil and groundwater)**, summarized in **Table 11**, and discussed below. The child is the most sensitive receptor for the estimation of noncarcinogenic hazard. Therefore, the child receptor HIs have been presented in the risk/hazard summary tables as being protective of both the adult/child scenarios. However, both the child and adult receptor HIs are presented in **Tables 7.1.RME/CTE** for informational purposes and to aid in decision-making.

The total potential HIs per target endpoint associated with a hypothetical future on-site resident exposure scenario are the same for both surface soil and groundwater and combined surface and subsurface soil and groundwater. These total potential HIs, 50 (RME) and 30 (CTE), exceed USEPA's target HI of 1. The following table presents a summary of the chemical-specific and total noncancer HIs for the hypothetical future on-site resident scenario, including the soil and groundwater EPCs on which the HIs were based:

Scenario/ COPC	**Surface Soil**		**Combined Surface and Subsurface Soil**		**Groundwater**		**Total HI (Soil and Groundwater)**
	EPC (µg/kg)	**HI**	**EPC (µg/kg)**	**HI**	**EPC (µg/L)**	**HI**	
RME Scenario:							
PFOS	108	0.09	47	0.04	9.68	24	24
PFOA	NCOPC	NCOPC	NCOPC	NCOPC	8.74	22	22
Total HI (rounded to one significant figure):							**50**
CTE Scenario:							
PFOS	108	0.03	47	0.01	9.68	15	15
PFOA	NCOPC	NCOPC	NCOPC	NCOPC	8.74	14	14
Total HI (rounded to one significant figure):							**30**

NCOPC - Not identified as a COPC based on the Tier I screening evaluation.

As shown in the above table, the total potential HIs estimated for the hypothetical future on-site residential scenario are driven by the concentrations of PFOS and PFOA in groundwater. Therefore, PFOS and PFOA were identified as COCs in groundwater for the RME and CTE scenarios based on their individual potential HIs associated with the ingestion of groundwater as drinking water pathway, which are greater than the target HI of 1. PFOS and PFOA each contribute an equal amount to the estimated total HI.

PFOS was the only soil COPC identified based on the Tier I screening evaluation for further evaluation in the Tier II HHRA. As shown in the above table, the total potential HIs associated with the surface soil exposure pathways alone are 0.09 and 0.03 for the RME and CTE scenarios, respectively. The total potential HIs associated with the combined surface and subsurface soil exposure pathways alone are 0.04 and 0.01 for the RME and CTE scenarios, respectively. These HIs associated with soil exposure are over ten times less than the target HI of 1, and contribute negligibly to the total HI associated with soil and groundwater exposure combined. Therefore, exposure to soil at the site does not pose an unacceptable hazard to this receptor, and no soil COCs are identified based on a noncarcinogenic hazard.

Description of ELCR Estimates

Estimates of ELCR represent the potential risk of cancer from exposure to COPCs at the site. Pathway- and medium-specific potential ELCRs for COPCs are summed and presented as total receptor risks. The potential ELCRs for the child and adult resident scenarios have been summed to present the total potential cancer risk for the hypothetical future on-site resident scenario. The cumulative potential ELCR for the hypothetical future on-site resident scenario based on exposure to site soil (i.e., surface soil or combined surface and subsurface soil) and groundwater are presented in **Tables 9.1.RME/CTE (surface soil and groundwater) and 9.2.RME/CTE (combined surface and subsurface soil and groundwater)**, summarized in **Table 11**, and discussed below.

The cumulative potential ELCRs associated with a hypothetical future on-site resident exposure scenario are 8×10^{-6} (RME) and 3×10^{-6} (CTE). These potential cumulative ELCR's are within USEPA's target ELCR range of 10^{-6} to 10^{-4}, and are also less than MDE's target ELCR of 1×10^{-5}. Therefore, exposure to soil and groundwater at the site does not pose an unacceptable risk to this receptor, and no soil or groundwater COCs are identified based on carcinogenic risk. The following table presents a summary of the chemical-specific and cumulative potential ELCRs for the hypothetical future on-site resident scenario, including the soil and groundwater EPCs on which the HIs were based:

Scenario/ COPC	Surface Soil		Combined Surface and Subsurface Soil		Groundwater		Cumulative ELCR (Soil and Groundwater)
	EPC (µg/kg)	**ELCR**	**EPC (µg/kg)**	**ELCR**	**EPC (µg/L)**	**ELCR**	
RME Scenario:							
PFOS	108	N/A	47	N/A	9.68	N/A	N/A
PFOA	NCOPC	NCOPC	NCOPC	NCOPC	8.74	8E-06	8E-06
						Cumulative ELCR:	**8E-06**
CTE Scenario:							
PFOS	108	N/A	47	N/A	9.68	N/A	N/A
PFOA	NCOPC	NCOPC	NCOPC	NCOPC	8.74	3E-06	3E-06
						Cumulative ELCR:	**3E-06**

NCOPC - Not identified as a COPC based on the Tier I screening evaluation.
N/A - Not applicable; cancer toxicity value not available for PFOA.

5. DESCRIPTION OF UNCERTAINTIES

Estimation of potential risks to human health that may result from exposure to chemicals in the environment is a complex process that often requires the combined efforts of multiple disciplines. Each assumption, whether regarding the toxicity value to use for a particular chemical or the value of a parameter in an exposure equation, has a degree of variability and uncertainty associated with it. In each step of the risk assessment process, beginning with the data collection and analysis and continuing through the toxicity assessment, exposure assessment, and risk characterization, conservative assumptions are made that are intended to be protective of human health and to ensure that risks are not underestimated. There is a probability of overestimating health risks or hazards for a number of reasons. The following subsections provide a discussion of the key uncertainties that may affect the final estimates of human health risk in this HHRA. Uncertainties are arranged by topic.

5.1 ENVIRONMENTAL SAMPLING AND ANALYSIS

The process of environmental sampling and analysis results in uncertainties from several sources, including errors inherent in sampling procedures or analytical methods. One area of uncertainty is sampling procedures. Since it is not possible to sample the entire area of interest at a given site, several samples are taken from each medium within a site, and the results are considered representative of the chemicals present throughout the site. This assumption may overestimate or underestimate risk.

The focused soil investigation conducted for this Phase I RI verified the PFAS source area associated with the FBP, PFAS have not been fully delineated in soil. Therefore, this contributes uncertainty to the potential risk estimates in the HHRA. However, given the HHRA evaluated soil and groundwater concentrations in the source areas, in and adjacent to the FBP and Evaporation Pond, the soil and groundwater EPCs provide a conservative estimate of concentrations to which humans have the potential to be exposed. Therefore, further delineation of soil during later phases of the RI are not considered to change the overall conclusions of the HHRA.

Groundwater samples were collected as grab samples using DPT, in accordance with the SAP (Resolution, 2016a), as part of this Phase I RI. Due to their construction, grab samples are likely to have more turbidity-entrained soil particulates than a monitoring well sample would have, potentially biasing groundwater results high. This potential bias contributes uncertainty to the potential risk/hazard estimates in the HHRA. The HHRA identified PFOS and PFOA as groundwater COCs based on a hypothetical future on-site resident’s potential exposure via the ingestion of groundwater as drinking water pathway. However, as discussed in this HHRA, groundwater underlying the site is not used for drinking water, and potable water for on-site buildings and other infrastructure is supplied by the Anne Arundel County Public Water system. Due to the absence of monitoring wells on-site in the adjacent area, a limited groundwater data set exists for evaluation in the HHRA. The results of the DPT groundwater samples may be used to select locations for further groundwater sampling via monitoring wells in later phases of the RI, as warranted.

Analytical methods also involved uncertainties. All analytical soil, groundwater, drinking water, sediment, and surface water data were evaluated, validated, and qualified prior to use in the risk assessment. All analytical data were found to be of acceptable quality and appropriate for use as qualified in the HHRA without limitations. No analytical results were rejected during the data validation process. However, due to uncertainty of quantification, individual chemicals were sometimes listed as detected but with the value qualified as estimated by laboratory qualification or validation procedures. The estimated value was used in the HHRA. This uncertainty may either overestimate or underestimate risk depending on how close the estimated value is to the true value.

5.2 COPC SELECTION

For the soil, groundwater, sediment, and surface water datasets, a comparison of maximum detected PFAS concentrations to risk-based screening levels based on a target risk level of 1×10^{-6} and a target HQ of 0.1 (to account for potential cumulative effects of multiple chemicals acting on the same target organ) was conducted as part of the COPC selection process. The conservative risk-based values are used when selecting COPCs so as not to omit a chemical that might contribute significantly to risk. Chemicals whose maximum concentrations were less than their respective screening value were not identified as COPCs or carried through the Tier II HHRA. It is unlikely that this risk-based screening excluded chemicals that would be of concern, based on the conservative exposure assumptions and conservatively derived toxicity criteria that are the basis of the screening level. Although following this methodology does not provide a quantitative risk estimate for all PFAS, it focuses the assessment on the chemicals accounting for the greatest risks (i.e., chemicals whose maximum concentrations exceeded their respective screening levels).

Although the overall potential risk estimates are uncertain, it is not expected that actual risks will be significantly greater than estimated risks given that a reasonable effort was made to characterize current and future potential health risks given current knowledge.

5.3 EXPOSURE ASSESSMENT

The primary areas of uncertainty affecting exposure parameter estimation involve the assumptions regarding exposure pathways, the estimation of EPCs, and the parameters used to estimate chemical doses. The uncertainties associated with these various sources are discussed below.

The parameter values used to describe the extent, frequency, and duration of exposure are associated with some uncertainty. Actual risks for some individuals within an exposed population may vary from those predicted depending on the actual exposure durations, intake rates (e.g., soil ingestion rates), or body weights.

With respect to determining EPCs for this evaluation, one assumption was that the concentrations of PFAS in the medium evaluated would remain constant over the exposure time. Depending on the properties of the specific chemical and the medium in which it was detected, this assumption may overestimate risks, depending on the degree of chemical degradation to less toxic species or the potential for transport to other media. Conversely, environmental bioactivation of chemicals to more toxic chemicals was also not considered. Therefore, this assumption may underestimate risk if bioactivation mechanisms are significant. Given that PFOS and PFOA are themselves degradation products, and do not further degrade or transform in the environment, this mechanism is unlikely to result in an underestimate of the risk estimates provided in this HHRA.

Groundwater EPCs were calculated following USEPA guidance (USEPA, 2014b) and were based on data collected from locations identified within the core of the groundwater plume. The term “plume” is used in this HHRA to describe the areas of higher COPC concentrations in groundwater within the site. As a result, groundwater EPCs may be biased high given that they do not include groundwater data from wells with lower PFOS and PFOA concentrations located within the study area.

Several conservative exposure assumptions were used in the HHRA consistent with USEPA’s recommended default exposure assumptions (2014a). The RME exposure assumptions were selected to produce a reasonable upper-bound estimate of exposure in accordance with USEPA guidelines. Therefore, exposures and estimated potential risks for the evaluated receptors are likely to be representative of reasonable upper-bound exposures.

Dermal Absorption from Groundwater

Based on currently available scientific data (Franko et al., 2012) and consistent with USEPA's approach for evaluation of PFOS, PFOA, and PFBS in water (USEPA, 2019a), the dermal contact pathway associated with PFOS and PFOA in groundwater was not quantitatively evaluated in the HHRA.

In assessing dermal exposure (USEPA, 2007), the potential dermal dose is the amount of a chemical which could be deposited on the skin during a given activity. The absorbed dermal dose is the amount of a chemical that is absorbed into the body through the skin. Passive diffusion is considered to be the main processes of dermal penetration of chemicals through the stratum corneum, the outermost layer of the skin. After a chemical has absorbed into the stratum corneum, it can pass through it into the viable epidermis (the next skin layer) and then into the dermis where it can be transported systemically by the dermal blood supply. To get into and through the skin, the chemical must dissolve into the stratum corneum, which is a stabilized lipid barrier. Hence lipid solubility is required initially, followed by water solubility, to pass through the water-based gel portion of the skin and the human body, which is water-based. The dermal permeability coefficient (K_p) indicates the rate of migration of a chemical through skin and may be a predicted or experimentally-derived value (USEPA, 2004). USEPA uses the K_p value (in units of centimeters per hour) to evaluate dermal exposure to chemicals in water, such as groundwater.

Dermal assessment is not recommended for chemicals with a very large or very small octanol-water partition coefficient (K_{ow}) value. These chemicals are considered to be outside of the "Effective Prediction Domain", which means that an appropriate K_p value cannot be predicted by the statistical model (USEPA, 2004). Specifically, for PFOS and PFOA, evidence of dermal absorption has been documented in experimental studies; however, the findings of two key dermal exposure studies suggest that the ionization state of PFOA is critical in understanding its dermal absorption and permeability potential. At normal stratum corneum pH, PFOA is largely ionized and very little penetration of human skin would be expected to occur (Franko et al., 2012). Franko et al. (2012) also notes that most real-world PFOA exposures, particularly very low-level environmental exposures, would be to the ionized form and not the un-ionized form, suggesting dermal absorption through human skin under typical environmental exposures would be likely negligible relative to the oral exposure route.

Based on currently available scientific data and information and consistent with USEPA (2004) guidance, quantitative estimation of dermal risk from groundwater was not included in this HHRA for PFOS and PFOA. While this process removes evaluation of analytes which contribute minimally to the dermal pathway, inclusion of quantitative estimates of potential risk associated with the dermal exposure route is not considered to change the conclusions of this HHRA.

5.4 TOXICOLOGICAL DATA

Uncertainty is associated with the toxicity values and toxicity information available to assess potential adverse effects.

One of the major contributors to uncertainty is the accuracy of the toxicity values used. A cancer potency value is a mathematical extrapolation of the slope of the dose-response curve from high doses administered to animals (or the exposures observed in epidemiological studies) to the low doses commonly experienced in the environment. The USEPA has developed potency values for chemicals classified as carcinogens, based on the premise that there is no threshold (i.e., there is no level of exposure below which there is no risk of a carcinogenic effect). USEPA's Guidelines for Carcinogen Risk Assessment (USEPA, 2005) acknowledges that the mode of action of a carcinogen may involve both threshold and non-threshold mechanisms. To the extent that the approach used to develop the potency estimate is incorrect, the extrapolated risks may be overestimations or underestimations. However, in the derivation of toxicity values, conservative assumptions are employed. Therefore, toxicity values tend to be biased toward overestimating potential risk.

For dermal exposure pathways, the absence of dermal toxicity criteria necessitated the use of oral toxicity data. A default oral absorption factor of 100% was used in this HHRA. The potential risk estimates for the dermal pathways may be overestimated or underestimated depending on how closely these values reflect the difference between the oral and dermal routes. Dermal absorption fractions (USEPA, 2004), which estimate the penetration of soil associated chemicals through the skin, are used to assess dermal exposures for soil. These estimates are uncertain and may result in either an overestimation or underestimation of risk.

Currently, there are no toxicity values associated with exposure to PFOA or PFOS available from Tier 1 or Tier 2 sources of human health dose-response values (USEPA, 2003; 2019b; 2019c). Therefore, toxicity values published by the USEPA Office of Water (USEPA, 2016b and 2016c) and endorsed by the DOD for use in CERCLA HHRAs (DOD, 2019) were utilized in this HHRA.

As discussed in Section 4.3.2, evidence for the carcinogenicity of PFOA is considered suggestive because only one species has been evaluated, the tumor response occurred primarily in males, and there is only one study with available/applicable dose-response data. USEPA (2005) generally does not attempt a dose-response assessment or recommend a CSF for use in quantitative assessment where suggestive evidence is identified (USEPA, 2016c). This oral CSF for PFOA is endorsed by the DOD for use in CERCLA HHRAs (DOD, 2019) and is also utilized in USEPA's most recent update to the RSL calculator (USEPA, 2019a). Therefore, the oral CSF was utilized in this HHRA. However, given the limited information on carcinogenic effects on which the CSF was derived, it is unknown as to whether use of this CSF may overestimate or underestimate the potential risk associated with exposure to PFOA. In addition, USEPA has not calculated a CSF for PFOS because the weight of evidence for the carcinogenicity of PFOS to humans is too limited to support a quantitative assessment.

USEPA released a draft toxicity assessment for Perfluoroalkyls in November 2018 for public review and comment (USEPA, 2018). The draft toxicity assessment proposes a lower oral RfD for PFBS (0.01 mg/kg-day) than the PPRTV value utilized in the development of Tier I A/B screening levels in this HHRA (0.02 mg/kg-day). The draft toxicity value may change prior to the issuing of the final USEPA toxicity assessment for PFBS. The maximum detected concentrations of PFBS in site-media are over an order of magnitude lower than the Tier IA/B screening levels used in this HHRA. Therefore, if the toxicity value for PFBS does change, it would not result in a change in the conclusions of this HHRA.

Potential exposure to airborne particles in outdoor air is not included in the HHRA because toxicity values for the inhalation exposure route are not available for PFOA, PFOS, or PFBS; therefore, quantitative assessment of the inhalation exposure pathway cannot be performed, which contributes some uncertainty in the assessment.

In addition to PFOS, PFOA, and PFBS, analytical sediment and surface water samples were analyzed for other PFAS compounds. Analytical data for these other PFAS compounds can be found in Appendix C of the Phase I RI report. However, the other PFAS compounds were not quantitatively evaluated in this HHRA due to the lack of available toxicity values from USEPA's hierarchy of sources of dose-response values (USEPA, 2003; 2019a). This contributes uncertainty to the quantitative risk/hazard estimates presented in this HHRA. However, based on the limited toxicity information for these other PFAS compounds, it cannot be determined whether this uncertainty may affect the overall HHRA conclusions.

6. SUMMARY AND CONCLUSIONS

The HHRA was conducted in accordance with Navy policy, and Navy and USEPA HHRA guidance as referenced throughout the previous sections of this HHRA. The primary objective of the HHRA is to evaluate whether exposure to PFAS (specifically PFOS, PFOA, and PFBS) concentrations in soil, groundwater, drinking water, sediment, and surface water attributable to past operations at the Former BHRA site pose a risk/hazard to human health above USEPA target levels. PFAS compounds were not detected in drinking water samples collected from residential wells located hydraulically down- or side-gradient of the site. Therefore, a current pathway to these wells does not exist, and drinking water results were not further evaluated in the HHRA.

The HHRA evaluated potentially complete exposure pathways for human receptors identified based on current and reasonable future land-use scenarios in accordance with the site CSM. Based on the current/anticipated land use, the following receptors were evaluated in the HHRA:

- Current/future recreational user (adult/child)
- Current/future on-site outdoor (commercial/industrial) worker
- Future construction/excavation/utility worker
- Hypothetical future on-site resident (adult/child)

The above receptors were evaluated for potential exposure to soil (all receptors), groundwater via incidental ingestion (workers) or ingestion as drinking water (hypothetical future resident), sediment (recreational user) via incidental ingestion and dermal contact and/or surface water (recreational user) via incidental ingestion. The inhalation exposure pathway was not quantitatively assessed for PFAS due to the absence of USEPA-approved toxicity values, and dermal contact with PFAS in groundwater was not quantitatively evaluated in accordance with the approach used by USEPA (2019a) due to the limited dermal absorption of PFAS in water through human skin.

There are currently no residents located on the site and there are no plans for residential use of the site in the future. Current ICs restrict future use of the property to non-residential development (DON, 2001b). In addition, groundwater underlying the site is not used for drinking water, and potable water for on-site buildings and other infrastructure is supplied by the Anne Arundel County Public Water system. However, a residential exposure scenario, including the use of groundwater under a potable/household use scenario, was evaluated in the HHRA as a conservative measure of hypothetical future site use to represent an UU/UE scenario and provide information for decision-making purposes.

6.1 TIER I SCREENING EVALUATION

The Tier I screening (i.e., COPC selection) step of the HHRA was conducted using a two-tiered screening process, including a comparison of the maximum detected concentration of chemicals within each medium and exposure point to generic (Tier IA) screening levels (available for soil and groundwater) and site-specific (Tier IB) screening levels (derived for soil, groundwater, sediment, and surface water). Chemicals detected at concentrations above the screening levels were further evaluated in the Tier II site-specific risk evaluation for the associated media, receptor/exposure scenario, and exposure point. The results of the Tier I screening evaluation are as follows:

- No COPCs were identified for the following receptors/exposure scenarios; therefore, the concentrations measured do not pose an unacceptable risk/hazard and were not further evaluated in the Tier II HHRA:
    - Current/future recreational user (adult/child) (soil, sediment, and surface water exposure);
    - Current/future on-site outdoor (commercial/industrial) worker (soil and groundwater exposure); and
    - Future construction/excavation/utility worker (soil and groundwater exposure);
- COPCs were identified for the following receptors/exposure scenarios; therefore, these scenarios were further evaluated I the Tier II HHRA:
    - Hypothetical future on-site residential exposure to:
        - PFOS in surface soil;
        - PFOS in combined surface and subsurface soil; and
        - PFOS and PFOA in groundwater.

6.2 TIER II HHRA

The Tier II HHRA performed a quantitative estimation of potential risk/hazard for a hypothetical future on-site residential exposure scenario, which is the only human receptor for which COPCs (PFOS and PFOA) were identified in the Tier I screening evaluation. Both the RME and CTE scenarios were evaluated in the Tier II HHRA.

The cumulative potential ELCR and noncancer HI (per target endpoint) for each exposure scenario were evaluated in comparison to USEPA's target risk range of 10^{-6} to 10^{-4} and target HI of 1. Cumulative potential ELCR's were also discussed in comparison to the Maryland Department of the Environment's target ELCR of 1 x 10^{-5} (MDE, 2019). For each associated exposure scenario (i.e., RME/CTE/receptor/medium) with a potential risk/HI above USEPA target levels, COCs were defined as COPCs with an individual ELCR > 10^{-6} or HI > 1.

A summary of the potential ELCR and HI results for a hypothetical future on-site residential exposure scenario is presented below and on **Table 11.**

Scenario	**Potential ELCR**				**Potential Noncancer HI**				
	SS	**Combined SS and SB**	**GW**	**Total ELCR**	**SS**	**Combined SS and SB**	**GW**	**Total HI (SS and GW)**	**Total HI (Combined SS, SB, and GW)**
RME Scenario:									
	N/A	N/A	8E-06	8E-06	9E-02	4E-02	5E+01	**5E+01**	**5E+01**
CTE Scenario:									
	N/A	N/A	3E-06	3E-06	3E-02	1E-02	3E+01	**3E+01**	**3E+01**

GW - Groundwater.
SS - Surface soil.
SB - Subsurface soil.
Bold font indicates an exceedance of USEPA's target HI of 1.

In summary, the conclusions of the HHRA indicate that the potential cumulative ELCRs associated with a hypothetical future on-site resident's exposure to soil and groundwater do not exceed

USEPA's target ELCR range of 10^{-6} to 10^{-4} nor MDE's target ELCR of 1×10^{-5}. However, the HI associated with a hypothetical future on-site resident's exposure to soil and groundwater is greater than the USEPA's target HI of 1, and is primarily driven by the potential ingestion/consumption of site groundwater as a drinking water source if used in the future. Therefore, PFOS and PFOA were identified as site-related COCs in groundwater for a hypothetical future use scenario in which groundwater underlying the site is used as a source of drinking water or other potable use. Lastly, based on the Tier I and Tier II screening, no soil COCs were identified based on all the exposure scenarios evaluated, including the hypothetical future on-site residential scenario.

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Figures

CONTRACT NO 60444465	
CARTOGRAPHY BY A. Weber	
CHECKED BY A. Gupta	DATE January 2016
SCALE 1" = 49,500'	SHEET 1 of 1
Fig_10-1_Site_Location_Map.mxd	

Figure 1
Former Bay Head Road Annex Facility Location Map
Former Bay Head Road Annex Facility
Annapolis, MD

Source: Bing Maps, 2015; USGS NHD, 2015; ESRI, 2015

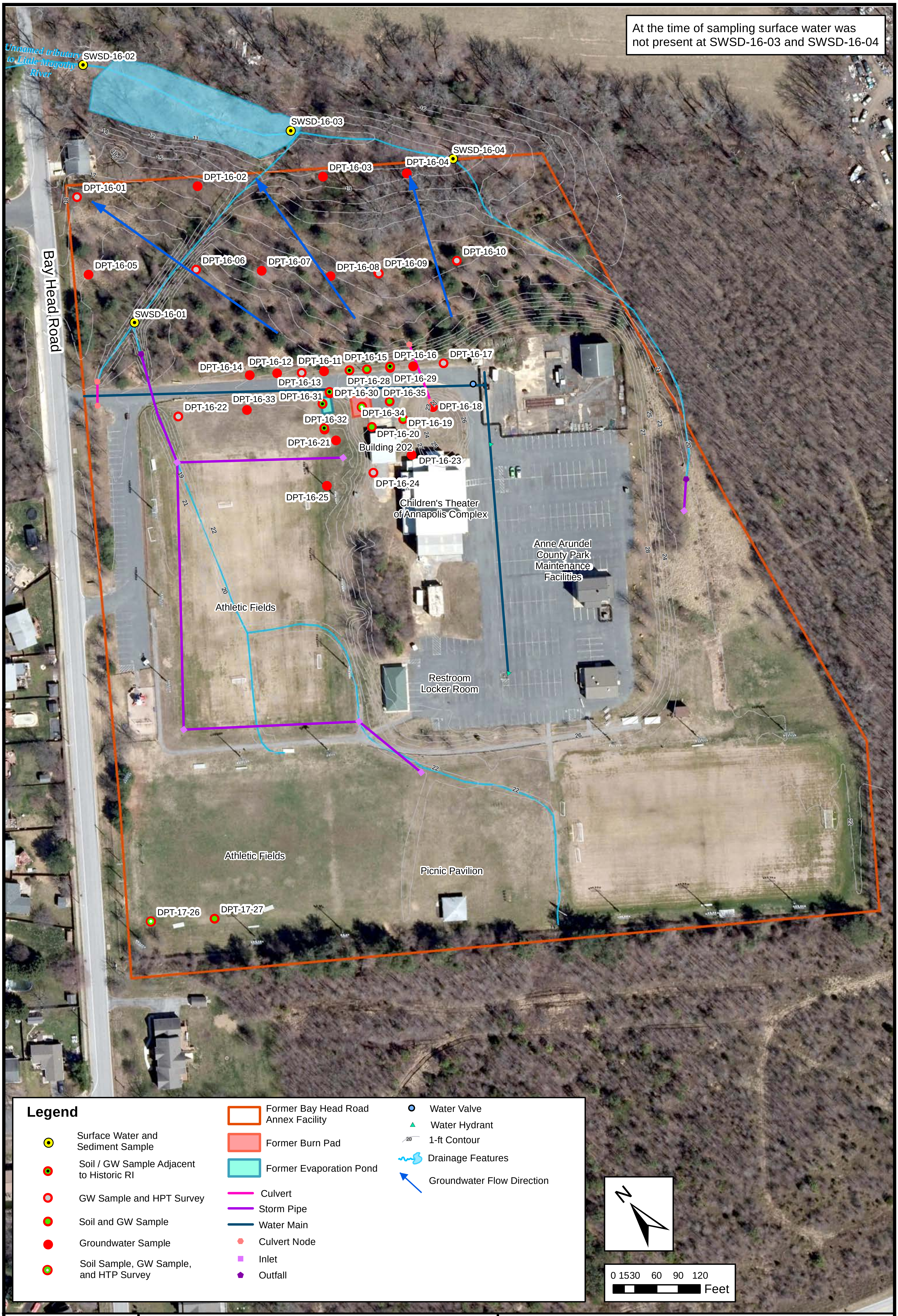

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Fig_10-3 _Historic_and_Proposed_Sample_Locations.mxd	

Figure 2
Soil, Groundwater and On/Near Site
(East of Bay Head Road) Sediment and Surface
Water Sampling Locations
Former Bay Head Road Annex Facility
Annapolis, MD

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

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Figure 3
Off-Site (West of Bay Head Road) Sediment and
Surface Water Sampling Locations
Former Bay Head Road Annex Facility
Annapolis, MD

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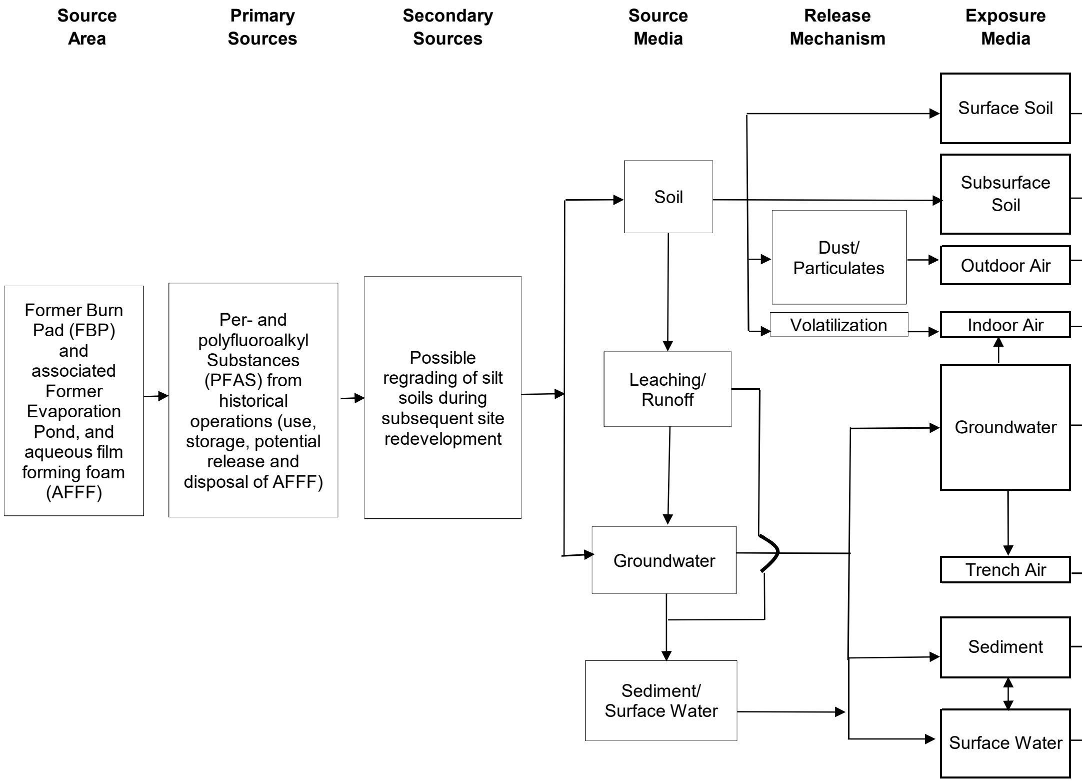
Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

Figure 4
Human Health Conceptual Site Model
Former Bay Head Road Annex Facility
Annapolis, MD



Exposure Media	Potential Exposure Route	Potential Human Receptors/Exposure Pathways			
		Current/ Future On-site Worker	Future Construction/ Excavation/ Utility Worker	Current/ Future Recreational User	Hypothetical Future On-site Resident
Surface Soil	Incidental Ingestion	●	●	●	●
	Dermal Contact	●	●	●	●
Subsurface Soil	Incidental Ingestion	●(c)	●	●(c)	●(c)
	Dermal Contact	●(c)	●	●(c)	●(c)
Outdoor Air	Inhalation	◐(b)	◐(b)	◐(b)	◐(b)
Indoor Air	Inhalation	○	○	○	○
Groundwater	Ingestion as Drinking Water	○(e)	○	○	●(d)
	Dermal Contact	◐(a,f)	◐(a)	○	◐(a)
	Incidental Ingestion	●(f)	●	○	○
	Inhalation of volatiles while bathing	○	○	○	○
Trench Air	Inhalation	○	○	○	○
Sediment	Incidental Ingestion	○	○	●	○
	Dermal Contact	○	○	●	○
Surface Water	Incidental Ingestion	○	○	●	○
	Dermal Contact	○	○	◐(a)	○

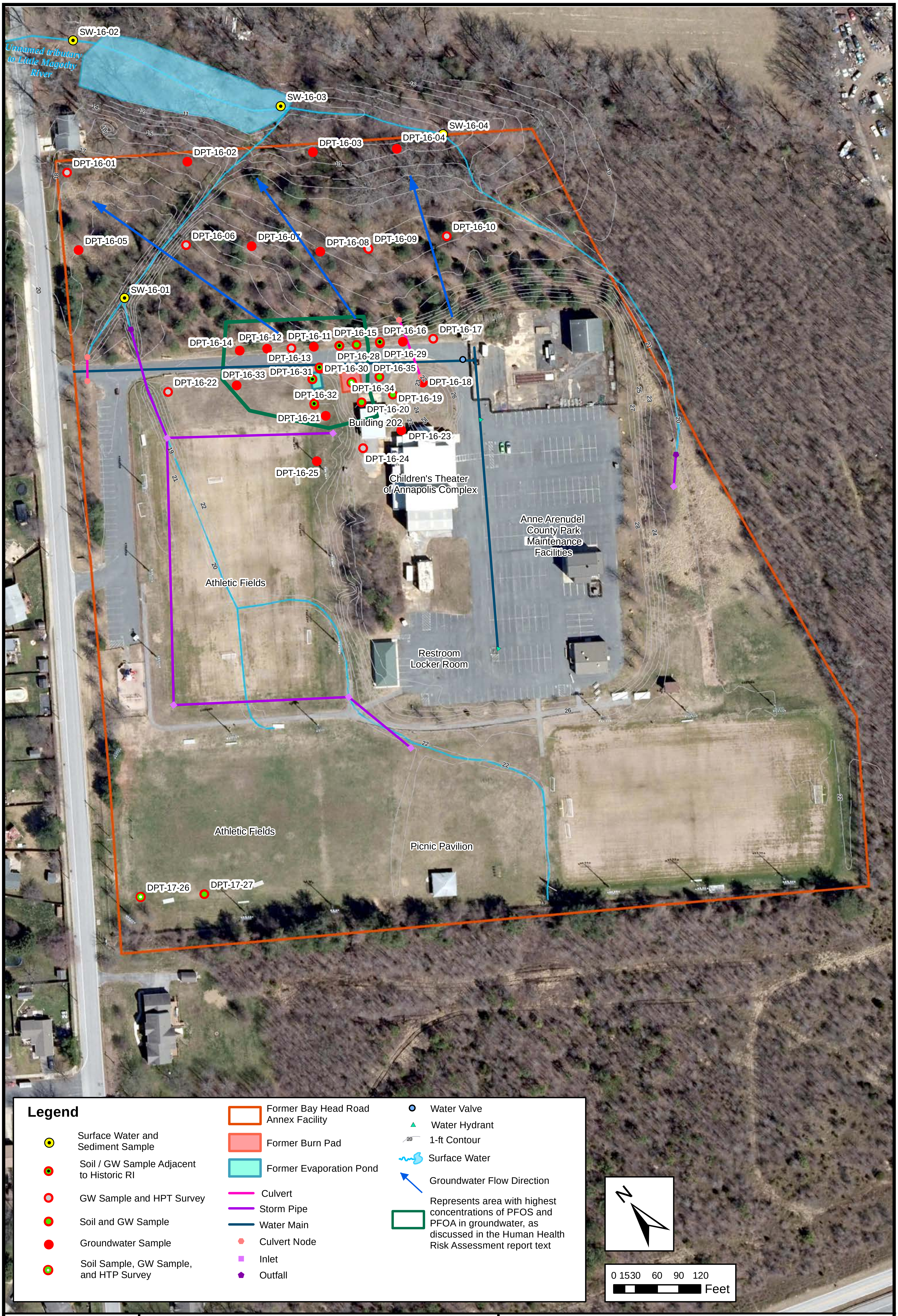
Notes:

● Potentially complete pathway.

◐ Potentially complete pathway, but not quantitatively evaluated, as discussed in the report text.

○ Pathway considered to be incomplete or insignificant.

(a) Dermal contact with PFOS, PFOA, and PFBS in water was not quantitatively evaluated consistent with USEPA's approach (USEPA, 2019a) due to limited dermal absorption of PFAS.
(b) Inhalation toxicity values are not currently available for PFAS, therefore the inhalation pathway cannot be quantified.
(c) Exposure to subsurface soil is considered a potentially complete pathway for the future use scenario only, assuming deeper soils may be brought to the surface and made available for contact during development for future use.
(d) Drinking water is currently provided to the area by municipal water. On-site groundwater is not currently used for potable use and institutional controls restrict site use to non-residential. However, a hypothetical future use scenario of on-site groundwater was evaluated for informational purposes to assess an unlimited use/unrestricted exposure (UU/UE) scenario. Off-site residential drinking water wells are present.
(e) On-site outdoor (commercial/industrial) workers are not assumed to use groundwater for potable purposes. However, the evaluation of groundwater under a hypothetical future residential scenario (see footnote (d)) is also protective of potable use by commercial/industrial receptors.
(f) Site groundwater is not currently used by on-site workers. However, under a hypothetical future use scenario in which irrigation wells are installed on the site, future on-site workers may contact



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1 of 1

Fig_10-3 _Historic_and_Proposed_Sample_Locations.mxd

Figure 5
Locations With Highest Concentrations of PFOS and PFOA In Groundwater
Former Bay Head Road Annex Facility
Annapolis, MD

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

Tables

TABLE 1

SUMMARY OF RECEPTORS, EXPOSURE POINTS, MEDIA, AND EXPOSURE PATHWAYS FOR EVALUATION

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/ Future	Soil	Surface Soil or Combined Surface and Subsurface Soil (a)	On-Site	On-Site Outdoor (Commercial/ Industrial) Worker	Adult	Dermal	Quant	Assumes full time workers, including maintenance workers, landscapers, etc. may be present on-site and be exposed to soil.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS.
						Ingestion	Quant	Assumes full time workers, including maintenance workers, landscapers, etc. may be present on-site and be exposed to soil.
				Recreational User	Adult	Dermal	Quant	The site is currently used for recreational purposes as a park, including athletic fields and a children's theatre. Assumes recreational users may be exposed to soil while walking, picnicking, playing, etc.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS.
						Ingestion	Quant	The site is currently used for recreational purposes as a park, including athletic fields and a children's theatre. Assumes recreational users may be exposed to soil while walking, picnicking, playing, etc.
					Child	Dermal	Quant	The site is currently used for recreational purposes as a park, including athletic fields and a children's theatre. Assumes recreational users may be exposed to soil while walking, picnicking, playing, etc.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS.
						Ingestion	Quant	The site is currently used for recreational purposes as a park, including athletic fields and a children's theatre. Assumes recreational users may be exposed to soil while walking, picnicking, playing, etc.
	Sediment	Sediment	Bay and Creek (West of Bay Head Road)	Recreational User	Adult	Dermal	Quant	Assumes recreational users may be exposed to sediment in the creek and/or bay of the river located downgradient from the site during wading and/or swimming activities.
						Ingestion	Quant	
					Child	Dermal	Quant	
						Ingestion	Quant	
			Creek - On/Near Site (East of Bay Head Road)	Recreational User	Adult	Dermal	Quant	Assumes recreational users may be exposed to sediment in the creek on and/or adjacent to the site during wading activities.
						Ingestion	Quant	
					Child	Dermal	Quant	
						Ingestion	Quant	
	Surface Water	Surface Water	Bay and Creek (West of Bay Head Road)	Recreational User	Adult	Dermal	Qual	Pathway was not quantitatively evaluated in the HHRA, as discussed in the HHRA report text.
						Ingestion	Quant	Assumes recreational users may be exposed to surface water in the creek and/or bay of the river located downgradient from the site during wading and/or swimming activities.
					Child	Dermal	Qual	Pathway was not quantitatively evaluated in the HHRA, as discussed in the HHRA report text.
						Ingestion	Quant	Assumes recreational users may be exposed to surface water in the creek and/or bay of the river located downgradient from the site during wading and/or swimming activities.
			Creek - On/Near Site (East of Bay Head Road)	Recreational User	Adult	Dermal	Qual	Pathway was not quantitatively evaluated in the HHRA, as discussed in the HHRA report text.
						Ingestion	Quant	Assumes recreational users may be exposed to surface water in the creek on and/or adjacent to the site during wading activities.
					Child	Dermal	Qual	Pathway was not quantitatively evaluated in the HHRA, as discussed in the HHRA report text.
						Ingestion	Quant	Assumes recreational users may be exposed to surface water in the creek on and/or adjacent to the site during wading activities.

TABLE 1

SUMMARY OF RECEPTORS, EXPOSURE POINTS, MEDIA, AND EXPOSURE PATHWAYS FOR EVALUATION

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Soil	Surface Soil or Combined Surface and Subsurface Soil (a)	On-Site	Construction/ Excavation/ Utility Worker	Adult	Dermal	Quant	Assumes construction, excavation, and/or utility work could be performed, leading to potential exposure to soil.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS.
						Ingestion	Quant	Assumes construction, excavation, and/or utility work could be performed, leading to potential exposure to soil.
				Hypothetical On-Site Resident	Adult	Dermal	Quant	Residential use is not an anticipated future use of the site. However, a hypothetical future residential exposure scenario is evaluated for informational purposes to represent a UU/UE scenario.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS.
						Ingestion	Quant	Residential use is not an anticipated future use of the site. However, a hypothetical future residential exposure scenario is evaluated for informational purposes to represent a UU/UE scenario.
					Child	Dermal	Quant	Residential use is not an anticipated future use of the site. However, a hypothetical future residential exposure scenario is evaluated for informational purposes to represent a UU/UE scenario.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS.
						Ingestion	Quant	Residential use is not an anticipated future use of the site. However, a hypothetical future residential exposure scenario is evaluated for informational purposes to represent a UU/UE scenario.
	Groundwater	Groundwater	Core of Groundwater Plume	Hypothetical On-Site Resident	Adult	Dermal	Qual	Pathway was not quantitatively evaluated in the HHRA, as discussed in the HHRA report text.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS; compounds are not volatile.
						Ingestion	Quant	Residential use is not an anticipated future use of the site and potable water is supplied by the Anne Arundel County Public Water system. However, a hypothetical future residential exposure scenario (including use of groundwater as source of potable water) is evaluated for informational purposes to represent a UU/UE scenario.
					Child	Dermal	Qual	Pathway was not quantitatively evaluated in the HHRA, as discussed in the HHRA report text.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS; compounds are not volatile.
						Ingestion	Quant	Residential use is not an anticipated future use of the site and potable water is supplied by the Anne Arundel County Public Water system. However, a hypothetical future residential exposure scenario (including use of groundwater as source of potable water) is evaluated for informational purposes to represent a UU/UE scenario.
				On-Site Outdoor (Commercial/ Industrial) Worker	Adult	Dermal	Qual	Pathway was not quantitatively evaluated in the HHRA, as discussed in the HHRA report text.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS; compounds are not volatile.
						Ingestion	Quant	Assumes exposure to groundwater during irrigation or other similar non-potable activities, if on-site water wells are installed/used under a future scenario.
		Shallow Groundwater	Core of Groundwater Plume	Construction/ Excavation/ Utility Worker	Adult	Dermal	Qual	Pathway was not quantitatively evaluated in the HHRA, as discussed in the HHRA report text.
						Inhalation	None	No inhalation toxicity values available for PFOS, PFOA, or PFBS; compounds are not volatile.
						Ingestion	Quant	Assumes construction, excavation, and/or utility work could be performed, leading to potential exposure to groundwater while working in an excavation trench.

Notes:

HHRA - Human Health Risk Assessment.

PFBS - Perfluorobutanesulfonic acid.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctane sulfonate.

UU/UE - Unlimited Use/Unrestricted Exposure.

(a) Assumes exposure to surface soil or combined surface and subsurface soil. Exposure to combined surface and subsurface soil may occur as a result of subsurface soils being brought to the surface during potential redevelopment activities.

TABLE 2.1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE SOIL
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Concentration Used for Screening (3)	Background Value (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Tier 1A - Residential Scenario			Tier 1A/1B - On-Site Outdoor Worker (Commercial/ Industrial) Scenario			Tier 1B - Recreational User (Child [0-6 yrs] and Adult) Scenario			Tier 1B - Construction/ Excavation/Utility Worker Scenario		
													Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)
On-Site		**PFAS**																						
	1763-23-1	PFOS	2.50E-01 J	1.70E+02	µg/kg	DPT-16-19 (0 - 1 ft)	11 / 12	0.6 - 0.6	1.70E+02	N/A	N/A	N/A	1.26E+02 NC	Y	ASL	1.64E+03 NC	N	BSL	8.51E+02 NC	N	BSL	5.36E+02 NC	N	BSL
	335-67-1	PFOA	2.20E-01 J	1.20E+01	µg/kg	DPT-16-35 (0 - 1 ft)	12 / 12	N/A	1.20E+01	N/A	N/A	N/A	1.26E+02 NC	N	BSL	1.64E+03 NC	N	BSL	8.51E+02 NC	N	BSL	5.36E+02 NC	N	BSL
	375-73-5	PFBS	1.20E-01 J	2.10E-01 J	µg/kg	DPT-16-35 (0 - 1 ft)	5 / 12	0.33 - 0.36	2.10E-01	N/A	N/A	N/A	1.26E+05 NC	N	BSL	1.64E+06 NC	N	BSL	8.51E+05 NC	N	BSL	5.36E+06 NC	N	BSL

Notes:

Refer to Attachment A for samples included in the data set.

Surface soil is defined as soil samples collected from 0 to 1 ft bgs.

µg/kg - Micrograms per kilogram.

ARAR/TBC - Applicable or Relevant and Appropriate Requirements/To be Considered.

bgs - Below ground surface.

CAS - Chemical Abstracts Service.

COPC - Chemical of Potential Concern.

ft - Feet.

N/A - Not Applicable or Not Available.

NC - Noncancer. Screening value is based on the screening level protective of noncarcinogenic effects.

PFAS - Per- and Polyfluoroalkyl Substances.

PFBS - Perfluorobutanesulfonic acid.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctane sulfonate.

RSL - USEPA Regional Screening Level

USEPA - United States Environmental Protection Agency.

(1) Minimum/maximum detected concentration and associated data flags.
J - The chemical was positively identified; however, the associated numerical value is an estimated concentration.

(2) Limits of detection (LODs) are shown where the frequency of detection is less than 100%.

(3) Maximum detected concentration used for screening.

(4) Background values were not used for COPC screening purposes.

(5) Calculated using the USEPA Regional Screening Level (RSL) Calculator (USEPA, 2019) and the following inputs:
- A target risk level of 1E-6 and target hazard quotient of 0.1 to account for cumulative effects on the same target organ;
- USEPA's chronic oral reference dose (RfD) (2E-5 mg/kg-day) and oral cancer slope factor (7E-2 per mg/kg-day) for PFOA published in "Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)" [EPA 822-R-16-005; May 2016];
- USEPA's chronic oral RfD for PFOS (2E-5 mg/kg-day) published in "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" [EPA 822-R-16-004; May 2016];
- USEPA's chronic RfD (2E-2 mg/kg-day) and subchronic RfD (2E-1 mg/kg-day) for PFBS published in 'USEPA's Provisional Peer-Reviewed Toxicity Values (PPRTV) for Perfluorobutane Sulfonate (CASRN 375-73-5) and Related Compound Potassium (CASRN 29420-49-3). Superfund Health Risk Technical Support Center, National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency. Final. July 2014.
- Screening levels for the residential scenario were calculated using default exposure assumptions associated with a residential soil exposure scenario (USEPA, 2014 and 2019);
- Screening levels for the worker and recreational user scenarios were calculated using exposure assumptions protective of site-specific soil exposure scenarios, as discussed in the human health risk assessment text.

(6) Rationale Codes:
Selection Reason: Above Screening Level (ASL)
Deletion Reason: Below Screening Level (BSL)

USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.
USEPA, 2019. USEPA Regional Screening Level (RSL) Calculator. May 2019 version.

TABLE 2.2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - COMBINED SURFACE AND SUBSURFACE SOIL
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Combined surface and subsurface soil

													Tier 1A - Residential Scenario			Tier 1A/1B - On-Site Outdoor Worker (Commercial/ Industrial) Scenario			Tier 1B - Recreational User (Child [0-6 yrs] and Adult) Scenario			Tier 1B - Construction/ Excavation/Utility Worker Scenario		
Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Concentration Used for Screening (3)	Background Value (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)
On-Site		**PFAS**																						
	1763-23-1	PFOS	2.50E-01 J	1.70E+02	µg/kg	DPT-16-19 (0 - 1 ft)	21 / 24	0.36 - 0.6	1.70E+02	N/A	N/A	N/A	1.26E+02 NC	Y	ASL	1.64E+03 NC	N	BSL	8.51E+02 NC	N	BSL	5.36E+02 NC	N	BSL
	335-67-1	PFOA	2.20E-01 J	1.20E+01	µg/kg	DPT-16-35 (0 - 1 ft)	22 / 24	0.36 - 0.36	1.20E+01	N/A	N/A	N/A	1.26E+02 NC	N	BSL	1.64E+03 NC	N	BSL	8.51E+02 NC	N	BSL	5.36E+02 NC	N	BSL
	375-73-5	PFBS	1.20E-01 J	2.10E-01 J	µg/kg	DPT-16-35 (0 - 1 ft)	5 / 24	0.33 - 0.37	2.10E-01	N/A	N/A	N/A	1.26E+05 NC	N	BSL	1.64E+06 NC	N	BSL	8.51E+05 NC	N	BSL	5.36E+06 NC	N	BSL

Notes:

Refer to Attachment A for samples included in the data set.

Combined surface and subsurface soil includes soil samples collected at depths ranging from 0 to 20 ft bgs. See text for further details.

µg/kg - Micrograms per kilogram.
ARAR/TBC - Applicable or Relevant and Appropriate Requirements/To be Considered.
bgs - Below ground surface.
CAS - Chemical Abstracts Service.
COPC - Chemical of Potential Concern.
ft - Feet.
N/A - Not Applicable or Not Available.
NC - Noncancer. Screening value is based on the screening level protective of noncarcinogenic effects.
PFAS - Per- and Polyfluoroalkyl Substances.
PFBS - Perfluorobutanesulfonic acid.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
RSL - USEPA Regional Screening Level
USEPA - United States Environmental Protection Agency.

(1) Minimum/maximum detected concentration and associated data flags.
J - The chemical was positively identified; however, the associated numerical value is an estimated concentration.
(2) Limits of detection (LODs) are shown where the frequency of detection is less than 100%.
(3) Maximum detected concentration used for screening.
(4) Background values were not used for COPC screening purposes.
(5) Calculated using the USEPA Regional Screening Level (RSL) Calculator (USEPA, 2019) and the following inputs:
- A target risk level of 1E-6 and target hazard quotient of 0.1 to account for cumulative effects on the same target organ;
- USEPA's chronic oral reference dose (RfD) (2E-5 mg/kg-day) and oral cancer slope factor (7E-2 per mg/kg-day) for PFOA published in "Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)" [EPA 822-R-16-005; May 2016];
- USEPA's chronic oral RfD for PFOS (2E-5 mg/kg-day) published in "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" [EPA 822-R-16-004; May 2016];
- USEPA's chronic RfD (2E-2 mg/kg-day) and subchronic RfD (2E-1 mg/kg-day) for PFBS published in 'USEPA's Provisional Peer-Reviewed Toxicity Values (PPRTV) for Perfluorobutane Sulfonate (CASRN 375-73-5) and Related Compound Potassium (CASRN 29420-49-3). Superfund Health Risk Technical Support Center, National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency. Final. July 2014.
- Screening levels for the residential scenario were calculated using default exposure assumptions associated with a residential soil exposure scenario (USEPA, 2014 and 2019);
- Screening levels for the worker and recreational user scenarios were calculated using exposure assumptions protective of site-specific soil exposure scenarios, as discussed in the human health risk assessment text.

(6) Rationale Codes:
Selection Reason: Above Screening Level (ASL)
Deletion Reason: Below Screening Level (BSL)

USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.
USEPA, 2019. USEPA Regional Screening Level (RSL) Calculator. May 2019 version.

TABLE 2.3

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER

HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater

													Tier 1A - Residential Scenario			Tier 1B - On-Site Outdoor Worker (Commercial/ Industrial) Scenario			Tier 1B - Construction/ Excavation/Utility Worker Scenario		
Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Concentration Used for Screening (3)	Background Value (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)	Screening Level (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)
On-Site		**PFAS**																			
	1763-23-1	PFOS	1.60E-03 J-	4.20E+01 J	µg/L	DPT-16-31 (19 - 23 ft)	65 / 68	0.003 - 0.0083	4.20E+01	N/A	N/A	N/A	4.01E-02 NC	Y	ASL	7.79E+01 NC	N	BSL	9.34E+01 NC	N	BSL
	335-67-1	PFOA	9.20E-04 J-	2.80E+01 J	µg/L	DPT-16-31 (19 - 23 ft)	64 / 68	0.002 - 0.0024	2.80E+01	N/A	N/A	N/A	4.01E-02 NC	Y	ASL	7.79E+01 NC	N	BSL	9.34E+01 NC	N	BSL
	375-73-5	PFBS	1.10E-03 J	1.10E+00 J	µg/L	DPT-16-21 (19 - 23 ft) DPT-16-31 (19 - 23 ft)	59 / 68	0.0019 - 0.2	1.10E+00	N/A	N/A	N/A	4.01E+01 NC	N	BSL	7.79E+04 NC	N	BSL	9.34E+05 NC	N	BSL

Notes:

Refer to Attachment A for samples included in the data set.

µg/L - Micrograms per liter.

ARAR/TBC - Applicable or Relevant and Appropriate Requirements/To be Considered.

CAS - Chemical Abstracts Service.

COPC - Chemical of Potential Concern.

ft - Feet.

N/A - Not Applicable or Not Available.

NC - Noncancer. Screening value is based on the screening level protective of noncarcinogenic effects.

PFAS - Per- and Polyfluoroalkyl Substances.

PFBS - Perfluorobutanesulfonic acid.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctane sulfonate.

RSL - USEPA Regional Screening Level

USEPA - United States Environmental Protection Agency.

(1) Minimum/maximum detected concentration and associated data flags.
J - The chemical was positively identified; however, the associated numerical value is an estimated concentration.
J- - The chemical was positively identified; however, the associated numerical value is an estimated low concentration.

(2) Limits of detection (LODs) are shown where the frequency of detection is less than 100%.

(3) Maximum detected concentration used for screening.

(4) Background values were not used for COPC screening purposes, although applicable background values may be considered in the risk characterization portion of the risk assessment, if available.

(5) Calculated using the USEPA Regional Screening Level (RSL) Calculator (USEPA, 2019) and the following inputs:
- A target risk level of 1E-6 and target hazard quotient of 0.1 to account for cumulative effects on the same target organ;
- USEPA's chronic oral reference dose (RfD) (2E-5 mg/kg-day) and oral cancer slope factor (7E-2 per mg/kg-day) for PFOA published in "Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)" [EPA 822-R-16-005; May 2016];
- USEPA's chronic oral RfD for PFOS (2E-5 mg/kg-day) published in "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" [EPA 822-R-16-004; May 2016];
- USEPA's chronic RfD (2E-2 mg/kg-day) and subchronic RfD (2E-1 mg/kg-day) for PFBS published in 'USEPA's Provisional Peer-Reviewed Toxicity Values (PPRTV) for Perfluorobutane Sulfonate (CASRN 375-73-5) and Related Compound Potassium (CASRN 29420-49-3). Superfund Health Risk Technical Support Center, National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency. Final. July 2014.
- Screening levels for the residential scenario were calculated using default exposure assumptions associated with a residential drinking water (tapwater) exposure scenario (USEPA, 2014 and 2019); Screening levels for the worker scenarios were calculated using exposure assumptions protective of site-specific groundwater exposure scenarios, as discussed in the human health risk assessment text.

(6) Rationale Codes:
Selection Reason: Above Screening Level (ASL)
Deletion Reason: Below Screening Level (BSL)

USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.

USEPA, 2019. USEPA Regional Screening Level (RSL) Calculator. May 2019 version.

TABLE 2.4
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SEDIMENT
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Concentration Used for Screening (3)	Background Value (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Tier 1B Screening Toxicity Value (NC/C) (5)	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)
Bay and Creek (West of Bay Head Road)		**PFAS**													
	1763-23-1	PFOS	3.20E-01 J	4.40E+01	µg/kg	SD-18-02 (0 - 0.5 ft)	28 / 29	4.5 - 4.5	4.40E+01	N/A	N/A	N/A	8.51E+02 NC	N	BSL
	335-67-1	PFOA	5.00E-01 J	4.50E+00 J	µg/kg	SD-18-03 (0 - 0.5 ft)	10 / 29	0.95 - 5.3	4.50E+00	N/A	N/A	N/A	8.51E+02 NC	N	BSL
	375-73-5	PFBS	2.80E-01 J	2.80E-01 J	µg/kg	SD-18-03 (0 - 0.5 ft)	1 / 29	0.38 - 4.6	2.80E-01	N/A	N/A	N/A	8.51E+05 NC	N	BSL
Creek - On/Near Site (East of Bay Head Road)		**PFAS**													
	1763-23-1	PFOS	4.20E-01 J	6.60E+00	µg/kg	SD-16-03 (0 - 0.5 ft)	4 / 4	N/A	6.60E+00	N/A	N/A	N/A	8.51E+02 NC	N	BSL
	335-67-1	PFOA	1.80E-01 J	2.80E-01 J	µg/kg	SD-16-03 (0 - 0.5 ft)	4 / 4	N/A	2.80E-01	N/A	N/A	N/A	8.51E+02 NC	N	BSL

Notes:

Refer to Attachment A for samples included in the data set.

µg/kg - Micrograms per kilogram.

ARAR/TBC - Applicable or Relevant and Appropriate Requirements/To be Considered.

CAS - Chemical Abstracts Service.

COPC - Chemical of Potential Concern.

ft - Feet.

N/A - Not Applicable or Not Available.

NC - Noncancer. Screening value is based on the screening level protective of noncarcinogenic effects.

PFAS - Per- and Polyfluoroalkyl Substances.

PFBS - Perfluorobutanesulfonic acid.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctanesulfonic acid.

RSL - Regional Screening Level.

USEPA - United States Environmental Protection Agency.

(1) Minimum/maximum detected concentration and associated data flags.

J - The chemical was positively identified; however, the associated numerical value is an estimated concentration.

(2) Limits of Detection (LODs) are shown where the frequency of detection is less than 100%.

(3) Maximum detected concentration used for screening.

(4) Background values were not used for COPC screening purposes.

(5) Calculated using the USEPA Regional Screening Level (RSL) Calculator (USEPA, 2019) for a recreator adult/child scenario, and the following inputs:

- A target risk level of 1E-6 and target hazard quotient of 0.1 to account for cumulative effects on the same target organ;
- Exposure frequency = 52 days/year (assumes 2 days/week for 26 weeks (6 warmer months) of the year);
- Exposure time = 3 hours/day;
- Sediment ingestion rate = 100 mg/day (adult); 200 mg/day (child);
- Values for exposure duration, body weight, skin surface area, and adherence factors were conservatively set equal to the USEPA default values for a residential soil exposure scenario, as utilized in the RSL calculator.
- USEPA's chronic oral reference dose (RfD) (2E-5 mg/kg-day) and oral cancer slope factor (7E-2 per mg/kg-day) for PFOA published in "Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)" [EPA 822-R-16-005; May 2016];
- USEPA's chronic oral RfD for PFOS (2E-5 mg/kg-day) published in "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" [EPA 822-R-16-004; May 2016];
- USEPA's chronic RfD (2E-2 mg/kg-day) and subchronic RfD (2E-1 mg/kg-day) for PFBS published in 'USEPA's Provisional Peer-Reviewed Toxicity Values (PPRTV) for Perfluorobutane Sulfonate (CASRN 375-73-5) and Related Compound Potassium (CASRN 29420-49-3). Superfund Health Risk Technical Support Center, National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency. Final. July 2014.

(6) Rationale Codes:

Deletion Reason: Below Screening Level (BSL)

USEPA, 2019. USEPA Regional Screening Level (RSL) Calculator. May 2019 version.

TABLE 2.5

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE WATER

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Concentration Used for Screening (3)	Background Value (4)	Tier 1B Screening Toxicity Value (NC/C) (5)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (6)
Bay and Creek (West of Bay Head Road)		**PFAS**													
	1763-23-1	PFOS	3.20E-03	6.60E-01 J	µg/L	SW-18-02	48 / 48	N/A	6.60E-01	N/A	1.40E+03 NC	N/A	N/A	N	BSL
	335-67-1	PFOA	3.30E-03	5.30E-01 J	µg/L	SW-18-03	48 / 48	N/A	5.30E-01	N/A	1.40E+03 NC	N/A	N/A	N	BSL
	375-73-5	PFBS	1.60E-03 J	5.70E-02	µg/L	SW-18-03	48 / 48	N/A	5.70E-02	N/A	1.40E+06 NC	N/A	N/A	N	BSL
Creek - On/Near Site (East of Bay Head Road)		**PFAS**													
	1763-23-1	PFOS	1.20E-01	2.70E-01	µg/L	SW-16-01	2 / 2	N/A	2.70E-01	N/A	1.40E+03 NC	N/A	N/A	N	BSL
	335-67-1	PFOA	2.30E-02	4.20E-02	µg/L	SW-16-02	2 / 2	N/A	4.20E-02	N/A	1.40E+03 NC	N/A	N/A	N	BSL
	375-73-5	PFBS	8.90E-03	2.00E-02	µg/L	SW-16-01	2 / 2	N/A	2.00E-02	N/A	1.40E+06 NC	N/A	N/A	N	BSL

Notes:

Refer to Attachment A for samples included in the data set.

µg/L - Micrograms per liter.

ARAR/TBC - Applicable or Relevant and Appropriate Requirements/To be Considered.

CAS - Chemical Abstracts Service.

COPC - Chemical of Potential Concern.

N/A - Not Applicable or Not Available.

NC - Noncancer. Screening value is based on the screening level protective of noncarcinogenic effects.

PFAS - Per- and Polyfluoroalkyl Substances.

PFBS - Perfluorobutanesulfonic acid.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctanesulfonic acid.

RSL - Regional Screening Level.

USEPA - United States Environmental Protection Agency.

(1) Minimum/maximum detected concentration and associated data flags.

J -The chemical was positively identified; however, the associated numerical value is an estimated concentration.

(2) Limits of Detection (LODs) are shown where the frequency of detection is less than 100%.

(3) Maximum detected concentration used for screening.

(4) Background values were not used for COPC screening purposes.

(5) Calculated using the USEPA Regional Screening Level (RSL) Calculator (USEPA, 2019) for a recreator adult/child scenario, and the following inputs:

- A target risk level of 1E-6 and target hazard quotient of 0.1 to account for cumulative effects on the same target organ;
- Exposure frequency = 52 days/year (assumes 2 days/week for 26 weeks (6 warmer months) of the year);
- Exposure time = 3 hours/day;
- Surface water ingestion rate = Swimming: 0.05 liters/hour; Wading: 0.01 liters/hour (adult); 0.05 liters/hour (child);
- Values for exposure duration, body weight, and skin surface area were conservatively set equal to the USEPA default values for a residential water exposure scenario, as utilized in the RSL calculator.
- USEPA's chronic oral reference dose (RfD) (2E-5 mg/kg-day) and oral cancer slope factor (7E-2 per mg/kg-day) for PFOA published in "Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)" [EPA 822-R-16-005; May 2016];
- USEPA's chronic oral RfD for PFOS (2E-5 mg/kg-day) published in "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" [EPA 822-R-16-004; May 2016];
- USEPA's chronic RfD (2E-2 mg/kg-day) and subchronic RfD (2E-1 mg/kg-day) for PFBS published in 'USEPA's Provisional Peer-Reviewed Toxicity Values (PPRTV) for Perfluorobutane Sulfonate (CASRN 375-73-5) and Related Compound Potassium (CASRN 29420-49-3). Superfund Health Risk Technical Support Center, National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency. Final. July 2014.

(6) Rationale Codes:

Deletion Reason: Below Screening Level (BSL)

USEPA, 2019. USEPA Regional Screening Level (RSL) Calculator. May 2019 version.

TABLE 3.1.RME/CTE

EXPOSURE POINT CONCENTRATION SUMMARY - SURFACE SOIL

REASONABLE MAXIMUM EXPOSURE AND CENTRAL TENDENCY EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Surface soil

Exposure Point	Chemical of Potential Concern	CAS Number	Units	Frequency of Detection	Arithmetic Mean (1)	UCL (Distribution) (2)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
								Value	Units	Statistic (3)	Rationale
On-Site	**PFAS**										
	PFOS	1763-23-1	µg/kg	11 / 12	3.34E+01	1.08E+02 (G)	1.70E+02	1.08E+02	µg/kg	95% KM Bootstrap t UCL	(4)

Notes:
µg/kg - Micrograms per kilogram.
CAS - Chemical Abstracts Service.
EPC - Exposure point concentration.
PFAS - Per- and Polyfluoroalkyl Substances.
PFOS - Perfluorooctane sulfonate.
UCL - Upper confidence limit.
USEPA - United States Environmental Protection Agency.

(1) Where the frequency of detection is less than 100%, the Kaplan Meier mean concentration, calculated using USEPA's ProUCL software referenced in footnote (2), is presented.

(2) UCL calculations were performed using USEPA's ProUCL software version 5.1.002. For data sets with multiple detection limits for non-detects, the use of the Kaplan Meier non-parametric test procedure is recommended and used to calculate an appropriate UCL. For the Kaplan Meier test procedure, the type of data distribution was determined using a series of tests (Shapiro-Wilk, Kolmogorov-Smirnov, Anderson-Darling) for normal, lognormal, or gamma data distributions. The results of these distribution tests determined which UCL calculation was performed. The UCL suggested by ProUCL is used, unless otherwise noted. In cases where more than one UCL is suggested, the higher UCL is used, unless otherwise noted.
G - Gamma.

(3) Indicates the statistic on which the exposure point concentration is based.

(4) The selected EPC is equal to the UCL suggested by ProUCL, as described in (2).

TABLE 3.2.RME/CTE
EXPOSURE POINT CONCENTRATION SUMMARY - COMBINED SURFACE AND SUBSURFACE SOIL
REASONABLE MAXIMUM EXPOSURE AND CENTRAL TENDENCY EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Combined surface and subsurface soil

Exposure Point	Chemical of Potential Concern	CAS Number	Units	Frequency of Detection	Arithmetic Mean (1)	UCL (Distribution) (2)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
								Value	Units	Statistic (3)	Rationale
On-Site	**PFAS**										
	PFOS	1763-23-1	µg/kg	21 / 24	2.51E+01	4.70E+01 (G)	1.70E+02	4.70E+01	µg/kg	95% Gamma Adjusted KM-UCL	(4)

Notes:
µg/kg - Micrograms per kilogram.
CAS - Chemical Abstracts Service.
EPC - Exposure point concentration.
PFAS - Per- and Polyfluoroalkyl Substances.
PFOS - Perfluorooctane sulfonate.
UCL - Upper confidence limit.
USEPA - United States Environmental Protection Agency.

(1) Where the frequency of detection is less than 100%, the Kaplan Meier mean concentration, calculated using USEPA's ProUCL software referenced in footnote (2), is presented.

(2) UCL calculations were performed using USEPA's ProUCL software version 5.1.002. For data sets with multiple detection limits for non-detects, the use of the Kaplan Meier non-parametric test procedure is recommended and used to calculate an appropriate UCL. For the Kaplan Meier test procedure, the type of data distribution was determined using a series of tests (Shapiro-Wilk, Kolmogorov-Smirnov, Anderson-Darling) for normal, lognormal, or gamma data distributions. The results of these distribution tests determined which UCL calculation was performed.
The UCL suggested by ProUCL is used, unless otherwise noted. In cases where more than one UCL is suggested, the higher UCL is used, unless otherwise noted.
G - Gamma.

(3) Indicates the statistic on which the exposure point concentration is based.

(4) The selected EPC is equal to the UCL suggested by ProUCL, as described in (2).

TABLE 3.3.RME/CTE

EXPOSURE POINT CONCENTRATION SUMMARY - GROUNDWATER

REASONABLE MAXIMUM EXPOSURE AND CENTRAL TENDENCY EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Point	Chemical of Potential Concern	CAS Number	Units	Frequency of Detection	Arithmetic Mean (1)	UCL (Distribution) (2)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
								Value	Units	Statistic (3)	Rationale
Core of Groundwater Plume	**PFAS**										
	PFOS	1763-23-1	µg/L	26 / 26	6.33E+00	9.68E+00 (G)	4.20E+01 J	9.68E+00	µg/L	95% Adjusted Gamma UCL	(4)
	PFOA	335-67-1	µg/L	26 / 26	3.24E+00	8.74E+00 (NP)	2.80E+01 J	8.74E+00	µg/L	95% Chebyshev (Mean, Sd) UCL	(4)

Notes:

The core of groundwater plume includes locations DPT-16-11, DPT-16-12, DPT-16-13, DPT-16-14, DPT-16-15, DPT-16-20, DPT-16-21, DPT-16-28, DPT-16-30, DPT-16-31, DPT-16-32, DPT-16-33, and DPT-16-34.

µg/L - Micrograms per liter.

CAS - Chemical Abstracts Service.

PFAS - Per- and Polyfluoroalkyl Substances.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctane sulfonate.

UCL - Upper confidence limit.

USEPA - United States Environmental Protection Agency.

(1) Arithmetic mean calculated from core of groundwater plume. See text for detail.

(2) UCL calculations were performed using USEPA's ProUCL software version 5.1.002. For data sets with multiple detection limits for non-detects, the use of the Kaplan Meier non-parametric test procedure is recommended and used to calculate an appropriate UCL. For the Kaplan Meier test procedure, the type of data distribution was determined using a series of tests (Shapiro-Wilk, Kolmogorov-Smirnov, Anderson-Darling) for normal, lognormal, or gamma data distributions. The results of these distribution tests determined which UCL calculation was performed.
The UCL suggested by ProUCL is used, unless otherwise noted. In cases where more than one UCL is suggested, the higher UCL is used, unless otherwise noted.
G - Gamma; NP - Non-parametric.

(3) Indicates the statistic on which the exposure point concentration is based.

(4) The selected EPC is equal to the UCL suggested by ProUCL, as described in (2).

TABLE 4.1.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS - SOIL

REASONABLE MAXIMUM EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil / Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Incidental Ingestion	Hypothetical Future On-site Resident	Adult	On-Site	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	See Table 3s	Intake (mg/kg-day) =
				IR	Ingestion Rate	100	mg/day	USEPA, 2014	CS x IR x EF x ED x CF x FI
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	20	years	USEPA, 2014	
				FI	Fraction Ingested from Site	1	unitless	(1)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 1989	
		Child	On-Site	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	See Table 3s	Intake (mg/kg-day) =
				IR	Ingestion Rate	200	mg/day	USEPA, 2014	CS x IR x EF x ED x CF x FI
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				FI	Fraction Ingested from Site	1	unitless	(1)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 1989	

TABLE 4.1.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS - SOIL

REASONABLE MAXIMUM EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil / Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Hypothetical Future On-site Resident	Adult	On-Site	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	See Table 3s	Intake (mg/kg-day) =
				SA	Surface Area	6,032	cm^2	USEPA, 2014 (3)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.07	mg/cm^2-event	USEPA, 2014 (4)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	(7)	
				EV	Event Frequency	1	event/day	(2)	
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	
				ED	Exposure Duration	20	years	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 1989	
		Child	On-Site	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	See Table 3s	Intake (mg/kg-day) =
				SA	Surface Area	2,373	cm^2	USEPA, 2014 (5)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.2	mg/cm^2-event	USEPA, 2014 (6)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	(7)	
				EV	Event Frequency	1	event/day	(2)	
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 1989	

TABLE 4.1.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS - SOIL
REASONABLE MAXIMUM EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil / Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name

Notes:

< - less than.

RME - reasonable maximum exposure.

USEPA - United States Environmental Protection Agency.

(1) Professional judgment; conservatively assumes 100 percent of soil ingested is from the site.

(2) Based on professional judgment.

(3) Represents the weighted mean surface area for male and female adults, including hands, forearms, lower legs, and head (USEPA, 2011; Table 7-2).

(4) Represents the geometric mean (50th percentile) of weighted average body-specific (hands, forearms, lower legs and face) adherence factors for gardeners (USEPA, 2004; Exhibit C-2).

(5) Represents the weighted mean surface area for males and females ages 0 to <6 years old, including head, hands, forearms, lower legs, and feet (USEPA, 2011; Table 7-2).

(6) Represents the geometric mean (50th percentile) of weighted average body-specific (hands, forearms, lower legs and face) adherence factors for children playing (wet soil) (USEPA, 2004; Exhibit C-2).

(7) Dermal absorption factors are equal to those utilized in USEPA's Regional Screening Level (RSL) Calculator (2019); a factor of 0.1 is used for PFOS.

Sources:

USEPA, 1989. Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2004. Risk Assessment Guidance for Superfund. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. EPA/540/R/99/005.

USEPA, 2011. Exposure Factors Handbook. September 2011.

USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.

Unit Intake Calculations

Incidental Ingestion Intake [(mg/kg-day)(kg/mg)] = (IR x EF x ED x CF x FI)/(BW x AT) [CS is factored into the risk calculation in Table 7s]

Dermal Intake [(mg/kg-day)(kg/mg)] = (SA x AF x EV x EF x ED x CF)/(BW x AT) [CS and ABS are factored into the risk calculation in Table 7s]

Hypothetical Future On-site Resident - Adult:	Cancer Ingestion Intake =	3.42E-07	Cancer Dermal Intake =	1.45E-06
Hypothetical Future On-site Resident - Adult:	Noncancer Ingestion Intake =	1.20E-06	Noncancer Dermal Intake =	5.06E-06
Hypothetical Future On-site Resident - Child:	Cancer Ingestion Intake =	1.10E-06	Cancer Dermal Intake =	2.60E-06
Hypothetical Future On-site Resident - Child:	Noncancer Ingestion Intake =	1.28E-05	Noncancer Dermal Intake =	3.03E-05

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.1.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS - SOIL

CENTRAL TENDENCY EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil / Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Incidental Ingestion	Hypothetical Future On-site Resident	Adult	On-Site	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	See Table 3s	Intake (mg/kg-day) =
				IR	Ingestion Rate	50	mg/day	USEPA, 1993	CS x IR x EF x ED x CF x FI
				EF	Exposure Frequency	234	days/yr	USEPA, 1993	BW x AT
				ED	Exposure Duration	13	years	USEPA, 2011 (3)	
				FI	Fraction Ingested from Site	1	unitless	(1)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	4,745	days	USEPA, 1989	
		Child	On-Site	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	See Table 3s	Intake (mg/kg-day) =
				IR	Ingestion Rate	100	mg/day	USEPA, 1993	CS x IR x EF x ED x CF x FI
				EF	Exposure Frequency	234	days/yr	USEPA, 1993	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				FI	Fraction Ingested from Site	1	unitless	(1)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 1989	

TABLE 4.1.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS - SOIL

CENTRAL TENDENCY EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil / Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Hypothetical Future On-site Resident	Adult	On-Site	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	See Table 3s	Intake (mg/kg-day) =
				SA	Surface Area	6,032	cm^2	USEPA, 2014 (5)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.01	mg/cm^2-event	USEPA, 2004 (2)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	(7)	
				EV	Event Frequency	1	event/day	(4)	
				EF	Exposure Frequency	234	days/yr	USEPA, 1993	
				ED	Exposure Duration	13	years	USEPA, 2011 (3)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	4,745	days	USEPA, 1989	
		Child	On-Site	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	See Table 3s	Intake (mg/kg-day) =
				SA	Surface Area	2,373	cm^2	USEPA, 2014 (6)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.04	mg/cm^2-event	USEPA, 2004 (2)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	(7)	
				EV	Event Frequency	1	event/day	(4)	
				EF	Exposure Frequency	234	days/yr	USEPA, 1993	
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 1989	

TABLE 4.1.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS - SOIL

CENTRAL TENDENCY EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil / Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name

Notes:

< - less than.

CTE - central tendency exposure.

USEPA - United States Environmental Protection Agency.

(1) Professional judgment; conservatively assumes 100 percent of soil ingested is from the site.

(2) Value recommended for CTE scenario in Exhibit 3-5 (USEPA, 2004).

(3) Mean current residence time (USEPA, 2011; Table 16-5).

(4) Based on professional judgment.

(5) Represents the weighted mean surface area for male and female adults, including hands, forearms, lower legs, and head (USEPA, 2011; Table 7-2).

(6) Represents the weighted mean surface area for males and females ages 0 to <6 years old, including head, hands, forearms, lower legs, and feet (USEPA, 2011; Table 7-2).

(7) Dermal absorption factors are equal to those utilized in USEPA's Regional Screening Level (RSL) Calculator (2019); a factor of 0.1 is used for PFOS.

Sources:

USEPA, 1989. Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1993. USEPA Superfund's Standard Default Exposure Factors For the Central Tendency and Reasonable Maximum Exposure. Preliminary Review Draft. May 5, 1993.

USEPA, 2004. Risk Assessment Guidance for Superfund. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. EPA/540/R/99/005.

USEPA, 2011. Exposure Factors Handbook. September 2011.

USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.

Unit Intake Calculations

Incidental Ingestion Intake [(mg/kg-day)(kg/mg)] = (IR x EF x ED x CF x FI)/(BW x AT) [CS is factored into the risk calculation in Table 7s]

Dermal Intake [(mg/kg-day)(kg/mg)] = (SA x AF x EV x EF x ED x CF)/(BW x AT) [CS and ABS are factored into the risk calculation in Table 7s]

Hypothetical Future On-site Resident - Adult:	Cancer Ingestion Intake =	7.44E-08	Cancer Dermal Intake =	8.98E-08
Hypothetical Future On-site Resident - Adult:	Noncancer Ingestion Intake =	4.01E-07	Noncancer Dermal Intake =	4.83E-07
Hypothetical Future On-site Resident - Child:	Cancer Ingestion Intake =	3.66E-07	Cancer Dermal Intake =	3.48E-07
Hypothetical Future On-site Resident - Child:	Noncancer Ingestion Intake =	4.27E-06	Noncancer Dermal Intake =	4.06E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.2.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS - GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Hypothetical Future On-site Resident	Adult	On-Site	CW	Chemical Concentration in Water	Chemical Specific	ug/L	See Table 3s	Intake (mg/kg-day) =
				IR	Ingestion Rate	2.5	liters/day	USEPA, 2014	CW x IR x EF x ED x CF
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	20	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 1989	
		Child	On-Site	CW	Chemical Concentration in Water	Chemical Specific	ug/L	See Table 3s	Intake (mg/kg-day) =
				IR	Ingestion Rate	0.78	liters/day	USEPA, 2014	CW x IR x EF x ED x CF
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 1989	

Notes:

RME - reasonable maximum exposure.

USEPA - United States Environmental Protection Agency.

Sources:

USEPA, 1989. Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.

Unit Intake Calculations

Incidental Ingestion Intake [(mg/kg-day)(L/ug)]= (IR x EF x ED x CF)/(BW x AT) [CW is factored into the risk calculation in Table 7s]

Hypothetical Future On-site Resident - Adult:	Cancer Ingestion Intake =	8.56E-06
Hypothetical Future On-site Resident - Adult:	Noncancer Ingestion Intake =	3.00E-05
Hypothetical Future On-site Resident - Child:	Cancer Ingestion Intake =	4.27E-06
Hypothetical Future On-site Resident - Child:	Noncancer Ingestion Intake =	4.99E-05

Cancer risk from ingestion = Groundwater concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Hazard Index from ingestion = Groundwater concentration x Noncancer Ingestion Intake / Oral Reference Dose

TABLE 4.2.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS - GROUNDWATER

CENTRAL TENDENCY EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Hypothetical Future On-site Resident	Adult	On-Site	CW	Chemical Concentration in Water	Chemical Specific	ug/L	See Table 3s	Intake (mg/kg-day) =
				IR	Ingestion Rate	1.4	liters/day	USEPA, 2011 (1)	CW x IR x EF x ED x CF
				EF	Exposure Frequency	234	days/yr	USEPA, 1993	BW x AT
				ED	Exposure Duration	13	years	USEPA, 2011 (2)	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	4,745	days	USEPA, 1989	
		Child	On-Site	CW	Chemical Concentration in Water	Chemical Specific	ug/L	See Table 3s	Intake (mg/kg-day) =
				IR	Ingestion Rate	0.74	liters/day	USEPA, 2011 (3)	CW x IR x EF x ED x CF
				EF	Exposure Frequency	234	days/yr	USEPA, 1993	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 1989	

Notes:

CTE - central tendency exposure.

USEPA - United States Environmental Protection Agency.

(1) Mean tap water intake for adults (ages 20 to 64 years) (USEPA, 2011; Table 3-57).

(2) Mean current residence time (USEPA, 2011; Table 16-5).

(3) Mean tap water intake for children (ages 1 to 10 years) (USEPA, 2011; Table 3-57).

Sources:

USEPA, 1989. Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1993. USEPA Superfund's Standard Default Exposure Factors For the Central Tendency and Reasonable Maximum Exposure. Preliminary Review Draft. May 5, 1993.

USEPA, 2011. Exposure Factors Handbook. September 2011.

USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.

Unit Intake Calculations

Incidental Ingestion Intake [(mg/kg-day)(L/ug)]= (IR x EF x ED x CF)/(BW x AT) [CW is factored into the risk calculation in Table 7s]

Hypothetical Future On-site Resident - Adult:	Cancer Ingestion Intake =	2.08E-06
Hypothetical Future On-site Resident - Adult:	Noncancer Ingestion Intake =	1.12E-05
Hypothetical Future On-site Resident - Child:	Cancer Ingestion Intake =	2.71E-06
Hypothetical Future On-site Resident - Child:	Noncancer Ingestion Intake =	3.16E-05

Cancer risk from ingestion = Groundwater concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Hazard Index from ingestion = Groundwater concentration x Noncancer Ingestion Intake / Oral Reference Dose

TABLE 5.1

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Chemical of Potential Concern	CAS Number	Chronic/ Subchronic (1)	Oral RfD		Oral Absorption Efficiency for Dermal (2)	Absorbed RfD for Dermal (3)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
			Value	Units		Value	Units			Source(s)	Date(s) (4) (MM/YYYY)
CHRONIC TOXICITY VALUES											
PFAS											
PFOA	335-67-1	Chronic	2.0E-05	mg/kg-day	N/A	2.0E-05	mg/kg-day	Developmental	30	USEPA (5)	5/2016
PFOS	1763-23-1	Chronic	2.0E-05	mg/kg-day	N/A	2.0E-05	mg/kg-day	Developmental	30	USEPA (5)	5/2016
SUBCHRONIC TOXICITY VALUES											
PFAS											
PFOA	335-67-1	(a)	2.0E-05	mg/kg-day	N/A	2.0E-05	mg/kg-day	Developmental	30	USEPA (5)	5/2016
PFOS	1763-23-1	(a)	2.0E-05	mg/kg-day	N/A	2.0E-05	mg/kg-day	Developmental	30	USEPA (5)	5/2016

Notes:

CAS - Chemical Abstracts Service.

IRIS - Integrated Risk Information System.

N/A - Not applicable or not available.

mg/kg-day - Milligram per kilogram per day.

PFAS - Per- and Polyfluoroalkyl Substances.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctane sulfonate.

RfD - Reference dose.

USEPA - United States Environmental Protection Agency.

(1) Published value where available. Where not available, when the chronic RfD is based on a subchronic study, a subchronic RfD has been developed by the elimination of the uncertainty factor for subchronic to chronic adjustment. If no subchronic data are available, the chronic RfD has been adopted as the subchronic RfD.

(a) The chronic RfD is considered appropriate for use in evaluating subchronic exposures because the critical effect is a developmental endpoint and can potentially result from a short-term exposure during a critical period of development.

(2) Oral Absorption Efficiencies from Exhibit 4-1 (USEPA, 2004. Risk Assessment Guidance for Superfund, Part E).

(3) Calculated as: (oral RfD) x (oral to dermal adjustment factor).

(4) Reflects the date associated with the source of the toxicity information. For online databases, including IRIS, the date reflects the date on which the information was obtained from the online source.

(5) Chronic RfDs for PFOS and PFOA recommended by USEPA in the following documents published by the USEPA Office of Water in May 2016: "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" [EPA 822-R-16-004] and "Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)" [EPA 822-R-16-005].

TABLE 6.1

CANCER TOXICITY DATA -- ORAL/DERMAL

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Chemical of Potential Concern	CAS Number	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal	Absorbed Cancer Slope Factor for Dermal (2)		Weight of Evidence/ Cancer Guideline Description	Oral CSF		Mutagen?
		Value	Units		Value	Units		Source(s)	Date(s) (3) (MM/YYYY)	
PFAS										
PFOA	335-67-1	7.0E-02	$(mg/kg\text{-}day)^{-1}$	(1)	7.0E-02	$(mg/kg\text{-}day)^{-1}$	N/A	USEPA (4)	5/2016	No
PFOS	1763-23-1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No

Notes:

CAS - Chemical Abstracts Service.

CSF - Cancer slope factor.

mg/kg-day - Milligram per kilogram per day.

N/A - Not applicable or not available.

PFAS - Per- and Polyfluoroalkyl Substances.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctane sulfonate.

USEPA - United States Environmental Protection Agency.

(1) Oral absorption efficiency exceeds 50%. Therefore, no adjustment of the oral slope factor is necessary (USEPA, 2004. Exhibit 4-1).

(2) Calculated as: (oral slope factor) / (oral to dermal adjustment factor).

(3) Reflects the date associated with the source of the toxicity information.

(4) CSF for PFOA derived in the USEPA in "Health Effects Support Document for Perfluorooctanoic Acid (PFOA)" published by the USEPA Office of Water in May 2016 [EPA 822-R-16-003].

TABLE 7.1a.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - HYPOTHETICAL FUTURE ON-SITE RESIDENT (ADULT)
REASONABLE MAXIMUM EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult

							Cancer Risk Calculations						Noncancer Hazard Calculations				
	Exposure	Exposure	Exposure	Chemical of	EPC		Intake/Exposure Concentration		CSF or IUR			Cancer	Intake/Exposure Concentration		RfD or RfC		Hazard
Medium	Medium	Point	Route	Potential Concern	Value	Units	Value	Units	Value	Units	ADAF	Risk	Value	Units	Value	Units	Quotient
Surface Soil	Surface Soil	On-Site	Incidental Ingestion	**PFAS**													
				PFOS	1.08E-01	mg/kg (1)	3.70E-08	mg/kg-day	N/A	kg-day/mg	N/A	N/A	1.29E-07	mg/kg-day	2.00E-05	mg/kg-day	6.5E-03
			Exp. Route Total									N/A					6E-03
			Dermal	**PFAS**													
				PFOS	1.08E-01	mg/kg (1)	1.56E-08	mg/kg-day	N/A	kg-day/mg	N/A	N/A	5.46E-08	mg/kg-day	2.00E-05	mg/kg-day	2.7E-03
			Exp. Route Total									N/A					3E-03
		Exposure Point Total										N/A					9E-03
	Exposure Medium Total											N/A					9E-03
Surface Soil Total												N/A					9E-03
Combined Surface and Subsurface Soil	Combined Surface and Subsurface Soil	On-Site	Incidental Ingestion	**PFAS**													
				PFOS	4.70E-02	mg/kg (1)	1.61E-08	mg/kg-day	N/A	kg-day/mg	N/A	N/A	5.63E-08	mg/kg-day	2.00E-05	mg/kg-day	2.8E-03
			Exp. Route Total									N/A					3E-03
			Dermal	**PFAS**													
				PFOS	4.70E-02	mg/kg (1)	6.79E-09	mg/kg-day	N/A	kg-day/mg	N/A	N/A	2.38E-08	mg/kg-day	2.00E-05	mg/kg-day	1.2E-03
			Exp. Route Total									N/A					1E-03
		Exposure Point Total										N/A					4E-03
	Exposure Medium Total											N/A					4E-03
Combined Surface and Subsurface Soil Total												N/A					4E-03
Groundwater	Groundwater	Core of Groundwater Plume	Ingestion	**PFAS**													
				PFOS	9.68E+00	µg/L	8.28E-05	mg/kg-day	N/A	kg-day/mg	N/A	N/A	2.90E-04	mg/kg-day	2.00E-05	mg/kg-day	1.4E+01
				PFOA	8.74E+00	µg/L	7.49E-05	mg/kg-day	7.00E-02	kg-day/mg	N/A	5.2E-06	2.62E-04	mg/kg-day	2.00E-05	mg/kg-day	1.3E+01
			Exp. Route Total									5E-06					3E+01
		Exposure Point Total										5E-06					3E+01
	Exposure Medium Total											5E-06					3E+01
Groundwater Total												5E-06					3E+01
Total Receptor Risk/Hazard												(2)					(2)

TABLE 7.1a.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - HYPOTHETICAL FUTURE ON-SITE RESIDENT (ADULT)

REASONABLE MAXIMUM EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult

							Cancer Risk Calculations						Noncancer Hazard Calculations				
	Exposure	Exposure	Exposure	Chemical of	EPC		Intake/Exposure Concentration		CSF or IUR			Cancer	Intake/Exposure Concentration		RfD or RfC		Hazard
Medium	Medium	Point	Route	Potential Concern	Value	Units	Value	Units	Value	Units	ADAF	Risk	Value	Units	Value	Units	Quotient

Notes:
µg/L - Microgram per liter.
ADAF - Age-Dependent Adjustment Factor.
CSF - Cancer Slope Factor.
EPC - Exposure Point Concentration.
IUR - Inhalation unit risk.
N/A - Not applicable.
mg/kg - Milligram per kilogram.
mg/kg-day - Milligram per kilogram per day
kg-day/mg - Kilogram per day per milligram
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
RfC - Inhalation Reference Concentration.
RfD - Oral Reference Dose.
RME - Reasonable Maximum Exposure.
(1) Soil EPCs were converted from microgram per kilogram (µg/kg) to milligram per kilogram (mg/kg)
(2) Presented on corresponding summary of risk/hazard table.

TABLE 7.1b.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - HYPOTHETICAL FUTURE ON-SITE RESIDENT (CHILD)

REASONABLE MAXIMUM EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Child

							Cancer Risk Calculations						Noncancer Hazard Calculations				
	Exposure	Exposure	Exposure	Chemical of	EPC		Intake/Exposure Concentration		CSF or IUR			Cancer	Intake/Exposure Concentration		RfD or RfC		Hazard
Medium	Medium	Point	Route	Potential Concern	Value	Units	Value	Units	Value	Units	ADAF	Risk	Value	Units	Value	Units	Quotient
Surface Soil	Surface Soil	On-Site	Incidental Ingestion	**PFAS**													
				PFOS	1.08E-01	mg/kg (1)	1.18E-07	mg/kg-day	N/A	kg-day/mg	N/A	N/A	1.38E-06	mg/kg-day	2.00E-05	mg/kg-day	6.9E-02
			Exp. Route Total									N/A					7E-02
			Dermal	**PFAS**													
				PFOS	1.08E-01	mg/kg (1)	2.81E-08	mg/kg-day	N/A	kg-day/mg	N/A	N/A	3.27E-07	mg/kg-day	2.00E-05	mg/kg-day	1.6E-02
			Exp. Route Total									N/A					2E-02
		Exposure Point Total										N/A					9E-02
	Exposure Medium Total											N/A					9E-02
Surface Soil Total												N/A					9E-02
Combined Surface and Subsurface Soil	Combined Surface and Subsurface Soil	On-Site	Incidental Ingestion	**PFAS**													
				PFOS	4.70E-02	mg/kg (1)	5.15E-08	mg/kg-day	N/A	kg-day/mg	N/A	N/A	6.01E-07	mg/kg-day	2.00E-05	mg/kg-day	3.0E-02
			Exp. Route Total									N/A					3E-02
			Dermal	**PFAS**													
				PFOS	4.70E-02	mg/kg (1)	1.22E-08	mg/kg-day	N/A	kg-day/mg	N/A	N/A	1.43E-07	mg/kg-day	2.00E-05	mg/kg-day	7.1E-03
			Exp. Route Total									N/A					7E-03
		Exposure Point Total										N/A					4E-02
	Exposure Medium Total											N/A					4E-02
Combined Surface and Subsurface Soil Total												N/A					4E-02
Groundwater	Groundwater	Core of Groundwater Plume	Ingestion	**PFAS**													
				PFOS	9.68E+00	µg/L	4.14E-05	mg/kg-day	N/A	kg-day/mg	N/A	N/A	4.82E-04	mg/kg-day	2.00E-05	mg/kg-day	2.4E+01
				PFOA	8.74E+00	µg/L	3.74E-05	mg/kg-day	7.00E-02	kg-day/mg	N/A	2.6E-06	4.36E-04	mg/kg-day	2.00E-05	mg/kg-day	2.2E+01
			Exp. Route Total									3E-06					5E+01
		Exposure Point Total										3E-06					5E+01
	Exposure Medium Total											3E-06					5E+01
Groundwater Total												3E-06					5E+01
Total Receptor Risk/Hazard												(2)					(2)

TABLE 7.1b.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - HYPOTHETICAL FUTURE ON-SITE RESIDENT (CHILD)

REASONABLE MAXIMUM EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Child

							Cancer Risk Calculations						Noncancer Hazard Calculations				
	Exposure	Exposure	Exposure	Chemical of	EPC		Intake/Exposure Concentration		CSF or IUR			Cancer	Intake/Exposure Concentration		RfD or RfC		Hazard
Medium	Medium	Point	Route	Potential Concern	Value	Units	Value	Units	Value	Units	ADAF	Risk	Value	Units	Value	Units	Quotient

Notes:
µg/L - Microgram per liter.
ADAF - Age-Dependent Adjustment Factor.
CSF - Cancer Slope Factor.
EPC - Exposure Point Concentration.
IUR - Inhalation unit risk.
N/A - Not applicable.
mg/kg - Milligram per kilogram.
mg/kg-day - Milligram per kilogram per day.
kg-day/mg - Kilogram per day per milligram
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
RfC - Inhalation Reference Concentration.
RfD - Oral Reference Dose.
RME - Reasonable Maximum Exposure.
(1) Soil EPCs were converted from microgram per kilogram (µg/kg) to milligram per kilogram (mg/kg)
(2) Presented on corresponding summary of risk/hazard table.

TABLE 7.1a.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - HYPOTHETICAL FUTURE ON-SITE RESIDENT (ADULT)
CENTRAL TENDENCY EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult

							Cancer Risk Calculations						Noncancer Hazard Calculations				
	Exposure	Exposure	Exposure	Chemical of	EPC		Intake/Exposure Concentration		CSF or IUR			Cancer	Intake/Exposure Concentration		RfD or RfC		Hazard
Medium	Medium	Point	Route	Potential Concern	Value	Units	Value	Units	Value	Units	ADAF	Risk	Value	Units	Value	Units	Quotient
Surface Soil	Surface Soil	On-Site	Incidental Ingestion	**PFAS**													
				PFOS	1.08E-01	mg/kg (1)	8.03E-09	mg/kg-day	N/A	kg-day/mg	N/A	N/A	4.32E-08	mg/kg-day	2.00E-05	mg/kg-day	2.2E-03
			Exp. Route Total									N/A					2E-03
			Dermal	**PFAS**													
				PFOS	1.08E-01	mg/kg (1)	9.69E-10	mg/kg-day	N/A	kg-day/mg	N/A	N/A	5.22E-09	mg/kg-day	2.00E-05	mg/kg-day	2.6E-04
			Exp. Route Total									N/A					3E-04
		Exposure Point Total										N/A					2E-03
	Exposure Medium Total											N/A					2E-03
Surface Soil Total												N/A					2E-03
Combined Surface and Subsurface Soil	Combined Surface and Subsurface Soil	On-Site	Incidental Ingestion	**PFAS**													
				PFOS	4.70E-02	mg/kg (1)	3.50E-09	mg/kg-day	N/A	kg-day/mg	N/A	N/A	1.88E-08	mg/kg-day	2.00E-05	mg/kg-day	9.4E-04
			Exp. Route Total									N/A					9E-04
			Dermal	**PFAS**													
				PFOS	4.70E-02	mg/kg (1)	4.22E-10	mg/kg-day	N/A	kg-day/mg	N/A	N/A	2.27E-09	mg/kg-day	2.00E-05	mg/kg-day	1.1E-04
			Exp. Route Total									N/A					1E-04
		Exposure Point Total										N/A					1E-03
	Exposure Medium Total											N/A					1E-03
Combined Surface and Subsurface Soil Total												N/A					1E-03
Groundwater	Groundwater	Core of Groundwater Plume	Ingestion	**PFAS**													
				PFOS	9.68E+00	µg/L	2.02E-05	mg/kg-day	N/A	kg-day/mg	N/A	N/A	1.09E-04	mg/kg-day	2.00E-05	mg/kg-day	5.4E+00
				PFOA	8.74E+00	µg/L	1.82E-05	mg/kg-day	7.00E-02	kg-day/mg	N/A	1.3E-06	9.81E-05	mg/kg-day	2.00E-05	mg/kg-day	4.9E+00
			Exp. Route Total									1E-06					1E+01
		Exposure Point Total										1E-06					1E+01
	Exposure Medium Total											1E-06					1E+01
Groundwater Total												1E-06					1E+01
Total Receptor Risk/Hazard												(2)					(2)

TABLE 7.1a.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - HYPOTHETICAL FUTURE ON-SITE RESIDENT (ADULT)

CENTRAL TENDENCY EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult

							Cancer Risk Calculations						Noncancer Hazard Calculations				
	Exposure	Exposure	Exposure	Chemical of	EPC		Intake/Exposure Concentration		CSF or IUR			Cancer	Intake/Exposure Concentration		RfD or RfC		Hazard
Medium	Medium	Point	Route	Potential Concern	Value	Units	Value	Units	Value	Units	ADAF	Risk	Value	Units	Value	Units	Quotient

Notes:
µg/L - Microgram per liter.
ADAF - Age-Dependent Adjustment Factor.
CSF - Cancer Slope Factor.
CTE - Central Tendency Exposure.
EPC - Exposure Point Concentration.
IUR - Inhalation unit risk.
N/A - Not applicable.
mg/kg - Milligram per kilogram.
mg/kg-day - Milligram per kilogram per day.
kg-day/mg - Kilogram per day per milligram
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
RfC - Inhalation Reference Concentration.
RfD - Oral Reference Dose.
(1) Soil EPCs were converted from microgram per kilogram (µg/kg) to milligram per kilogram (mg/kg)
(2) Presented on corresponding summary of risk/hazard table.

TABLE 7.1b.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - HYPOTHETICAL FUTURE ON-SITE RESIDENT (CHILD)

CENTRAL TENDENCY EXPOSURE

HUMAN HEALTH RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Child

							Cancer Risk Calculations						Noncancer Hazard Calculations				
	Exposure	Exposure	Exposure	Chemical of	EPC		Intake/Exposure Concentration		CSF or IUR			Cancer	Intake/Exposure Concentration		RfD or RfC		Hazard
Medium	Medium	Point	Route	Potential Concern	Value	Units	Value	Units	Value	Units	ADAF	Risk	Value	Units	Value	Units	Quotient
Surface Soil	Surface Soil	On-Site	Incidental Ingestion	**PFAS**													
				PFOS	1.08E-01	mg/kg (1)	3.95E-08	mg/kg-day	N/A	kg-day/mg	N/A	N/A	4.61E-07	mg/kg-day	2.00E-05	mg/kg-day	2.3E-02
			Exp. Route Total									N/A					2E-02
			Dermal	**PFAS**													
				PFOS	1.08E-01	mg/kg (1)	3.75E-09	mg/kg-day	N/A	kg-day/mg	N/A	N/A	4.38E-08	mg/kg-day	2.00E-05	mg/kg-day	2.2E-03
			Exp. Route Total									N/A					2E-03
		Exposure Point Total										N/A					3E-02
	Exposure Medium Total											N/A					3E-02
Surface Soil Total												N/A					3E-02
Combined Surface and Subsurface Soil	Combined Surface and Subsurface Soil	On-Site	Incidental Ingestion	**PFAS**													
				PFOS	4.70E-02	mg/kg (1)	1.72E-08	mg/kg-day	N/A	kg-day/mg	N/A	N/A	2.01E-07	mg/kg-day	2.00E-05	mg/kg-day	1.0E-02
			Exp. Route Total									N/A					1E-02
			Dermal	**PFAS**													
				PFOS	4.70E-02	mg/kg (1)	1.63E-09	mg/kg-day	N/A	kg-day/mg	N/A	N/A	1.91E-08	mg/kg-day	2.00E-05	mg/kg-day	9.5E-04
			Exp. Route Total									N/A					1E-03
		Exposure Point Total										N/A					1E-02
	Exposure Medium Total											N/A					1E-02
Combined Surface and Subsurface Soil Total												N/A					1E-02
Groundwater	Groundwater	Core of Groundwater Plume	Ingestion	**PFAS**													
				PFOS	9.68E+00	µg/L	2.62E-05	mg/kg-day	N/A	kg-day/mg	N/A	N/A	3.06E-04	mg/kg-day	2.00E-05	mg/kg-day	1.5E+01
				PFOA	8.74E+00	µg/L	2.37E-05	mg/kg-day	7.00E-02	kg-day/mg	N/A	1.7E-06	2.77E-04	mg/kg-day	2.00E-05	mg/kg-day	1.4E+01
			Exp. Route Total									2E-06					3E+01
		Exposure Point Total										2E-06					3E+01
	Exposure Medium Total											2E-06					3E+01
Groundwater Total												2E-06					3E+01
Total Receptor Risk/Hazard												(2)					(2)

TABLE 7.1b.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - HYPOTHETICAL FUTURE ON-SITE RESIDENT (CHILD)
CENTRAL TENDENCY EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Child

							Cancer Risk Calculations						Noncancer Hazard Calculations				
	Exposure	Exposure	Exposure	Chemical of	EPC		Intake/Exposure Concentration		CSF or IUR			Cancer	Intake/Exposure Concentration		RfD or RfC		Hazard
Medium	Medium	Point	Route	Potential Concern	Value	Units	Value	Units	Value	Units	ADAF	Risk	Value	Units	Value	Units	Quotient

Notes:
µg/L - Microgram per liter.
ADAF - Age-Dependent Adjustment Factor.
CSF - Cancer Slope Factor.
CTE - Central Tendency Exposure.
EPC - Exposure Point Concentration.
IUR - Inhalation unit risk.
N/A - Not applicable.
mg/kg - Milligram per kilogram.
mg/kg-day - Milligram per kilogram per day.
kg-day/mg - Kilogram per day per milligram
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
RfC - Inhalation Reference Concentration.
RfD - Oral Reference Dose.
(1) Soil EPCs were converted from microgram per kilogram (µg/kg) to milligram per kilogram (mg/kg)
(2) Presented on corresponding summary of risk/hazard table.

TABLE 9.1.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - HYPOTHETICAL FUTURE ON-SITE RESIDENT (ON-SITE SURFACE SOIL AND GROUNDWATER)
REASONABLE MAXIMUM EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk Child + Adult				Non-Carcinogenic Hazard Quotient Child				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	On-Site	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	7E-02	N/A	2E-02	9E-02
			Chemical Total	N/A	N/A	N/A	N/A		7E-02	N/A	2E-02	9E-02
		Exposure Point Total					N/A					9E-02
	Exposure Medium Total						N/A					9E-02
Surface Soil Total							N/A					9E-02
Groundwater	Groundwater	Core of Groundwater Plume	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	2E+01	N/A	N/A	2E+01
			PFOA	8E-06	N/A	N/A	8E-06	Developmental	2E+01	N/A	N/A	2E+01
			Chemical Total	8E-06	N/A	N/A	8E-06		5E+01	N/A	N/A	5E+01
		Exposure Point Total					8E-06					5E+01
	Exposure Medium Total						8E-06					5E+01
Groundwater Total							8E-06					5E+01
						Total of Receptor Risks:	8E-06				**Total of Receptor HI (Combined Endpoints):**	5E+01

Total Developmental HI (Surface Soil + Groundwater)= 5E+01

Notes:

COPC - Chemical of Potential Concern.
HI - Hazard Index.
HQ - Hazard Quotient.
MDE - Maryland Department of the Environment.
N/A - Not applicable.
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
RME - Reasonable Maximum Exposure.
USEPA - United States Environmental Protection Agency.
Green shading indicates the receptor-specific cumulative potential risk and/or HI (per target endpoint) is greater than USEPA's target risk range of 1E-6 to 1E-4 or target HI of 1, respectively. For each associated exposure scenario (i.e., receptor/medium) with a potential risk/HI above USEPA's cumulative target risk/HI level, risk drivers were defined as COPCs with an individual risk > 1E-6 or HQ > 1 . These risk drivers are also highlighted.
There are no exceedances of MDE’s target risk level of 1E-5.

TABLE 9.1.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - HYPOTHETICAL FUTURE ON-SITE RESIDENT (ON-SITE SURFACE SOIL AND GROUNDWATER)
CENTRAL TENDENCY EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk Child + Adult				Non-Carcinogenic Hazard Quotient Child				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	On-Site	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	2E-02	N/A	2E-03	3E-02
			Chemical Total	N/A	N/A	N/A	N/A		2E-02	N/A	2E-03	3E-02
		Exposure Point Total					N/A					3E-02
	Exposure Medium Total						N/A					3E-02
Surface Soil Total							N/A					3E-02
Groundwater	Groundwater	Core of Groundwater Plume	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	2E+01	N/A	N/A	2E+01
			PFOA	3E-06	N/A	N/A	3E-06	Developmental	1E+01	N/A	N/A	1E+01
			Chemical Total	3E-06	N/A	N/A	3E-06		3E+01	N/A	N/A	3E+01
		Exposure Point Total					3E-06					3E+01
	Exposure Medium Total						3E-06					3E+01
Groundwater Total							3E-06					3E+01
						Total of Receptor Risks:	3E-06				**Total of Receptor HI (Combined Endpoints):**	3E+01

Total Developmental HI (Surface Soil + Groundwater)= 3E+01

Notes:
COPC - Chemical of Potential Concern.
CTE - Central Tendency Exposure.
HI - Hazard Index.
HQ - Hazard Quotient.
MDE - Maryland Department of the Environment.
N/A - Not applicable.
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
USEPA - United States Environmental Protection Agency.
Green shading indicates the receptor-specific cumulative potential risk and/or HI (per target endpoint) is greater than USEPA's target risk range of 1E-6 to 1E-4 or target HI of 1, respectively. For each associated exposure scenario (i.e., receptor/medium) with a potential risk/HI above USEPA's cumulative target risk/HI level, risk drivers were defined as COPCs with an individual risk > 1E-6 or HQ > 1 . These risk drivers are also highlighted.
There are no exceedances of MDE’s target risk level of 1E-5.

TABLE 9.2.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - HYPOTHETICAL FUTURE ON-SITE RESIDENT (ON-SITE COMBINED SURFACE AND SUBSURFACE SOIL AND GROUNDWATER)
REASONABLE MAXIMUM EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk Child + Adult				Non-Carcinogenic Hazard Quotient Child				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Combined Surface and Subsurface Soil	Combined Surface and Subsurface Soil	On-Site	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	3E-02	N/A	7E-03	4E-02
			Chemical Total	N/A	N/A	N/A	N/A		3E-02	N/A	7E-03	4E-02
		Exposure Point Total					N/A					4E-02
	Exposure Medium Total						N/A					4E-02
Combined Surface and Subsurface Soil Total							N/A					4E-02
Groundwater	Groundwater	Core of Groundwater Plume	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	2E+01	N/A	N/A	2E+01
			PFOA	8E-06	N/A	N/A	8E-06	Developmental	2E+01	N/A	N/A	2E+01
			Chemical Total	8E-06	N/A	N/A	8E-06		5E+01	N/A	N/A	5E+01
		Exposure Point Total					8E-06					5E+01
	Exposure Medium Total						8E-06					5E+01
Groundwater Total							8E-06					5E+01
						Total of Receptor Risks:	8E-06				**Total of Receptor HI (Combined Endpoints):**	5E+01

Total Developmental HI (Combined Surface and Subsurface Soil + Groundwater)= 5E+01

Notes:

COPC - Chemical of Potential Concern.
HI - Hazard Index.
HQ - Hazard Quotient.
MDE - Maryland Department of the Environment.
N/A - Not applicable.
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
RME - Reasonable Maximum Exposure.
USEPA - United States Environmental Protection Agency.

Green shading indicates the receptor-specific cumulative potential risk and/or HI (per target endpoint) is greater than USEPA's target risk range of 1E-6 to 1E-4 or target HI of 1, respectively. For each associated exposure scenario (i.e., receptor/medium) with a potential risk/HI above USEPA's cumulative target risk/HI level, risk drivers were defined as COPCs with an individual risk > 1E-6 or HQ > 1 . These risk drivers are also highlighted.

There are no exceedances of MDE's target risk level of 1E-5.

TABLE 9.2.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - HYPOTHETICAL FUTURE ON-SITE RESIDENT (ON-SITE COMBINED SURFACE AND SUBSURFACE SOIL AND GROUNDWATER)
CENTRAL TENDENCY EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk Child + Adult				Non-Carcinogenic Hazard Quotient Child				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Combined Surface and Subsurface Soil	Combined Surface and Subsurface Soil	On-Site	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	1E-02	N/A	1E-03	1E-02
			Chemical Total	N/A	N/A	N/A	N/A		1E-02	N/A	1E-03	1E-02
		Exposure Point Total					N/A					1E-02
	Exposure Medium Total						N/A					1E-02
Combined Surface and Subsurface Soil Total							N/A					1E-02
Groundwater	Groundwater	Core of Groundwater Plume	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	2E+01	N/A	N/A	2E+01
			PFOA	3E-06	N/A	N/A	3E-06	Developmental	1E+01	N/A	N/A	1E+01
			Chemical Total	3E-06	N/A	N/A	3E-06		3E+01	N/A	N/A	3E+01
		Exposure Point Total					3E-06					3E+01
	Exposure Medium Total						3E-06					3E+01
Groundwater Total							3E-06					3E+01
						Total of Receptor Risks:	3E-06				**Total of Receptor HI (Combined Endpoints):**	3E+01

Total Developmental HI (Combined Surface and Subsurface Soil + Groundwater)= 3E+01

Notes:

COPC - Chemical of Potential Concern.
CTE - Central Tendency Exposure.
HI - Hazard Index.
HQ - Hazard Quotient.
MDE - Maryland Department of the Environment.
N/A - Not applicable.
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
USEPA - United States Environmental Protection Agency.
Green shading indicates the receptor-specific cumulative potential risk and/or HI (per target endpoint) is greater than USEPA's target risk range of 1E-6 to 1E-4 or target HI of 1, respectively. For each associated exposure scenario (i.e., receptor/medium) with a potential risk/HI above USEPA's cumulative target risk/HI level, risk drivers were defined as COPCs with an individual risk > 1E-6 or HQ > 1 . These risk drivers are also highlighted.
There are no exceedances of MDE’s target risk level of 1E-5.

TABLE 10.1.RME
SUMMARY OF RISK DRIVERS - HYPOTHETICAL FUTURE ON-SITE RESIDENT
REASONABLE MAXIMUM EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk Child + Adult				Non-Carcinogenic Hazard Quotient Child				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Core of Groundwater Plume	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	2E+01	N/A	N/A	2E+01
			PFOA	N/A	N/A	N/A	N/A	Developmental	2E+01	N/A	N/A	2E+01
			Chemical Total	N/A	N/A	N/A	N/A		2E+01	N/A	N/A	5E+01
		Exposure Point Total					N/A					5E+01
	Exposure Medium Total						N/A					5E+01
Groundwater Total							N/A					5E+01
Receptor Total							N/A					5E+01

Total Developmental HI = 5E+01

Notes:
HI - Hazard Index.
N/A - Not applicable.
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
RME - Reasonable Maximum Exposure.

TABLE 10.1.CTE
SUMMARY OF RISK DRIVERS - HYPOTHETICAL FUTURE ON-SITE RESIDENT
CENTRAL TENDENCY EXPOSURE
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe: Future
Receptor Population: Hypothetical On-Site Resident
Receptor Age: Adult and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk Child + Adult				Non-Carcinogenic Hazard Quotient Child				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Core of Groundwater Plume	**PFAS**									
			PFOS	N/A	N/A	N/A	N/A	Developmental	2E+01	N/A	N/A	2E+01
			PFOA	N/A	N/A	N/A	N/A	Developmental	1E+01	N/A	N/A	1E+01
			Chemical Total	N/A	N/A	N/A	N/A		1E+01	N/A	N/A	3E+01
		Exposure Point Total					N/A					3E+01
	Exposure Medium Total						N/A					3E+01
Groundwater Total							N/A					3E+01
Receptor Total							N/A					3E+01

Total Developmental HI = 3E+01

Notes:

CTE - Central Tendency Exposure.
HI - Hazard Index.
N/A - Not applicable.
PFAS - Per- and Polyfluoroalkyl Substances.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.

TABLE 11
OVERALL SUMMARY OF POTENTIAL EXCESS LIFETIME CANCER RISKS AND NONCANCER HAZARDS
HUMAN HEALTH RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe	**Receptor**	**Exposure Scenario (b)**	**Potential Excess Lifetime Cancer Risk (a)**					**Noncancer Hazard Index (a)**					
			Surface Soil	**Combined Surface and Subsurface Soil**	**Groundwater**	**Total ELCR**	**Risk Drivers/ COCs (b)**	**Surface Soil**	**Combined Surface and Subsurface Soil**	**Groundwater**	**Total HI (Surface Soil and Groundwater)**	**Total HI (Combined Surface and Subsurface Soil and Groundwater)**	**Risk Drivers/ COCs (b)**
			On-Site	**On-Site**	**Core of Groundwater Plume**			**On-Site**	**On-Site**	**Core of Groundwater Plume**			
Future	Hypothetical On-Site Resident (Adult/Child)	RME	N/A	N/A	8E-06	8E-06	N/A	9E-02	4E-02	5E+01	**5E+01**	**5E+01**	GW: PFOA and PFOS
		CTE	N/A	N/A	3E-06	3E-06	N/A	3E-02	1E-02	3E+01	**3E+01**	**3E+01**	GW: PFOA and PFOS

Notes:
COC - Chemical of concern.
COPC - Chemical of potential concern.
CTE - Central tendency exposure.
ELCR - Excess lifetime cancer risk.
GW - Groundwater.
HI - Hazard index.
MDE - Maryland Department of the Environment.
N/A - Not applicable.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctane sulfonate.
RME - Reasonable maximum exposure.
USEPA - United States Environmental Protection Agency.
Highlighting indicates the receptor-specific cumulative potential ELCR and/or total HI (per target endpoint) is greater than USEPA's target risk range of 1E-6 to 1E-4 or target HI of 1, respectively. There are no exceedances of MDE's target risk level of 1E-5.
(a) Potential cancer risk and noncancer hazard calculations are presented in Risk Assessment Guidance for Superfund (RAGS) Part D Tables 7s and 9s.
(b) Risk drivers/COCs are identified where the receptor-specific cumulative potential ELCR and/or total HI (per target endpoint) exceed USEPA target levels. A risk driver/COC is then defined per exposure scenario (i.e., RME/CTE/receptor/medium) as a chemical with an individual ELCR > 1E-6 or hazard quotient (HQ) > 1 .

Attachment A
Analytical Data Summary Tables

Table A-1 Soil Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Interval (ft bgs)	Sample ID	Sample Type Code	PFBS (µg/kg)	PFOS (µg/kg)	PFOA (µg/kg)
On-Site	DPT-16-15	11/2/2016	0 - 1 ft	DPT-16-15-SO-00-01	N	0.14 J	27	0.98
On-Site	DPT-16-15	11/2/2016	0 - 1 ft	DPT-16-15-SO-00-01-DUP	FD	0.12 J	27	0.92
On-Site	DPT-16-15	11/21/2016	14 - 15 ft	DPT-16-15-SO-14-15	N	< 0.37 U	11	0.51 J
On-Site	DPT-16-19	11/22/2016	0 - 1 ft	DPT-16-19-SO-00-01	N	0.18 J	170	3.8
On-Site	DPT-16-19	11/22/2016	17 - 17 ft	DPT-16-19-SO-17-18	N	< 0.37 U	6.5	0.37 J
On-Site	DPT-16-20	11/2/2016	0 - 1 ft	DPT-16-20-SO-00-01	N	< 0.33 U	12	0.70
On-Site	DPT-16-20	11/15/2016	16 - 17 ft	DPT-16-20-SO-16-17	N	< 0.37 U	10 J	0.46 J
On-Site	DPT-16-20	11/15/2016	16 - 17 ft	DPT-16-20-SO-16-17-DUP	FD	< 0.36 U	20 J	0.78
On-Site	DPT-16-28	11/2/2016	0 - 1 ft	DPT-16-28-SO-00-01	N	< 0.36 U	8.9	0.27 J
On-Site	DPT-16-28	11/21/2016	14 - 15 ft	DPT-16-28-SO-14-15	N	< 0.35 U	10	0.45 J
On-Site	DPT-16-29	11/2/2016	0 - 1 ft	DPT-16-29-SO-00-01	N	0.19 J	38	1.8
On-Site	DPT-16-29	11/18/2016	14 - 15 ft	DPT-16-29-SO-14-15	N	< 0.37 U	1.5	0.49 J
On-Site	DPT-16-30	11/2/2016	0 - 1 ft	DPT-16-30-SO-00-01	N	0.12 J	20	1.0
On-Site	DPT-16-30	11/21/2016	14 - 15 ft	DPT-16-30-SO-14-15	N	< 0.36 U	57	5.5
On-Site	DPT-16-31	11/2/2016	0 - 1 ft	DPT-16-31-SO-00-01	N	< 0.33 U	5.9	0.26 J
On-Site	DPT-16-31	11/21/2016	14 - 15 ft	DPT-16-31-SO-14-15	N	< 0.36 U	11	0.27 J
On-Site	DPT-16-32	11/2/2016	0 - 1 ft	DPT-16-32-SO-00-01	N	< 0.35 U	10	0.24 J
On-Site	DPT-16-32	11/21/2016	14 - 15 ft	DPT-16-32-SO-14-15	N	< 0.36 U	46	1.1
On-Site	DPT-16-34	11/2/2016	0 - 1 ft	DPT-16-34-SO-00-01	N	< 0.33 U	80	8.9
On-Site	DPT-16-34	11/14/2016	14 - 15 ft	DPT-16-34-SO-14-15	N	< 0.37 U	35	3.2 J+
On-Site	DPT-16-35	11/22/2016	0 - 1 ft	DPT-16-35-SO-00-01	N	0.21 J	28	12
On-Site	DPT-16-35	11/22/2016	19 - 20 ft	DPT-16-35-SO-19-20	N	< 0.36 U	4.0	0.56 J
On-Site	DPT-17-26	1/12/2017	0 - 1 ft	DPT-17-26-SO-00-01	N	< 0.36 U	0.25 J	0.22 J
On-Site	DPT-17-26	1/12/2017	12 - 13 ft	DPT-17-26-SO-12-13	N	< 0.36 U	< 0.36 U	< 0.36 U
On-Site	DPT-17-27	1/12/2017	0 - 1 ft	DPT-17-27-SO-00-01	N	< 0.36 U	< 0.60 U	0.25 J
On-Site	DPT-17-27	1/12/2017	13 - 14 ft	DPT-17-27-SO-13-14	N	< 0.36 U	< 0.36 U	< 0.36 U

Notes: µg/kg = micrograms per kilogram
bgs = Below ground surface
FD = Field duplicate sample
ft = Feet
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Table A-2 Groundwater Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Depth to Groundwater (ft bgs)	Interval (ft bgs)	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
On-Site	DPT-16-01	11/14/2016	3.0	17 - 21 ft	DPT-16-01-GW-17-21	N	0.011 J-	0.98 J-	0.062 J-
On-Site	DPT-16-02	11/11/2016	2.5	6 - 10 ft	DPT-16-02-GW-06-10	N	0.0061 J-	0.12 J-	0.033 J-
On-Site	DPT-16-02	11/11/2016	2.5	6 - 10 ft	DPT-16-02-GW-06-10-DUP	FD	0.0059 J-	0.12 J-	0.028 J-
On-Site	DPT-16-02	11/11/2016	2.5	17 - 21 ft	DPT-16-02-GW-17-21	N	0.0099 J-	0.21 J-	0.036 J-
On-Site	DPT-16-03	11/30/2016	2.0	31 - 35 ft	DPT-16-03-GW-31-35	N	< 0.0020 UJ	0.13 J-	0.019 J-
On-Site	DPT-16-03	11/30/2016	2.0	18 - 22 ft	DPT-16-03-GW-18-22	N	< 0.0019 UJ	0.0071 J-	0.00092 J-
On-Site	DPT-16-04	11/30/2016	2.0	31 - 35 ft	DPT-16-04-GW-31-35	N	< 0.0020 UJ	0.0016 J-	< 0.0020 UJ
On-Site	DPT-16-04	11/30/2016	2.0	18 - 22 ft	DPT-16-04-GW-18-22	N	< 0.0020 UJ	0.027 J-	0.0027 J-
On-Site	DPT-16-05	11/14/2016	5.0	17 - 21 ft	DPT-16-05-GW-17-21	N	0.050 J	2.8 J-	0.19 J-
On-Site	DPT-16-06	12/1/2016	6.0	31 - 35 ft	DPT-16-06-GW-31-35	N	0.28 J-	2.7 J-	1.6 J-
On-Site	DPT-16-06	12/1/2016	6.0	18 - 22 ft	DPT-16-06-GW-18-22	N	0.20 J-	2.8 J-	1.9 J-
On-Site	DPT-16-07	12/1/2016	8.0	31 - 35 ft	DPT-16-07-GW-31-35	N	0.18 J-	3.1 J-	1.2 J-
On-Site	DPT-16-07	12/1/2016	8.0	18 - 22 ft	DPT-16-07-GW-18-22	N	0.17 J-	1.9 J-	0.37 J-
On-Site	DPT-16-08	12/1/2016	7.5	31 - 35 ft	DPT-16-08-GW-31-35	N	0.0056 J-	0.022 J-	0.0045 J-
On-Site	DPT-16-08	12/1/2016	7.5	18 - 22 ft	DPT-16-08-GW-18-22	N	0.0030 J-	0.038 J-	0.0075 J-
On-Site	DPT-16-09	11/30/2016	7.0	31 - 35 ft	DPT-16-09-GW-31-35	N	0.0027 J-	0.017 J-	0.0021 J-
On-Site	DPT-16-09	11/30/2016	7.0	18 - 22 ft	DPT-16-09-GW-18-22	N	0.0043 J-	0.019 J-	0.0045 J-
On-Site	DPT-16-10	11/30/2016	8.0	31 - 35 ft	DPT-16-10-GW-31-35	N	< 0.0020 UJ	0.11 J-	0.014 J-
On-Site	DPT-16-10	11/30/2016	7.0	18 - 22 ft	DPT-16-10-GW-18-22	N	0.010 J-	0.030 J-	0.0062 J-
On-Site	DPT-16-11	12/1/2016	10.0	31 - 35 ft	DPT-16-11-GW-31-35	N	0.080 J-	0.86 J-	0.33 J-
On-Site	DPT-16-11	12/1/2016	10.0	31 - 35 ft	DPT-16-11-GW-31-35-DUP	FD	0.076 J-	0.88 J-	0.33 J-
On-Site	DPT-16-11	12/1/2016	10.0	18 - 22 ft	DPT-16-11-GW-18-22	N	0.18 J-	6.0 J-	2.0 J-
On-Site	DPT-16-12	12/5/2016	10.0	31 - 35 ft	DPT-16-12-GW-31-35	N	0.060	0.69	0.24
On-Site	DPT-16-12	12/5/2016	10.0	19 - 23 ft	DPT-16-12-GW-19-23	N	0.22	4.6	1.7
On-Site	DPT-16-13	11/29/2016	9.0	31 - 35 ft	DPT-16-13-GW-31-35	N	0.060 J	0.62 J	0.31 J
On-Site	DPT-16-13	11/29/2016	9.0	18 - 22 ft	DPT-16-13-GW-18-22	N	0.91 J	14 J	7.0 J
On-Site	DPT-16-14	12/5/2016	9.0	31 - 35 ft	DPT-16-14-GW-31-35	N	0.20	5.4	0.67
On-Site	DPT-16-14	12/5/2016	9.0	19 - 23 ft	DPT-16-14-GW-19-23	N	0.15	6.4	1.0
On-Site	DPT-16-15	11/21/2016	11.0	18 - 22 ft	DPT-16-15-GW-18-22	N	0.54 J-	12 J-	15 J-
On-Site	DPT-16-15	11/21/2016	11.0	31 - 35 ft	DPT-16-15-GW-31-35	N	0.048 J-	0.45 J-	0.27 J
On-Site	DPT-16-16	12/5/2016	12.0	31 - 35 ft	DPT-16-16-GW-31-35	N	0.28	1.9	2.3
On-Site	DPT-16-16	12/5/2016	12.0	19 - 23 ft	DPT-16-16-GW-19-23	N	0.060	0.88	0.22
On-Site	DPT-16-17	11/17/2016	13.0	16 - 20 ft	DPT-16-17-GW-16-20	N	0.11	0.23	0.49
On-Site	DPT-16-17	11/17/2016	13.0	31 - 35 ft	DPT-16-17-GW-31-35	N	0.063	0.26	0.45
On-Site	DPT-16-18	11/23/2016	12.0	21 - 25 ft	DPT-16-18-GW-21-25	N	0.15	2.0	0.84
On-Site	DPT-16-18	11/23/2016	12.0	31 - 35 ft	DPT-16-18-GW-31-35	N	0.057	0.37	0.24
On-Site	DPT-16-18	11/23/2016	12.0	31 - 35 ft	DPT-16-18-GW-31-35-DUP	FD	0.060	0.38	0.25

Table A-2 Groundwater Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Depth to Groundwater (ft bgs)	Interval (ft bgs)	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
On-Site	DPT-16-19	11/23/2016	12.0	21 - 25 ft	DPT-16-19-GW-21-25	N	0.17	2.6	0.34
On-Site	DPT-16-19	11/23/2016	12.0	31 - 35 ft	DPT-16-19-GW-31-35	N	0.33	0.68	0.93
On-Site	DPT-16-20	11/15/2016	12.0	16 - 20 ft	DPT-16-20-GW-16-20	N	0.017 J-	0.66 J-	0.15 J-
On-Site	DPT-16-20	11/15/2016	12.0	26 - 30 ft	DPT-16-20-GW-26-30	N	< 0.20 UJ	6.8 J-	1.0 J-
On-Site	DPT-16-21	11/28/2016	11.0	19 - 23 ft	DPT-16-21-GW-19-23	N	1.1 J	12 J	15 J
On-Site	DPT-16-21	11/28/2016	11.0	31 - 35 ft	DPT-16-21-GW-31-35	N	0.16 J	3.2 J	0.74 J
On-Site	DPT-16-22	12/5/2016	11.0	31 - 35 ft	DPT-16-22-GW-31-35	N	0.29	0.61	0.18
On-Site	DPT-16-22	12/5/2016	11.0	31 - 35 ft	DPT-16-22-GW-31-35-DUP	FD	0.27	0.56	0.16
On-Site	DPT-16-22	12/5/2016	11.0	19 - 23 ft	DPT-16-22-GW-19-23	N	0.070	0.82	0.17
On-Site	DPT-16-23	11/23/2016	11.5	21 - 25 ft	DPT-16-23-GW-21-25	N	0.32	0.96	0.84
On-Site	DPT-16-23	11/23/2016	11.5	31 - 35 ft	DPT-16-23-GW-31-35	N	0.11	0.27	0.34
On-Site	DPT-16-24	12/6/2016	11.5	21 - 25 ft	DPT-16-24-GW-21-25	N	0.029	0.41	0.044
On-Site	DPT-16-24	12/6/2016	11.5	31 - 35 ft	DPT-16-24-GW-31-35	N	0.043	0.47	0.15
On-Site	DPT-16-25	12/6/2016	11.5	31 - 35 ft	DPT-16-25-GW-31-35	N	0.060	0.39	0.17
On-Site	DPT-16-25	12/6/2016	11.5	19 - 23 ft	DPT-16-25-GW-19-23	N	0.31	1.1	0.57
On-Site	DPT-16-28	12/6/2016	11.0	31 - 35 ft	DPT-16-28-GW-31-35	N	0.21	0.43	0.61
On-Site	DPT-16-28	12/6/2016	11.0	19 - 23 ft	DPT-16-28-GW-19-23	N	0.16	4.9	0.66
On-Site	DPT-16-29	11/18/2016	11.0	31 - 35 ft	DPT-16-29-GW-31-35	N	0.034	0.14	0.15
On-Site	DPT-16-29	11/18/2016	11.0	16 - 20 ft	DPT-16-29-GW-16-20	N	0.11	2.1	0.27
On-Site	DPT-16-30	11/29/2016	11.0	31 - 35 ft	DPT-16-30-GW-31-35	N	0.31 J	11 J	1.4 J
On-Site	DPT-16-30	11/29/2016	11.0	18 - 22 ft	DPT-16-30-GW-18-22	N	0.21 J	6.6 J	1.4 J
On-Site	DPT-16-31	11/28/2016	11.0	19 - 23 ft	DPT-16-31-GW-19-23	N	1.1 J	42 J	28 J
On-Site	DPT-16-31	11/28/2016	11.0	31 - 35 ft	DPT-16-31-GW-31-35	N	0.086 J	2.0 J	0.34 J
On-Site	DPT-16-32	11/28/2016	11.0	19 - 23 ft	DPT-16-32-GW-19-23	N	0.14 J	9.2 J	0.68 J
On-Site	DPT-16-32	11/28/2016	11.0	31 - 35 ft	DPT-16-32-GW-31-35	N	0.12 J	2.1 J	0.65 J
On-Site	DPT-16-33	12/5/2016	11.0	31 - 35 ft	DPT-16-33-GW-31-35	N	0.15	1.3	0.96
On-Site	DPT-16-33	12/5/2016	11.0	19 - 23 ft	DPT-16-33-GW-19-23	N	0.23 J	8.3	2.8
On-Site	DPT-16-34	11/14/2016	11.0	31 - 35 ft	DPT-16-34-GW-31-35	N	0.12 J-	1.4 J-	1.0 J-
On-Site	DPT-16-34	11/15/2016	11.0	16 - 20 ft	DPT-16-34-GW-16-20	N	0.028 J-	1.6 J-	0.40 J-
On-Site	DPT-16-35	11/22/2016	11.0	21 - 25 ft	DPT-16-35-GW-21-25	N	0.28 J-	2.4 J-	0.76 J-
On-Site	DPT-16-35	11/22/2016	11.0	31 - 35 ft	DPT-16-35-GW-31-35	N	0.38 J-	0.80 J-	1.4 J-
On-Site	DPT-17-26	1/11/2017	13.0	18 - 22 ft	DPT-17-26-GW-18-22	N	0.0011 J	< 0.0083 U	0.0059
On-Site	DPT-17-26	1/11/2017	13.0	29 - 33 ft	DPT-17-26-GW-29-33	N	< 0.0019 U	0.0083	< 0.0024 U
On-Site	DPT-17-27	1/11/2017	13.0	18 - 22 ft	DPT-17-27-GW-18-22	N	< 0.0020 U	< 0.0030 U	< 0.0020 U
On-Site	DPT-17-27	1/11/2017	13.0	29 - 33 ft	DPT-17-27-GW-29-33	N	< 0.0020 U	< 0.0040 U	< 0.0020 U

Table A-2 Groundwater Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Depth to Groundwater (ft bgs)	Interval (ft bgs)	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)

Notes:
µg/L = micrograms per liter
bgs = Below ground surface
FD = Field duplicate sample
ft = Feet
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers:
J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Table A-3 Drinking Water Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
DW-16-01	11/16/2016	DW-16-01-111616	N	< 0.0060 U	< 0.0032 U	< 0.0032 U
DW-16-01	11/16/2016	DW-16-01-111616-DUP	FD	< 0.0060 U	< 0.0032 U	< 0.0032 U
DW-16-02	11/18/2016	DW-16-02-111816	N	< 0.0060 U	< 0.0032 U	< 0.0032 U

Notes: µg/L = micrograms per liter
FD = Field duplicate sample
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Table A-4 Sediment Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/kg)	PFOS (µg/kg)	PFOA (µg/kg)
On/Near Site (East of Bay Head Road)	SD-16-01	11/2/2016	SWSD-16-01-SD	N	< 0.37 U	1.7	0.23 J
On/Near Site (East of Bay Head Road)	SD-16-02	11/2/2016	SWSD-16-02-SD	N	< 0.69 U	5.1	< 0.69 U
On/Near Site (East of Bay Head Road)	SD-16-02	11/2/2016	SWSD-16-02-SD-DUP	FD	< 0.68 U	4.2	0.23 J
On/Near Site (East of Bay Head Road)	SD-16-03	11/2/2016	SWSD-16-03-SD	N	< 0.63 U	6.6	0.28 J
On/Near Site (East of Bay Head Road)	SD-16-04	11/2/2016	SWSD-16-04-SD	N	< 0.38 U	0.42 J	0.18 J
Off-Site (West of Bay Head Road)	SWSD-18-01	4/26/2018	SWSD-18-01-SD	N	< 0.38 U	12	1.2
Off-Site (West of Bay Head Road)	SWSD-18-01	11/19/2018	SD-18-01	N	< 0.84 U	0.42 J	< 0.95 U
Off-Site (West of Bay Head Road)	SWSD-18-02	4/26/2018	SWSD-18-02-SD	N	< 0.59 U	44	3.7
Off-Site (West of Bay Head Road)	SWSD-18-02	11/19/2018	SD-18-02	N	< 1.2 U	15	1.4 J
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SD	N	0.28 J	31 J	3.7 J
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SD-DUP	FD	< 0.91 UJ	28 J	4.5 J
Off-Site (West of Bay Head Road)	SWSD-18-03	11/20/2018	SD-18-03	N	< 2.4 UJ	24 J	3.4 J
Off-Site (West of Bay Head Road)	SWSD-18-03	11/20/2018	SD-18-03-DUP	FD	< 2.2 UJ	8.9 J	2.3 J
Off-Site (West of Bay Head Road)	SWSD-18-04	4/26/2018	SWSD-18-04-SD	N	< 0.76 UJ	19 J	2.4 J
Off-Site (West of Bay Head Road)	SWSD-18-04	11/20/2018	SD-18-04	N	< 3.7 UJ	8.3 J	< 4.2 UJ
Off-Site (West of Bay Head Road)	SWSD-18-05	4/26/2018	SWSD-18-05-SD	N	< 1.5 UJ	18 J	1.2 J
Off-Site (West of Bay Head Road)	SWSD-18-05	11/19/2018	SD-18-05	N	< 3.0 UJ	5.1 J	< 3.4 UJ
Off-Site (West of Bay Head Road)	SWSD-18-06	11/20/2018	SD-18-06	N	< 0.80 U	14	1.4
Off-Site (West of Bay Head Road)	SWSD-18-07	11/20/2018	SD-18-07	N	< 0.72 U	1.7 J	< 0.81 U
Off-Site (West of Bay Head Road)	SWSD-18-07	11/20/2018	SD-18-07-DUP	FD	< 0.89 U	6.7 J	0.50 J
Off-Site (West of Bay Head Road)	SWSD-18-08	11/19/2018	SD-18-08	N	< 1.4 U	0.59 J	< 1.6 U
Off-Site (West of Bay Head Road)	SWSD-18-09	11/19/2018	SD-18-09	N	< 0.85 U	0.36 J	< 0.96 U
Off-Site (West of Bay Head Road)	SWSD-18-10	11/19/2018	SD-18-10	N	< 0.91 U	0.32 J	< 1.0 U
Off-Site (West of Bay Head Road)	SWSD-18-11	11/19/2018	SD-18-11	N	< 2.6 UJ	4.4 J	< 3.0 UJ
Off-Site (West of Bay Head Road)	SWSD-18-12	11/19/2018	SD-18-12	N	< 3.7 UJ	5.3 J	< 4.2 UJ
Off-Site (West of Bay Head Road)	SWSD-18-13	11/19/2018	SD-18-13	N	< 2.4 UJ	1.5 J	< 2.7 UJ
Off-Site (West of Bay Head Road)	SWSD-18-13	11/19/2018	SD-18-13-DUP	FD	< 2.5 UJ	1.2 J	< 2.8 UJ
Off-Site (West of Bay Head Road)	SWSD-18-14	11/19/2018	SD-18-14	N	< 2.5 UJ	1.0 J	0.93 J
Off-Site (West of Bay Head Road)	SWSD-18-15	11/19/2018	SD-18-15	N	< 2.1 UJ	0.86 J	< 2.4 UJ
Off-Site (West of Bay Head Road)	SWSD-18-16	11/19/2018	SD-18-16	N	< 2.8 UJ	2.1 J	< 3.2 UJ
Off-Site (West of Bay Head Road)	SWSD-18-17	11/19/2018	SD-18-17	N	< 3.4 UJ	3.5 J	< 3.8 UJ
Off-Site (West of Bay Head Road)	SWSD-18-18	11/19/2018	SD-18-18	N	< 0.93 U	0.50 J	< 1.0 U
Off-Site (West of Bay Head Road)	SWSD-18-19	11/19/2018	SD-18-19	N	< 0.93 U	0.37 J	< 1.1 U
Off-Site (West of Bay Head Road)	SWSD-18-20	11/19/2018	SD-18-20	N	< 1.1 U	0.62 J	< 1.2 U
Off-Site (West of Bay Head Road)	SWSD-18-21	11/19/2018	SD-18-21	N	< 3.3 UJ	2.7 J	< 3.8 UJ
Off-Site (West of Bay Head Road)	SWSD-18-22	11/19/2018	SD-18-22	N	< 4.1 UJ	< 4.5 UJ	< 4.7 UJ
Off-Site (West of Bay Head Road)	SWSD-18-23	11/19/2018	SD-18-23	N	< 4.6 UJ	4.7 J	< 5.3 UJ
Off-Site (West of Bay Head Road)	SWSD-18-24	11/20/2018	SD-18-24	N	< 1.5 U	2.2	< 1.6 U

Table A-4 Sediment Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/kg)	PFOS (µg/kg)	PFOA (µg/kg)

Notes: µg/kg = micrograms per kilogram
FD = Field duplicate sample
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Table A-5 Surface Water Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
On/Near Site (East of Bay Head Road)	SW-16-01	12/5/2016	SW-16-01-SW	N	0.020	0.27	0.023
On/Near Site (East of Bay Head Road)	SW-16-02	12/5/2016	SW-16-02-SW	N	0.0084	0.12	0.042
On/Near Site (East of Bay Head Road)	SW-16-02	12/5/2016	SW-16-02-SW-DUP	FD	0.0089	0.12	0.041
Off-Site (West of Bay Head Road)	SWSD-18-01	4/26/2018	SWSD-18-01-SW	N	0.0076	0.18	0.055
Off-Site (West of Bay Head Road)	SWSD-18-01	11/19/2018	SW-18-01-H	N	0.0075 J	0.12	0.041
Off-Site (West of Bay Head Road)	SWSD-18-02	4/26/2018	SWSD-18-02-SW	N	0.029	0.66 J	0.43 J
Off-Site (West of Bay Head Road)	SWSD-18-02	11/19/2018	SW-18-02-H	N	0.017 J	0.3	0.26
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SW	N	0.057	0.4 J	0.49 J
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SW-DUP	FD	0.054	0.55 J	0.53 J
Off-Site (West of Bay Head Road)	SWSD-18-03	11/19/2018	SW-18-03-H	N	0.026 J	0.21	0.26
Off-Site (West of Bay Head Road)	SWSD-18-03	11/20/2018	SW-18-03-L	N	0.031	0.27	0.36
Off-Site (West of Bay Head Road)	SWSD-18-04	4/26/2018	SWSD-18-04-SW	N	0.031	0.27	0.26
Off-Site (West of Bay Head Road)	SWSD-18-04	11/19/2018	SW-18-04-H	N	0.0019	0.0043	0.0046
Off-Site (West of Bay Head Road)	SWSD-18-04	11/20/2018	SW-18-04-L	N	0.016	0.075	0.11
Off-Site (West of Bay Head Road)	SWSD-18-05	4/26/2018	SWSD-18-05-SW	N	0.015	0.14	0.13
Off-Site (West of Bay Head Road)	SWSD-18-05	11/19/2018	SW-18-05-H	N	0.0017 J	0.0039	0.0037
Off-Site (West of Bay Head Road)	SWSD-18-05	11/19/2018	SW-18-05-H-DUP	FD	0.0015 J	0.0035	0.0038
Off-Site (West of Bay Head Road)	SWSD-18-05	11/20/2018	SW-18-05-L	N	0.014	0.087	0.1
Off-Site (West of Bay Head Road)	SWSD-18-05	11/20/2018	SW-18-05-L-DUP	FD	0.015	0.082	0.1
Off-Site (West of Bay Head Road)	SWSD-18-06	11/20/2018	SW-18-06	N	0.0084	0.13	0.057
Off-Site (West of Bay Head Road)	SWSD-18-07	11/20/2018	SW-18-07	N	0.0092	0.15	0.073
Off-Site (West of Bay Head Road)	SWSD-18-08	11/19/2018	SW-18-08-H	N	0.0019	0.0045	0.0049
Off-Site (West of Bay Head Road)	SWSD-18-08	11/20/2018	SW-18-08-L	N	0.0040	0.014	0.017
Off-Site (West of Bay Head Road)	SWSD-18-09	11/19/2018	SW-18-09-H	N	0.0026 J	0.0069	0.0073
Off-Site (West of Bay Head Road)	SWSD-18-09	11/20/2018	SW-18-09-L	N	0.0038	0.011	0.011
Off-Site (West of Bay Head Road)	SWSD-18-10	11/19/2018	SW-18-10-H	N	0.0021	0.0064	0.0066
Off-Site (West of Bay Head Road)	SWSD-18-10	11/20/2018	SW-18-10-L	N	0.0068	0.029	0.039
Off-Site (West of Bay Head Road)	SWSD-18-11	11/19/2018	SW-18-11-H	N	0.0016 J	0.0032	0.0033
Off-Site (West of Bay Head Road)	SWSD-18-11	11/20/2018	SW-18-11-L	N	0.0091 J	0.046	0.059
Off-Site (West of Bay Head Road)	SWSD-18-11	11/20/2018	SW-18-11-L-DUP	FD	0.0091	0.047	0.058
Off-Site (West of Bay Head Road)	SWSD-18-12	11/19/2018	SW-18-12-H	N	0.0017	0.0047	0.0042
Off-Site (West of Bay Head Road)	SWSD-18-12	11/20/2018	SW-18-12-L	N	0.012	0.081	0.081
Off-Site (West of Bay Head Road)	SWSD-18-13	11/19/2018	SW-18-13-H	N	0.0019 J	0.017	0.0059
Off-Site (West of Bay Head Road)	SWSD-18-13	11/20/2018	SW-18-13-L	N	0.0032	0.0078	0.0093
Off-Site (West of Bay Head Road)	SWSD-18-14	11/19/2018	SW-18-14-H	N	0.0020 J	0.0048	0.0056
Off-Site (West of Bay Head Road)	SWSD-18-14	11/20/2018	SW-18-14-L	N	0.0040	0.014	0.017
Off-Site (West of Bay Head Road)	SWSD-18-15	11/19/2018	SW-18-15-H	N	0.0017 J	0.0045	0.0047
Off-Site (West of Bay Head Road)	SWSD-18-15	11/20/2018	SW-18-15-L	N	0.0050	0.02	0.024
Off-Site (West of Bay Head Road)	SWSD-18-15	11/20/2018	SW-18-15-L-DUP	FD	0.0049	0.019	0.024
Off-Site (West of Bay Head Road)	SWSD-18-16	11/19/2018	SW-18-16-H	N	0.0018	0.0044	0.0046
Off-Site (West of Bay Head Road)	SWSD-18-16	11/20/2018	SW-18-16-L	N	0.0052	0.018	0.023
Off-Site (West of Bay Head Road)	SWSD-18-17	11/19/2018	SW-18-17-H	N	0.0018	0.0042	0.0044
Off-Site (West of Bay Head Road)	SWSD-18-17	11/20/2018	SW-18-17-L	N	0.0056	0.02	0.028

Table A-5 Surface Water Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
Off-Site (West of Bay Head Road)	SWSD-18-18	11/19/2018	SW-18-18-H	N	0.0024	0.0074	0.0081
Off-Site (West of Bay Head Road)	SWSD-18-18	11/20/2018	SW-18-18-L	N	0.0028	0.0067	0.0078
Off-Site (West of Bay Head Road)	SWSD-18-19	11/19/2018	SW-18-19-H	N	0.0025	0.0079	0.0092
Off-Site (West of Bay Head Road)	SWSD-18-19	11/20/2018	SW-18-19-L	N	0.0032	0.0070	0.0080
Off-Site (West of Bay Head Road)	SWSD-18-20	11/19/2018	SW-18-20-H	N	0.0031	0.012 J	0.013 J
Off-Site (West of Bay Head Road)	SWSD-18-20	11/19/2018	SW-18-20-H-DUP	FD	0.0023	0.0065 J	0.0082 J
Off-Site (West of Bay Head Road)	SWSD-18-20	11/20/2018	SW-18-20-L	N	0.0033	0.0090	0.011
Off-Site (West of Bay Head Road)	SWSD-18-21	11/19/2018	SW-18-21-H	N	0.0024	0.0064	0.0076
Off-Site (West of Bay Head Road)	SWSD-18-21	11/20/2018	SW-18-21-L	N	0.0028 J	0.017	0.0088
Off-Site (West of Bay Head Road)	SWSD-18-22	11/19/2018	SW-18-22-H	N	0.0023	0.0059	0.0065
Off-Site (West of Bay Head Road)	SWSD-18-22	11/20/2018	SW-18-22-L	N	0.0031	0.025	0.013
Off-Site (West of Bay Head Road)	SWSD-18-23	11/19/2018	SW-18-23-H	N	0.0020	0.0053	0.0055
Off-Site (West of Bay Head Road)	SWSD-18-23	11/20/2018	SW-18-23-L	N	0.0072	0.039	0.044
Off-Site (West of Bay Head Road)	SWSD-18-24	11/20/2018	SW-18-24	N	0.028	0.057	0.058

Notes: µg/L = micrograms per liter
FD = Field duplicate sample
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Attachment B

Site-Specific Exposure Factors Used to Calculate Tier IB Screening Levels

ATTACHMENT B
SUMMARY OF EXPOSURE ASSUMPTIONS USED TO DEVELOP TIER 1B (SITE-SPECIFIC) RISK-BASED SCREENING LEVELS
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Parameter	Current/Future Exposure Scenarios									Future Exposure Scenario		
	Recreational User						On-Site Outdoor Worker (Commercial/Industrial)			On-Site Construction/Utility/Excavation Worker		
	Child (0 to <6 year)			Adult								
	Value	Basis	Reference	Value	Basis	Reference	Value	Basis	Reference	Value	Basis	Reference
Parameters Used in the Soil (Incidental Ingestion and Dermal Contact) Pathways												
Exposure Frequency (days/year)	52	2 days/week, 26 weeks/year; Assumes access to site soil may occur from May to October; potential activities are assumed to include walking, picnicking, playing on athletic fields, etc.	Professional judgment	52	2 days/week, 26 weeks/year; Assumes access to soil may occur from May to October; potential activities are assumed to include walking, picnicking, playing on athletic fields, etc.	Professional judgment	250	5 days/week, 50 weeks/year, performing outdoor maintenance, landscaping, etc.	USEPA, 2014	250	5 days/week, 50 weeks/year performing soil excavation or other intrusive activities	Represents a full time worker scenario
Exposure Duration (year)	6	Represents receptor-specific age range of 0 to <6 years old. Equal to USEPA default exposure duration for a child resident.	Professional judgment	20	Equal to USEPA default exposure duration for an adult resident	Professional judgment	25		USEPA, 2014	1	Assumes construction or associated project occurs over a 1-year period.	Professional judgment
Ingestion Rate (mg/day)	200	Upper-bound estimate of soil and dust ingestion. Equal to USEPA default ingestion rate for a child resident.	Professional judgment based on USEPA (2014)	100	Upper-bound estimate of soil and dust ingestion. Equal to USEPA default ingestion rate for an adult resident.	Professional judgment based on USEPA (2014) recommended value for soil	100		USEPA, 2014	330		USEPA, 2002
Exposed Skin Surface Area (cm^2)	2373	Weighted average of mean values for head, hands, forearms, lower legs, and feet. Equal to USEPA default exposed skin surface area for a child resident. Conservatively assumes children may play in any accessible areas of soil.	Professional judgment based on USEPA (2014)	6032	Equal to USEPA default exposed skin surface area for soil contact by an adult resident. Equal to the weighted average of mean values for head, hands, forearms, and lower legs.	Professional judgment based on USEPA (2014)	3527	Weighted average of mean values for head, hands, and forearms	USEPA, 2014	3527	Weighted average of mean values for head, hands, and forearms	USEPA, 2014
Adherence Factor (mg/cm^2-event)	0.2	Mean value for children playing in wet soil. Equal to USEPA default adherence factor for a child resident.	Professional judgment based on USEPA (2004 and 2014)	0.07	Mean value for gardeners. Equal to USEPA default adherence factor for an adult resident.	Professional judgment based on USEPA (2014)	0.12	Weighted average of mean values for face, hands, and forearms (commercial/industrial workers)	USEPA, 2014	0.3	95th percentile weighted value for head, hands, and forearms (construction worker)	USEPA, 2004
Body Weight (kg)	15		USEPA, 2014	80		USEPA, 2014	80		USEPA, 2014	80		USEPA, 2014
Parameters Used in the Groundwater (Incidental Ingestion) Pathway												
Exposure Frequency (days/year)	NA	NA	NA	NA	NA	NA	150	Assumes use for non-potable purposes, such as irrigation, 3 days per week for 50 weeks of the year	Professional judgment for non-potable use (irrigation)	125	Assumes 50% of time on site spent in contact with groundwater in an excavation trench	Professional judgment
Exposure Duration (year)	NA	NA	NA	NA	NA	NA	25		USEPA, 2014	1		Professional judgment
Water Ingestion Rate (L/day)	NA	NA	NA	NA	NA	NA	0.005	Value is one-tenth of that assumed to occur during a swimming event via incidental ingestion	USEPA, 1989; USEPA, 2011	0.005	Value is one-tenth of that assumed to occur during a swimming event via incidental ingestion	USEPA, 1989; USEPA, 2011
Body Weight (kg)	NA	NA	NA	NA	NA	NA	80		USEPA, 2014	80		USEPA, 2014

ATTACHMENT B
SUMMARY OF EXPOSURE ASSUMPTIONS USED TO DEVELOP TIER 1B (SITE-SPECIFIC) RISK-BASED SCREENING LEVELS
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Parameter	Current/Future Exposure Scenarios									Future Exposure Scenario		
	Recreational User						On-Site Outdoor Worker (Commercial/Industrial)			On-Site Construction/Utility/Excavation Worker		
	Child (0 to <6 year)			Adult								
	Value	Basis	Reference	Value	Basis	Reference	Value	Basis	Reference	Value	Basis	Reference
Parameters Used in the Sediment (Incidental Ingestion and Dermal Contact) Pathways												
Exposure Frequency (days/year)	52	2 days/week, 26 weeks/year; Assumes access to sediment may occur from May to October; potential activities are assumed to include swimming and/or wading.	Professional judgment	52	2 days/week, 26 weeks/year; Assumes access to sediment may occur from May to October; potential activities are assumed to include swimming and/or wading.	Professional judgment	NA	NA	NA	NA	NA	NA
Exposure Duration (year)	6	Represents receptor-specific age range of 0 to <6 years old. Equal to USEPA default exposure duration for a child resident.	Professional judgment	20	Equal to USEPA default exposure duration for an adult resident	Professional judgment	NA	NA	NA	NA	NA	NA
Ingestion Rate (mg/day)	200	Equal to USEPA default soil ingestion rate for a child resident.	Professional judgment based on USEPA (2014)	100	Equal to USEPA default soil ingestion rate for a child resident.	Professional judgment based on USEPA (2014) recommended value for soil	NA	NA	NA	NA	NA	NA
Exposed Skin Surface Area (cm^2)	2373	Equal to USEPA default exposed skin surface area for soil contact by a child resident. Equal to the weighted average of mean values for head, hands, forearms, lower legs, and feet.	Professional judgment based on USEPA (2014)	6032	Equal to USEPA default exposed skin surface area for soil contact by an adult resident. Equal to the weighted average of mean values for head, hands, forearms, and lower legs.	Professional judgment based on USEPA (2014)	NA	NA	NA	NA	NA	NA
Adherence Factor (mg/cm^2-event)	0.2	Mean value for children playing in wet soil. Equal to USEPA default soil adherence factor for a child resident.	Professional judgment based on USEPA (2004 and 2014)	0.07	Mean value for gardeners. Equal to USEPA default soil adherence factor for an adult resident.	Professional judgment based on USEPA (2014)	NA	NA	NA	NA	NA	NA
Body Weight (kg)	15		USEPA, 2014	80		USEPA, 2014	NA	NA	NA	NA	NA	NA

ATTACHMENT B
SUMMARY OF EXPOSURE ASSUMPTIONS USED TO DEVELOP TIER 1B (SITE-SPECIFIC) RISK-BASED SCREENING LEVELS
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Parameter	Current/Future Exposure Scenarios									Future Exposure Scenario		
	Recreational User						On-Site Outdoor Worker (Commercial/Industrial)			On-Site Construction/Utility/Excavation Worker		
	Child (0 to <6 year)			Adult								
	Value	Basis	Reference	Value	Basis	Reference	Value	Basis	Reference	Value	Basis	Reference
Parameters Used in the Surface Water (Incidental Ingestion) Pathway												
Exposure Frequency (days/year)	52	2 days/week, 26 weeks/year; Assumes access to surface water may occur from May to October; potential activities are assumed to include swimming and/or wading.	Professional judgment	52	2 days/week, 26 weeks/year; Assumes access to surface water may occur from May to October; potential activities are assumed to include swimming and/or wading.	Professional judgment	NA	NA	NA	NA	NA	NA
Event Time (hours/event)	3	Assumes 3 hours of contact with surface water per event.	Professional judgment	3	Assumes 3 hours of contact with surface water per event.	Professional judgment	NA	NA	NA	NA	NA	NA
Exposure Duration (year)	6	Represents receptor-specific age range of 0 to <6 years old. Equal to USEPA default exposure duration for a child resident.	Professional judgment	20	Equal to USEPA default exposure duration for an adult resident	Professional judgment	NA	NA	NA	NA	NA	NA
Water Ingestion Rate (L/day)	0.05		U.S. EPA, 1989	0.05		U.S. EPA, 1989	NA	NA	NA	NA	NA	NA
Exposed Skin Surface Area (cm^2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Event Frequency (event/day)	1		Professional judgment	1		Professional judgment	NA	NA	NA	NA	NA	NA
Body Weight (kg)	15		USEPA, 2014	80		USEPA, 2014	NA	NA	NA	NA	NA	NA

Notes:
NA - Not applicable.
USEPA - United States Environmental Protection Agency.
USEPA, 1989. Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.
USEPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December, 2002.
USEPA, 2004. Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part E. EPA/540/R/99/005. Exhibit 3-3.
USEPA, 2011. Exposure Factors Handbook. September 2011.
USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Corrected September 2015.
cm^2 - square centimeter.
kg - kilogram.
L/day - liters per day.
mg/cm^2-event - milligram per square centimeter per event.
mg/day - milligram per day.

Attachment C
ProUCL Output

ProUCL Output - Surface Soil
Former Bay Head Road Annex (BHRA)

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                              UCL Statistics for Data Sets with Non-Detects

           User Selected Options
      Date/Time of Computation   ProUCL 5.18/21/2019 8:38:53 AM
                     From File   Input_SurfSoil.xls
                Full Precision   OFF
        Confidence Coefficient   95%
  mber of Bootstrap Operations   2000

Perfluorooctanesulfonic Acid (PFOS)

                                          General Statistics
          Total Number of Observations     12                Number of Distinct Observations    12
                     Number of Detects     11                           Number of Non-Detects    1
            Number of Distinct Detects     11                  Number of Distinct Non-Detects    1
                        Minimum Detect     0.25                           Minimum Non-Detect     0.6
                        Maximum Detect   170                              Maximum Non-Detect     0.6
                      Variance Detects  2447                              Percent Non-Detects    8.333
                          Mean Detects    36.37                                    SD Detects   49.46
                        Median Detects    20                                       CV Detects    1.36
                      Skewness Detects     2.358                             Kurtosis Detects    5.835
                 Mean of Logged Detects    2.74                         SD of Logged Detects     1.688

                                      Normal GOF Test on Detects Only
            Shapiro Wilk Test Statistic    0.689                   Shapiro Wilk GOF Test
         5% Shapiro Wilk Critical Value    0.85        Detected Data Not Normal at 5% Significance Level
               Lilliefors Test Statistic   0.305                     Lilliefors GOF Test
           5% Lilliefors Critical Value    0.251       Detected Data Not Normal at 5% Significance Level
                             Detected Data Not Normal at 5% Significance Level

             Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs
                                KM Mean    33.36                      KM Standard Error of Mean    14
                                  KM SD    46.24                              95% KM (BCA) UCL    58.65
                         95% KM (t) UCL    58.5                 95% KM (Percentile Bootstrap) UCL  57.13
                         95% KM (z) UCL    56.39                         95% KM Bootstrap t UCL   107.9
                   90% KM Chebyshev UCL    75.36                          95% KM Chebyshev UCL    94.39
                 97.5% KM Chebyshev UCL   120.8                           99% KM Chebyshev UCL   172.7

                                 Gamma GOF Tests on Detected Observations Only
                      A-D Test Statistic   0.301                 Anderson-Darling GOF Test
                   5% A-D Critical Value   0.766 etected data appear Gamma Distributed at 5% Significance Lev
                      K-S Test Statistic   0.149                 Kolmogorov-Smirnov GOF
                   5% K-S Critical Value   0.266 etected data appear Gamma Distributed at 5% Significance Lev
                           Detected data appear Gamma Distributed at 5% Significance Level

                                    Gamma Statistics on Detected Data Only
                            k hat (MLE)    0.707                    k star (bias corrected MLE)    0.575
                        Theta hat (MLE)   51.44                 Theta star (bias corrected MLE)   63.27
                           nu hat (MLE)   15.55                         nu star (bias corrected)  12.65
                         Mean (detects)   36.37

                                 Gamma ROS Statistics using Imputed Non-Detects
                      GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
     GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)
                               For such situations, GROS method may yield incorrect values of UCLs and BTVs
                                        This is especially true when the sample size is small.
           For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates
                                Minimum    0.01                                          Mean   33.34
                                Maximum  170                                           Median   16
                                     SD   48.32                                            CV    1.449
                            k hat (MLE)    0.466                    k star (bias corrected MLE)    0.405
                        Theta hat (MLE)   71.57                 Theta star (bias corrected MLE)   82.33
                           nu hat (MLE)   11.18                         nu star (bias corrected)    9.718
            Adjusted Level of Significance (β)    0.029
        Approximate Chi Square Value (9.72, α)     3.767             Adjusted Chi Square Value (9.72, β)    3.222
   95% Gamma Approximate UCL (use when n>=50)     86.02      95% Gamma Adjusted UCL (use when n<50)   100.6
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ProUCL Output - Surface Soil
Former Bay Head Road Annex (BHRA)

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	33.36	SD (KM)	46.24
Variance (KM)	2138	SE of Mean (KM)	14
k hat (KM)	0.52	k star (KM)	0.446
nu hat (KM)	12.49	nu star (KM)	10.7
theta hat (KM)	64.11	theta star (KM)	74.82
80% gamma percentile (KM)	54.41	90% gamma percentile (KM)	92.35
95% gamma percentile (KM)	133.5	99% gamma percentile (KM)	235.7

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (10.70, α)	4.384	Adjusted Chi Square Value (10.70, β)	3.786
5% Gamma Approximate KM-UCL (use when n>=50)	81.42	95% Gamma Adjusted KM-UCL (use when n<50)	94.27

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.895	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.193	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.251	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	33.4	Mean in Log Scale	2.493
SD in Original Scale	48.27	SD in Log Scale	1.822
95% t UCL (assumes normality of ROS data)	58.43	95% Percentile Bootstrap UCL	56.36
95% BCA Bootstrap UCL	67.73	95% Bootstrap t UCL	107.3
95% H-UCL (Log ROS)	787.3		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	2.396	KM Geo Mean	10.98
KM SD (logged)	1.917	95% Critical H Value (KM-Log)	4.781
KM Standard Error of Mean (logged)	0.58	95% H-UCL (KM -Log)	1093
KM SD (logged)	1.917	95% Critical H Value (KM-Log)	4.781
KM Standard Error of Mean (logged)	0.58		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	33.36	Mean in Log Scale	2.411
SD in Original Scale	48.3	SD in Log Scale	1.971
95% t UCL (Assumes normality)	58.4	95% H-Stat UCL	1432

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Gamma Distributed at 5% Significance Level

Suggested UCL to Use

95% KM Bootstrap t UCL	107.9	d KM-UCL (use when k<=1 and 15 < n < 50 but k<=1)	94.27

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
owever, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia

ProUCL Output - Combined Surface and Subsurface Soil
Former Bay Head Road Annex (BHRA)

```
                                  UCL Statistics for Data Sets with Non-Detects

          User Selected Options
     Date/Time of Computation   ProUCL 5.18/21/2019 8:51:09 AM
                    From File   Input_Soil.xls
               Full Precision   OFF
       Confidence Coefficient   95%
 mber of Bootstrap Operations   2000

Perfluorooctanesulfonic Acid (PFOS)

                                          General Statistics
            Total Number of Observations    24                  Number of Distinct Observations    20
                       Number of Detects    21                          Number of Non-Detects     3
              Number of Distinct Detects    18                 Number of Distinct Non-Detects     2
                          Minimum Detect     0.25                         Minimum Non-Detect     0.36
                          Maximum Detect   170                            Maximum Non-Detect     0.6
                        Variance Detects  1457                           Percent Non-Detects    12.5%
                            Mean Detects    28.67                                 SD Detects    38.18
                          Median Detects    12                                    CV Detects     1.332
                        Skewness Detects     2.85                           Kurtosis Detects     9.511
                   Mean of Logged Detects     2.635                    SD of Logged Detects     1.42

                                      Normal GOF Test on Detects Only
              Shapiro Wilk Test Statistic     0.664                Shapiro Wilk GOF Test
           5% Shapiro Wilk Critical Value     0.908   Detected Data Not Normal at 5% Significance Level
                Lilliefors Test Statistic     0.228                 Lilliefors GOF Test
             5% Lilliefors Critical Value     0.188   Detected Data Not Normal at 5% Significance Level
                              Detected Data Not Normal at 5% Significance Level

                 Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs
                                  KM Mean    25.12                   KM Standard Error of Mean     7.55
                                    KM SD    36.09                           95% KM (BCA) UCL    38.49
                          95% KM (t) UCL    38.06          95% KM (Percentile Bootstrap) UCL    38.61
                          95% KM (z) UCL    37.53                     95% KM Bootstrap t UCL    53.02
                    90% KM Chebyshev UCL    47.77                      95% KM Chebyshev UCL    58.03
                  97.5% KM Chebyshev UCL    72.26                      99% KM Chebyshev UCL   100.2

                                Gamma GOF Tests on Detected Observations Only
                       A-D Test Statistic     0.317              Anderson-Darling GOF Test
                     5% A-D Critical Value     0.779 etected data appear Gamma Distributed at 5% Significance Lev
                       K-S Test Statistic     0.141              Kolmogorov-Smirnov GOF
                     5% K-S Critical Value     0.196 etected data appear Gamma Distributed at 5% Significance Lev
                          Detected data appear Gamma Distributed at 5% Significance Level

                                       Gamma Statistics on Detected Data Only
                               k hat (MLE)     0.82                   k star (bias corrected MLE)     0.735
                           Theta hat (MLE)    34.95               Theta star (bias corrected MLE)    39.02
                              nu hat (MLE)    34.45                      nu star (bias corrected)    30.86
                            Mean (detects)    28.67

                                    Gamma ROS Statistics using Imputed Non-Detects
                   GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
  GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)
                          For such situations, GROS method may yield incorrect values of UCLs and BTVs
                                      This is especially true when the sample size is small.
         For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates
                                   Minimum     0.01                                         Mean    25.09
                                   Maximum   170                                          Median    11
                                        SD    36.89                                           CV     1.471
                               k hat (MLE)     0.435                  k star (bias corrected MLE)     0.408
                           Theta hat (MLE)    57.68               Theta star (bias corrected MLE)    61.43
                              nu hat (MLE)    20.88                      nu star (bias corrected)    19.6
            Adjusted Level of Significance (β)     0.0392
       Approximate Chi Square Value (19.60, α)    10.56            Adjusted Chi Square Value (19.60, β)    10.09
  95% Gamma Approximate UCL (use when n>=50)    46.58      95% Gamma Adjusted UCL (use when n<50)    48.73
```

ProUCL Output - Combined Surface and Subsurface Soil
Former Bay Head Road Annex (BHRA)

```
                         Estimates of Gamma Parameters using KM Estimates
                        Mean (KM)    25.12                                      SD (KM)    36.09
                    Variance (KM)    1303                               SE of Mean (KM)    7.55
                       k hat (KM)    0.484                                   k star (KM)    0.451
                      nu hat (KM)    23.24                                  nu star (KM)    21.67
                   theta hat (KM)    51.87                               theta star (KM)    55.63
        80% gamma percentile (KM)    41                        90% gamma percentile (KM)    69.36
        95% gamma percentile (KM)    100                       99% gamma percentile (KM)    176.2

                                 Gamma Kaplan-Meier (KM) Statistics
     Approximate Chi Square Value (21.67, α)    12.09        Adjusted Chi Square Value (21.67, β)    11.59
5% Gamma Approximate KM-UCL (use when n>=50)    45.01   95% Gamma Adjusted KM-UCL (use when n<50)    46.97

                          Lognormal GOF Test on Detected Observations Only
               Shapiro Wilk Test Statistic    0.939              Shapiro Wilk GOF Test
            5% Shapiro Wilk Critical Value    0.908   Detected Data appear Lognormal at 5% Significance Level
                  Lilliefors Test Statistic    0.138                Lilliefors GOF Test
              5% Lilliefors Critical Value    0.188   Detected Data appear Lognormal at 5% Significance Level
                       Detected Data appear Lognormal at 5% Significance Level

                          Lognormal ROS Statistics Using Imputed Non-Detects
                     Mean in Original Scale    25.2                            Mean in Log Scale    2.29
                       SD in Original Scale    36.81                             SD in Log Scale    1.622
     95% t UCL (assumes normality of ROS data)    38.08              95% Percentile Bootstrap UCL    38.47
                        95% BCA Bootstrap UCL    43.03                       95% Bootstrap t UCL    49.94
                        95% H-UCL (Log ROS)    118.7

          Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution
                         KM Mean (logged)    2.132                                 KM Geo Mean    8.431
                           KM SD (logged)    1.857               95% Critical H Value (KM-Log)    3.851
        KM Standard Error of Mean (logged)    0.388                      95% H-UCL (KM -Log)    210.1
                           KM SD (logged)    1.857               95% Critical H Value (KM-Log)    3.851
        KM Standard Error of Mean (logged)    0.388

                                          DL/2 Statistics
                    DL/2 Normal                                      DL/2 Log-Transformed
                     Mean in Original Scale    25.11                           Mean in Log Scale    2.112
                       SD in Original Scale    36.87                             SD in Log Scale    1.938
              95% t UCL (Assumes normality)    38.01                             95% H-Stat UCL    270.2
          DL/2 is not a recommended method, provided for comparisons and historical reasons

                              Nonparametric Distribution Free UCL Statistics
                      Detected Data appear Gamma Distributed at 5% Significance Level

                                          Suggested UCL to Use
KM-UCL (use when k<=1 and 15 < n < 50 but k<=1)    46.97

 Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
                      Recommendations are based upon data size, data distribution, and skewness.
  These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
owever, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia
```

ProUCL Output - Core of Groundwater Plume
Former Bay Head Road Annex (BHRA)

```
                                    UCL Statistics for Uncensored Full Data Sets

         User Selected Options
   Date/Time of Computation   ProUCL 5.18/26/2019 8:08:39 AM
                  From File   Input_WG_CoreOfPlume.xls
             Full Precision   OFF
     Confidence Coefficient   95%
mber of Bootstrap Operations  2000


Perfluorooctanesulfonic Acid (PFOS)

                                              General Statistics
                 Total Number of Observations   26                  Number of Distinct Observations   25
                                                                     Number of Missing Observations   0
                                      Minimum   0.43                                           Mean   6.328
                                      Maximum   42                                           Median   4.75
                                           SD   8.366                            Std. Error of Mean   1.641
                     Coefficient of Variation   1.322                                      Skewness   3.306

                                               Normal GOF Test
                    Shapiro Wilk Test Statistic   0.64              Shapiro Wilk GOF Test
                  5% Shapiro Wilk Critical Value   0.92      Data Not Normal at 5% Significance Level
                        Lilliefors Test Statistic   0.24              Lilliefors GOF Test
                    5% Lilliefors Critical Value   0.17      Data Not Normal at 5% Significance Level
                                  Data Not Normal at 5% Significance Level

                                           Assuming Normal Distribution
                95% Normal UCL                                 95% UCLs (Adjusted for Skewness)
                       95% Student's-t UCL   9.131                   95% Adjusted-CLT UCL (Chen-1995)   10.16
                                                                     95% Modified-t UCL (Johnson-1978)   9.308

                                               Gamma GOF Test
                            A-D Test Statistic   0.465              Anderson-Darling Gamma GOF Test
                          5% A-D Critical Value   0.778 etected data appear Gamma Distributed at 5% Significance Lev
                            K-S Test Statistic   0.116           Kolmogorov-Smirnov Gamma GOF Test
                          5% K-S Critical Value   0.177 etected data appear Gamma Distributed at 5% Significance Lev
                      Detected data appear Gamma Distributed at 5% Significance Level

                                              Gamma Statistics
                                  k hat (MLE)   0.895                      k star (bias corrected MLE)   0.817
                              Theta hat (MLE)   7.074                  Theta star (bias corrected MLE)   7.746
                                 nu hat (MLE)   46.52                          nu star (bias corrected)   42.48
                      MLE Mean (bias corrected)   6.328                           MLE Sd (bias corrected)   7.001
                                                                   Approximate Chi Square Value (0.05)   28.54
                   Adjusted Level of Significance   0.0398                         Adjusted Chi Square Value   27.79

                                           Assuming Gamma Distribution
    95% Approximate Gamma UCL (use when n>=50)   9.42         95% Adjusted Gamma UCL (use when n<50)   9.676

                                              Lognormal GOF Test
                    Shapiro Wilk Test Statistic   0.951           Shapiro Wilk Lognormal GOF Test
                  5% Shapiro Wilk Critical Value   0.92      Data appear Lognormal at 5% Significance Level
                        Lilliefors Test Statistic   0.146          Lilliefors Lognormal GOF Test
                    5% Lilliefors Critical Value   0.17      Data appear Lognormal at 5% Significance Level
                                Data appear Lognormal at 5% Significance Level

                                             Lognormal Statistics
                      Minimum of Logged Data   -0.844                                 Mean of logged Data   1.191
                      Maximum of Logged Data   3.738                                    SD of logged Data   1.23

                                           Assuming Lognormal Distribution
                                  95% H-UCL   14.03                         90% Chebyshev (MVUE) UCL   12.44
                      95% Chebyshev (MVUE) UCL   15.04                       97.5% Chebyshev (MVUE) UCL   18.66
                      99% Chebyshev (MVUE) UCL   25.76

                                    Nonparametric Distribution Free UCL Statistics
                            Data appear to follow a Discernible Distribution at 5% Significance Level
```

```
                         Nonparametric Distribution Free UCLs
                  95% CLT UCL    9.027                         95% Jackknife UCL    9.131
       95% Standard Bootstrap UCL    8.889                    95% Bootstrap-t UCL    11.7
          95% Hall's Bootstrap UCL    20.7            95% Percentile Bootstrap UCL    9.328
            95% BCA Bootstrap UCL    10.32
     90% Chebyshev(Mean, Sd) UCL    11.25            95% Chebyshev(Mean, Sd) UCL    13.48
   97.5% Chebyshev(Mean, Sd) UCL    16.57            99% Chebyshev(Mean, Sd) UCL    22.65

                              Suggested UCL to Use
           95% Adjusted Gamma UCL    9.676

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
                 Recommendations are based upon data size, data distribution, and skewness.
  These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
owever, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia


Perfluorooctanoic Acid (PFOA)

                                 General Statistics
      Total Number of Observations    26              Number of Distinct Observations    22
                                                       Number of Missing Observations    0
                            Minimum    0.15                                      Mean    3.243
                            Maximum    28                                      Median    0.85
                                 SD    6.436                         Std. Error of Mean    1.262
           Coefficient of Variation    1.985                                   Skewness    2.947

                                  Normal GOF Test
          Shapiro Wilk Test Statistic    0.512                 Shapiro Wilk GOF Test
      5% Shapiro Wilk Critical Value    0.92        Data Not Normal at 5% Significance Level
            Lilliefors Test Statistic    0.384                  Lilliefors GOF Test
         5% Lilliefors Critical Value    0.17        Data Not Normal at 5% Significance Level
                      Data Not Normal at 5% Significance Level

                             Assuming Normal Distribution
      95% Normal UCL                                  95% UCLs (Adjusted for Skewness)
               95% Student's-t UCL    5.399           95% Adjusted-CLT UCL (Chen-1995)    6.098
                                                       95% Modified-t UCL (Johnson-1978)    5.52

                                   Gamma GOF Test
                  A-D Test Statistic    2.578            Anderson-Darling Gamma GOF Test
                5% A-D Critical Value    0.802    Data Not Gamma Distributed at 5% Significance Level
                  K-S Test Statistic    0.268          Kolmogorov-Smirnov Gamma GOF Test
                5% K-S Critical Value    0.18     Data Not Gamma Distributed at 5% Significance Level
                 Data Not Gamma Distributed at 5% Significance Level

                                  Gamma Statistics
                          k hat (MLE)    0.571               k star (bias corrected MLE)    0.531
                      Theta hat (MLE)    5.679           Theta star (bias corrected MLE)    6.11
                         nu hat (MLE)    29.69                   nu star (bias corrected)    27.6
           MLE Mean (bias corrected)    3.243                    MLE Sd (bias corrected)    4.451
                                                     Approximate Chi Square Value (0.05)    16.62
        Adjusted Level of Significance    0.0398                  Adjusted Chi Square Value    16.05

                             Assuming Gamma Distribution
95% Approximate Gamma UCL (use when n>=50))    5.386    95% Adjusted Gamma UCL (use when n<50)    5.575

                                  Lognormal GOF Test
          Shapiro Wilk Test Statistic    0.903          Shapiro Wilk Lognormal GOF Test
      5% Shapiro Wilk Critical Value    0.92        Data Not Lognormal at 5% Significance Level
            Lilliefors Test Statistic    0.18             Lilliefors Lognormal GOF Test
         5% Lilliefors Critical Value    0.17        Data Not Lognormal at 5% Significance Level
                    Data Not Lognormal at 5% Significance Level

                                 Lognormal Statistics
              Minimum of Logged Data    -1.897                       Mean of logged Data    0.0863
              Maximum of Logged Data    3.332                          SD of logged Data    1.332

                            Assuming Lognormal Distribution
                           95% H-UCL    5.834                    90% Chebyshev (MVUE) UCL    4.86
            95% Chebyshev (MVUE) UCL    5.931                  97.5% Chebyshev (MVUE) UCL    7.417
            99% Chebyshev (MVUE) UCL    10.34
```

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	5.319	95% Jackknife UCL	5.399
95% Standard Bootstrap UCL	5.295	95% Bootstrap-t UCL	7.482
95% Hall's Bootstrap UCL	5.842	95% Percentile Bootstrap UCL	5.319
95% BCA Bootstrap UCL	6.046		
90% Chebyshev(Mean, Sd) UCL	7.029	95% Chebyshev(Mean, Sd) UCL	8.744
97.5% Chebyshev(Mean, Sd) UCL	11.12	99% Chebyshev(Mean, Sd) UCL	15.8

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	8.744

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
owever, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician

Appendix F
Ecological Risk Assessment

APPENDIX F
ECOLOGICAL RISK ASSESSMENT

Former Bay Head Road Annex IR Program Site 1
Former Naval Surface Warfare Center
Carderock Division
Annapolis Detachment
Annapolis, Maryland

Final

Prepared for:

Naval Facilities Engineering Command
NAVFAC WASHINGTON

Department of the Navy
Naval Facilities Engineering Command, Washington
1314 Harwood Street SE
Washington Navy Yard, DC 20374-5018

July 2020

APPENDIX F
ECOLOGICAL RISK ASSESSMENT

Former Bay Head Road Annex IR Program Site 1
Former Naval Surface Warfare Center
Carderock Division
Annapolis Detachment
Annapolis, Maryland

Final

Prepared for:

Naval Facilities Engineering Command
NAVFAC WASHINGTON

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Manchester, NH 03101

Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-17-D-1800, CTO N4008018F4822

July 2020

CONTENTS

FIGURES

TABLES

ATTACHMENTS

LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
>	greater than
<	less than
ATSDR	Agency for Toxic Substances and Disease
AUF	area use factor
BAF	bioaccumulation factor
BCF	bioconcentration factor
BERA	baseline ecological risk assessment
BHRA	Bay Head Road Annex
BMF	biomagnification factor
CBF	Chesapeake Bay Foundation
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CEQG	Canadian Environmental Quality Guideline
C_f	concentration of COPC in food
COPC	chemical of potential concern
C_o	concentration in the organism
COC	chemical of concern
CRC CARE	Cooperative Research Centre for Contamination Assessment and Remediation of the Environment
C_s	concentration of COPC in sediment
CSM	conceptual site model
C_w	concentration of COPC in water
DEPA	Danish Environmental Protection Agency
dw	dry weight
ECCC	Environment and Climate Change Canada
EPC	exposure point concentration
ERA	ecological risk assessment
FBP	Former Burn Pad
ft	foot or feet
ft/day	feet per day
HQ	hazard quotient
IR_f	ingestion rate of food
IR_s	ingestion rate of sediment
IR_w	ingestion rate of water

kg/day	kilogram per day
L/day	liter per day
LOAEL	lowest observed adverse effects level
LOD	limit of detection
MDCH	Michigan Department of Community Health
ng/mL	nanograms/milliliter
NERP	Navy Environmental Restoration Program
NFA	no further action
NOAEL	no observed adverse effects level
NOEC	no observed effect concentration
NPCA	Norwegian Pollution Control Authority
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesufonic acid
PFOA	perfluorooctanic acid
PFOS	perfluorooctanesulfonic acid
PNEC	predicted no-effects concentration
RI	remedial investigation
SAP	sampling and analysis plan
SMDP	scientific/management decision point
SRA	screening risk assessment
SUF	Seasonal Use Factor
TDD	total daily dose
TIR	thermal infrared spectroscopy
TL	trophic level
TRV	toxicity reference value
UCL	upper confidence limit
µg/kg	microgram per kilogram
µg/kg$_{BW}$/day	microgram of chemical per kilogram of body weight per day
µg/L	microgram per liter
U.K.	United Kingdom
U.S.	United States
USEPA	United States Environmental Protection Agency
ww	wet weight

EXECUTIVE SUMMARY

This appendix presents an ecological risk assessment (ERA) conducted for the Former Bay Head Road Annex (BHRA) facility in Annapolis, Maryland (site). The ERA was conducted as part of the Remedial Investigation (RI) report, which is being submitted on behalf of the Naval Facilities Engineering Command (NAVFAC) Washington, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62742-17-D-1800, Contract Task Order (CTO) F4822.

The scope of this ERA is limited to per- and polyfluoroalkyl substances (PFAS) compounds (specifically perfluorooctane sulfonate [PFOS], perfluorooctanoic acid [PFOA], and perfluorobutanesulfonic acid [PFBS]) in soil, sediment, and surface water attributable to past operations at the site. This ERA includes an assessment of potentially complete exposure pathways in the upland portion of the site that currently supports recreational use, as well as the on-site drainages features and downstream off-site aquatic habitats that meander through residential areas before discharging into the Little Magothy River.

ERA Dataset

The dataset evaluated in the ERA is as follows:

- The ERA soil dataset included results from surface soil samples collected from 0 to 1 feet (ft) below ground surface (bgs) from 12 on-site locations sampled during the November 2016 and/or January 2017 sampling events.
- The ERA sediment dataset included results for sediment samples collected from 4 locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016, and from 24 locations at downgradient off-site locations to the north of the site (off-site, west of Bay Head Road) in April and/or November 2018.
- The ERA surface water dataset included results for surface water samples collected from 2 locations on or adjacent to the site (on/near site, east of Bay Head Road) in November 2016, and from 24 locations at downgradient off-site locations to the north of the site (off-site, west of Bay Head Road) in April and/or November 2018.

Receptors and Exposure Scenarios Evaluated

The following exposure pathways were evaluated in the ERA:

- Soil invertebrates and terrestrial plants directly exposed to PFAS in soil in the vicinity of the former fire testing area of the former facility.
- Terrestrial birds and mammals exposed to PFAS in soil in the vicinity of the former fire testing area of the former facility through incidental ingestion of soil and by ingestion of contaminated prey items impacted by soil.
- Benthic invertebrates and aquatic (water-column) organisms directly exposed to PFAS in surface sediment and surface water in the on/near-site drainage features and off-site wetlands, the unnamed creek, and the bay of the Little Magothy River.
- Aquatic-dependent birds and mammals exposed to PFAS through incidental ingestion of sediment or surface water, and by ingestion of contaminated prey items impacted by sediment or surface water in the on-site drainage and off-site wetlands, the unnamed creek, and the Little Magothy River.

ERA Approach and Findings

This ERA has been structured according to U.S. Navy policy (Department of the Navy [DON], 1999a,b) and includes the Tier 1 ecological screening risk assessment (SRA), which is consistent with Steps 1 and 2 of the United States Environmental Protection Agency (USEPA) Comprehensive Long-Term Environmental Action (CERCLA) ERA process (USEPA, 1997), and the first step of the Tier 2 baseline ecological risk assessment (BERA), which is consistent with Step 3a of the USEPA CERCLA ERA process.

Upon completion of the Tier 1 ecological SRA, it was determined that complete exposure pathways exist from site surface soil, sediment, or surface water to plants, invertebrates (and potentially fish) or wildlife receptors. This assessment illustrated that there is a concern for ecological receptors from exposure to on-site surface soil and on/near-site and off-site surface water that warrants further evaluation. The following chemicals of potential concern (COPCs) were considered further in the Tier 2, Step 3a evaluation:

- Terrestrial birds and mammals – PFOS in soil
- Aquatic-dependent birds and mammals – PFOS and PFOA in surface water

The first phase of the Tier 2, Step 3a evaluation involved a comparison of the 95 percent (%) upper confidence limits of the arithmetic mean concentration (UCL) to the same screening levels used in the SRA to re-calculate hazard quotients (HQs) for specific media and receptors retained at the conclusion of the SRA. COPCs with HQs greater than 1 based on the UCLs were subjected to a sample-by-sample evaluation and a more intensive investigation of the data. In addition to evaluating the UCL for surface water to refine the exposure assumptions in the Tier 2, Step 3a assessment, specific avian and mammalian wildlife receptors potentially exposed to PFOS in surface water at the site were selected and more site-specific food web models compiled to generate exposure doses for these selected target receptors. No observed adverse effects level (NOAEL) and lowest observed adverse effects level (LOAEL)-based HQs were calculated for PFOS with these Step 3a exposure doses to provide a range of risk estimates from this more robust evaluation for surface water. This level of re-evaluation is not warranted for PFOS in surface soil, for which very few literature-based bioaccumulation factors (BAFs) are available, and PFOS is not expected to bioaccumulate to the same degree in terrestrial habitats. Furthermore, the current use of the upland habitat as a recreational area for sports and similar routine human activities precludes significant foraging and use by terrestrial wildlife.

The findings of the Tier 2, Step 3a evaluation indicated a low potential for risk to terrestrial wildlife based on the relatively low HQs in consideration of the conservative nature of the bioaccumulation screening levels for soil. The developed areas, particularly surrounding the buildings, where the two highest detections of PFOS occurred, would be less attractive to wildlife than the small on-site naturally vegetated area and the expansive surrounding off-site naturally vegetated areas characterized by much lower PFOS concentrations in soil. Redevelopment in this area entailed the removal of native vegetation and surface regrading to produce the current paved access road and the level, grass-surfaced (frequently mowed) athletic fields. Removing these two locations from the surface soil dataset resulted in 95% UCLs only slightly greater than 1. These results demonstrate that outside of these two highest locations, mammals at the site have a low potential to be adversely impacted by site COPCs. Given these lines of evidence, the bioaccumulation pathway for upland wildlife exposed to PFOS in soil is considered a complete but insignificant pathway based on currently available screening levels, and further evaluation at this time is not warranted.

The findings of the Tier 2, Step 3a evaluation indicated a low potential for risk to aquatic-dependent mammals and highly piscivorous birds based on the relatively low HQs in consideration of the conservative nature of the exposure and toxicity parameters applied in the site-specific food web models developed for the selected target species: great blue heron, belted kingfisher, osprey, otter, and mink. All HQs were less than 1 for the otter, mink, osprey, and great blue heron, while the NOAEL toxicity reference value (TRV)-based HQ was greater than 1 for the belted kingfisher (LOAEL TRV-based HQ less than 1). Therefore, a site-specific surface water screening level was back-calculated for the belted kingfisher to be protective of all aquatic-dependent birds and mammals that could be exposed to site-related PFOS.

The outcome of the sample-by-sample comparison of the site surface water data to the site-specific screening level for the belted kingfisher (0.28 microgram per liter [µg/L]) indicated a low potential for risk to omnivorous aquatic birds from exposure to PFOS in surface water, with recognition of the level of uncertainty introduced by the use of literature-based water-to-invertebrate bioconcentration factors (BCFs) and BAFs for fish that may or may not be reflective of actual conditions in the vicinity of the site.

The sample-specific HQs for the kingfisher for the two 2016 samples collected in on/near the site drainages were less than 1. Risk estimates for the kingfisher for the off-site creek and bay samples collected in 2018 were slightly elevated in samples collected immediately downstream, west of Bay Head Road (HQs approximately ≤ 2), with decreasing HQs farther downstream towards the bay (HQs < 1). Maximum detected concentrations of PFOS occur in samples collected approximately 400 ft and 700 ft upstream of where the creek empties into the Little Magothy River. The 2018 off-site samples demonstrate delineation of the downstream extent of the off-site PFOS migration, with risk estimates at acceptable levels for the kingfisher beyond this area immediately downstream of the site, as the creek widens into the broader channel of the Little Magothy River. The off-site creek samples with the highest PFOS concentrations in surface water may not provide ideal foraging conditions for the belted kingfisher, but the samples farther downstream that do not exceed the site-specific surface water screening level may provide more suitable habitat for this receptor in terms of the types of invertebrates and fish present.

Given the low HQs for the belted kingfisher using conservative exposure assumptions (e.g., local population obtains 60% of total daily dose from the site), the bioaccumulation pathway for aquatic-dependent wildlife exposed to PFOS in surface water is considered a complete but insignificant pathway based on the currently available exposure and effects data, with recognition of the level of uncertainty introduced by the use of literature-based BAFs. The selected BAFs are, however, expected to err on the conservative side based on a comparison to the BAFs used to derive the generic surface water screening levels for birds and mammals, reducing the potential for underestimation of exposure and risk. Additionally, these results for PFOS are expected to also apply to PFOA, which studies have demonstrated has a much lower capacity for bioaccumulation in the aquatic food web. Therefore, based on this evaluation, at this time no further evaluation is warranted for ecological receptors potentially exposed to PFAS associated with the site.

1. INTRODUCTION

This appendix presents an ecological risk assessment (ERA) conducted for the Former Bay Head Road Annex (BHRA) facility in Annapolis, Maryland (site). The ERA was conducted as part of the Remedial Investigation (RI) report, which is being submitted on behalf of the Naval Facilities Engineering Command (NAVFAC) Washington, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62742-17-D-1800, Contract Task Order (CTO) F4822. The site location is shown on **Figure 1** and detailed site information is presented in the RI Report.

The scope of this ERA is limited to per- and polyfluoroalkyl substances (PFAS) compounds (specifically perfluorooctane sulfonate [PFOS], perfluorooctanoic acid [PFOA], and perfluorobutanesulfonic acid [PFBS]) in soil, sediment, and surface water attributable to past operations at the site. This ERA includes an assessment of potentially complete exposure pathways in the upland portion of the site that currently supports recreational use, as well as the on-site drainages features and downstream off-site aquatic habitats that meander through residential areas before discharging into the into a bay on the Little Magothy River.

1.1 OBJECTIVES

The primary objective of this ERA is to evaluate whether chemicals of potential concern (COPCs) attributable to past operations have the potential to cause unacceptable adverse risk to ecological receptors. The specific objectives of the ERA are as follows:

- Determine whether any complete exposure pathways associated with soil, sediment, and/or surface water exist at the site.
- For areas with complete exposure pathways, compare the concentrations of chemicals detected in site media to ecological risk-based screening criteria to determine the site COPCs for further evaluation.
- Evaluate chemicals found to exceed screening criteria for potential to cause unacceptable adverse risk to ecological receptors.

This ERA focuses on upland exposure pathways originating from soil, and aquatic exposure pathways originating from sediment and surface water. Chemicals in soil may be contacted directly by terrestrial plants and soil invertebrates living in and on the soil. Similarly, chemicals in sediment may be contacted directly by benthic organisms that reside in and on the sediment surface, and aquatic organisms (plants, water-column invertebrates and fish) may have direct contact with chemicals in surface water. Wildlife foraging within the site could also be exposed directly to chemicals in soil, sediment, or surface water through incidental ingestion of these media while grooming and foraging, and indirectly by ingestion of contaminated prey items.

1.2 APPROACH FOR THE ERA

The ERA was conducted in accordance with Navy and United States Environmental Protection Agency (USEPA) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) risk assessment guidance and policies. The ERA was conducted in accordance with *Navy Policy for Conducting Ecological Risk Assessments* and *Navy Guidance for Conducting Ecological Risk Assessments* (DON, 1999a,b). This approach is consistent with the eight-step tiered approach to ERA presented in *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final* (USEPA, 1997). Additional guidance documentation includes, but is not limited to, the following:

- *Department of the Navy Environmental Restoration Program (NERP) Manual* (DON, 2018)

- *Navy Policy on the Use of Background Chemical Levels* (DON, 2004)
- *Navy Policy on Sediment Site Investigation and Response Action* (DON, 2002)
- *Guidelines for Ecological Risk Assessment* (USEPA, 1998)
- *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA, 2001a)

As described in Navy guidance (DON, 1999a,b), a three tiered approach that incorporates different levels of assessment complexity is used to evaluate the potential for ecological risk. The tiered approach may be implemented in its entirety depending upon the level and magnitude of risk that is determined in prior tiers. This approach consists of the following tiers:

- Tier 1 – Ecological Screening Risk Assessment (SRA)
- Tier 2 – Baseline Ecological Risk Assessment (BERA)
- Tier 3 – Risk Evaluation of Remedial Alternatives

The ERA has been structured according to U.S. Navy policy (DON, 1999a,b) so that it fulfills both the requirements of an eight step USEPA ERA (USEPA, 1997) and a U.S. Navy ERA. This includes the Tier 1 SRA, which is consistent with Steps 1 and 2 of the USEPA process, and the first step of the Tier 2 BERA, which is consistent with Step 3a of the USEPA process.

Step 3a refines the list of COPCs that are initially selected during Step 2 of the USEPA process. Steps 3b through 7 consist of additional site-specific investigations/biological studies. Steps 3b through 7 are conducted if additional evaluations or investigations are necessary. Aspects of Step 8, risk management, are addressed throughout the ERA process, in cooperation with state and USEPA regulators. The Navy Tier 3 evaluation will be presented separately, if warranted.

1.3 REPORT ORGANIZATION

This risk assessment report is organized into the following sections:

- Section 1.0: Introduction
- Section 2.0: Analytical Data Summary
- Section 3.0: Tier 1 Ecological Screening Risk Assessment
- Section 4.0: Tier 2 Step 3a – Refinement of COPCs
- Section 5.0: Summary and Conclusions
- Section 6.0: References

2. ANALYTICAL DATA SUMMARY

This section summarizes the available environmental data (soil, sediment, and surface water) and discusses how the analytical data were compiled and summarized for evaluation in the ERA. Sampling was conducted on and in the vicinity of the site during multiple stages of investigation. Detailed discussions of the sampling events performed as part of each phase of site investigation and the nature and extent of PFAS in site media are provided in Sections 3 and 4 of the RI report, respectively.

The purpose of this section is to identify the data used to assess the type and amount of chemicals present at the site and to select the COPCs for the ERA.

2.1 SUMMARY OF ANALYTICAL DATA EVALUATED IN THE RISK ASSESSMENT

A brief description of the soil, sediment, and surface water data evaluated in the risk assessment is provided below. Summary tables of analytical data evaluated in the risk assessment are presented in **Attachment A**.

PFAS testing of soil, groundwater, surface water and sediment was conducted on samples collected within the site boundary and in the adjacent wooded area to the north (**Figure 2**). Results of this sampling indicate that PFOS and PFOA are present in all media sampled. Groundwater data were not evaluated in the ERA since ecological receptors are typically not directly exposed to groundwater and surface water data are available for evaluation within the potential aquatic habitat on and near the site. Sub-surface soil was not evaluated in the ERA since ecological receptors are more frequently exposed to surface soil.

Surface soil samples (0 to 1 foot [ft] below ground surface [bgs]) collected in November 2016 and January 2017 from 12 on-site locations within the former facility area were evaluated in the ERA. Ten samples were collected in the vicinity of the Former Burn Pad (FBP) and encompass approximately 0.39 acres and two samples were collected approximately 710 ft to the southwest of the FBP. In addition, sediment samples collected from four locations and surface water samples collected from two locations in November and December 2016 from the drainage channels east of Bay Head Road adjacent to the former facility (on/near-site) were also evaluated.

Off-site PFAS testing of surface water and sediment was conducted in April 2018 along the creek draining from the BHRA site into a bay on the Little Magothy River. This effort entailed the collection and analyses of collocated surface water and sediment samples at five locations. Results indicate that PFAS are present in both media and suggest that off-site PFAS migration is occurring via site surface water runoff and groundwater discharge into the creek entering the southwest end of Little Magothy River.

The Navy conducted additional PFAS testing along the creek and at the discharge into the river in November 2018. Additional surface water and sediment sampling for PFAS analyses was conducted at locations depicted on **Figures 2 and 3**, as follows:

- Recollected collocated surface water and sediment samples at the five previously sampled locations (SWSD-18-01 through -05) along the creek draining into the river to evaluate seasonal variability in PFAS concentrations.
- Collected surface water and sediment samples at three additional locations along the creek (SWSD-18-06, -07, and -24) based on the presence of seeps identified during the thermal infrared (TIR) spectroscopy survey to potentially refine the area of BHRA site groundwater discharge into the creek.

- Collected an additional 16 (SWSD-18-08 through-23) collocated surface water and sediment samples at approximate 100-ft intervals as indicated on **Figures 2 and 3** along the River shoreline within the bay.
- Collected collocated surface water and sediment samples at all 24 locations during the low tidal stage and collected an additional round of surface water samples only at the high tidal stage at all locations except SWSD-18-01, -02, -06, -07, and -24, which are above tidal influence.

In summary, the 29 sediment and 48 surface water samples (and associated field duplicate samples) collected off-site in April and November 2018 downstream of the BHRA (west of Bay Head Road) were evaluated in the ERA. Samples for both media, including quality control samples, were analyzed for PFAS via USEPA Modified Method 537. Data for all PFAS analyzed under this method were reported, and only data for PFOS, PFOA, and PFBS were included in the quantitative risk evaluation.

Analytical results for samples used in the ERA are presented in **Attachment A** and **Figures 2 and 3** identify the soil, sediment, and surface water sampling locations. These datasets are summarized in **Tables 1 through 3**.

2.2 DATA TREATMENT

Analytical data were evaluated, validated, and qualified prior to use in the risk assessment. A “Stage 2A” level data validation was completed on all PFAS compounds. Data validation included a comparison of the site data to corresponding blank (laboratory, field, equipment, and trip) concentration data. Estimated concentrations are those generated from samples containing PFAS above the detection limit, but below the limit of quantitation. These concentrations were “J” qualified and were used in the risk assessment without modification. Non-detect concentrations are those generated from samples that did not contain PFAS at or above the detection limit. Non-detects were flagged with “U” or “UJ,” and the result was considered a non-detect value in the ERA. All analytical data were found to be of acceptable quality and appropriate for use as qualified in the ERA without limitations. No analytical results were rejected during the data validation process. Further details on data validation are provided in the ‘Summary of the Data Validation and a Quality Assurance Based Data Usability Assessment’, and data validation memos for all stages of the RI, which are included as Appendix D to the RI Report.

For sample locations in which a duplicate sample was also collected, the duplicate sample results were processed for use in the calculation of summary statistics. Duplicates were resolved as follows: (1) where both the sample and the duplicate results are not detected, the resulting value is the maximum limit of detection (LOD); (2) where both the sample and the duplicate result are detected, the resulting value is the maximum of the detected results; and (3) where one of the pair is reported as not detected and the other is detected, the detected concentration is used.

Analytical data for site media were compiled into summary statistics. For each chemical detected at least once, the summary statistics include frequency of detection, range of detection limits, range of detected concentrations, mean of detected concentrations, and location of maximum detected result. The following guidance documents were used to develop the summary statistics:

- *U.S. Navy Human Health Risk Assessment Guidance* (DON, 2008)
- *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual, Parts A and D* (USEPA, 1989; 2001b)
- *Navy Guidance for Conducting Ecological Risk Assessments* (DON, 1999a,b).

The summary statistics for surface soil, sediment, and surface water are provided in **Tables 1 through 3**, respectively. All soil data were collected on-site. For sediment, the data were divided into two groups based on proximity to the site: creek - on/near site (east of Bay Head Road) and bay and creek (west of Bay Head Road). For surface water, the data were grouped as follows based on proximity to the site and tidal stage: All 2016 Data for Creek - On/Near Site (east of Bay Head Road), and the 2018 data from the Bay and Creek (west of Bay Head Road) were further categorized into All 2018 Surface Water Data, Non-Tidal Surface Water (Creek), High Tide Surface Water (Little Magothy River), and Low Tide Surface Water (Little Magothy River).

3. TIER 1 ECOLOGICAL SCREENING RISK ASSESSMENT

The primary objective for a Tier 1 SRA is to determine which, if any, exposure pathways and COPCs warrant further evaluation in a more refined ERA. The Navy Tier 1 ecological SRA process can be described in two steps. Step 1 is equivalent to Step 1 of the USEPA (1997) ERA process and includes a site description, pathway identification/problem formulation, and toxicity evaluation. The goals of this step are to describe the ecological setting of the site and determine whether complete ecological exposure pathways are potentially complete. Step 2 of the Navy Tier 1 ecological SRA process is equivalent to Step 2 of the USEPA (1997) ERA process. First, potential exposure is evaluated based on conservative assumptions. Then, risk is estimated by comparing the chemical concentrations detected in each medium of concern to conservative, screening-level, medium-specific benchmark criteria.

After Step 2 in the risk assessment process, a Scientific/Management Decision Point (SMDP) is normally reached to determine whether exit criteria for Tier 1, Step 2 have been met. The potential outcomes of the SMDP are as follows:

- The site passes the ecological SRA based on an absence of complete exposure pathways and/or an absence of unacceptable risks (i.e., all maximum concentrations less than benchmarks). Under these conditions, the decision is made that the site poses no unacceptable risks to ecological resources, further ERA or site remediation is unwarranted, and the site may be closed out for ecological concerns.
- The site fails the ecological SRA on the basis that complete pathways and potential unacceptable risks are indicated for at least one chemical. Under these conditions, the decision is made to either initiate interim cleanup or proceed to Tier 2 of the ERA process. The Tier 1 process also identifies those chemicals that should be retained for further consideration and those chemicals that can be eliminated from the risk assessment.

Based on the results of the Tier 1 ecological SRA described in Section 3.2.3.1 a preliminary Tier 2, Step 3a BERA was conducted to further assess the potential for adverse effects to ecological receptors at the site. If necessary, a SMDP conference with the regulatory and Navy risk managers will be scheduled to discuss the Tier 2 results. The Preliminary Tier 2 assessment will be revised in response to regulatory comments.

3.1 STEP 1 – SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION

Problem formulation is the first step of an ERA. The problem formulation process enables the risk assessor to identify the ecological resources to be protected (known as assessment endpoints); the measurements that were used to evaluate risks to those resources (known as measures of effects); and the chemicals, geographic areas, and environmental media relevant to the risk assessment.

3.1.1 Environmental Setting

The site is located in Anne Arundel County, Maryland, approximately five miles northeast of the City of Annapolis (**Figure 1**). The site was a former Nike missile facility used by the Army for Nike missile defense operations from 1954 until 1969. The Army closed the Nike missile facility and removed the missiles in 1969, and transferred the site to the Navy in the early 1970s. The Navy used the site for research, consisting primarily of burn testing to determine heat resistant properties of materials used onboard Navy ships. Materials were burned in a concrete pit at the Former Burn Pad (FBP) and analyzed for off- gas production and fire hazard potential. The Navy's operations at the site ended in the late 1990s. In 1995, the Naval Surface Warfare Center - Annapolis Detachment (including the site) was scheduled for closure under Base Realignment and Closure IV. The site was officially closed in December 1999 (DON, 2001). The base closure process for the site was completed, including substantive removal or decommissioning of all remaining Army Nike missile facility structures and the Navy concrete burn pit by early 2003, with the transfer of the property to the Department of the Interior, and subsequently conveyance of the site to Anne Arundel County in September 2003.

Currently, nearly all of the upland portions of the site have been cleared of trees and developed, with only a small portion along the north covered in natural vegetation (**Figure 2**). The site is currently the location of Bay Head Park, including the Children's Theater of Annapolis, the Infinity Theater, and recreational areas (i.e., two ballfields, a picnic pavilion, and a restroom/locker room located in the southern portion of the site). A septic system is located between the ballfields. This septic system, which includes drain and leaching fields, serves the pavilion between the two ballfields (DON, 2001).

The site is approximately twenty-four acres and located on the peninsula between the Magothy and Severn Rivers, less than two miles from the Chesapeake Bay. There are no permanent water bodies at the site. Surface water runoff from the site is directed to the on-site stormwater drainage system, located east of the Bay Head Road. The on-site drainage system runs intermittently and discharges to an off-site drainage ("unnamed tributary") that continues on the western side of Bay Head Road. The unnamed tributary discharges into a wetland and creek, which discharge to the Little Magothy River and ultimately to the Chesapeake Bay. Depth to groundwater at the site ranges from nine to sixteen ft. Groundwater flow is estimated at 0.48 ft/day and generally flows to the northwest toward the off-site northwesterly flowing tributaries, which discharge to the Little Magothy River (DON, 2001).

The Little Magothy River runs approximately 2.5 miles and is a Chesapeake Bay tidal freshwater tributary. The Little Magothy River is bordered by the community of Cape Saint Claire to the west and residential homes and farmland along Bay Head Road to the east. The site is located southeast of the Little Magothy River. Chesapeake Bay's tidal freshwater tributaries provide habitat for a range of benthic invertebrates, shellfish, and fish. Freshwater trophic level (TL) 2/3 fish include mummichog (*Fundulus heteroclitus*), American shad (*Alosa sapidissima*), hickory shad (*Alosa mediocris*), blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), carp (various species), channel catfish (*Ictalurus punctatus*), crappie (*Pomoxis sp.*), American eel (*Anguilla rostrata*), and shortnose Atlantic sturgeon (*Acipenser brevirostrum*); while freshwater TL 3/4 fish include yellow perch (*Perca flavescens*), white perch (*Morone americana*), striped bass or rockfish (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), trout (various species), walleye (*Sander vitreus*), northern pike (*Esox lucius*), chain pickerel (*Esox niger*), and muskellunge (*Esox masquinongy*) (Maryland Fishing and Crabbing, 2019; Chesapeake Bay Foundation [CBF], 2019a). Documented sport fish caught in the Little Magothy River include yellow perch and striped bass (Hook and Bullet, 2014).

Waterfowl and other migratory birds that utilize the Chesapeake Bay watershed for foraging and shelter include the common loon (*Gavia immer)*, tundra swan (*Cygnus columbianus*), Canada geese (*Branta canadensis)*, and various ducks. It is also a nesting area for the bald eagle (*Haliaeetus leucocephalus*), brown pelican (*Pelecanus occidentalis*), double-crested cormorants (*Phalacrocorax auritus*), and, with over 2,000 nesting pairs, the Chesapeake Bay has the world's largest population of osprey (*Pandion haliaetus*) (CBF, 2019a). Year-round avian residents of the watershed include the great blue heron (*Ardea herodias*) and the belted kingfisher (*Megaceryle alcyon*) (Maryland Department of Natural Resources [MDNR], 2019a; Cornell University, 2017a).

Aquatic mammals present in the Chesapeake Bay include river otters (*Lutra canadensis*), bottlenose dolphins (*Tursiops sp.*), harbor seals (*Phoca vitulina)*, and whales (CBF, 2019a). Semi-aquatic river otters are common throughout tidal areas of Maryland and live in a variety of habitats including streams, fresh and salt water marshes, rivers, and lakes (MDNR, 2019b). Upland mammalian species in the Chesapeake Bay watershed include the white-tailed deer (*Odocoileus virginianus*), sika deer (*Cervus nippon*), bobcat (*Lynx rufus*), marsh rabbit (*Sylvilagus palustris*), muskrat (*Ondatra zibethicus*), and red fox (*Vulpes vulpes*). Mink (*Neovison vison*) are present throughout much of Maryland, except along the Eastern shore (MDNR, 2019c). There have been no reports of mink in the area of Bay Head Park or generally in the Annapolis area (MDNR 2019d).

Various reptiles and amphibians are present in the Chesapeake Bay watershed, including the diamond back terrapin (*Malaclemys terrapin*), loggerhead turtle (*Caretta caretta*), northern green frog (*Lithobates clamitans melanota*), and numerous other species of frogs, toads, snakes, salamanders, and newts (CBF, 2019a).

Attachment B provides a log of photographs that have been taken of the creek and wetland areas present downgradient of the BHRA, on the west side of Bay Head Road. As indicated in the photographs, portions of the creek are shallow and narrow. These shallow portions of the creek may be ephemeral (only contains water during portions of the year) and are unlikely to provide significant habitat for fish or piscivores. Further downstream, the photographs show a larger tidal creek/wetland system that discharges into an embayment of the Little Magothy River.

3.1.2 Potential Sources of Contamination

Potential sources of contamination, nature and extent of contamination, and fate and transport mechanisms are discussed in detail in the RI Report. In general, sources of environmental contamination are related to historical use of aqueous film-forming foam (AFFF) used in firefighting equipment testing and training.

Primary sources include PFAS releases from historical operations of the AFFF fire suppression system at the FBP and the associated evaporation pond. Potential secondary source areas include PFAS-impacted soil/sediment erosion and overland stormwater runoff within site drainage features (grass-lined swales that discharge to the drainage feature to the north of the site). The regrading of PFAS-impacted silt soils during redevelopment of the site is also a possible secondary source of PFAS.

3.1.3 Potential Exposure Pathways

Exposure pathways differ in importance from species to species and from site to site. It is anticipated that ecological receptors may come in contact with soil in the upland habitat and sediment and surface water in the aquatic habitats, especially those off-site farther downstream from the former facility.

The following exposure pathways were evaluated in the ERA:

- Soil invertebrates and terrestrial plants directly exposed to PFAS in soil in the vicinity of the former fire testing area of the former facility.
- Terrestrial birds and mammals exposed to PFAS in soil in the vicinity of the former fire testing area of the former facility through incidental ingestion of soil and by ingestion of contaminated prey items impacted by soil.
- Benthic invertebrates and aquatic (water-column) organisms directly exposed to PFAS in surface sediment and surface water in the on-site drainage features and off-site wetlands, the unnamed creek, and the Little Magothy River.
- Aquatic-dependent birds and mammals exposed to PFAS through incidental ingestion of sediment or surface water, and by ingestion of contaminated prey items impacted by sediment

or surface water in the on-site drainage and off-site wetlands, the unnamed creek, and the Little Magothy River.

3.1.4 Assessment Endpoints and Measures of Effect

Assessment endpoints describe the characteristics of an ecosystem that have an intrinsic environmental value that is to be protected (e.g., protection of piscivorous bird community). Typically, assessment endpoints and receptors are selected for their potential exposure, ecological significance, economic importance, and/or societal relevance. Because the SRA represents a very conservative screening level assessment, the assessment endpoints are stated in generic terms. Assessment endpoints are critical to problem formulation, because they link the risk assessment to management concerns and are central to refining the conceptual site model (CSM) (USEPA, 1997).

Because assessment endpoints often cannot be measured directly, measures of effect are a set of surrogate endpoints used to provide a quantitative metric for evaluating potential effects of chemicals on the ecosystem components potentially at risk. Measurement endpoints provide the actual measurements used to evaluate ecological risk and are selected to represent mechanisms of toxicity and exposure pathways.

Ecological receptors are defined as plant and animal populations, communities, habitats, or sensitive environments. The following assessment endpoints, and their associated measures of effect, were considered in the ERA.

Assessment Endpoint	Measures of Effect
Protection and maintenance of plant and soil invertebrate communities within the terrestrial habitat at levels similar to those of nearby populations not exposed to site-related chemicals.	Comparison of soil PFAS concentrations collected in the upland portion of the site to soil screening levels protective of direct toxicity to plants and invertebrates.
Protection and maintenance of terrestrial wildlife receptors (i.e., wildlife receptors expected to forage within the upland area) at levels similar to those of nearby populations not exposed to site-related chemicals.	Comparison of soil PFAS concentrations collected in the upland portion of the site to soil screening levels protective of dietary toxicity (bioaccumulation) to birds and mammals.
Protection and maintenance of benthic invertebrate communities within the unnamed creek and Little Magothy River at levels similar to those of nearby populations not exposed to site-related chemicals.	Comparison of sediment PFAS concentrations collected in the vicinity of the site to direct toxicity freshwater sediment screening levels.
Protection and maintenance of aquatic organism communities within the unnamed creek and Little Magothy River at levels similar to those of nearby populations not exposed to site-related chemicals.	Comparison of surface water PFAS concentrations collected in the vicinity of the site to direct toxicity freshwater surface water screening levels.
Protection and maintenance of semi-aquatic wildlife receptors (i.e., wildlife receptors expected to forage within the unnamed creek and Little Magothy River) at levels similar to those of nearby populations not exposed to site-related chemicals.	Comparison of surface water PFAS concentrations collected in the vicinity of the site to freshwater surface water screening levels for PFAS protective of dietary toxicity to birds/mammals. If dietary toxicity screening levels are exceeded, comparison of calculated total daily dose (TDD) from exposure to PFAS in surface water, sediment, and ingestion of contaminated prey items to chemical-specific toxicity reference values (TRVs).

Screening on the basis of toxicity due to direct exposure in the SRA was done by comparing the maximum detected site concentrations against appropriate risk-based soil, sediment, and surface water screening levels. The risk-based screening levels used in the SRA are discussed in Section 3.2.1.

Food web models were used to assess risks to aquatic-dependent mammals and birds due to the outcome of the Step 2 screening, potential for PFOS to bioaccumulate in the aquatic food web, and high level of uncertainty in the bioaccumulation-based screening levels for this chemical. PFOS also has the potential to bioaccumulate in terrestrial habitats, but not to the same degree and fewer bioaccumulation studies are available for terrestrial dietary components. Bioaccumulation-based measures of effects corresponding to the survival, growth, and reproductive assessment endpoints for indirect exposure of representative aquatic-dependent wildlife species (i.e., birds and mammals) were identified and are discussed in Section 3.2.2. The expected exposure of the representative species was modeled from measured PFOS concentrations in off-site sediment and surface water to estimate the measurement endpoint (ingestion/uptake) in the representative species. The expected exposure was compared to the TRVs to estimate the likelihood of adverse effects to birds and mammals potentially foraging in the Little Magothy River and its tributaries.

3.1.5 Conceptual Site Model

An ecological CSM was developed to provide a clear and concise description of how ecological receptors may come into contact with site-related COPCs via release mechanisms and exposure to soil, sediment, and/or surface water. The ecological CSM presented in **Figure 4** provides the framework for the ERA and is used to identify appropriate exposure pathways and receptors for evaluation in the risk assessment.

The primary source of PFAS contamination at the site is the historical use of AFFF for firefighting equipment testing and training. Soil may have been impacted by these former site activities and by the regrading of PFAS-impacted silt soils during redevelopment of the site. , Surface water and sediment in nearby drainage features may have been impacted via surface runoff or stormwater discharges. Further downstream transport to the wetland and larger riverine environment may have also occurred.

Chemicals in soil may be contacted directly by terrestrial plants and invertebrates living in the soil or on the soil surface. Chemicals in surface water and sediment may be contacted directly by fish and aquatic and benthic invertebrates living in the water column or sediment. Wildlife foraging within the study area (i.e., on-site and off-site) could also be exposed directly to chemicals in these media through incidental ingestion and indirectly by ingestion of contaminated prey items.

3.2 STEP 2 – SCREENING LEVEL EXPOSURE ESTIMATE AND RISK QUOTIENTS

As described in Section 2.1, PFAS were analyzed for in 12 surface soil samples collected from the upland area of the former facility, as well as four surface sediment and two surface water samples from the adjacent drainage features located to the east of Bay Head Road. Upland surface soil characterization was primarily targeted in the area where former fire/burn testing activities occurred and, therefore, these data represent worst-case conditions for terrestrial ecological receptors. In addition, 29 sediment and 48 surface water samples were collected from the off-site, downstream wetland and riverine system located to the west of Bay Head Road.

3.2.1 Ecological Effects Evaluation

The preliminary ecological effects evaluation is an investigation of the relationship between the exposure to a chemical and the potential for adverse effects resulting from exposure. In this step, conservative ecological screening levels for soil, sediment, and surface water are identified.

These values are expressed as concentrations (in microgram/kilogram [µg/kg] on a dry weight [dw] basis for soil and sediment and microgram/liter [µg/L] for water) of a chemical believed to have little or no effect on the long-term health of the representative species of concern. **Table 4** identifies the media-specific ecological screening levels for PFOS, PFOA, and PFBS.

3.2.1.1 ECOLOGICAL SCREENING LEVELS

For the surface soil, sediment, and surface water datasets, the maximum detected concentrations of PFOS, PFOA, and PFBS were compared to the most currently available ecological screening levels to assess the potential for risks to ecological receptors. Chemicals detected above these screening levels were identified as COPCs for further evaluation in the Tier 2 BERA.

The selected ecological screening levels typically focus on protecting the majority of the exposed communities (e.g., 95 percent [%] of exposed taxa) from adverse effects related to survival, growth and reproduction under conditions of chronic or sensitive life-stage exposure. Ecological screening levels for PFAS have not yet been developed by USEPA or other federal agencies, and therefore, were identified based a review of the available literature. Since the receiving area of the Little Magothy River is a tidally-influenced brackish habitat, both freshwater and marine screening values for sediment and surface water were considered to address the range of potential aquatic receptors and their relative sensitivities.

Soil. Recent Canadian federal environmental quality guidelines were selected preferentially as screening levels for soil (Environment and Climate Change Canada [ECCC], 2017), when available. The following soil screening levels were selected for the SRA:

- Canadian Environmental Quality Guidelines (CEQGs) for PFOS (ECCC, 2017) – PFOS, direct toxicity to plants and soil invertebrates, dietary (bioaccumulation) toxicity to birds and mammals
- Maximum permissible concentrations (Predicted No-Effects Concentrations [PNECs]) for the United Kingdom (U.K. Environment Agency, 2017) – PFOA, direct toxicity to plants and soil invertebrates, dietary (bioaccumulation) toxicity to mammals
- No adverse effects concentrations published in *Perfluoroalkylsulfonic and carboxylic acids in earthworms (Eisenia fetida): Accumulation and effects results from spiked soils at PFAS concentrations bracketing environmental relevance* (Karnjanapiboonwong et al., 2018) – PFBS, direct toxicity to plants and soil invertebrates

Soil screening levels or reasonable surrogates were available for all three PFAS to address the potential for direct toxicity to the plant and soil invertebrate communities. Similarly, soil screening levels or surrogates were available for PFOS and PFOA to address the potential for dietary toxicity to wildlife exposed via bioaccumulation. Soil screening levels for birds and mammals were not identified for PFBS, and no appropriate (i.e., short-chain PFAS) surrogates are available. Lack of dietary-based soil screening levels for PFBS is not considered a significant uncertainty given that short-chain PFAS are not expected to bioaccumulate in terrestrial animal tissues to a significant degree and due to the short biological residence time making the potential for chronic effects in animals questionable (Danish Environmental Protection Agency [DEPA], 2015; Agency for Toxic Substances and Disease Registry [ATSDR], 2018).

The CEQGs provide benchmarks for the quality of the ambient environment based solely on the toxicological effects or hazard of PFOS (ECCC, 2017). These screening levels for plants, invertebrates, birds, and mammals are not effluent limits or “never-to-be-exceeded” values but may be used to derive them. Therefore, they are appropriately conservative for the SRA and were preferred as the only screening levels identified from a North American federal agency.

In the absence of North American screening levels for PFOA, the soil criteria for plants, invertebrates and mammals presented by the U.K. Environment Agency (2017) were selected. These criteria represent PNECs corresponding to the environmental concentration below which no adverse ecotoxicological effects of exposure on soil organisms, ecosystems and function are expected.

No soil screening levels were identified for PFBS, and therefore the primary literature was consulted. During this focused literature search, several studies on uptake of PFBS into plants (crops) from soils and biosolids were identified, but the only phytotoxicity study found for PFBS indicated it to be practically non-toxic to algae (DEPA, 2015). For soil invertebrates, one recent study was identified in which a no observed effect concentration (NOEC) of 1,000 mg/kg for earthworm growth was established (1,000,000 µg/kg; $p>0.05$), and very limited effects on survival were observed during this 21-day study (2.5% decrease from control) (Karnjanapiboonwong et al., 2018). Given the lack of mortality and sublethal effects for this known sensitive test species that has intimate contact with soil constituents, this study was selected to estimate the potential for adverse effects to community-level receptors from exposure to PFBS in soil. Uncertainty factors of 10 to address the sublethal exposure duration and 10 to account for the singular test species were applied to generate a final soil screening level of 10,000 µg/kg for use in this ERA.

Although soil screening levels for birds were not identified for PFOA, the avian screening level for PFOS is a reasonable surrogate to consider for PFOA. Limited avian toxicity data are available for PFOA, and some studies suggest that PFOA may have adverse effects to reproductive and developmental endpoints that are similar to those endpoints observed for PFOS, i.e., reduced hatching success, decreased chick survival, behavioral effects, *etc*. (Yanai et al., 2008; Pinkas et al., 2010; O’Brien et al., 2009; Nordén et al., 2016). The modes of action for PFOS and PFOA are still under study, are not well understood, and may not necessarily be exactly similar; however, given that both are of the same chemical class and similar adverse effects in birds have been observed for PFOS and PFOA in some studies, PFOS is considered to be a reasonable surrogate for PFOA. The uncertainties regarding the use of PFOS as a surrogate for PFOA is discussed in Section 4.5.1.

The soil screening levels for wildlife assume exposure to PFAS in prey items (e.g., earthworms that have bioaccumulated PFAS) through the food chain. These screening levels are subject to a high level of uncertainty, due to the use of assumed bioaccumulation factors (BAFs), safety factors and derived TRVs, and food and water ingestion rates resulting in extremely low soil screening levels that are likely to be unnecessarily conservative and exceedances of such conservative values do not mean that adverse effects have already occurred or are likely to occur, but only that additional evaluation may be warranted.

Sediment. One sediment screening level was identified in the available literature: a PNEC for marine environments developed by the Norwegian Pollution Control Authority (NPCA, 2008). This PNEC for PFOS was selected as the sediment screening level protective of direct toxicity to the marine benthic community. Concentrations below this level are classified as “Good/No toxic effects” and are not associated with toxic effects on benthic invertebrates although no specific toxicity information is provided.

The available surface water screening levels based on direct toxicity to aquatic organisms indicate that PFOS is the most toxic of the three PFAS evaluated. Therefore, it is reasonable to consider the sediment screening level for PFOS as a surrogate for PFOA and PFBS, with the acknowledgement that this approach results in an overestimate of ecological hazards from exposure to PFOA and PFBS.

Surface Water. Recent Canadian federal environmental quality guidelines were selected preferentially as screening levels for surface water (ECCC, 2018), when available. The following surface water screening levels were selected for the SRA:

- Canadian Environmental Quality Guidelines for PFOS (ECCC, 2018) – PFOS, direct toxicity to freshwater aquatic life
- Ecological screening levels for PFOS and PFOA developed for Australia (CRC CARE, 2017) – PFOS, direct toxicity to marine aquatic life; PFOA, direct toxicity to freshwater and marine aquatic life
- Chronic freshwater criteria published in *Aquatic Toxicology of Perfluorinated Chemicals* (Giesy et al., 2010) – PFBS, direct toxicity to freshwater aquatic life and dietary (bioaccumulation) toxicity to birds; PFOA, dietary (bioaccumulation) toxicity to birds
- Maximum permissible concentrations (equivalent to PNECs) for the Netherlands (National Institute for Public Health and the Environment [RIVM], 2010) – PFOS, dietary (bioaccumulation) toxicity to mammals

Surface water screening levels or reasonable surrogates were available for all three PFAS to address the potential for direct toxicity to the aquatic community and the potential for dietary toxicity to wildlife exposed via bioaccumulation. In the absence of specific criteria for marine habitats, the freshwater criteria may be considered.

The surface water CEQG for PFOS of 6.8 µg/L (ECCC, 2018) is similar to the value of 5.1 µg/L derived previously by Giesy et al. (2010). Toxicity to leopard frogs has occurred within the concentration range that has been shown to cause effects in fish and invertebrates (Giesy et al., 2010), therefore, it is assumed that the selected PFOS screening level is also protective of amphibians.

Although surface water screening levels for wildlife were not identified for PFOA, the avian and mammalian screening levels for PFOS are reasonable surrogates to consider for PFOA. Based on the fact that USEPA's human health advisory levels for PFOS and PFOA are the same, as similar effects on reproductive and developmental endpoints (among others) have been observed in mammals (USEPA, 2016a,b), it is reasonable to apply the PFOS screening level for mammals to PFOA as well. As discussed above, given that PFOS and PFOA are of the same chemical class and similar adverse effects in birds have been observed for PFOS and PFOA in some studies (Yanai et al., 2008; Pinkas et al., 2010; O'Brien et al., 2009; Nordén et al., 2016), PFOS is considered to be a reasonable surrogate for PFOA for the evaluation of potential effects on birds.

Similarly to the soil screening levels, the surface water screening levels for wildlife assume exposure to PFAS in prey items (e.g., fish that have bioaccumulated PFAS) through the food chain. These screening levels are also subject to a high level of uncertainty for the reasons previously described. The PFOS and PFBS screening levels for birds are protective of piscivorous birds such as herring gull, bald eagle, or osprey and may be overly protective of birds feeding on small fish and/or invertebrates (Giesy et al., 2010). Similarly, the screening level for mammals is conservatively based on the lowest identified toxicity value for mammals and assumes ingestion of upper-trophic-level fish that have bioaccumulated PFOS (RIVM, 2010). This results in extremely low surface water screening levels that are likely to be unnecessarily conservative and exceedances of such conservative values do not mean that adverse effects have already occurred or are likely to occur, but only that additional evaluation may be warranted. (See uncertainty assessment in Section 4.5.2 for an analysis of the bioaccumulation data used in these studies.)

3.2.2 Exposure Characterization

In order to conclude whether a chemical has the potential to impact an ecological receptor, a relevant chemical concentration or dose must first be determined. That concentration/dose is then compared to the ecological effects data presented above. For the SRA, the maximum detected concentration was evaluated as the exposure point concentration (EPC). Alternate EPCs were considered in Step 3a (see Section 4).

Mechanisms for exposure of a representative species to chemicals depend on the physical and behavioral characteristics of the organism. Most exposure for community-level receptors like plants and invertebrates can be loosely termed "direct contact." For example, invertebrates have in common the ability to absorb chemicals from soil, sediment, or water through external body surfaces or by intake of food or incidental ingestion of these abiotic media.

Wildlife species may be exposed to chemicals in soil, sediment, or surface water through direct incidental ingestion of abiotic media or indirectly by ingestion of contaminated food organisms. Information used to calculate exposure includes EPCs, species-specific exposure factors, chemical-specific exposure factors, and exposure equations.

3.2.3 Risk Characterization

The integration of toxicity and exposure information is used to predict possible adverse effects to ecological receptors. The hazard quotient (HQ) method is used to screen sites when potential adverse effects to ecological receptors occur.

To estimate risks to ecological receptors, screening level HQs were calculated by comparing the maximum detected concentration for each chemical (i.e., an estimate of exposure) to the appropriate media-specific screening level (i.e., an estimate of effects) using the following formula:

$$\text{HQ} = \text{Maximum detected concentration/ screening level}$$

Due to the consistently applied conservative assumptions implicit in a Tier 1 SRA the presence of HQs above 1 does not necessarily constitute ecological risk; only that additional consideration is warranted.

3.2.3.1 SELECTION OF CHEMICAL OF POTENTIAL CONCERN

The selection of initial COPCs is the final part of the Tier 1 SRA. Chemicals initially selected as COPCs were further evaluated in Step 3a to determine if they should be retained as final COPCs. The initial ecological COPCs were selected if the comparison of soil, sediment, or surface water data to screening levels resulted in HQs above 1.

Chemicals without screening levels were also initially selected as COPCs, but were evaluated only qualitatively.

The Tier 1 SRA risk calculation is a conservative risk estimate designed to ensure that potential ecological threats are not overlooked. At the end of this step, one of the following conclusions is made:

1) There is adequate information to conclude that ecological risks are negligible, and therefore no quantifiable ecological risk exists; or

2) There may be quantifiable ecological risk, and additional evaluations are required.

3.2.3.1.1 COPCs for Plants and Soil Invertebrates

The potential effects on terrestrial plants and soil invertebrates was evaluated by comparing maximum detected surface soil concentrations with direct contact soil screening levels (**Table 1**). Maximum concentrations of PFOS, PFOA, and PFBS in soil were less than these soil screening levels (i.e., all HQs were below 1), and no further evaluation is necessary to protect terrestrial community-level receptors.

3.2.3.1.2 COPCs for Terrestrial Birds and Mammals

The potential for effects on terrestrial birds and mammals was evaluated by comparing maximum detected surface soil concentrations with soil screening levels that account for exposure through plant and prey consumption and incidental ingestion of soil. The maximum concentration of PFOS in soil has a HQ of 14 (**Table 1**); therefore, this soil COPC is recommended for the Tier 2 evaluation to further assess the potential for risk to terrestrial wildlife. The maximum concentration of PFOA in soil results in an HQ below 1 so no further evaluation of PFOA is warranted to protect wildlife receptors.

Lack of a bioaccumulation soil screening level for PFBS is not considered a significant uncertainty given that the maximum detected concentration of PFBS in soil (0.21 µg/kg) was well below the lowest wildlife screening level values for PFOA and PFOS, and low potential for short-chain PFAS, like PFBS to bioaccumulate in animal tissues. For these reasons, PFBS was not retained as a soil COPC.

3.2.3.1.3 COPCs for Benthic Invertebrates

The potential for effects on benthic invertebrates residing in the sediment and on the sediment surface was evaluated by comparing maximum detected surface sediment concentrations from the on/near-site and off-site creek and bay samples with direct contact sediment screening levels. Maximum concentrations of PFOS, PFOA, and PFBS in sediment were less than the PFOS sediment screening level, which was used as a surrogate for PFOA and PFBS (**Table 2)**, and no further evaluation of PFOS and PFOA is necessary to protect the benthic community.

3.2.3.1.4 COPCs for Aquatic Organisms

The potential for effects on aquatic organisms residing in the water-column was evaluated by comparing maximum detected surface water concentrations in each of the five data groupings (2016 All Sediment Data, 2018 All Sediment Data, 2018 Non-Tidal Surface Water, 2018 High Tide Surface Water, and 2018 Low Tide Surface Water) with direct contact surface water screening levels (**Table 3**). Maximum concentrations of PFOS, PFOA, and PFBS in surface water were less than these direct toxicity surface water screening levels (i.e., all HQs were below 1**)**, and no further evaluation is necessary to protect aquatic organisms from direct exposure to PFAS in the water column.

3.2.3.1.5 COPCs for Aquatic-Dependent Birds and Mammals

The potential for effects on aquatic-dependent birds and mammals was evaluated by comparing maximum detected surface water concentrations with surface water screening levels that account for exposure through plant and prey consumption and incidental ingestion of surface water. Maximum concentrations of PFOS and PFOA in all of the surface water datasets evaluated (2016 All Sediment Data, 2018 All Sediment Data, 2018 Non-Tidal Surface Water, 2018 High Tide Surface Water, and 2018 Low Tide Surface Water) exceed the screening levels resulting in HQs greater than 1, using PFOS as a surrogate for PFOA (**Table 3**). Surface water HQs range from 6.5 to 254 for PFOS and from 5 to 204 for PFOA. Therefore, these surface water COPCs are recommended for the Tier 2 evaluation to further assess the potential for risk to aquatic-dependent wildlife.

Maximum concentrations of PFBS in all five of the surface water datasets were less than the wildlife screening level value for PFBS (**Table 3**); therefore, no further evaluation of PFBS is necessary to protect wildlife.

3.3 TIER 1 CONCLUSIONS/RECOMMENDATIONS

In this Tier 1 ecological SRA, it was determined that complete exposure pathways exist from surface soil, sediment, or surface water to plants, invertebrates (and potentially fish) or wildlife receptors. This assessment illustrated that there is a concern for ecological receptors from exposure to on-site surface soil and on-site and off-site surface water at the BHRA that warrants further attention. The following COPCs were retained for further evaluation:

- Terrestrial birds and mammals – PFOS in surface soil
- Aquatic-dependent birds and mammals – PFOS and PFOA in surface water

3.3.1 Tier 1, Step 2 Exit Criteria

One of three outcomes is possible at this point in the ecological SRA:

- There is adequate information to conclude that the ecological risks are negligible and, therefore, there is no need for remediation based on ecological risk.
- The information is not adequate to make a decision at this point, and the ERA process will continue to the Tier 2, Step 3a BERA.
- The information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted.

Maximum concentrations of PFOS in site surface soil and PFOA and PFOS in surface water may pose a potential risk to wildlife, with Tier 1 HQs greater than 1. Therefore, the surface soil and surface water pathways require further evaluation in a Tier 2 assessment.

3.3.2 Scientific/Management Decision Point

The Tier 1 ecological SRA is being submitted with the RI report for regulatory review. If necessary, an SMDP conference with the regulatory and Navy risk managers will be scheduled to discuss the Tier 1 results. Based on the results of the Tier 1 ecological SRA, the Navy has prepared a Tier 2, Step 3a BERA to further assess the potential for adverse effects to ecological receptors potentially exposed to PFAS associated with BHRA.

4. TIER 2 STEP 3A – REFINEMENT OF COPCS

The ecological SRA covered Tier 1, Steps 1 and 2, conducted in accordance with USEPA (1997) guidance. In this section, the preliminary Tier 2, Step 3a evaluation is presented, based on the data evaluated in the Tier 1 SRA but with site-specific adjustments to exposure and toxicity assumptions.

Because the Step 1 and 2 SRA yields very conservative results, and a complete BERA encompassing Steps 3 through 7 of the risk assessment process is a lengthy and complex process, USEPA recognized the possibility of an intermediate decision point based on a refinement of the COPCs following completion of the SRA (USEPA, 2001a). This decision point is called under Navy protocol Tier 2, Step 3a. Tier 2, Step 3a evaluates the same assessment endpoints as the Tier 1 SRA, but only for pathways and COPCs that failed to be eliminated in the Tier 1 SRA.

4.1 OVERVIEW OF TIER 2, STEP 3A PROCESS

The purpose of Tier 2, Step 3a is to re-evaluate COPCs that were retained from Tier 1 for further evaluation in a Tier 2 BERA, and to identify and eliminate from further consideration those COPCs that were retained because of the use of very conservative exposure scenarios. In this case, a good example is the conservative bioaccumulation-based soil and surface water screening levels for PFOS and PFOA. As described in Section 4.2, the Tier 1 ecological SRA risk estimates were re-calculated using more realistic Tier 2, Step 3a assumptions, for the pathways and COPCs retained at the end of the Tier 1 SRA.

These recalculated risk estimates were used to refine the list of COPCs identified in the Tier 1 ecological SRA. Step 3a of Tier 2 refines the Tier 1 ecological SRA by asking:

- Are high concentrations and risks widespread across the study area or limited to discrete locations (magnitude and extent of contamination and risk)?
- Could the COPC be in a chemical form that is less hazardous (bioavailability of the COPC)?
- Are the conservative exposure assumptions used in Tier 1 representative of site-specific exposure?

The Navy Step 3a re-evaluation/refinement process for the BHRA site follows these steps:

- Revise exposure assumptions and calculate Tier 2, Step 3a EPCs and HQ risk estimates.
- Conduct a sample-by-sample comparison to ecological screening levels to identify locations or clusters of locations with exceedances of the screening levels and assess the magnitude of the exceedance relative to the confidence in the screening level.
- Identify media, COPCs, and/or receptors with a HQ less than 1, or an elevated HQ of relatively low magnitude in light of the conservative nature of the bioaccumulation screening level, and eliminate from further evaluation.
- Review detection frequency to identify COPCs with low detection frequencies (and sufficient data for acceptable site characterization). If a COPC was detected in only a very small percentage of the samples collected (5% or less), the risk identified in the SRA may be over-estimated and further evaluation of the COPC is not warranted.
- For PFOS in surface water, use the Tier 2, Step 3a EPC in site-specific food web models for selected avian and mammals receptors using both NOAEL and LOAEL TRVs to provide a risk range for risk managers to consider.

- Evaluate the receptor-specific HQs generated for PFOS in surface water using selected literature-based BCFs and BAFs to formulate conclusions regarding the potential for exposure and risk to aquatic-dependent wildlife.
- Derive a site-specific screening level for surface water based on the PFOS food web model and use that value to evaluate surface water data.

After the re-evaluation/refinement, the decision criteria for Tier 2 Step 3a include:

- If the re-evaluation of the conservative exposure assumptions used in the SRA supports an acceptable risk determination for all COPCs, then a no further action (NFA) designation is warranted, and the site exits the ERA process.
- If the re-evaluation of the conservative exposure assumptions does not support an acceptable risk for all chemicals, the BERA process continues to Step 3b and subsequent steps, or to remedial decisions.

4.2 TIER 2, STEP 3A REFINEMENT APPROACH

One of the more realistic Tier 2, Step 3a adjustments is the use of an EPC that accounts for exposure across the range of concentrations, rather than at the maximum level considered in the SRA. The Tier 2, Steps 3a EPC is represented by the 95% upper confidence limit (UCL) on the arithmetic mean concentration or the maximum detected concentration, whichever is lower (USEPA, 2002). USEPA's ProUCL Version 5.1.002 software (USEPA, 2016c) was utilized to calculate 95% UCL on the arithmetic mean concentrations for COPCs. The ProUCL outputs for the surface soil and surface water datasets are provided in **Attachment D.**

The first phase of the Tier 2, Step 3a evaluation involved a comparison of the refined EPCs (i.e., UCLs) to the same screening levels used in the SRA to re-calculate HQs for specific media and receptors retained at the conclusion of the SRA. COPCs with HQs greater than 1 based on the UCLs were subjected to a sample-by-sample evaluation and a more intensive investigation of the data (e.g., detection frequency, magnitude of screening level exceedances, locations with exceedances, confidence in the screening levels, etc.) to build a weight of evidence upon which to base conclusions regarding the potential for ecological risk.

In addition to evaluating the UCL for surface water to refine the exposure assumptions in the Tier 2, Step 3a assessment, specific avian and mammalian wildlife receptors potentially exposed to PFOS in surface water near the site were selected and site-specific food web models compiled to generate exposure doses for these selected target receptors. NOAEL and LOAEL-based HQs were calculated with these Step 3a exposure doses to provide a range of risk estimates. Given the high potential for biomagnification of PFOS in the aquatic food web, which is reflected in the surface water screening levels for birds and mammals, and the high uncertainty associated with these screening levels, a more robust food web evaluation was conducted for this pathway.

This level of re-evaluation is not warranted for PFOS in surface soil, for which even fewer literature-based BAFs are available, and PFOS is not expected to bioaccumulate to the same degree in terrestrial habitats. Furthermore, the current use of the upland habitat as a recreational area for sports and similar routine human activities precludes significant foraging and use by terrestrial wildlife.

Although PFOA was also retained for potential wildlife risks due to surface water exposure, sufficient information was not identified to support a PFOA food web model. As described in Section 4.4.1, available bioaccumulation studies indicate PFOA was not detected in fish or benthic invertebrates, even though there were high concentrations detected in water (Kannan et al., 2005), or PFOA was detected at very low levels indicative of BAF less than 1 (Martin et al., 2004). PFOS is a reasonable surrogate for PFOA, although this approach is likely to err on the conservative side, so the findings of the PFOS food web model are expected to be applicable to PFOA exposures as well.

4.3 COPC REFINEMENT FOR TERRESTRIAL BIRDS AND MAMMALS

As indicated in **Table 1**, the maximum concentration of PFOS exceeded the lowest of the available wildlife soil screening levels selected for the SRA. For further evaluation in Tier 2, Step 3a, a 95% UCL was calculated for PFOS in surface soil. The Tier 2, Step 3a calculation presents comparisons of the refined maximum soil EPC (represented by the 95% UCL) to the avian and mammalian-specific screening values considered in the SRA (see **Table 4**).

Table 5 presents the refined maximum soil EPC (95% UCL) and associated receptor-specific HQs for PFOS. The PFOS HQ was above 1 for mammals (HQ of 9.0), but below 1 for birds, when the refined maximum EPC was compared to the screening levels. Therefore, no further evaluation of PFOS is warranted to protect avian receptors potentially exposed to PFOS in surface soil.

A sample-by-sample screen of the PFOS surface soil data (**Table 6**) shows that the PFOS screening level exceedances for mammals occur at six of the twelve locations. The PFOS concentrations at DPT-16-19 and DPT-16-34 are approximately fourteen and seven times higher than the mammalian screening level, respectively. DPT-16-34 is located at the FBP, while DPT-16-19 is located immediately southeast, next to Building 202 (**Figure 2**). Of the remaining four locations with PFOS concentrations exceeding the mammalian screening level, one location (DPT-16-29) has a PFOS concentration approximately three times the screening level and three locations (DPT-16-15, DPT-16-30, DPT-16-35) have concentrations approximately twice the screening level.

The 95% UCL for PFOS considered in **Table 5** appears to be driven by the two locations with the highest PFOS concentrations: DPT-16-19 at 170 μg/kg and DPT16-34 at 80 μg/kg. To assess the impact of these locations on the risk estimates, a second set of UCLs was calculated by removing only the DPT-16-19 sample result, as well as both DPT-16-19 and DPT-16-34 sample results from the UCL dataset (**Attachment D-2**).

These revised 95% UCLs for PFOS were compared against the mammalian soil screening level to assess whether mammals outside of these two highest locations would be adversely impacted. The PFOS 95% UCL was reduced from 108 μg/kg to 34 μg/kg by removing only the maximum sample result at DPT-16-19 and down to 22 μg/kg when both DPT-16-19 and DPT-16-34 were removed. The resulting HQs (95% UCL divided the mammalian screening value of 12 μg/kg) are only slightly greater than 1 at 2.8 and 1.8, respectively. These results show that outside of these two highest locations, particularly DPT-16-19, mammals at the site have a low potential to be adversely impacted by PFOS in surface soil. It is also noted that the surface soil sampling locations are all located within a relatively limited portion of the site that has been re-developed and is unlikely to provide significant habitat for foraging mammals. Redevelopment in this area entailed the removal of native vegetation and surface regrading to produce the current paved access road and the level, grass-surfaced (frequently mowed) athletic fields.

To further evaluate the potential risks to mammals, the basis for the mammalian screening level was also assessed. The mammalian soil screening level identified in **Table 4** is based on the insectivorous common shrew (ECCC, 2017). The insectivorous mammal screening level was derived based on the daily threshold effects dose for herbivorous mammals (the lowest effects dose for herbivorous mammals divided by an uncertainty factor of 2), shrew-specific factors (i.e., body weight, ingestion rates), and the assumption the shrew's diet is comprised of 95% soil invertebrates using a bioconcentration factor (BCF) of 10.9 (ECCC, 2017). Other mammalian soil screening levels from this same source range from 170 µg/kg for omnivorous mammals (based on deer mouse) to 2,200 µg/kg for herbivorous mammals (based on meadow vole) to 2,600 µg/kg for carnivorous mammals (based on wolf). The maximum PFOS surface soil concentration (170 µg/kg at DPT-16-19) is equal to or less than these other mammalian soil screening levels, which are also based on conservative exposure assumptions.

In addition, as discussed in Section 3.1.1, most of the site has been cleared of trees and developed (buildings and recreational areas), with only a small portion along the north covered in natural vegetation (**Figure 2**). The developed areas, particularly surrounding the buildings, where the two highest detections of PFOS occurred (DPT-16-19 and DPT-16-34), would be less attractive to wildlife than the small on-site naturally vegetated area and the expansive surrounding off-site naturally vegetated areas, which are located distant to the FBP and the elevated soil concentrations (**Figure 2**).

To summarize these findings for the upland area:

- Refined EPCs demonstrated HQs of less than 1 for birds and 9.0 for insectivorous mammals.
- The elevated HQ for insectivorous mammals is driven by DPT-16-19, and DPT-16-34 to a lesser extent, and both locations are from the vicinity of the FBP that has been redeveloped (low habitat quality, limited foraging resources for insectivorous rodents).
- More attractive foraging habitat for terrestrial receptors is nearby, and the remaining locations within the historical source area have much lower PFOS concentrations (low risk).

For these reasons, the bioaccumulation pathway for upland wildlife exposed to PFOS in surface soil, including populations of insectivorous mammals, is considered a complete but insignificant pathway based on currently available screening levels.

4.4 COPC REFINEMENT FOR AQUATIC-DEPENDENT BIRDS AND MAMMALS

Due to the elevated HQs based on the maximum detected concentrations of PFOS and PFOA in the surface water datasets (**Table 3**), more realistic estimates of surface water exposure for mobile wildlife receptors (e.g., birds, mammals) were calculated (i.e., 95% UCLs) and used in separate bird and mammal HQ calculations in **Table 7**. Due to a lack of bioaccumulation screening levels for PFOA, PFOS screening levels were used to evaluate the PFOA data.

Table 7 presents bioaccumulation HQs for aquatic-dependent mammals and birds for all five of the surface water datasets previously evaluated in **Table 3**.

Based on the "All 2018 Surface Water Data”, bioaccumulation HQs for aquatic-dependent mammals ranged from 54 (PFOA) to 62 (PFOS), and from 3.0 (PFOA) to 3.5 (PFOS) for aquatic-dependent birds. The surface water HQs based on the UCLs are highest for the 2018 non-tidal sample dataset, followed by the “All 2016” dataset (mammals) and “All 2018” dataset (birds), with the lowest HQs calculated for the 2018 high and low tide datasets. Use of the 95% UCL results in bird HQs less than or equivalent to 1 for PFOS and PFOA in the samples collected at tidal locations during both high and low tide events (HQs ranging from 0.2 to 1.1).

A closer evaluation of the surface water data indicates that all detected concentrations of PFOA and PFOS exceed the PFOS screening value for mammals (**Table 8**). Detections of PFOS, but not PFOA, in both of the 2016 on-site surface water samples (SW-16-01 and SW-1-02) collected from ephemeral drainages near the former facility (surface water not present at the remaining two on-site locations; **Figure 3**) also exceed the screening values for birds. Of the 48 off-site samples analyzed for PFOS and PFOA, exceedances of the PFOS screening level for birds were noted at 15 locations (31%) for

PFOS and 16 locations (33%) for PFOA. The majority of the exceedances of the PFOS screening value for birds occur in samples collected from the creek as opposed to the Little Magothy River that provides more attractive foraging habitat to aquatic-dependent wildlife.

Maximum detected concentrations of PFOS (0.66 µg/L) and PFOA (0.53 µg/L) occur in samples collected from SWSD-18-02 and SWSD-18-03, respectively (**Figure 3**), which are approximately 400 ft and 700 ft upstream of where the creek empties into the Little Magothy River. The surface water sample collected at the point where the creek discharges to the Little Magothy River (SWSD-18-04) indicates lower levels of PFOS (0.27 µg/L) and PFOA (0.26 µg/L) for the same sampling event (April 26, 2018), and the remaining samples collected farther downstream (i.e., SWSD-18-05) and in the open river demonstrate decreasing concentrations.

Some variability is evident in samples collected along the banks of the river, especially at low tide, but decreasing trends from the upstream creek locations to the river are clearly apparent. The potential exists for non-site sources of PFAS to influence surface concentrations in the river, given the sporadic higher hits farther downstream from the site (e.g., PFOS at high tide, SWSD-18-13 and SWSD-18-20). Another observation is the higher, sometimes much higher, concentrations detected in the creek in April 2018 compared to November of the same year, indicating seasonal fluctuations in potential PFAS exposure for ecological receptors.

Given the frequency of the exceedances of the bioaccumulation screening levels by surface water concentrations of PFOS and PFOA, further evaluation was warranted to address the potential for hazard to aquatic-dependent birds and mammals. Therefore, risks to mammals and birds from exposure to PFOS in surface water were further evaluated using food web models. Section 4.4.1 presents the Step 3a food web model refinements and Section 4.4.2 presents the results of the food web model calculations.

As stated in Section 4.2, although PFOA was also retained for potential wildlife risks due to surface water exposure, sufficient information (e.g. TRVs, uptake factors) was not identified to support a PFOA food web model and the findings of the PFOS food web model are expected to be applicable to PFOA exposures as well.

4.4.1 Food Web Model Refinement Approach

PFOS was evaluated in Step 3a using a food web model to refine the risk estimates for semi-aquatic receptors generated during the SRA (Steps 1 and 2). This section describes the site-specific target receptors, exposure assumptions, and toxicity reference values (TRVs) selected to refine the HQs calculated in the previous section.

The methods for conducting ecological risk assessments for PFAS are still evolving as more studies on key exposure routes and potential toxicological effects are published, and there currently is no standard of practice or repository of agency-accepted TRVs or uptake factors for wildlife receptors. More data applicable to PFAS ERA are available for aquatic systems than for terrestrial systems, based on the high potential for biomagnification of certain PFAS, primary PFOS, in aquatic tissues.

To further evaluate the elevated HQs for PFOS identified in Section 4.4, a site-specific food web model was developed to represent the off-site, downstream portion of the unnamed creek, wetlands, and Little Magothy River sampled in 2018, i.e., where aquatic-dependent wildlife is more likely to be present (as opposed to the on-site drainages sampled in 2016). In this phase of the Step 3a, avian and mammalian TRVs were selected and compared to the doses estimated from these models to re-calculate HQs for PFOS, which are intended to better predict ecological exposure and risk than the conservative and fairly outdated bioaccumulation screening levels for PFOS in surface water (**Attachment D**).

As discussed in Section 4.4, elevated HQs were also identified for PFOA. Since available studies indicate PFOA was not detected in fish or benthic invertebrates, even though there were high concentrations detected in water (Kannan et al. 2005), or PFOA was detected at very low levels indicative of BAF less than 1 (Martin et al. 2004), the potential for this COPC to bioaccumulate or biomagnify in the aquatic habitat is questionable. For this reason, i.e., primarily due to the absence of reliable fish BAFs for PFOA in the literature, and because PFOS has been shown to biomagnify to a much more significant degree in aquatic biota than PFOA, the refined ERA focused on site-specific risk estimates for PFOS, which is also expected to protect wildlife receptors from exposure to PFOA. As shown on **Figures 2 and 3** and **Table 8**, detected concentrations of PFOS and PFOA are very similar for many samples, and within the same order of magnitude for the majority of surface water samples collected. This co-occurrence of the two PFAS compounds further supports the idea that risk-based recommendations for PFOS will also address PFOA.

4.4.1.1 SELECTION OF SITE-SPECIFIC TARGET RECEPTORS

To further evaluate potential risks to birds and mammals through the food chain, selection of a particular species is required, so that intake, through eating and drinking, can be estimated. The selected receptors are either present at or near the site or are similar to receptors present in the vicinity of the site. The availability of exposure parameters such as body mass, feeding rate, and drinking rate are also important factors in selecting surrogate species. The following target species were selected for food chain modeling within the creek/bay:

- Piscivorous semi-aquatic avian raptor – osprey
- Piscivorous semi-aquatic avian wader – great blue heron
- Omnivorous semi-aquatic avian diver – belted kingfisher
- Omnivorous semi-aquatic large mammal – otter
- Omnivorous semi-aquatic small mammal – mink

Because it is not practical to quantify risks for all species potentially present on a given site, these indicator species were selected based on the following criteria:

- Year-round residents;
- Representative of an important ecological guild or niche;
- Present during a sensitive life stage (e.g., during breeding season);
- Susceptible to bioaccumulation or biomagnifications (e.g., higher trophic-level predators); and
- Potential sensitivity to exposure to PFAS.

Semi-Aquatic Birds. As mentioned earlier, the Chesapeake Bay watershed is home to the largest population of nesting osprey. This piscivorous raptor is likely to be present in the vicinity of the site during the spring breeding season and almost exclusively consumes medium-sized fish. Osprey nest along shorelines, marshes, rivers and open waters. They fly over waterbodies, dive toward the water, and capture prey with their talons (CBF, 2019b; Cornell University, 2017b). The great blue heron is a year-round resident of Chesapeake Bay and primarily consumes fish, but may also ingest insects, amphibians, reptiles, crustaceans, and other small animals. It wades into shallow water, silently stalks prey, and captures it by plunging its bill into the water (CBF, 2019c; Cornell University, 2017c). The belted kingfisher is also a year-round resident of Chesapeake Bay and primarily eats small fish, but also consumes benthic invertebrates (crayfish, mollusks, and other crustaceans), insects, amphibians, reptiles, other small animals, and berries. The belted kingfisher perches on bare tree branches or structures (e.g., telephone wires, pier piling) that overhang the water and then dive into the water and capture prey with its bill. (CBF, 2019d; Cornell University, 2017d). All three species are noted as being observed on the Little Magothy River (Magothy River Association, 2019).

Semi-Aquatic Mammals. The river otter is a native, year-round resident of Chesapeake Bay and lives along the shores of the Bay and throughout its tributaries in rivers, streams, fresh and saltwater marshes, and lakes. The river otter primarily consumes fish, but also eats benthic invertebrates (e.g., crayfish, crab), amphibians, and small mammals (CBF, 2019e; MDNR, 2019e). As mentioned previously, mink presence is limited in Eastern Maryland and there have been no reports of mink in the area of Bay Head Park or generally in the Annapolis area (MDNR, 2019c; MDNR 2019d). However, mink was selected as a representative species because of their lower body weight (as compared to the otter) and known sensitivity to specific bioaccumulative chemicals (i.e., polychlorinated biphenyls) and potential sensitivity to other bioaccumulative chemicals (e.g., PFOS). Mink have a varied diet that changes with the seasons, it includes small birds and mammals, fish, benthic invertebrates (e.g., crayfish), amphibians (e.g., frogs) and aquatic insects (e.g., beetles) (MDNR, 2019c).

4.4.1.2 CALCULATION OF RECEPTOR-SPECIFIC TDDS

To estimate potential dietary exposure, a TDD was estimated for each species. The TDD calculation considers the following factors: concentrations of the COPCs in the food items that the species would consume, estimated amounts of surface water that it would incidentally ingest, estimated amounts of sediment that it would incidentally ingest, the relative amount of different food items in its diet, body weight, seasonal use factor (SUF), species-specific area use factor (AUF), and food ingestion rates.

The following generalized equation was used to evaluate the TDD from all sources (i.e., food or prey item, drinking water, incidental ingestion) for the COPC:

$$\mathrm{TDD} = \frac{\Sigma([\mathrm{IR}_f \times \mathrm{C}_f] + [\mathrm{IR}_s \times \mathrm{C}_s] + [\mathrm{IR}_w \times \mathrm{C}_w]) \times \mathrm{SUF} \times \mathrm{AUF}}{\text{Body Weight}}$$

where:

IR_f = Ingestion rate of food (kg/day)

IR_s = Incidental ingestion rate of sediment (kg/day)

IR_w = Ingestion rate of water (L/day)

C_f = Concentration of COPC in food (µg/kg)

C_s= Concentration of COPC in sediment (µg/kg)

C_w = Concentration of COPC in water (µg/L)

SUF = Seasonal use factor (fraction of time receptor spends within exposure area)

AUF = Area use factor (ratio of the contaminated area relative to the receptor's home range)

The sum of the doses from the various sources represents the full TDD for the COPC that a receptor may be exposed to as a result of foraging within an exposure area. This generalized equation was modified for each representative species using species-specific exposure parameters. The species-specific exposure factors are summarized in **Table 9**.

The food web model included certain conservative species- and chemical-specific assumptions regarding exposure factors:

- Assumed 100% bioavailability of PFOS.
- Assumed all species are present year-round (SUF = 1), with specific-specific AUF.
- Diets of the receptors were modeled as exclusive aquatic diets (i.e., consisting of only fish and/or benthic invertebrates with no ingestion of upland prey items).

Site-specific tissue data were not available for food items; therefore, tissue concentrations need to be estimated using media concentrations and media-specific uptake factors for PFOS. Exposure of representative species also depends, to some extent, on chemical-specific factors, such as solubility, or tendency to bioaccumulate. In order to estimate site-specific tissue concentrations, PFOS water to invertebrate tissue BCFs and fish BAFs (account for fish exposures through direct contact with water and prey consumption) were selected with the following preferred study parameters:

- North American studies preferred
- Studies in which dietary component included for higher trophic levels, e.g., fish
- Field studies preferred over laboratory studies
- Studies in which whole organism tissue measured, as oppose to fillet or organ or blood
- Freshwater studies preferred, since more relevant to species in the Little Magothy River and tributaries and should be protective of estuarine food web (Houde et al. 2006)
- Studies in which testing included three or more trophic levels of the aquatic food web (i.e., multiple species) were preferred

The high solubility potential of PFOS and other long-chain PFAS coupled with their high capacity for uptake from the water-column into aquatic tissues is reflected in the very limited studies on sediment-related bioaccumulation of PFOS (e.g., few biota-to-sediment-accumulation-factors). Therefore, relying on the site surface water data to predict invertebrate and fish tissue concentrations is not expected to introduce significant uncertainty in the exposure assessment, as benthic organisms residing at the sediment-water interface have been shown to bioconcentration PFOS (literature BCFs available; Kannan et al., 2005, Houde et al., 2008).

The selected BAF studies were from the Great Lakes region and rivers in Michigan, where most published PFAS studies have been conducted to date. The geometric mean of the relevant BAFs studies was selected to estimate risk due to the wide variability in literature values. The geometric mean is not as sensitive to outliers and skewed datasets and, therefore, was selected to manage this variability in the BAFs. Only two BCFs were identified and, therefore, the average of these two similar values was selected. During the literature review process it was discovered that most studies with BCFs and BAFs were compiled in two fairly recent publications, and these publications were consulted for the BAF values (the primary studies also obtained). The water to invertebrate (TL2) BCFs and TL2/3 fish (primarily invertivorous fish) and TL3/4 fish (predatory fish) BAFs for PFOS identified in the literature are presented in **Table 10** (note: TL1 assumed to be plankton), as well as the final selected values.

The only TL2 BCFs identified for PFOS were very similar (1,000 to 1,200), but the TL2/3 and TL3/4 BAFs varied widely: TL2/3 BAFs ranged from 2,367 to 95,000 and TL3/4 BAFs ranged from 5,129 to 20,000 (see **Table 10** for references). These BAFs demonstrate the high, but variable, capacity for PFOS to biomagnify in the aquatic food web. See Section 4.5.2 for a more detailed discussion of the selected BCFs and BAFs, including a comparison of these values to the BAFs reflected in the generic surface water screening levels for birds and mammals.

Site-specific fish and benthic invertebrate PFOS concentrations were estimated using the surface water concentrations and the selected tissue-specific uptake factors (i.e., BCFs and BAFs), as described below. Benthic invertebrate tissue PFOS EPCs were estimated using the 95% UCL surface water concentration and the arithmetic mean water to TL2 invertebrate BCFs with the following equation:

$$C_{BI} = C_W * BCF_{TL2}$$

where:
C_{BI} = Chemical concentration in the benthic invertebrate (µg/kg_{ww})
C_W = Chemical concentration in water (µg/L)
BCF_{TL2} = Water to TL 2 invertebrate BCF (L/kg_{ww})

TL2/3 fish tissue PFOS EPCs were estimated using the 95% UCL surface water concentration, and the geometric mean of the water to TL2/3 fish BAFs with the following equation:

$$C_{TL2/3F} = C_W * BAF_{TL2/3}$$

where:
$C_{TL2/3F}$ = Chemical concentration in the TL 2/3 fish (µg/kg_{ww})
C_W = Chemical concentration in water (µg/L)
$BAF_{TL2/3}$ = TL 2/3 fish BAF (L/kg_{ww})

TL3/4 fish tissue PFOS EPCs were estimated using the 95% UCL surface water concentration, and the geometric mean of the water to TL3/4 fish BAFs with the following equation:

$$C_{TL3/4F} = C_W * BAF_{TL3/4}$$

where:
$C_{TL3/4F}$ = Chemical concentration in the TL 3/4 fish (µg/kg_{ww})
C_W = Chemical concentration in water (µg/L)
$BAF_{TL3/4}$ = TL 3/4 fish BAF (L/kg_{ww})

4.4.1.3 DOSE-BASED TRVS FOR WILDLIFE

As part of the Step 3a evaluation, risks to mammals and birds from exposure to PFOS in surface water were determined using food web models to estimate the TDD which was compared to chemical-specific TRVs representing acceptable daily doses in micrograms per kilogram body weight per day (µg/kg-BW/day). Currently, there are no federal or state sources of TRVs for PFOS; therefore, TRVs were derived from studies presented in the literature. Avian and mammalian TRVs based on No Observed Adverse Effect Levels (NOAELs) and Lowest Observed Adverse Effect Levels (LOAELs) were selected for use in the food web model to provide a range of risk estimates for risk management consideration.

In developing TRVs for avian and mammalian receptors, environmentally relevant dietary dose-response studies are generally preferred over other less relevant methods of dosage such as egg injection, dermal painting or in vitro studies. The ideal study is based on a range of dietary doses administered to a test species over a chronic exposure duration including sensitive life stages such as embryonic, juvenile or breeding stages, and measures effects on sensitive sub-lethal end points that may affect reproduction, growth and development.

The current state of the science for PFAS research is very active and studies with new information are continuously being published. Therefore, the literature review conducted for this ERA is not meant to be universally comprehensive. Efforts were made to gather as much readily available information as possible, and obtain primary literature articles referenced in secondary sources and guidance documents. However, the fact that other information may be available or may become available in the near future is a recognized uncertainty.

When suitable data are available, there are two major methods for development of TRVs for ecological receptors, as described below:

- For well-studied chemicals, numerous dose-response studies of high quality may be available using multiple test species within a single taxonomic class and covering a wide range of doses, exposure durations and sensitive endpoints. In such cases, NOAEL and LOAEL values can be selected for individual receptor species or groups of interest at a project site using several critical studies. Generic NOAELs and LOAELs that are protective of multiple species within a class (e.g., birds, mammals) can also be developed by selecting the highest NOAEL or lowest LOAELs or by estimating the geometric mean of the NOAEL and LOAEL.
- For emerging chemicals and less well-studied chemicals, far fewer qualified studies may be available and are typically limited to a few conventional test species and exposure conditions. The test species may not be directly comparable to the trophic levels and body weights of the receptor groups of interest at a project site. In such cases, the NOAELs and LOAELs available from the few studies (or the reported dose-response data, if NOAELs and LOAELs are not provided) may be modified by Uncertainty Factors (UFs), as appropriate. The lowest of the few NOAELs and LOAELs is often then selected as the generic NOAEL and LOAEL that would be protective of the entire class (e.g., birds, mammals).

For the PFOS, few reliable dose-response studies were available for birds and mammals. Therefore, the second approach described above was adopted. A single NOAEL and LOAEL value was selected to represent all birds in the food web model, regardless of trophic level; similarly, a single set of NOAEL and LOAEL values was selected for all mammals, regardless of trophic level.

Avian TRVs. As stated above, dietary TRVs were preferred. Only one suitable avian study was identified with two test species: bobwhite quail (*Colinus virginianus*) and mallard duck (*Anas platyrhynchos*) (Newsted et al, 2005). Another avian study could not be used due to lack of sufficient information and uncertainties regarding dosing regimen, test species and effects (Environment Canada 2013).

The study described by Newsted et al. (2005) evaluated chronic dietary exposure to adult birds. Multiple endpoints were evaluated and included: growth, behavior, histopathology of adult and offspring, and reproduction (egg production, fertility, hatchability, and hatching survival and growth). Observed effects included: increase in the incidence of small testes in male bobwhite and mallard, and slight reductions in fertility, hatchability and offspring survival in quail.

NOAELs and LOAELs were developed by Newsted et al. (2005) for both male and female mallards and bobwhites for each endpoint, when possible. NOAELs could not always be calculated due to the range of concentrations tested and the occurrence of treatment-related effects at all tested concentrations. The authors determined that the lowest LOAEL, based on the most sensitive reproduction endpoint for the female bobwhite, was the final LOAEL from this study that would be protective of all mallards and bobwhites. Newsted et al. then used that value of 770 µg/kg-BW/day to develop the second TRV (21 µg/kg-BW/day) for a generic TL4 (trophic level - predator) for fish-eating birds (e.g., eagles and osprey). The authors calculated the generic TRV by using the selected LOAEL for the bobwhite and dividing it by UFs. UFs were assigned by using the Great Lakes Initiative methodology (USEPA, 1995). A final UF of 36 was based on three categorical uncertainties with (1) intertaxon extrapolation, (2) toxicological endpoint, and (3) duration exposure.

However, applying certain kinds of UFs, particularly, inter-species UFs, are generally no longer standard practice (personal communications with California Environmental Protection Agency) and would not be needed since the mode of action would not be expected to be substantially different within a taxonomic class. Therefore, the generic TL4 TRV for fish-eating birds was not applied. However, an uncertainty factor of 10 is generally accepted to convert a LOAEL to a NOAEL (USEPA, 2005; Sample et al., 1996). Therefore, a NOAEL (77 µg/kg-BW/day) was calculated from the bobwhite LOAEL (770 µg/kg-BW/day) using the uncertainty factor of 10. No other UFs were applied because the study conditions simulated chronic, sublethal exposure during a sensitive life stage.

The final selected avian TRVs were based on the most sensitive endpoint and species (reproduction for bobwhite quail), using the NOAEL (77 µg/kg-BW/day) and the LOAEL (770 µg/kg-BW/day).

Mammalian TRVs. Several literature-based TRVs for mammals were based on dietary exposures, including ingestion of feed (RIVM, 2010; Environment Canada, 2006; Stahl et al., 2011; and Dietz et al,. 2015) and all reported the same NOAEL TRV of 100 ug/kg-BW/day. The test species reviewed include mice, rats, rabbits and monkeys. Observed effects on these test species included reproductive endpoints (e.g., decreased litter size, birth weight and pup survival, and developmental abnormalities) based on singular and multi-generational studies.

All four studies that reported NOAEL TRVs of 100 µg/kg-BW/day were based on reviews from multiple studies and species. RIVM (2010) selected a NOAEL/LOAEL based on a rabbit study by Case et al. (2001). Environment Canada (2006) reported the NOAEL/LOAEL based on a 2-generation rat study. Stahl et al. (2011) noted a chronic rat study with an exposure duration of 42 days which included exposure before mating, during gestation, and nursing based on a study by Christian et al. (1999). Dietz et al. (2015) discuss a NOAEL/LOAEL based on reduced rat pup survival and weight by Seed (2000).

Similar to the avian TRV for PFOS, the mammalian TRV derived from a dietary concentration of 4.6 µg/kg feed from Environment Canada (2013) was orders of magnitude lower than other diet-based TRVs from the literature and is accompanied by high uncertainty (unknown test species, endpoints, and exposure conditions). Therefore, it was not considered further.

The final selected mammalian NOAEL TRV was based on four review studies (RIVM 2010; Environment Canada, 2006; Stahl et al., 2011; and Dietz et al., 2015) that developed the same NOAEL of 100 µg/kg-BW/day based on rats and rabbits. The LOAEL TRV for mammals was based on the LOAEL TRV (400 µg/kg-BW/day) for rats and rabbits (Environment Canada, 2006; Stahl et al., 2011; and Dietz et al., 2015). No adjustments or uncertainty factors were applied to these literature-based TRVs because the study conditions reflected chronic, sublethal exposure during a sensitive life stage.

4.4.1.4 REFINED HQ CALCULATIONS FOR AQUATIC-DEPENDENT BIRDS AND MAMMALS

For aquatic-dependent wildlife receptors potentially exposed to PFOS in aquatic media, risk estimates were also based on the HQ in the Step 3a evaluation, defined as the ingested dose divided by the species-specific TRV:

$$HQ = TDD/TRV$$

Two types of HQs were calculated for birds and mammals using the NOAEL and LOAEL TRVs to estimate the potential for adverse effects to these wildlife receptors. By calculating two HQs, one equal to the dose divided by the NOAEL and one equal to the dose divided by the LOAEL, a risk manager can more definitively assess risk to the typical individual and to the overall population.

The interpretation of each HQ for avian and mammalian target receptors is summarized in the following table:

NOAEL HQ<1	LOAEL HQ>1	NOAEL HQ>1 and LOAEL HQ<1
HQ<1 indicates no unacceptable risk to target receptor at individual or population level	HQ>1 indicates potential unacceptable risk to target receptor at population level	$HQ_{(NOAEL)}>1$ and $HQ_{(LOAEL)}<1$ indicates potential unacceptable risk to target receptor at individual level but not likely at population level. However, the magnitude of the risk is uncertain.

For estimated exposures that fall between the lower and upper bounded HQs, the associated complete exposure pathways will be considered in greater detail to develop conclusions about the likelihood that a hazard is present. As common (non-listed) species of aquatic-dependent birds and mammals are expected to be present in the vicinity of the site, more emphasis will be placed on LOAEL HQs.

4.4.2 Food Web Model Results

As discussed above, HQs based on the site-specific food web models were calculated using realistic Step 3a exposure parameters, such as species-specific AUFs (**Table 9**) and 95% UCLs as EPCs **(Attachment D, Table D2)**. The selected BAFs (**Table 10**) were incorporated into the models based on the wide variability in these parameters, and both NOAEL and LOAEL TRVs were applied (**Attachment D, Table D3)**. The Step 3a food web model calculations are presented in **Attachment D**, and **Table 11** summarizes the Step 3a food web model HQs. The results of the refined evaluation are presented below for each of the wildlife receptors.

Great Blue Heron. The heron was assumed to consume a diet comprised entirely of TL 3/4 fish. It was also assumed that the heron obtained 13% of its overall diet (AUF = 0.13) from prey at in the vicinity of the site and foraged at the site year-round. All HQs were less than 1 for the great blue heron in the food web evaluation.

Belted Kingfisher. The kingfisher was assumed to have a diet primarily of fish, both TL 2/3 fish (50%) and TL 3/4 fish (30%), with a smaller portion of aquatic or benthic invertebrates (20%). It is assumed that the kingfisher obtained 59% of its overall diet (AUF = 0.59) from prey obtained in the vicinity of the site and foraged near the site year-round. The NOAEL-based HQ was above 1 for the belted kingfisher (HQ = 5.2), but the LOAEL-based HQ was less than 1.

Osprey. The osprey was assumed to consume a diet comprised entirely of TL 3/4 fish. It was also assumed that the osprey obtained 6% of its overall diet (AUF = 0.06) from prey in the vicinity of the site and foraged near the site year-round. All HQs were less than 1 for the osprey in the food web evaluation.

Otter. The river otter was assumed to consume a diet primarily of fish, both TL 2/3 fish (35%) and TL 3/4 fish (45%), with a smaller portion of benthic invertebrates (20%) It was assumed that the otter obtained 2% of its overall diet (AUF = 0.02) from prey obtained in the vicinity of the site and foraged near the site year-round. All HQs were less than 1 for the otter in the food web evaluation.

Mink. The mink was assumed to have a diet with fairly equal components of TL 2/3 fish (34%), TL 3/4 fish (33%), and benthic invertebrates (33%). It was assumed that the mink obtained 30% of its overall diet (AUF = 0.30) from prey obtained in the vicinity of the site and foraged near the site year-round. All HQs were less than 1 for the mink in the food web evaluation.

These results indicate that piscivorous birds (great blue heron and osprey) and omnivorous mammals (otter and mink) are not expected to be adversely impacted by PFOS (or PFOA) while foraging near the site. No further evaluation is necessary to protect these target receptors. However, additional evaluation was conducted to further assess the potential for risk to omnivorous avian divers (belted kingfisher) based on the elevated NOAEL HQ using the site-specific food web model. Potential adverse impacts to the kingfisher are further evaluated in the Tier 2, Step 3a Risk Characterization (Section 4.6), which includes a weight of evidence evaluation and incorporates uncertainties inherent in the ERA process (Section 4.5).

4.5 ECOLOGICAL RISK UNCERTAINTY ANALYSIS

The results of the ERA depend primarily on the use of multiple lines of evidence supporting particular conclusions, and each line of evidence is subject to varying degrees of uncertainty. Because of the complexity of ecosystems and the associated mechanisms that cause ecological stress, uncertainty in environmental risk characterization is inevitable. Uncertainty could be attributable to a number of sources, including but not limited to the following:

- Sampling and statistical variability
- Difficulty of extrapolating from laboratory data to field data
- Use of surrogate toxicity values in the absence of chemical-specific toxicity data to assess the potential for adverse effects.

Additional sources of uncertainty associated with this ecological risk characterization are described below. In general, the assumptions made in the ERA tend to err on the side of over-estimating risks. The cumulative impact of multiple conservative assumptions is more likely to over-estimate, than under-estimate, potential risks to ecological receptors.

4.5.1 Uncertainties in Ecological Screening Levels

As emerging chemicals of concern, established ecological standards and associated regulatory guidance for PFAS are not currently available in the United States. Therefore, a literature review was conducted to provide context for the potential for ecological risks relative to the available site data and the most conservative screening levels were identified for use in the SRA. The available literature for PFAS chemicals continues to grow as research and field studies are completed, which provide additional information and scientific knowledge about PFAS toxicity and bioaccumulation. In general, PFOS has been the focus of most regulatory interest with less toxicity data available for PFOA, PFBS, and other PFAS compounds. PFOS screening levels were identified for each of the potential exposure media and pathways evaluated in the ERA. Lack of screening levels for PFOA and PFBS and the application of surrogates is discussed below relative to uncertainty.

Soil. While PFBS did have a soil screening level value for community-level receptors (soil invertebrates/terrestrial plants), it lacked a screening level value for evaluation for protection of wildlife (**Table 1**). However, the maximum detected concentration of PFBS in soil (0.21 µg/kg) was well below the lowest wildlife screening level values for PFOA and PFOS; therefore, the lack of a wildlife soil screening level value for PFBS is unlikely to have resulted in the underprediction of risk to terrestrial wildlife in the ERA. In addition, studies have demonstrated that short-chain PFAS, like PFBS do not bioaccumulate in animal tissues.

Sediment. Very little sediment toxicity information was discussed in the literature and only one dry weight-based sediment screening levels was identified. The value of 220 µg/kg published by the NPCA (2008) is a PNEC based on direct toxicity. The value is used to evaluate marine and coastal sediments, but the underlying toxicity data are not provided so it is unknown if the data are for marine or freshwater species or both.

Both PFOA and PFBS were detected in the sediment dataset and lack sediment screening values (**Table 2**). PFOA was detected in the "All 2016 Sediment Data" at a maximum concentration of 0.28 µg/kg and in the "All 2018 Sediment Data" at a maximum concentration of 4.5 µg/kg. PFBS was detected in the "All 2018 Sediment Data" at a maximum concentration of 0.28 µg/kg and was not detected in the 2016 samples. However, PFOA and PFBS maximum detected concentrations are less than the PFOS screening level of 220 µg/kg (NPCA, 2008).

The limited PFAS sediment toxicity data may be attributed to the high solubility potential of PFOS and other long-chain PFAS coupled with their high capacity for uptake from the water-column into aquatic tissues. Benthic organisms residing at the sediment-water interface have been shown to bioconcentrate PFOS from the water (i.e., water-based BCFs are available in the literature with far fewer sediment uptake factors). Therefore, the lack of sediment screening values for PFOA and PFBS, lack of additional benthic community-level-based screening values for PFOS, and reliance on the site surface water data to evaluate risk to invertebrates and fish is not expected to introduce significant uncertainty in the ERA.

Surface Water. PFOA was detected in Site surface water but lacked wildlife screening values (**Table 3**). However, the PFOS wildlife surface water screening value was used as a surrogate in the Tier 1 screening (**Table 3**) and Tier 2, Step 3a refined screening (**Table 7**). Although the modes of action for PFOS and PFOA are still under study and may not necessarily be the same, both are of the same chemical class and similar adverse effects in birds and mammals have been observed for PFOS and PFOA (USEPA, 2016a,b; Yanai et al., 2008; Pinkas et al., 2010; O'Brien et al., 2009; Nordén et al., 2016); thus, this is a reasonable assumption. However, the use of the PFOS surrogate screening value may overestimate risk to aquatic-dependent wildlife in these screenings because bioaccumulation of PFOA appears to be much lower than PFOS. As discussed in Section 4.4.1, available bioaccumulation studies indicate PFOA was not detected in fish or benthic invertebrates, even though there were high concentrations detected in water (Kannan et al., 2005), or PFOA was detected at very low levels indicative of BAF less than 1 (Martin et al., 2004).

4.5.2 Uncertainties in Ecological Exposure Estimation

Bioavailability in prey items is likely overestimated because the food web models assumed that the PFOS consumed by wildlife receptors is present in a form that is 100% bioavailable (100% of the COPC is assimilated by the organism after ingestion); however, this is unlikely and overestimates risks. While the AUFs used in Step 3a reflect foraging outside of the creek/bay study area, the SUF remained at 1 which may overestimate risks as some avian receptors (i.e., osprey) may not be present year-round. In addition, mink are only expected to be transiently present in this part of the state so the SUF is likely to be overly conservative. There have been no reports of mink in the area of Bay Head Park or generally in the Annapolis area (MDNR, 2019c; MDNR 2019d).

The estimate of PFOS transfer from surface water into benthic and aquatic invertebrates and fish is a key source of uncertainty in the ERA. For conventional lipophilic organic chemicals, like polychlorinated biphenyls and organochlorine pesticides, bioaccumulation data can be normalized to the percentage of lipids of the organisms, strongly reducing uptake variability for these substances (RIVM 2010). Since PFAS bind to proteins in the blood and not to lipids, normalization is not possible under the current state of the science. This disparity can introduce significant uncertainty in estimating the biomagnification potential of PFOS, which is reflected in the high variability of the accumulation data.

As shown below, the geometric mean TL 2/3 fish BAF used in the current evaluation is approximately two to three times higher than the TL 2/3 fish BAFs used to derive the generic surface water screening levels presented in **Table 4** (RIVM, 2010; Giesy et al., 2010). The geometric mean TL 3/4 fish BAFs from the current evaluation and Giesy et al. (2010) are equivalent, while this BAF from the current study is approximately 1.4 times lower than the TL 3/4 fish BAF in RIVM (2010). These values are discussed in more detail below.

Source	**TL 2 inverts BCFs (L/kg_{ww})**	**TL 2/3 fish BAFs (L/kg_{ww})**	**TL 3/4 fish BAFs (L/kg_{ww})**
Mammal SL RIVM 2010	Not reported	2,800[1]	14,000
Bird SL Giesy et al. 2010	Not reported	1,994[1]	9,970
Current Evaluation	1,100	6,513	10,120

[1] Both described as water-to-fish BCFs in source studies.
SL = Surface water screening level

Water-to-invertebrate BCFs were only identified in two studies and were not specifically reported or applied in the derivation of the generic surface water screening levels. Therefore, the arithmetic mean of these two values (1,000 and 1,200) was selected as the TL 2/3 invertebrate BCF. For both generic surface water screening level studies (RIVM, 2010; Giesy et al., 2010), it is not clear if the accumulation measurements for TL 2/3 fish are inclusive of dietary intake (use of the term BCF implies only water to fish uptake measurement).

As shown in **Table 6**, the current study incorporated BAFs from four to five independent freshwater studies and the geometric mean of these studies per trophic level was selected as the final BAFs. Some of these BAF studies, e.g., Kannan et al., 2005 and Houde et al., 2008, were also included in the development of the generic surface water screening levels (RIVM, 2010; Giesy et al., 2010); however, additional data and related bioaccumulation information were also evaluated for the current study (Concawe, 2016; Franklin et al., 2015; Michigan Department of Community Health [MDCH], 2015).

In RIVM (2010), the water-to-bluegill sunfish “BCF” used to represent TL 2/3 fish is an experimental (laboratory) value derived from a potentially outdated source (3M, 2003). To this TL 2/3 BCF of 2,800 (note, BCF is the term used in RIVM 2010), a generic biomagnification factor) BMF of 5 was applied to generate the TL 3/4 BAF of 14,000. In Giesy et al. (2010), the geometric mean of two values, also termed “BCFs”, was used to represent TL 2/3 fish: a BCF of 3,614 based on kinetic analysis (Drottar et al., 2001) and a BCF of 1,100 based on a rainbow trout carcass (Martin et al., 2003). Similarly to RIVM (2010), Giesy et al. (2010) applied a generic BMF of 5 to the BCF to generate the TL 3/4 BAF of 9,970.

For this current ERA, the increase in accumulation (or BMF) from TL 2/3 fish to TL 3/4 fish is approximately 2. Given the higher level of accumulation assumed for TL 2/3 fish in the current evaluation, however, this lower BMF still results in a reasonable TL 3/4 BAF. The higher TL 2/3 BAF used in the current evaluation is driven by the maximum BAF of 95,000 based on exposure by sculpin (*Cottus spp.*) (Houde et al., 2008). This species is tolerant of a wide variety of aquatic habitats and are present in the Chesapeake Bay watershed (Murphy and Stribling, 2015). For this reason, the high BAF was included in the geometric mean BAF calculation for TL 2/3 fish with recognition of its uncertainty.

In addition to using more current information and studies on PFOS bioaccumulation in the freshwater aquatic food web, with some studies like MDCH (2015) that reflect riverine habitats that may be similar to the site, applying geometric mean BAFs based on more robust sample sizes (albeit still low) and field data, was concluded to provide reasonably conservative and scientifically-based estimates of fish tissue concentrations.

The BCFs and BAFs, as well as the dietary proportions and TRVs, highly influence the risk estimates for the aquatic-dependent birds and mammals. Based on the conditions in the off-site aquatic habitats, primarily the creek and riverine environments (small, meandering creek through residential areas, then widening farther downstream), it is likely that TL 3/4 fish are not present in the upper reaches of this off-site habitat (closer to the former source area), limiting aquatic foraging resources for species like the osprey, otter, and heron. The TL 2/3 fish BAF of 2,367 shown in **Table 6** may be more reflective of fish expected to be present in the creek and river, as this study is based on whole-body fish tissue concentrations in species collected from riverine environments (yellow perch, golden shiner, bluegill sunfish, and juvenile white bass) in Michigan and Minnesota (MDCH, 2015), as opposed to lacustrine habitats. The uncertainties introduced in the ERA from the selected BAFs used to calculate the site-specific Step 3a HQs could result in an over- or under-prediction of exposure and risk, but are more likely to over-predict exposure to birds and mammals that could forage in the creek.

4.5.3 Uncertainties in Ecological Toxicity Assessment

The toxicological studies reported in the literature and used for generating screening levels or TRVs may not have been obtained under conditions that accurately represent the complexities of potential exposures in the field. Typically, studies conducted in the laboratory with bioavailable chemicals are likely to overestimate risks relative to weathered field conditions. It is recognized that the selection of TRVs for emerging contaminants, like PFOS, reflects the state of the science as it is rapidly developing and is subject to re-evaluation as more and more toxicological studies are published. The selected avian and mammalian TRVs have been cited in other guidance documents and selected for screening level development. However, interpretation of these toxicity studies in the literature included the application of various UFs in the development of a final TRV, which was re-examined for the current study (**Section 4.4.1.3**). The UFs applied to develop TRVs for the Step 3a are based on current science and understanding of toxicity influenced by body weight and inter-species (class) differences (no scaling factors used and no inter-species UFs applied). The selected TRVs could contribute to an over- or under-estimate of toxicity to birds and mammals.

Like birds and mammals, reptiles and amphibians are potentially exposed to contaminants through their diet (i.e., prey containing PFAS), but are not typically evaluated in ERAs due to the paucity of toxicity data for these receptors, especially reptiles. These receptors are likely to occur in the vicinity of the site (Section 3.1.1). Reptiles have generally slower metabolic rates than do birds and mammals and may be expected to ingest less food and receive less exposure to chemicals in food than would birds and mammals. However, the mechanism of toxicity for PFAS is not well understood in reptiles and this lack of information for this chemical class represents an uncertainty. Only one study for reptiles was identified. The researchers determined BAFs based on PFOS in blood serum of freshwater turtles and simultaneously sampled a 2 liter volume of water (RIVM, 2010). This study reports information associated with exposure (via bioaccumulation), but no information can be obtained with regards to toxicity, and there is uncertainty associated with the particular medium of exposure. Therefore, this information could not be used or directly applied to other toxicity data. However, it does provide information with regard to the potential for PFOS bioaccumulation by aquatic reptiles. Other studies on concentrations of PFOS in the Great Lakes food web have demonstrated that concentrations in snapping turtles (and chinook salmon and carp) are, on average, 5- to 10-fold less than those in upper trophic level birds and mammals that prey on turtles (mink and bald eagles) (Kannan et al., 2005).

Blood plasma of snapping turtles collected from the Great Lakes region contained considerable concentrations of PFOS ranging from 105 to 169 nanograms per milliliter (ng/mL) (mean: 137 ng/mL) in males and from <1 to 8.8 ng/mL (mean: 6.13 ng/mL) in females. This notable gender difference in the concentrations of PFOS in snapping turtles suggests oviparous transfer of PFOS through egg laying, similar to that observed for birds and fish (Kannan et al., 2005). Based on these data, it is reasonable to assume for risk assessment purposes that risk estimates for top-level predatory birds may also be used as a potential indicator of risk to reptiles in the absence of toxicity data specific to reptiles.

4.6 TIER 2, STEP 3A RISK CHARACTERIZATION

Terrestrial wildlife potentially exposed to PFOS in soil and aquatic-dependent wildlife potentially exposed to PFOS (and PFOA to a lesser extent) in surface water were retained for the Tier 2, Step 3a evaluation based on the findings of the Tier 1, SRA.

4.6.1 Terrestrial Wildlife

The Tier 2, Step 3a evaluation conducted for terrestrial wildlife incorporated refined maximum EPCs (represented by 95% UCLs) and entailed a more rigorous investigation of the soil data. The findings indicated a low potential for risk to terrestrial ecological receptors based on the relatively low HQs in consideration of the conservative nature of the bioaccumulation screening levels for soil. Only PFOS was retained for the refined evaluation. The PFOS HQ was above 1 for mammals (HQ of 9.0), but below 1 for birds, when the refined maximum EPC was compared to the soil screening levels. The 95% UCL for PFOS in soil appears to be driven by the two locations with the highest concentrations: DPT-16-19 (located at the FBP) and DPT16-34 (located immediately southeast, next to Building 202) (**Figure 2**). PFOS concentrations in the remaining surface soil samples are considered low at approximately 2 to 3 times higher than the bioaccumulation soil screening level. Removing these two locations, resulted in 95% UCLs only slightly greater than 1: HQ of 2.8 when only removing DPT-16-19, and HQ of 1.8 when removing both DPT-16-19 and DPT-16-34. These results demonstrate that outside of these two highest locations, particularly DPT-16-19, mammals at the site have a low potential to be adversely impacted by site COPCs.

The mammalian screening level of 12 μg/kg was based on the insectivorous common shrew. Soil concentrations were equal to or below additional soil screening levels derived for other surrogate mammals, including the deer mouse, meadow vole, and wolf (ECCC, 2017). These results indicate that impacts to the mammalian community as a whole may be overestimated by the mammalian screening level for the insectivorous common shrew.

Nearly all of the on-site upland habitat has been cleared of trees and developed (buildings and recreational areas), with only a small portion along the north covered in natural vegetation (**Figure 2**). The developed areas, particularly surrounding the buildings, where the two highest detections of PFOS occurred (DPT-16-19 and DPT-16-34), would be less attractive to wildlife than the small on-site naturally vegetated area and the expansive surrounding off-site naturally vegetated areas, which are located distant to the FBP and the discussed elevated soil concentrations (**Figure 2**).

Given these lines of evidence, the bioaccumulation pathway for upland wildlife exposed to PFOS in soil is considered a complete, but insignificant pathway based on currently available screening levels, and further evaluation at this time is not warranted.

4.6.2 Aquatic-Dependent Wildlife

The Tier 2 Step 3a aquatic-dependent wildlife evaluation incorporated refined maximum EPCs (represented by 95% UCLs) and entailed a more rigorous investigation of the surface water data. The findings of the comparison of the 95% UCLs to the bioaccumulation surface water screening levels indicated a potential for risk to aquatic-dependent wildlife based on the HQs above 1 primarily for PFOS: "All 2018 Surface Water Data” HQs for aquatic-dependent mammals ranged from 54 (PFOA) to 62 (PFOS), and from 3.0 (PFOA) to 3.5 (PFOS) for aquatic-dependent birds. Use of the 95% UCL results in bird HQs less than or equivalent to 1 for PFOS and PFOA in the samples collected at tidal locations during both high and low tide events. The majority of the exceedances of the PFOS screening value for birds occur in samples collected from the creek as opposed to the Little Magothy River that provides more attractive foraging habitat to aquatic-dependent wildlife. All detected concentrations of PFOA and PFOS exceeded the PFOS screening value for mammals. Maximum detected concentrations of PFOS and PFOA occur in samples collected from SWSD-18-02 and SWSD-18-03, respectively (**Figure 3**), which are approximately 400 ft and 700 ft upstream of where the creek empties into the Little Magothy River.

Given the exceedances of the bioaccumulation screening levels by surface water concentrations of PFOS and PFOA in the creek and to a lesser extent in the Little Magothy River, further evaluation was warranted to address the potential for hazard to aquatic-dependent birds and mammals. Therefore, risks to mammals and birds from exposure to PFOS in surface water were evaluated using food web models.

As discussed in Section 4.4.1, the potential for PFOA to bioaccumulate or biomagnify in the aquatic habitat is questionable given the low detections or lack of tissue detections in some of the primary studies consulted for PFOA BAFs (Kannan et al., 2005; Martin et al., 2004; Section 4.4.1.2). Due to the absence of reliable fish BAFs for PFOA in the literature, and because PFOS has been shown to biomagnify to a much more significant degree in aquatic biota than PFOA, refinement of risk estimates for PFOS is also expected to protect wildlife receptors from exposure to PFOA. Detected concentrations of PFOS and PFOA are very similar for many samples, and within the same order of magnitude for the majority of surface water samples collected. This co-occurrence of the two PFAS compounds further supports the idea that risk-based recommendations for PFOS will also address PFOA.

Food web models were developed for the following target species: great blue heron, belted kingfisher, osprey, otter, and mink. All HQs were less than 1 for the otter, mink, osprey, and great blue heron, while the NOAEL HQ was above 1 for the belted kingfisher.

As part of the additional evaluation of bioaccumulation exposures for PFOS, a site-specific surface water screening level was calculated for the belted kingfisher for a refined sample-by-sample comparison of the surface water data. It is expected that a screening level based on the most sensitive food web model receptor will be protective of all aquatic-dependent birds and mammals that could be exposed to site-related PFOS.

The following section describes the calculation of the site-specific screening level.

4.6.2.1 SITE-SPECIFIC SURFACE WATER SCREENING LEVEL FOR THE BELTED KINGFISHER

The surface water screening level for the kingfisher was calculated using the same exposure factors incorporated into the TDD to estimate HQs, as well as the BAFs for invertebrates and fish, and the LOAEL avian TRV for PFOS. These inputs and calculations are shown in Attachment D, Tables D10 and D11). The site-specific screening level of 0.28 μg/L was calculated using the following equation:

$$\text{Surface Water } SL_{kingfisher} = \frac{\text{Toxicity Reference Value x Body Weight}}{(IR_f \text{ x } (BCF_{TL2} \text{ x } PF) + (BAF_{TL2/3} \text{ x } PF) + (BAF_{TL3/4} \text{ x } PF)) + IR_w) \text{ x } AUF \text{ x } SUF}$$

where:

IR_f = Ingestion rate of food (kg/day)

IR_w = Ingestion rate of water (L/day)

BCF_{TL2} = Water to TL 2 invertebrate BCF (L/kg_{ww})

$BAF_{TL2/3}$ = TL 2/3 fish BAF (L/kg_{ww})
$BAF_{TL3/4}$ = TL 3/4 fish BAF (L/kg_{ww})
PF = proportion of food item; unitless
SUF = Seasonal use factor (fraction of time receptor spends within exposure area)
AUF = Area use factor (ratio of the contaminated area relative to the receptor's home range)

4.6.2.2 RESULTS OF SITE-SPECIFIC SURFACE WATER SCREENING

Table 12 presents the sample-by-sample comparison of the site surface water data for PFOS to the site-specific screening level for the belted kingfisher (0.28 μg/L). Although the generic bioaccumulation surface water screening levels for PFOS were applied as surrogates for PFOA in the Tier 1, SARA and Tier 2, Step 3a UCL and sample-by-sample comparisons, this conservative approach was not maintained for the site-specific surface water screening given the bioaccumulation data for PFOA described in Section 4.4.1 and noted in **Table 10** (minimal bioaccumulation in fish).

The 2016 surface water data from the drainages on/near the site were compared to this screening level in addition to the 2018 data collected from the more attractive off-site creek/riverine and Bay environment. Due to the ephemeral nature of the on/near Site drainages, surface water samples collected in 2016 were only available at two of the four target sample locations. Sample-specific HQs for the kingfisher for the two samples collected in on/near the site drainages (SW-16-02 and SW-16-01; **Table 12**) were less than 1.

Sample-specific HQs for the kingfisher for the off-site creek and Bay samples were greater than 1 in four samples (includes one duplicate; **Table 12**) collected from two locations SWSD-18-02 and SWSD-18-03 (**Figure 5**). The remaining samples had HQs below 1. SWSD-18-02 and SWSD-18-03 are approximately 400 ft and 700 ft upstream of where the creek empties into the Little Magothy River. The HQs for these locations are approximately ≤ 2. The surface water sample collected at the point where the creek starts to widen prior to discharging into the river (SWSD-18-04) indicates lower levels of PFOS (0.26 μg/L, i.e., HQ<1) for the same sampling event (April 26, 2018), and the remaining samples collected farther downstream (i.e., SWSD-18-05) towards the mouth of the Bay show decreasing concentrations. These samples demonstrate delineation of the downstream extent of the off-site PFOS migration, with risk estimates at acceptable levels for the kingfisher, representing all aquatic-dependent wildlife, beyond SWSD-18-04 as the creek widens into the broader channel of the Little Magothy River.

Shallow clear streams and rivers are required for the belted kingfisher. When prey is spotted while actively hunting, belted kingfishers either dive straight down or in a spiraling motion (Schablein, 2012). Shallow, headfirst dives frequently result in an incomplete submersion of the body. Both of these hunting methods require high water clarity and a shallow depth. These conditions are not expected to be present in the on/near site drainages east of Bay Head Road, or even immediately downstream of the site west of Bay Head Road, but are likely present in segments farther downstream as the creek deepens, as well as farther down in the Little Magothy River (**Attachment B**). The off-site creek samples with the highest PFOS concentrations in surface water (SWSD-18-02 and SWSD-18-03) may not provide ideal foraging conditions for the belted kingfisher, but the samples farther downstream that do not exceed the site-specific surface water screening level (e.g., SWSD-18-04 and SWSD-18-05) may provide more suitable habitat for this receptor in terms of the types of invertebrates and fish present.

Given the low HQs for the belted kingfisher using conservative exposure assumptions (e.g., local population obtains 60% of TDD from the site), the bioaccumulation pathway for aquatic-dependent wildlife exposed to PFOS in surface water is considered a complete but insignificant pathway based on the currently available exposure and effects data, with recognition of the level of uncertainty introduced by the use of literature-based BCFs and BAFs that may or may not be reflective of actual conditions at the site. The selected BAFs are, however, expected to err on the conservative side based on a comparison to the BAFs used to derive the generic surface water screening levels for birds and mammals, reducing the potential for underestimation of exposure and risk. Additionally, these results for PFOS are expected to also apply to PFOA, which studies have demonstrated PFOA to have a much lower capacity for bioaccumulation in the aquatic food web.

5. SUMMARY AND CONCLUSIONS

The ERA was conducted in accordance with Navy policy and Navy and USEPA CERCLA ERA guidance as referenced throughout Section 1.2. The primary objective of the ERA was to evaluate whether PFAS in surface soil, sediment, and surface water attributable to past site operations have the potential to cause unacceptable adverse risk to ecological receptors present in the on-site upland area and on/near-site drainages (east of Bay Head Road), as well as the off-site, downgradient freshwater aquatic habitats (west of Bay Head Road).

The following exposure pathways were evaluated in the ERA:

- Soil invertebrates and terrestrial plants directly exposed to PFAS in surface soil in the former facility area.
- Terrestrial birds and mammals exposed to PFAS through incidental ingestion of soil and by ingestion of contaminated prey items impacted by soil in the former facility area .
- Benthic invertebrates and aquatic (water-column) organisms directly exposed to PFAS in surface sediment and surface water in the on/near-site drainage features and off-site wetlands, the unnamed creek, and the Little Magothy River.
- Aquatic-dependent birds and mammals exposed to PFAS through incidental ingestion of sediment or surface water, and by ingestion of contaminated prey items impacted by sediment or surface water in the on-site drainage and off-site wetlands, the unnamed creek, and the Little Magothy River.

This ERA has been structured according to U.S. Navy policy (DON, 1999a,b) and includes the Tier 1 SRA, which is consistent with Steps 1 and 2 of the USEPA CERCLA ERA process (USEPA, 1997), and the first step of the Tier 2 BERA, which is consistent with Step 3a of the USEPA CERCLA ERA process.

Upon completion of the Tier 1 ecological SRA, it was determined that complete exposure pathways exist from site surface soil, sediment, or surface water to plants, invertebrates (and potentially fish) or wildlife receptors. This assessment illustrated that there is a concern for ecological receptors from exposure to on-site surface soil and on/near-site and off-site surface water at the BHRA that warrants further attention. The following COPCs were considered further in the Tier 2, Step 3a evaluation:

- Terrestrial birds and mammals – PFOS in soil
- Aquatic-dependent birds and mammals – PFOS and PFOA in surface water

The first phase of the Tier 2, Step 3a evaluation involved a comparison of the 95% UCLs to the same screening levels used in the SRA to re-calculate HQs for specific media and receptors retained at the conclusion of the SRA. COPCs with HQs greater than 1 based on the UCLs were subjected to a sample-by-sample evaluation and a more intensive investigation of the data. In addition to evaluating the UCL for surface water to refine the exposure assumptions in the Tier 2, Step 3a assessment, specific avian and mammalian wildlife receptors potentially exposed to PFOS in surface water at the site were selected and more site-specific food web models compiled to generate exposure doses for these selected target receptors. NOAEL and LOAEL-based HQs were calculated for PFOS with these Step 3a exposure doses to provide a range of risk estimates from this more robust evaluation for surface water. This level of re-evaluation is not warranted for PFOS in surface soil, for which very few literature-based BAFs are available, and PFOS is not expected to bioaccumulate to the same degree in terrestrial habitats. Furthermore, the current use of the upland habitat as a recreational area for sports and similar routine human activities precludes significant foraging and use by terrestrial wildlife.

The findings of the Tier 2, Step 3a evaluation indicated a low potential for risk to terrestrial wildlife based on the relatively low HQs in consideration of the conservative nature of the bioaccumulation screening levels for soil. The developed areas, particularly surrounding the buildings, where the two highest detections of PFOS occurred (DPT-16-19 and DPT-16-34), would be less attractive to wildlife than the small on-site naturally vegetated area and the expansive surrounding off-site naturally vegetated areas characterized by much lower PFOS concentrations in soil. Removing these two locations, resulted in 95% UCLs only slightly greater than 1. These results demonstrate that outside of these two highest locations, particularly DPT-16-19, mammals at the site have a low potential to be adversely impacted by site COPCs. Given these lines of evidence, the bioaccumulation pathway for upland wildlife exposed to PFOS in soil is considered a complete but insignificant pathway based on currently available screening levels, and further evaluation is not warranted.

The findings of the Tier 2, Step 3a evaluation indicated a low potential for risk to aquatic-dependent mammals and highly piscivorous birds based on the relatively low HQs in consideration of the conservative nature of the exposure and toxicity parameters applied in the site-specific food web models developed for the selected target species: great blue heron, belted kingfisher, osprey, otter, and mink. All HQs were less than 1 for the otter, mink, osprey, and great blue heron, while the NOAEL TRV-based HQ was greater than 1 for the belted kingfisher (LOAEL TRV-based HQ less than 1). Therefore, a site-specific surface water screening level was back-calculated for the belted kingfisher to be protective of all aquatic-dependent birds and mammals that could be exposed to site-related PFOS.

The outcome of the sample by sample comparison of the site surface water data to the site-specific screening level for the belted kingfisher (0.28 μg/L) indicated a low potential for risk to omnivorous aquatic birds from exposure to PFOS in surface water, with recognition of the level of uncertainty introduced by the use of literature-based BCFs and BAFs that may or may not be reflective of actual conditions in the vicinity of the site. The sample-specific HQs for the kingfisher for the two 2016 samples collected in on/near the site drainages were less than 1. Risk estimates for the kingfisher for the off-site creek and Bay samples collected in 2018 were slightly elevated in samples collected immediately downstream, west of Bay Head Road, with decreasing HQs farther downstream towards the Bay. Maximum detected concentrations of PFOS occur in samples collected approximately 400 ft and 700 ft upstream of where the creek empties into the Little Magothy River. The 2018 off-site samples demonstrate delineation of the downstream extent of the off-site PFOS migration, with risk estimates at acceptable levels for the kingfisher beyond SWSD-18-04 as the creek widens into the broader channel of the Little Magothy River. The off-site creek samples with the highest PFOS concentrations in surface water may not provide ideal foraging conditions for the belted kingfisher, but the samples farther downstream that do not exceed the site-specific surface water screening level (e.g., SWSD-18-04 and SWSD-18-05) may provide more suitable habitat for this receptor in terms of the types of invertebrates and fish present.

Given the low HQs for the belted kingfisher using conservative exposure assumptions (e.g., local population obtains 60% of TDD from the site), the bioaccumulation pathway for aquatic-dependent wildlife exposed to PFOS in surface water is considered a complete but insignificant pathway based on the currently available exposure and effects data, with recognition of the level of uncertainty introduced by the use of literature-based BCFs and BAFs. The selected BAFs are, however, expected to err on the conservative side based on a comparison to the BAFs used to derive the generic surface water screening levels for birds and mammals, reducing the potential for underestimation of exposure and risk. Additionally, these results for PFOS are expected to also apply to PFOA, which studies have demonstrated has a much lower capacity for bioaccumulation in the aquatic food web. Therefore, based on this evaluation, at this time no further evaluation is warranted for ecological receptors potentially exposed to PFAS associated with the site.

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Figures

CONTRACT NO 60444465	
CARTOGRAPHY BY A. Weber	
CHECKED BY A. Gupta	DATE January 2016
SCALE 1" = 49,500'	SHEET 1 of 1
Fig_10-1_Site_Location_Map.mxd	

Figure 1
Former Bay Head Road Annex Facility Location Map
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: Bing Maps, 2015; USGS NHD, 2015; ESRI, 2015

CONTRACT NO
60444465

CARTOGRAPHY BY
B. Norris

CHECKED BY
A. Gupta

DATE
September 2016

SCALE
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1 of 1

Fig_10-3 _Historic_and_Proposed_Sample_Locations.mxd

Figure 2
Soil and On/Near Site (East of Bay Head Road)
Sediment and Surface Water
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

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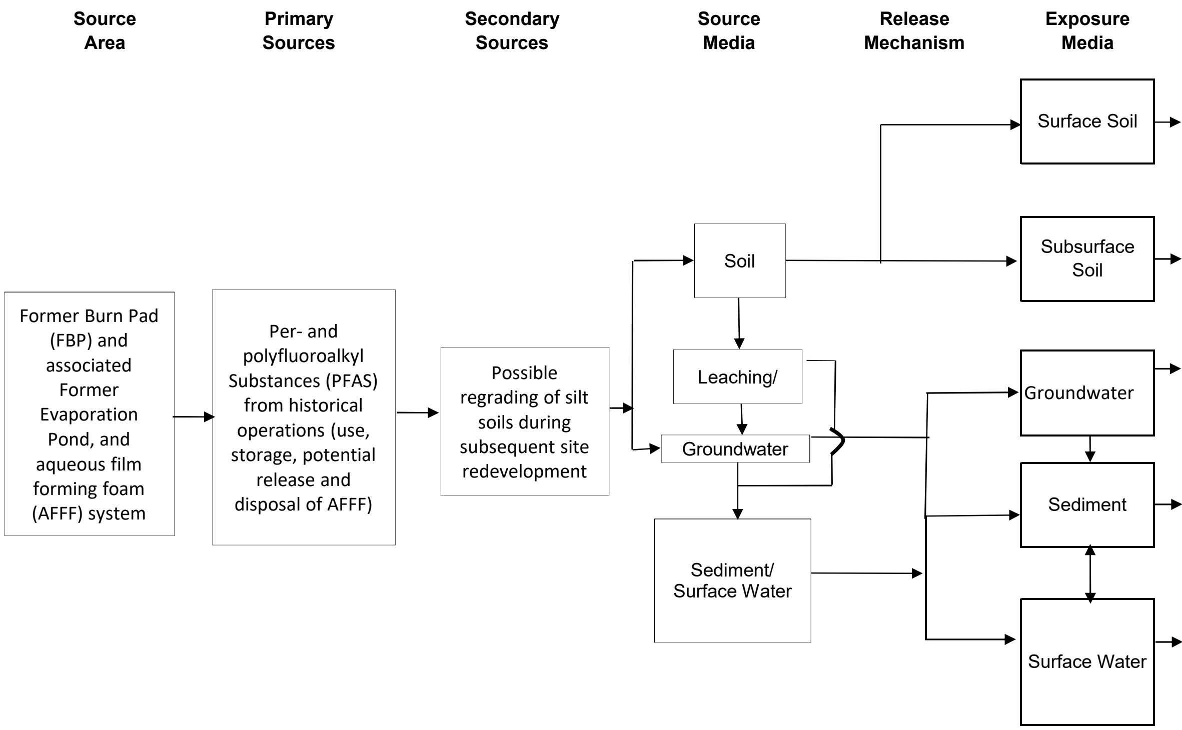
CARTOGRAPHY BY B. Norris	
CHECKED BY S. Tjan	DATE February, 2020
SCALE 1 " = 167 '	SHEET 1 of 1
Document Name: Fig_2-2	

Figure 3
Off-Site (West of Bay Head Road) Sediment and
Surface Water Sampling Locations
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

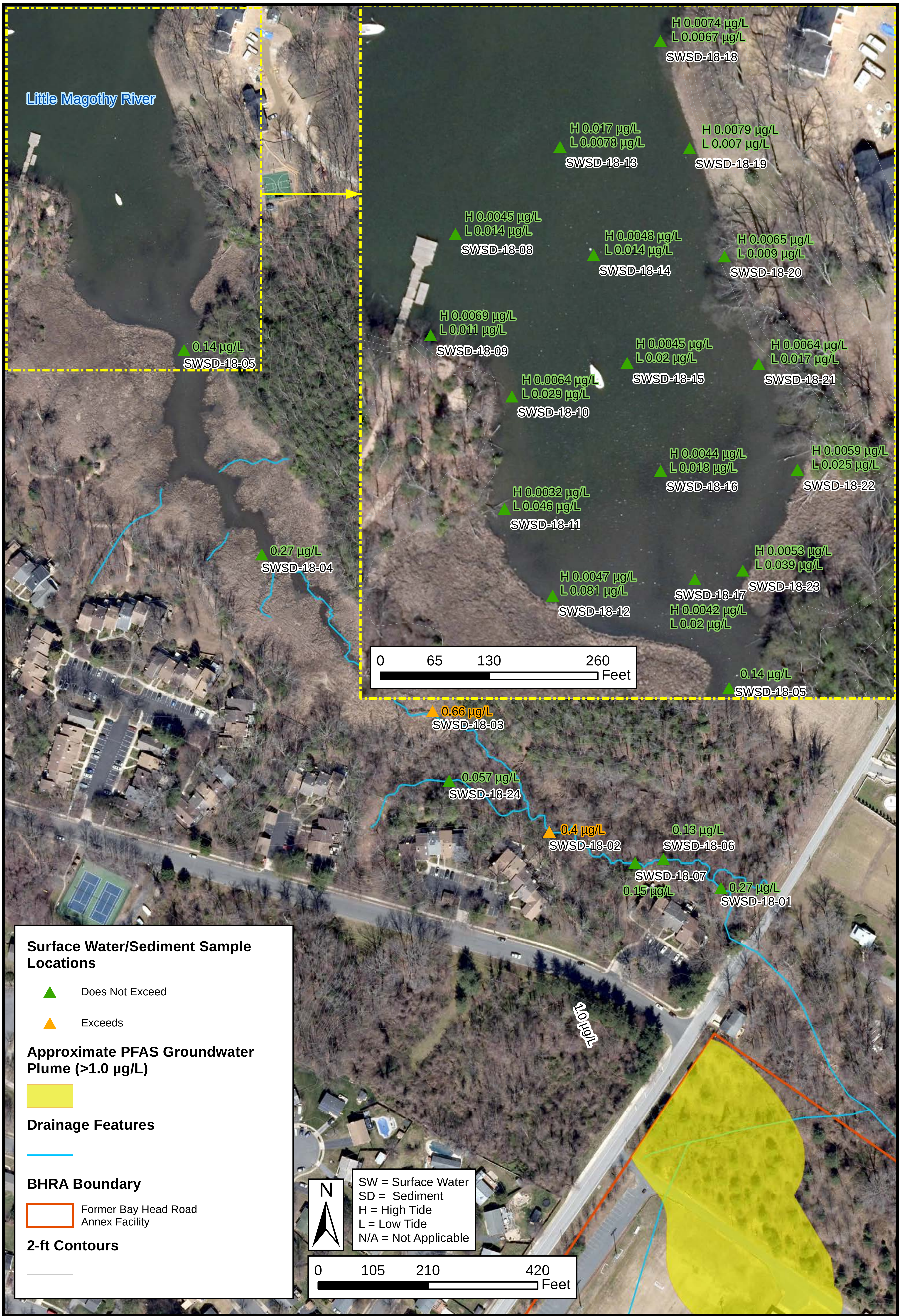
FIGURE 4
ECOLOGICAL CONCEPTUAL SITE MODEL
FORMER BHRA
ANNAPOLIS, MARYLAND



Exposure Media	Potential Exposure Route	Potential Ecological Receptors/Exposure Pathways: Terrestrial Plant Community	Soil Invertebrate Community	Amphibian/ Fish/Aquatic Invertebrate Community	Benthic Invertebrate Community	Avian and Mammalian Communities
Surface Soil	Incidental Ingestion	—	●	—	—	●
	Dermal / Direct Contact	●	●	—	—	○
	Bioaccumulation (Diet)	—	○	—	—	●
Subsurface Soil	Incidental Ingestion	—	○	—	—	○
	Dermal / Direct Contact	○	○	—	—	○
Groundwater	Dermal / Direct Contact	—	—	—	—	—
	Incidental Ingestion	—	—	—	—	—
Sediment	Incidental Ingestion	—	—	○	●	●
	Dermal / Direct Contact	—	—	○	●	○
	Bioaccumulation (Diet)	—	—	○	●	●
Surface Water	Incidental Ingestion	—	—	●	●(a)	●
	Dermal / Direct Contact	—	—	●	●(a)	○
	Bioaccumulation (Diet)	—	—	●	●(a)	●

Notes:
● Potentially complete pathway.
○ Pathway considered to be incomplete or insignificant and not evaluated quantitatively.
-- Exposure medium or exposure route not relevant to the receptor.

(a) The high solubility potential of PFOS and other long-chain PFAS results in a high capacity for uptake from the water-column into aquatic tissues as well as into benthic organism tissues at the sediment-surface water interface.



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SCALE 1 " = 167 '	SHEET 1 of 1
Document Name: Fig_5_Exceedances	

Figure 5
Exceedances of Site-Specific Surface Water
Screening Level – Belted Kingfisher
Former Bay Head Road Annex Facility
Annapolis, MD

AECOM

Source: ESRI, 2015; USGS National Hydrography Dataset, 2005

Tables

TABLE 1
OCCURRENCE, DISTRIBUTION AND TIER 1 SCREENING OF PFAS IN SURFACE SOIL
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe:	Current/Future
Medium:	Surface Soil
Exposure Medium:	Surface Soil

Exposure Point	Chemical	CAS Number	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Concentration Used for Screening (3)	Direct Toxicity		Bioaccumulation		HQ > 1 (Y/N)
										Screening Level (4)	Hazard Quotient (HQ) (5)	Lowest Screening Level (Receptor) (4)	Hazard Quotient (HQ) (5)	
On-Site (East of Bay Head Road)	**PFAS**													
	PFOA	335-67-1	0.22 J	12	µg/kg	DPT-16-35 (0 - 1 ft)	12 / 12	N/A	12	320 IP	0.038	22 M	0.55	N
	PFOS	1763-23-1	0.25 J	170	µg/kg	DPT-16-19 (0 - 1 ft)	11 / 12	0.6 - 0.6	170	11,000 IP	0.015	12 M	14	**Y**
	PFBS	375-73-5	0.12 J	0.21 J	µg/kg	DPT-16-35 (0 - 1 ft)	5 / 12	0.33 - 0.36	0.21	10,000 IP	0.000021	N/A	Not Calc.	N

Notes:

See Attachment A for analytical data used in the ERA.

CAS - Chemical Abstracts Service	N/A - Not Applicable or Not Available.
EPC - Exposure point concentration	ND - Not Detected.
ft - Feet.	PFAS - Poly- and Perfluoroalkyl Substances.
IP - Invertebrates/Plants	PFBS - Perfluorobutanesulfonic acid.
M - Mammals	PFOA - Perfluorooctanoic acid.
µg/kg - Microgram per kilogram.	PFOS - Perfluorooctanesulfonic acid.

(1) Minimum/maximum detected concentration and associated data flags.

J -The chemical was positively identified; however, the associated numerical value is an estimated concentration.

(2) Limits of Detection (LODs) are shown where the frequency of detection is less than 100%.

(3) Maximum detected concentration used for screening.

(4) The soil screening levels for direct toxicity (terrestrial plants/soil invertebrates) and the lowest of the available bioaccumulation (bird/mammal) were selected per chemical (see Table 4)

(5) Hazard quotients were calculated by dividing the maximum detected concentration by the screening level.

TABLE 2

OCCURRENCE, DISTRIBUTION AND TIER 1 SCREENING OF PFAS IN SURFACE SEDIMENT

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Point	Chemical	CAS Number	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Concentration Used for Screening (3)	Screening Level (M/FW) (4)	Hazard Quotient (HQ) (5)	HQ > 1 (Y/N) (6)
All 2016 Sediment Data												
Creek - On/Near Site (East of Bay Head Road)	**PFAS**											
	PFOA	335-67-1	0.18 J	0.28 J	µg/kg	SD-16-03 (0 - 0.5 ft)	4 / 4	N/A	0.28	220 M-S	0.0013	N
	PFOS	1763-23-1	0.42 J	6.6	µg/kg	SD-16-03 (0 - 0.5 ft)	4 / 4	N/A	6.6	220 M	0.030	N
	PFBS	375-73-5	ND	ND	µg/kg	N/A	0 / 4	0.37 - 0.69	ND	220 M-S	Not Calc.	N
All 2018 Sediment Data												
Bay and Creek (West of Bay Head Road)	**PFAS**											
	PFOA	335-67-1	0.50 J	4.5 J	µg/kg	SD-18-03 (0 - 0.5 ft)	10 / 29	0.95 - 5.3	4.5	220 M-S	0.020	N
	PFOS	1763-23-1	0.32 J	44	µg/kg	SD-18-02 (0 - 0.5 ft)	28 / 29	4.5 - 4.5	44	220 M	0.20	N
	PFBS	375-73-5	0.28 J	0.28 J	µg/kg	SD-18-03 (0 - 0.5 ft)	1 / 29	0.38 - 4.6	0.28	220 M-S	0.001	N

Notes:

See Attachment A for analytical data used in the ERA.

CAS - Chemical Abstracts Service

EPC - Exposure point concentration

ft - Feet.

FW - Freshwater

M - Marine

N/A - Not Applicable or Not Available.

ND - Not Detected.

M-S - Marine - PFOS used as a surrogate

µg/kg - Microgram per kilogram.

PFAS - Poly- and Perfluoroalkyl Substances.

PFBS - Perfluorobutanesulfonic acid.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctanesulfonic acid.

TABLE 2

OCCURRENCE, DISTRIBUTION AND TIER 1 SCREENING OF PFAS IN SURFACE SEDIMENT

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

(1) Minimum/maximum detected concentration and associated data flags.

J -The chemical was positively identified; however, the associated numerical value is an estimated concentration.

(2) Limits of Detection (LODs) are shown where the frequency of detection is less than 100%.

(3) Maximum detected concentration used for screening.

(4) The lowest of the available marine and freshwater screening levels for sediment were selected per chemical (see Table 4)

(5) Hazard quotients were calculated by dividing the maximum detected concentration by the screening level.

(6) The maximum detected concentrations of PFOA and PFBS are less than the PFOS screening level.

TABLE 3
OCCURRENCE, DISTRIBUTION AND TIER 1 SCREENING OF PFAS IN SURFACE WATER
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Scenario Timeframe Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Concentration Used for Screening (3)	Direct Toxicity: Lowest Screening Level (M/FW) (4)	Direct Toxicity: Hazard Quotient (HQ) (5)	Bioaccumulation: Lowest Screening Level (Receptor) (4)	Bioaccumulation: Hazard Quotient (HQ) (5)	HQ > 1 (Y/N)
All 2016 Surface Water Data														
Creek - On/Near Site (East of Bay Head Road)		**PFAS**												
	335-67-1	PFOA	0.023	0.042	µg/L	SW-16-02	2 / 2	N/A	0.042	220 FW	0.00019	0.0026 Mammal-S	16	**Y**
	1763-23-1	PFOS	0.12	0.27	µg/L	SW-16-01	2 / 2	N/A	0.27	6.8 FW	0.040	0.0026 Mammal	104	**Y**
	375-73-5	PFBS	0.0089	0.020	µg/L	SW-16-01	2 / 2	N/A	0.020	24,000 FW	8.33E-07	17,000 Bird	1.18E-06	N
All 2018 Surface Water Data														
Bay and Creek (West of Bay Head Road)		**PFAS**												
	335-67-1	PFOA	0.0033	0.53 J	µg/L	SW-18-03	48 / 48	N/A	0.53	220 FW	0.0024	0.0026 Mammal-S	204	**Y**
	1763-23-1	PFOS	0.0032	0.66 J	µg/L	SW-18-02	48 / 48	N/A	0.66	6.8 FW	0.097	0.0026 Mammal	254	**Y**
	375-73-5	PFBS	0.0016 J	0.057	µg/L	SW-18-03	48 / 48	N/A	0.057	24,000 FW	2.38E-06	17,000 Bird	3.35E-06	N
2018 Non-Tidal Surface Water (Creek)														
Bay and Creek (West of Bay Head Road)		**PFAS**												
	335-67-1	PFOA	0.041	0.53 J	µg/L	SW-18-03	10 / 10	N/A	0.53	220 FW	0.0024	0.0026 Mammal-S	204	**Y**
	1763-23-1	PFOS	0.057	0.66 J	µg/L	SW-18-02	10 / 10	N/A	0.66	6.8 FW	0.097	0.0026 Mammal	254	**Y**
	375-73-5	PFBS	0.0075 J	0.057	µg/L	SW-18-03	10 / 10	N/A	0.057	24,000 FW	2.38E-06	17,000 Bird	3.35E-06	N
2018 High Tide Surface Water (Little Magothy River)														
Bay and Creek (West of Bay Head Road)		**PFAS**												
	335-67-1	PFOA	0.0033	0.013 J	µg/L	SW-18-20	18 / 18	N/A	0.013	220 FW	0.0001	0.0026 Mammal-S	5.0	**Y**
	1763-23-1	PFOS	0.0032	0.017	µg/L	SW-18-13	18 / 18	N/A	0.017	6.8 FW	0.003	0.0026 Mammal	6.5	**Y**
	375-73-5	PFBS	0.0016 J	0.0031	µg/L	SW-18-20	18 / 18	N/A	0.0031	24,000 FW	1.29E-07	17,000 Bird	1.82E-07	N

TABLE 3

OCCURRENCE, DISTRIBUTION AND TIER 1 SCREENING OF PFAS IN SURFACE WATER

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

										Direct Toxicity			Bioaccumulation			
Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Concentration Used for Screening (3)	Lowest Screening Level (M/FW) (4)		Hazard Quotient (HQ) (5)	Lowest Screening Level (Receptor) (4)		Hazard Quotient (HQ) (5)	HQ > 1 (Y/N)
2018 Low Tide Surface Water (Little Magothy River)																
Bay and Creek (West of Bay Head Road)		**PFAS**														
	335-67-1	PFOA	0.0078	0.11	µg/L	SW-18-04	18 / 18	N/A	0.11	220	FW	0.0005	0.0026	Mammal-S	42	**Y**
	1763-23-1	PFOS	0.0067	0.087	µg/L	SW-18-05	18 / 18	N/A	0.087	6.8	FW	0.013	0.0026	Mammal	33	**Y**
	375-73-5	PFBS	0.0028	0.016	µg/L	SW-18-04	18 / 18	N/A	0.016	24,000	FW	6.67E-07	17,000	Bird	9.41E-07	N

Notes:

See Attachment A for analytical data used in the ERA.

'All 2018 Surface Water Data" includes non-tidal, high tide, low tide, and two tidal samples for which tidal position was not documented (April 2018 results for SWSD-18-04-SW and SWSD-18-05-SW).

CAS - Chemical Abstracts Service.

EPC - Exposure point concentration

FW - Freshwater

µg/L - Microgram per liter.

N/A - Not Applicable or Not Available.

Mammal-S - Mammal long-chain surrogate (PFOS) applied

PFAS - Poly- and Perfluoroalkyl Substances.

PFBS - Perfluorobutanesulfonic acid.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctanesulfonic acid.

(1) Minimum/maximum detected concentration and associated data flags.

J -The chemical was positively identified; however, the associated numerical value is an estimated concentration.

(2) Limits of Detection (LODs) are shown where the frequency of detection is less than 100%.

(3) Maximum detected concentration used for screening.

(4) The lowest of the available surface water screening levels for direct toxicity (marine/freshwater) and bioaccumulation (bird/mammal) were selected per chemical (see Table 4)

(5) Hazard quotients were calculated by dividing the maximum detected concentration by the screening level.

TABLE 4

ECOLOGICAL SCREENING LEVELS FOR SURFACE SOIL, SEDIMENT AND SURFACE WATER

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Analyte	CAS Number	Sediment Screening Levels (ug/kg-dw)		Soil Screening Levels (µg/kg-dw)			Surface Water Screening Levels (µg/L)					
		Freshwater	Marine	Soil Invertebrates/ Terrestrial Plants	Birds	Mammals	Freshwater			Marine		
							Aquatics	Birds	Mammals	Aquatics	Birds	Mammals
PFOA	335-67-1	N/A	N/A	320 b	N/A	22 b	220 g	N/A	N/A	8,500 g	N/A	N/A
PFOS	1763-23-1	N/A	220 a	11,000 d	330 d	12 d	6.8 d	0.047 e	0.0026 f	7.8 g	N/A	N/A
PFBS	375-73-5	N/A	N/A	10,000 c h	N/A	N/A	24,000 e	17,000 e	N/A	N/A	N/A	N/A

Notes:

CAS - Chemical Abstracts Service.

dw - Dry weight

µg/kg - Microgram per kilogram.

µg/L - Microgram per liter.

N/A - Not Applicable or Not Available.

PFBS - Perfluorobutanesulfonic acid.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctanesulfonic acid.

Sources:

(a) NPCA 2008

(b) U.K. EA 2017

(c) Karnjanapiboonwong 2017

(d) ECCC 2018

(e) Giesy et al. 2010

(f) RIVM 2010

(g) CRC Care March 2017

(h) An uncertainty factor of 100 was applied to account for sublethal exposure duration and singular test species.

TABLE 5

TIER 2 SCREENING FOR SURFACE SOIL

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Current/Future
Medium:	Surface Soil
Exposure Medium:	Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Exposure Point Concentration (EPC) (3)	Screening Level (Receptor) (4)	Hazard Quotient (HQ) (5)	HQ > 1 (Y/N)
On-Site (East of Bay Head Road)		**PFAS**										
	1763-23-1	PFOS	0.25 J	170	µg/kg	DPT-16-19 (0 - 1 ft)	11 / 12	0.6 - 0.6	108	330 Birds	0.33	N
	1763-23-1	PFOS	0.25 J	170	µg/kg	DPT-16-19 (0 - 1 ft)	11 / 12	0.6 - 0.6	108	12 Mammals	9.0	**Y**

Notes:

See Attachment A for analytical data used in the ERA and Attachment C for ProUCL output.

CAS - Chemical Abstracts Service.

EPC - Exposure point concentration

µg/kg - Microgram per kilogram.

N/A - Not Applicable or Not Available.

PFAS - Poly- and Perfluoroalkyl Substances.

PFOS - Perfluorooctanesulfonic acid.

(1) Minimum/maximum detected concentration and associated data flags.

J -The chemical was positively identified; however, the associated numerical value is an estimated concentration.

(2) Limits of Detection (LODs) are shown where the frequency of detection is less than 100%.

(3) The 95 percent (%) upper confidence limit (UCL) of the arithmetic mean used for refined screening. If more than one UCL was recommended, the higher UCL was used.

(4) See Table 4 for screening level sources

(5) Hazard quotients were calculated by dividing the EPC by the screening level.

TABLE 6
SAMPLE-BY-SAMPLE SCREENING FOR SURFACE SOIL
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

			Location Description	On-Site (East of Bay Head Road)												
			Location ID	DPT-16-15	DPT-16-15	DPT-16-19	DPT-16-20	DPT-16-28	DPT-16-29	DPT-16-30	DPT-16-31	DPT-16-32	DPT-16-34	DPT-16-35	DPT-17-26	DPT-17-27
			Sample ID	DPT-16-15-SO-00-01	DPT-16-15-SO-00-01-DUP	DPT-16-19-SO-00-01	DPT-16-20-SO-00-01	DPT-16-28-SO-00-01	DPT-16-29-SO-00-01	DPT-16-30-SO-00-01	DPT-16-31-SO-00-01	DPT-16-32-SO-00-01	DPT-16-34-SO-00-01	DPT-16-35-SO-00-01	DPT-17-26-SO-00-01	DPT-17-27-SO-00-01
			Collection Date	11/2/2016	11/2/2016	11/22/2016	11/2/2016	11/2/2016	11/2/2016	11/2/2016	11/2/2016	11/2/2016	11/2/2016	11/22/2016	1/12/2017	1/12/2017
			Interval (ft bgs)	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft
			Sample Type Code	N	FD	N	N	N	N	N	N	N	N	N	N	N
		Screening Levels (a)														
CAS	Analyte	Birds	Mammals													
1763-23-1	PFOS	330	12	27	27	170	12	8.9	38	20	5.9	10	80	28	0.25 J	< 0.60 U

Notes:
All units in microgram per kilogram (µg/kg) .
bgs - Below ground surface.
CAS - Chemical Abstracts Service.
FD - Field Duplicate.
ft - Feet.
J - Analyte positively detected but value is an approximate concentration.
N/A - Not Applicable or Not Available.
N - Normal Sample.
PFOS - Perfluorooctanesulfonic acid.
U - Analyte was not detected above the reported quantitation limit.

Value exceeds screening level for Mammals.
(a) Refer to Table 4 for screening level sources.

TABLE 7

TIER 2 SCREENING FOR SURFACE WATER

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Exposure Point Concentration (EPC) (3)	Screening Level (Receptor) (4)		Hazard Quotient (HQ) (5)	HQ > 1 (Y/N)
All 2016 Surface Water Data													
Creek - On/Near Site (East of Bay Head Road)		**PFAS**											
	335-67-1	PFOA	0.023	0.042	µg/L	SW-16-02	2 / 2	N/A	0.042	0.047	Birds-S	0.9	N
	335-67-1	PFOA	0.023	0.042	µg/L	SW-16-02	2 / 2	N/A	0.042	0.0026	Mammals-S	16	**Y**
	1763-23-1	PFOS	0.12	0.27	µg/L	SW-16-01	2 / 2	N/A	0.27	0.047	Birds	5.7	**Y**
	1763-23-1	PFOS	0.12	0.27	µg/L	SW-16-01	2 / 2	N/A	0.27	0.0026	Mammals	104	**Y**
All 2018 Surface Water Data													
Bay and Creek (West of Bay Head Road)		**PFAS**											
	335-67-1	PFOA	0.0033	0.53 J	µg/L	SW-18-03	48 / 48	N/A	0.142	0.047	Birds-S	3.0	**Y**
	335-67-1	PFOA	0.0033	0.53 J	µg/L	SW-18-03	48 / 48	N/A	0.142	0.0026	Mammals-S	54	**Y**
	1763-23-1	PFOS	0.0032	0.66 J	µg/L	SW-18-02	48 / 48	N/A	0.162	0.047	Birds	3.5	**Y**
	1763-23-1	PFOS	0.0032	0.66 J	µg/L	SW-18-02	48 / 48	N/A	0.162	0.0026	Mammals	62	**Y**
2018 Non-Tidal Surface Water (Creek)													
Bay and Creek (West of Bay Head Road)		**PFAS**											
	335-67-1	PFOA	0.041	0.53 J	µg/L	SW-18-03	10 / 10	N/A	0.32	0.047	Birds-S	6.8	**Y**
	335-67-1	PFOA	0.041	0.53 J	µg/L	SW-18-03	10 / 10	N/A	0.32	0.0026	Mammals-S	122	**Y**
	1763-23-1	PFOS	0.057	0.66 J	µg/L	SW-18-02	10 / 10	N/A	0.38	0.047	Birds	8.0	**Y**
	1763-23-1	PFOS	0.057	0.66 J	µg/L	SW-18-02	10 / 10	N/A	0.38	0.0026	Mammals	145	**Y**

TABLE 7

TIER 2 SCREENING FOR SURFACE WATER

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits (2)	Exposure Point Concentration (EPC) (3)	Screening Level (Receptor) (4)	Hazard Quotient (HQ) (5)	HQ > 1 (Y/N)
2018 High Tide Surface Water (Little Magothy River)												
Bay / Study Area (West of Bay Head Road)		**PFAS**										
	335-67-1	PFOA	0.0033	0.013 J	µg/L	SW-18-20	18 / 18	N/A	0.0071	0.047 Birds-S	0.2	N
	335-67-1	PFOA	0.0033	0.013 J	µg/L	SW-18-20	18 / 18	N/A	0.0071	0.0026 Mammals-S	2.7	**Y**
	1763-23-1	PFOS	0.0032	0.017	µg/L	SW-18-13	18 / 18	N/A	0.0078	0.047 Birds	0.2	N
	1763-23-1	PFOS	0.0032	0.017	µg/L	SW-18-13	18 / 18	N/A	0.0078	0.0026 Mammals	3.0	**Y**
2018 Low Tide Surface Water (Little Magothy River)												
Bay / Study Area (West of Bay Head Road)		**PFAS**										
	335-67-1	PFOA	0.0078	0.11	µg/L	SW-18-04	18 / 18	N/A	0.052	0.047 Birds-S	1.1	**Y**
	335-67-1	PFOA	0.0078	0.11	µg/L	SW-18-04	18 / 18	N/A	0.052	0.0026 Mammals-S	20	**Y**
	1763-23-1	PFOS	0.0067	0.087	µg/L	SW-18-05	18 / 18	N/A	0.044	0.047 Birds	0.9	N
	1763-23-1	PFOS	0.0067	0.087	µg/L	SW-18-05	18 / 18	N/A	0.044	0.0026 Mammals	17	**Y**

Notes:

See Attachment A for analytical data used in the ERA and Attachment C for ProUCL output.

'All 2018 Surface Water Data" includes non-tidal, high tide, low tide, and two tidal samples for which tidal position was not documented (April 2018 at SWSD-18-04-SW and SWSD-18-05-SW).

Bird-S - Bird surrogate (PFOS) applied

CAS - Chemical Abstracts Service.

EPC - Exposure point concentration

Mammal-S - Mammal surrogate (PFOS) applied

µg/L- Microgram per liter.

N/A - Not Applicable or Not Available.

PFAS - Poly- and Perfluoroalkyl Substances.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctanesulfonic acid.

(1) Minimum/maximum detected concentration and associated data flags.

J -The chemical was positively identified; however, the associated numerical value is an estimated concentration.

(2) Limits of Detection (LODs) are shown where the frequency of detection is less than 100%.

(3) The 95 percent (%) upper confidence limit (UCL) of the arithmetic mean used for refined screening. If a UCL could not be calculated from the dataset because of low sample size, the maximum

(4) See Table 4 for screening level sources

(5) Hazard quotients were calculated by dividing the EPC by the screening level.

TABLE 8
SAMPLE-BY-SAMPLE SCREENING FOR SURFACE WATER
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

			Location Description	Creek - On/Near Site (East of Bay Head Road)			Bay and Creek (West of Bay Head Road)											
			Location ID	SW-16-01	SW-16-02	SW-16-02	SWSD-18-01	SWSD-18-01	SWSD-18-02	SWSD-18-02	SWSD-18-03	SWSD-18-03	SWSD-18-03	SWSD-18-03	SWSD-18-04	SWSD-18-04	SWSD-18-04	SWSD-18-05
			Sample ID	SW-16-01-SW	SW-16-02-SW	SW-16-02-SW-DUP	SWSD-18-01-SW	SW-18-01-H	SWSD-18-02-SW	SW-18-02-H	SWSD-18-03-SW	SWSD-18-03-SW-DUP	SW-18-03-H	SW-18-03-L	SWSD-18-04-SW	SW-18-04-H	SW-18-04-L	SWSD-18-05-SW
			Collection Date	12/5/2016	12/5/2016	12/5/2016	4/26/2018	11/19/2018	4/26/2018	11/19/2018	4/26/2018	4/26/2018	11/19/2018	11/20/2018	4/26/2018	11/19/2018	11/20/2018	4/26/2018
			Sample Type Code	N	N	FD	N	N	N	N	N	FD	N	N	N	N	N	N
		Screening Levels (a)																
		Freshwater																
CAS	Analyte	Birds	Mammals															
335-67-1	PFOA	PFOS-S	PFOS-S	0.023	0.042	0.041	0.055	0.041	0.43 J	0.26	0.49 J	0.53 J	0.26	0.36	0.26	0.0046	0.11	0.13
1763-23-1	PFOS	0.047	0.0026	0.27	0.12	0.12	0.18	0.12	0.66 J	0.3	0.4 J	0.55 J	0.21	0.27	0.27	0.0043	0.075	0.14

Notes:
All units in microgram per kilogram (µg/L).
"H" in sample ID indicates sample collected at high tide.
"L" in sample ID indicates sample collected at low tide.
CAS - Chemical Abstracts Service.
FD - Field Duplicate.
J - Analyte positively detected but value is an approximate concentration.
N - Normal Sample.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctanesulfonic acid.
PFOS-S - PFOS screening level used as long-chain surrogate for PFOA
U - Analyte was not detected above the reported quantitation limit.

Value exceeds screening level for freshwater birds and mammals.

Value exceeds screening level for freshwater mammals.

(a) Refer to Table 4 for screening level sources.

TABLE 8
SAMPLE-BY-SAMPLE SCREENING FOR SURFACE WATER
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

			Location Description	Bay and Creek (West of Bay Head Road)														
			Location ID	SWSD-18-05	SWSD-18-05	SWSD-18-05	SWSD-18-05	SWSD-18-06	SWSD-18-07	SWSD-18-08	SWSD-18-08	SWSD-18-09	SWSD-18-09	SWSD-18-10	SWSD-18-10	SWSD-18-11	SWSD-18-11	SWSD-18-11
			Sample ID	SW-18-05-H	SW-18-05-H-DUP	SW-18-05-L	SW-18-05-L-DUP	SW-18-06	SW-18-07	SW-18-08-H	SW-18-08-L	SW-18-09-H	SW-18-09-L	SW-18-10-H	SW-18-10-L	SW-18-11-H	SW-18-11-L	SW-18-11-L-DUP
			Collection Date	11/19/2018	11/19/2018	11/20/2018	11/20/2018	11/20/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/20/2018
			Sample Type Code	N	FD	N	FD	N	N	N	N	N	N	N	N	N	N	FD
		Screening Levels (a)																
		Freshwater																
CAS	Analyte	Birds	Mammals															
335-67-1	PFOA	PFOS-S	PFOS-S	0.0037	0.0038	0.1	0.1	0.057	0.073	0.0049	0.017	0.0073	0.011	0.0066	0.039	0.0033	0.059	0.058
1763-23-1	PFOS	0.047	0.0026	0.0039	0.0035	0.087	0.082	0.13	0.15	0.0045	0.014	0.0069	0.011	0.0064	0.029	0.0032	0.046	0.047

Notes:
All units in microgram per kilogram (µg/L).
"H" in sample ID indicates sample collected at high tide.
"L" in sample ID indicates sample collected at low tide.
CAS - Chemical Abstracts Service.
FD - Field Duplicate.
J - Analyte positively detected but value is an approximate concentration.
N - Normal Sample.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctanesulfonic acid.
PFOS-S - PFOS screening level used as long-chain surrogate for PFOA
U - Analyte was not detected above the reported quantitation limit.

Value exceeds screening level for freshwater birds and mammals.

Value exceeds screening level for freshwater mammals.

(a) Refer to Table 4 for screening level sources.

TABLE 8
SAMPLE-BY-SAMPLE SCREENING FOR SURFACE WATER
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

			Location Description	Bay and Creek (West of Bay Head Road)														
			Location ID	SWSD-18-12	SWSD-18-12	SWSD-18-13	SWSD-18-13	SWSD-18-14	SWSD-18-14	SWSD-18-15	SWSD-18-15	SWSD-18-15	SWSD-18-16	SWSD-18-16	SWSD-18-17	SWSD-18-17	SWSD-18-18	SWSD-18-18
			Sample ID	SW-18-12-H	SW-18-12-L	SW-18-13-H	SW-18-13-L	SW-18-14-H	SW-18-14-L	SW-18-15-H	SW-18-15-L	SW-18-15-L-DUP	SW-18-16-H	SW-18-16-L	SW-18-17-H	SW-18-17-L	SW-18-18-H	SW-18-18-L
			Collection Date	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018
			Sample Type Code	N	N	N	N	N	N	N	N	FD	N	N	N	N	N	N
		Screening Levels (a)																
		Freshwater																
CAS	Analyte	Birds	Mammals															
335-67-1	PFOA	PFOS-S	PFOS-S	0.0042	0.081	0.0059	0.0093	0.0056	0.017	0.0047	0.024	0.024	0.0046	0.023	0.0044	0.028	0.0081	0.0078
1763-23-1	PFOS	0.047	0.0026	0.0047	0.081	0.017	0.0078	0.0048	0.014	0.0045	0.02	0.019	0.0044	0.018	0.0042	0.02	0.0074	0.0067

Notes:
All units in microgram per kilogram (µg/L).
"H" in sample ID indicates sample collected at high tide.
"L" in sample ID indicates sample collected at low tide.
CAS - Chemical Abstracts Service.
FD - Field Duplicate.
J - Analyte positively detected but value is an approximate concentration.
N - Normal Sample.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctanesulfonic acid.
PFOS-S - PFOS screening level used as long-chain surrogate for PFOA
U - Analyte was not detected above the reported quantitation limit.

Value exceeds screening level for freshwater birds and mammals.

Value exceeds screening level for freshwater mammals.

(a) Refer to Table 4 for screening level sources.

TABLE 8
SAMPLE-BY-SAMPLE SCREENING FOR SURFACE WATER
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

			Location Description	Bay and Creek (West of Bay Head Road)											
			Location ID	SWSD-18-19	SWSD-18-19	SWSD-18-20	SWSD-18-20	SWSD-18-20	SWSD-18-21	SWSD-18-21	SWSD-18-22	SWSD-18-22	SWSD-18-23	SWSD-18-23	SWSD-18-24
			Sample ID	SW-18-19-H	SW-18-19-L	SW-18-20-H	SW-18-20-H-DUP	SW-18-20-L	SW-18-21-H	SW-18-21-L	SW-18-22-H	SW-18-22-L	SW-18-23-H	SW-18-23-L	SW-18-24
			Collection Date	11/19/2018	11/20/2018	11/19/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/20/2018
			Sample Type Code	N	N	N	FD	N	N	N	N	N	N	N	N
		Screening Levels (a)													
		Freshwater													
CAS	Analyte	Birds	Mammals												
335-67-1	PFOA	PFOS-S	PFOS-S	0.0092	0.008	0.013 J	0.0082 J	0.011	0.0076	0.0088	0.0065	0.013	0.0055	0.044	0.058
1763-23-1	PFOS	0.047	0.0026	0.0079	0.007	0.012 J	0.0065 J	0.009	0.0064	0.017	0.0059	0.025	0.0053	0.039	0.057

Notes:
All units in microgram per kilogram (µg/L).
"H" in sample ID indicates sample collected at high tide.
"L" in sample ID indicates sample collected at low tide.
CAS - Chemical Abstracts Service.
FD - Field Duplicate.
J - Analyte positively detected but value is an approximate concentration.
N - Normal Sample.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctanesulfonic acid.
PFOS-S - PFOS screening level used as long-chain surrogate for PFOA
U - Analyte was not detected above the reported quantitation limit.

Value exceeds screening level for freshwater birds and mammals.

Value exceeds screening level for freshwater mammals.

(a) Refer to Table 4 for screening level sources.

TABLE 9
EXPOSURE PARAMETERS FOR WILDLIFE RECEPTORS
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Receptor Species	Body Weight (kg)	Assumed Diet Fraction of diet as %; Amount as kg_{ww}/day				Food Ingestion Rate (kg_{dw}/day)	Food Ingestion Rate (kg_{ww}/day)	Fraction Sediment in Diet (%) Amount as kg_{dw}/day	Water Intake Rate (kg/day)	Home Range (km)	Seasonal Use Factor (unitless)	Area Use Factor (unitless)
		Units	Fish		Aquatic and Benthic Invertebrates							
			TL 2/3	TL 3/4								
Birds												
Great Blue Heron	2.336 (a)	%	--	100% (b)	-- (b)	0.1453 (c)	0.5812 (d)	-- (e)	0.1042 (f)	5.3 (g)	1 (h)	0.13 (i)
(*Ardea herodias*)		kg_{ww}/day	--	0.5812	--			--				
Belted kingfisher	0.1473 (a)	%	50% (b)	30% (b)	20% (b)	0.0233 (c)	0.1054 (d)	2% (e)	0.0164 (f)	1.16 (g)	1 (h)	0.59 (i)
(*Megaceryle alcyon*)		kg_{ww}/day	0.0465	0.0279	0.03100			0.0005				
Osprey	1.629 (a)	%	--	100% (b)	--	0.1144 (c)	0.4576 (d)	-- (e)	0.0818 (f)	11.5 (g)	1 (h)	0.059 (i)
(*Pandion haliaetus*)		kg_{ww}/day	--	0.4576	--			--				
Mammals												
Otter	7.990 (a)	%	35% (b)	45% (b)	20% (b)	0.2586 (c)	1.1725 (d)	9.4% (e)	0.643 (f)	31 (g)	1 (h)	0.022 (i)
(*Lutra canadensis*)		kg_{ww}/day	0.3621	0.4656	0.3449			0.0243				
Mink	1.020 (a)	%	34% (b)	33% (b)	33% (b)	0.0559 (c)	0.2729 (d)	9.4% (e)	0.101 (f)	2.24 (g)	1 (h)	0.30 (i)
(*Neovison vison*)		kg_{ww}/day	0.0761	0.0738	0.1230			0.0053				

General Notes:

Food ingestion rates are wet weight for food items and dry weight for sediment/soil ingestion. As needed, rate may be converted.

Ingested abiotic media (i.e., soil or sediment) is in addition to 100% of dietary ingestion.

See individual organism notes for source, units, and conversion.

Moisture content of food items assumed to be as follows: 75% for fish and 85% for aquatic and benthic invertebrates (USEPA, 1993).

TABLE 9
EXPOSURE PARAMETERS FOR WILDLIFE RECEPTORS
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

BW - Body Weight
COPC - Constituent of Potential Concern
dw - Dry Weight
FIR - Food Ingestion Rate
kg - Kilogram
km - Kilometer
TL - Trophic Level
USEPA - United States Environmental Protection Agency
WIR - Water Ingestion Rate (1 L of water has weight of 1 kg)
ww - Wet Weight

Notes for Great Blue Heron (*Ardea herodias*):

(a) Average body weight of adult male and female herons (USEPA, 1993).

(b) Diet assumed to be exclusively fish (TL 3/4).

(c) Food ingestion rate calculated using algorithm for carnivorous birds developed by Nagy, 2001 [FIR (g_{dw}/day) = $0.849*BW^{0.663}$].

(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

FIR_{ww} = Sum {[(Proportion of $food_i$ in diet) x (FIR_{dw})] / (1-moisture $content_i$)}

(e) Fraction set to 0%. Assumption for wading bird based on best professional judgement and ingestion of TL 3/4 fish.

(f) Water ingestion rate calculated using algorithm for all birds developed by USEPA, 1993 [WIR (kg/day) = $0.059*BW^{0.67}$].

(g) Average adult foraging distance from colony based on studies conducted in riverine & coastal areas in South Dakota and North Carolina (USEPA, 1993).

(h) Great blue heron assumed to be present and actively foraging year-round.

(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

Notes for Belted Kingfisher (*Megaceryle alcyon*):

(a) Average body weight of adult male and female kingfishers (USEPA, 1993).

(b) Diet assumed to be exclusively fish and benthic invertebrates, dietary percentages based on professional judgement and EPA 1993.

(c) Food ingestion rate calculated using algorithm for carnivorous birds developed by Nagy, 2001 [FIR (g_{dw}/day) = $0.849*BW^{0.663}$].

(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

FIR_{ww} = Sum {[(Proportion of $food_i$ in diet) x (FIR_{dw})] / (1-moisture $content_i$)}

(e) Fraction set to 2%. Assumption for kingfisher based on best professional judgement and ingestion of invertebrates, and TL 2/3 and 3/4 fish.

(f) Water ingestion rate calculated using algorithm for all birds developed by USEPA, 1993 [WIR (kg/day) = $0.059*BW^{0.67}$].

(g) Average territory (km shoreline) based on studies conducted in streams in Pennsylvania and Ohio (USEPA, 1993).

(h) Belted kingfisher assumed to be present and actively foraging year-round.

(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

TABLE 9

EXPOSURE PARAMETERS FOR WILDLIFE RECEPTORS

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Notes for Osprey (P*andion haliaetus*):

(a) Average body weight of adult male and female osprey (USEPA, 1993).

(b) Diet assumed to be exclusively fish (TL 3/4).

(c) Food ingestion rate calculated using algorithm for carnivorous birds developed by Nagy, 2001 [FIR (gdw/day) = 0.849*BW0.663].

(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

FIR_{ww} = Sum {[(Proportion of $food_i$ in diet) x (FIR_{dw})] / (1-moisture $content_i$)}

(e) Fraction set to 0%. Assumption for osprey based on best professional judgement and ingestion of TL 3/4 fish.

(f) Water ingestion rate calculated using algorithm for all birds developed by USEPA, 1993 [WIR (kg/day) = 0.059*$BW^{0.67}$].

(g) Average territory radius (km) doubled to generate full linear range (diameter) based on studies conducted in lakes and coastal/bay area in Minnesota. Nova Scotia and NW California (USEPA, 1993).

(h) Osprey assumed to be present and actively foraging year-round.

(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

Notes for Otter

(a) Average body weight of adult male and female river otters (USEPA, 1993).

(b) Diet assumed to be exclusively fish and benthic invertebrates, dietary percentages based on professional judgement and EPA 1993.

(c) Food ingestion rate calculated using algorithm for mammals developed by Nagy, 2001 [FIR (gdw/day) = 0.323*BW0.744].

(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

FIR_{ww} = Sum {[(Proportion of $food_i$ in diet) x (FIR_{dw})] / (1-moisture $content_i$)}

(e) The incidental soil ingestion rate is based on the value identified by Beyer (1994) for the surrogate species used, raccoon.

(f) Water ingestion rate calculated using algorithm for all mammals developed by USEPA, 1993 [WIR (kg/day) = 0.099*BW0.90] using average body weight.

(g) Average adult female home range (km river) for river drainages in Idaho (USEPA, 1993).

(h) Otter assumed to be present and actively foraging year-round.

(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

TABLE 9

EXPOSURE PARAMETERS FOR WILDLIFE RECEPTORS

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

Notes for Mink

(a) Average body weight of adult male and female mink in Michigan and Montana (USEPA, 1993).

(b) A diet consisting of 33% invertebrates, and 67% fish was selected.

(c) Food ingestion rate calculated using algorithm for mammals developed by Nagy, 2001 [FIR (gdw/day) = 0.323*BW0.744].

(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

FIR_{ww} = Sum {[(Proportion of $food_i$ in diet) x (FIR_{dw})] / (1-moisture $content_i$)}

(e) The incidental soil ingestion rate is based on the value identified by Beyer (1994) for the surrogate species used, raccoon.

(f) Water ingestion rate calculated using algorithm for all mammals developed by USEPA, 1993 [WIR (kg/day) = 0.099*BW0.90] using average body weight.

(g) Average adult home range for stream habitats in Sweden (USEPA, 1993).

(h) Otter assumed to be present and actively foraging year-round.

(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

TABLE 10
WATER TO INVERTEBRATE BCFS AND FISH BAFs FOR PFOS
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

COPC	Water to TL2 Invertebrate Bioconcentration Factor	Fish Bioaccumulation Factor (Water + Diet)		Study Notes
	Trophic Level 2 Invertebrate	Trophic Level 2/3 Fish	Trophic Level 3/4 Fish	
Individual BCFs and BAFs from Source Studies				
PFOS	1,000 (a)	2,000 (a) min	10,000 (a)	Study based on water to crayfish to round goby/small mouth bass to salmon (liver). Low-end BMF used for TL3/4 fish because based on salmon liver, where PFOS is most concentrated, and not whole body. PFOA was non-detect in aquatic tissues in this study.
		4,000 (a) max	20,000 (a)	
PFOS	1,200 (b)	95,000 (b)	16,000 (b)	Study based on water to Mysis (benthic crustacean) to sculpin to lake trout.
PFOS		2,367 (c)	5,129 (c)	TL 2/3 BAF of 2,367 derived using data for yellow perch, golden shiner, bluegill sunfish, and white bass (bass considered TL 2/3 fish due to small size). No data were available for TL 3/4 fish, so study used extrapolation approach described in footnote c. Limited bioaccumulation data suggest that PFOA is not very bioaccumulative.
PFOS			6,468 (d)	Study was based on crustacean to forage fish to lake trout. By accounting for the known diet composition of lake trout, it was shown that bioaccumulation was indeed occurring at the top of the food web for all perfluoroalkyl compounds except PFOA.
Mean and Geomean BCFs and BAFs used in the ERA				
PFOS	**1,100** (f)	**6,513** (g)	**10,120** (h)	See footnotes

Notes:

BAF - Bioaccumulation Factor
BCF - Bioconcentration Factor
BMF - Biomagnification Factor
COPC - Chemical of Potential Concern
PFAS - Poly- and Perfluoroalkyl Substances
PFOS - Perfluorooctanesulfonic Acid
TL - Trophic Level

(a) Kannan et al. 2005: BCF obtained directly from source. TL 2/3 BAFs derived by multiplying the BCF by the min and max TL 2/3 BMFs (2 and 4, respectively) reported in the study. TL 3/4 BAFs derived by multiplying the derived TL 2/3 BAFs by the TL 3/4 BMF (5) reported in the study.

(b) Houde et al. 2008 (cited in Concawe 2016): BCF, TL 2/3 BAF, and TL 3/4 BAF obtained directly from source.

(c) MDCH 2015: TL 2/3 BAF was obtained directly from the source. Since no data were available for TL 3/4 fish, authors derived this BAF by multiplying the TL2/3 BAF by the ratio of the TL3/4 fillet BAF to the TL2/3 fillet BAF. TL 2/3 and TL 3/4 fillet BAFs = 2,329 and 5,047 L/kg, respectively.

(d) Martin et al. 2004 (as cited in Franklin 2015): The TL 3/4 BAF was derived by multiplying the TL 3/4 BMF (5.88) in this study to the average of the Kannan et al. 2005 BCF and Houde et al. 2008 BCF (1,100 L/kg) because no water to invertebrate BCF was provided in Martin et al. 2004.

(f) An average TL2 Invertebrate BCF was calculated based on the BCFs (n=2) obtained from Kannan et al. 2005 and Houde et al. 2008 (cited in Concawe 2016).

(g) A TL 2/3 fish geomean BAF was calculated based on the TL 2/3 BAFs (n=4) obtained or derived from Kannan et al. 2005, Houde et al. 2008 (as cited in Concawe 2016), and MDCH 2015.

(h) A TL 3/4 fish geomean BAF was calculated based on the TL 3/4 BAFs (n=5) obtained or derived from Kannan et al. 2005, Houde et al. 2008 (as cited in Concawe 2016), MDCH 2015, and Martin 2004 (as cited in Franklin 2015).

TABLE 11

SUMMARY OF RECEPTOR-SPECIFIC SURFACE WATER HQs FOR PFOS

ECOLOGICAL RISK ASSESSMENT

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

HQs for Potential PFOS Exposure - Using 95% UCL Abiotic Media & Species-Specific AUFs									
Great Blue Heron		Belted kingfisher		Osprey		Otter		Mink	
NOAEL-based HQ	LOAEL- based HQ	NOAEL-based HQ	LOAEL- based HQ	NOAEL-based HQ	LOAEL- based HQ	NOAEL-based HQ	LOAEL- based HQ	NOAEL-based HQ	LOAEL- based HQ
0.68	0.068	**5.2**	0.52	0.36	0.036	0.033	0.0083	0.67	0.17

Notes:

HQs above 1 are bolded and highlighted.

95% UCL - 95% Upper Confidence Limit of the Arithmetic Mean

AUF - Area Use Factor

HQ - Hazard Quotient (Dose/Toxicity Reference Value)

LOAEL - Lowest Observed Adverse Effects Level

NOAEL - No Observed Adverse Effects Level

PFOS - Perfluorooctanesulfonic Acid

TABLE 12
SAMPLE-BY-SAMPLE SITE-SPECIFIC SCREENING FOR SURFACE WATER
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

		Location Description	Creek - On/Near Site (East of Bay Head Road)			Bay and Creek (West of Bay Head Road)											
		Location ID	SW-16-01	SW-16-02	SW-16-02	SWSD-18-01	SWSD-18-01	SWSD-18-02	SWSD-18-02	SWSD-18-03	SWSD-18-03	SWSD-18-03	SWSD-18-03	SWSD-18-04	SWSD-18-04	SWSD-18-04	SWSD-18-05
		Sample ID	SW-16-01-SW	SW-16-02-SW	SW-16-02-SW-DUP	SWSD-18-01-SW	SW-18-01-H	SWSD-18-02-SW	SW-18-02-H	SWSD-18-03-SW	SWSD-18-03-SW-DUP	SW-18-03-H	SW-18-03-L	SWSD-18-04-SW	SW-18-04-H	SW-18-04-L	SWSD-18-05-SW
		Collection Date	12/5/2016	12/5/2016	12/5/2016	4/26/2018	11/19/2018	4/26/2018	11/19/2018	4/26/2018	4/26/2018	11/19/2018	11/20/2018	4/26/2018	11/19/2018	11/20/2018	4/26/2018
		Sample Type Code	N	N	FD	N	N	N	N	N	FD	N	N	N	N	N	N
CAS	Analyte	Site-Specific Screening Value based on Belted Kingfisher (a)															
1763-23-1	PFOS	0.28	0.27	0.12	0.12	0.18	0.12	0.66 J	0.30	0.4 J	0.55 J	0.21	0.27	0.27	0.0043	0.075	0.14

Notes:
All units in microgram per kilogram (µg/L).
"H" in sample ID indicates sample collected at high tide.
"L" in sample ID indicates sample collected at low tide.
CAS - Chemical Abstracts Service.
FD - Field Duplicate.
J - Analyte positively detected but value is an approximate concentration.
N - Normal Sample.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctanesulfonic acid.
PFOS-S - PFOS screening level used as long-chai
U - Analyte was not detected above the reported quantitation limit.

Value exceeds site-specific screening level.

(a) Based on belted kingfisher LOAEL-based HQ using the mid-range (average) bioaccumulation factors; see Attachment D.

TABLE 12
SAMPLE-BY-SAMPLE SITE-SPECIFIC SCREENING FOR SURFACE WATER
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

		Location Description	Bay and Creek (West of Bay Head Road)														
		Location ID	SWSD-18-05	SWSD-18-05	SWSD-18-05	SWSD-18-05	SWSD-18-06	SWSD-18-07	SWSD-18-08	SWSD-18-08	SWSD-18-09	SWSD-18-09	SWSD-18-10	SWSD-18-10	SWSD-18-11	SWSD-18-11	SWSD-18-11
		Sample ID	SW-18-05-H	SW-18-05-H-DUP	SW-18-05-L	SW-18-05-L-DUP	SW-18-06	SW-18-07	SW-18-08-H	SW-18-08-L	SW-18-09-H	SW-18-09-L	SW-18-10-H	SW-18-10-L	SW-18-11-H	SW-18-11-L	SW-18-11-L-DUP
		Collection Date	11/19/2018	11/19/2018	11/20/2018	11/20/2018	11/20/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/20/2018
		Sample Type Code	N	FD	N	FD	N	N	N	N	N	N	N	N	N	N	FD
CAS	Analyte	Site-Specific Screening Value based on Belted Kingfisher (a)															
1763-23-1	PFOS	0.28	0.0039	0.0035	0.087	0.082	0.13	0.15	0.0045	0.014	0.0069	0.011	0.0064	0.029	0.0032	0.046	0.047

Notes:
All units in microgram per kilogram (µg/L).
"H" in sample ID indicates sample collected at high tide.
"L" in sample ID indicates sample collected at low tide.
CAS - Chemical Abstracts Service.
FD - Field Duplicate.
J - Analyte positively detected but value is an approximate concentration.
N - Normal Sample.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctanesulfonic acid.
PFOS-S - PFOS screening level used as long-chai
U - Analyte was not detected above the reported quantitation limit.

Value exceeds site-specific screening level.

(a) Based on belted kingfisher LOAEL-based HQ using the mid-range (average) bioaccumulation factors; see Attachment D.

TABLE 12
SAMPLE-BY-SAMPLE SITE-SPECIFIC SCREENING FOR SURFACE WATER
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

		Location Description	Bay and Creek (West of Bay Head Road)														
		Location ID	SWSD-18-12	SWSD-18-12	SWSD-18-13	SWSD-18-13	SWSD-18-14	SWSD-18-14	SWSD-18-15	SWSD-18-15	SWSD-18-15	SWSD-18-16	SWSD-18-16	SWSD-18-17	SWSD-18-17	SWSD-18-18	SWSD-18-18
		Sample ID	SW-18-12-H	SW-18-12-L	SW-18-13-H	SW-18-13-L	SW-18-14-H	SW-18-14-L	SW-18-15-H	SW-18-15-L	SW-18-15-L-DUP	SW-18-16-H	SW-18-16-L	SW-18-17-H	SW-18-17-L	SW-18-18-H	SW-18-18-L
		Collection Date	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018
		Sample Type Code	N	N	N	N	N	N	N	N	FD	N	N	N	N	N	N
CAS	Analyte	Site-Specific Screening Value based on Belted Kingfisher (a)															
1763-23-1	PFOS	0.28	0.0047	0.081	0.017	0.0078	0.0048	0.014	0.0045	0.02	0.019	0.0044	0.018	0.0042	0.02	0.0074	0.0067

Notes:
All units in microgram per kilogram (µg/L).
"H" in sample ID indicates sample collected at high tide.
"L" in sample ID indicates sample collected at low tide.
CAS - Chemical Abstracts Service.
FD - Field Duplicate.
J - Analyte positively detected but value is an approximate concentration.
N - Normal Sample.
PFOA - Perfluorooctanoic acid.
PFOS - Perfluorooctanesulfonic acid.
PFOS-S - PFOS screening level used as long-chai
U - Analyte was not detected above the reported quantitation limit.

Value exceeds site-specific screening level.

(a) Based on belted kingfisher LOAEL-based HQ using the mid-range (average) bioaccumulation factors; see Attachment D.

TABLE 12
SAMPLE-BY-SAMPLE SITE-SPECIFIC SCREENING FOR SURFACE WATER
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

		Location Description	Bay and Creek (West of Bay Head Road)											
		Location ID	SWSD-18-19	SWSD-18-19	SWSD-18-20	SWSD-18-20	SWSD-18-20	SWSD-18-21	SWSD-18-21	SWSD-18-22	SWSD-18-22	SWSD-18-23	SWSD-18-23	SWSD-18-24
		Sample ID	SW-18-19-H	SW-18-19-L	SW-18-20-H	SW-18-20-H-DUP	SW-18-20-L	SW-18-21-H	SW-18-21-L	SW-18-22-H	SW-18-22-L	SW-18-23-H	SW-18-23-L	SW-18-24
		Collection Date	11/19/2018	11/20/2018	11/19/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/19/2018	11/20/2018	11/20/2018
		Sample Type Code	N	N	N	FD	N	N	N	N	N	N	N	N
CAS	Analyte	Site-Specific Screening Value based on Belted Kingfisher (a)												
1763-23-1	PFOS	0.28	0.0079	0.007	0.012 J	0.0065 J	0.009	0.0064	0.017	0.0059	0.025	0.0053	0.039	0.057

Notes:

All units in microgram per kilogram (µg/L).

"H" in sample ID indicates sample collected at high tide.

"L" in sample ID indicates sample collected at low tide.

CAS - Chemical Abstracts Service.

FD - Field Duplicate.

J - Analyte positively detected but value is an approximate concentration.

N - Normal Sample.

PFOA - Perfluorooctanoic acid.

PFOS - Perfluorooctanesulfonic acid.

PFOS-S - PFOS screening level used as long-chai

U - Analyte was not detected above the reported quantitation limit.

Value exceeds site-specific screening level.

(a) Based on belted kingfisher LOAEL-based HQ using the mid-range (average) bioaccumulation factors; see Attachment D.

Attachments

Attachment A
Analytical Data Considered in the Ecological Risk Assessment

Table A-1 Soil Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Interval (ft bgs)	Sample ID	Sample Type Code	PFBS (µg/kg)	PFOS (µg/kg)	PFOA (µg/kg)
On-Site	DPT-16-15	11/2/2016	0 - 1 ft	DPT-16-15-SO-00-01	N	0.14 J	27	0.98
On-Site	DPT-16-15	11/2/2016	0 - 1 ft	DPT-16-15-SO-00-01-DUP	FD	0.12 J	27	0.92
On-Site	DPT-16-19	11/22/2016	0 - 1 ft	DPT-16-19-SO-00-01	N	0.18 J	170	3.8
On-Site	DPT-16-20	11/2/2016	0 - 1 ft	DPT-16-20-SO-00-01	N	< 0.33 U	12	0.70
On-Site	DPT-16-28	11/2/2016	0 - 1 ft	DPT-16-28-SO-00-01	N	< 0.36 U	8.9	0.27 J
On-Site	DPT-16-29	11/2/2016	0 - 1 ft	DPT-16-29-SO-00-01	N	0.19 J	38	1.8
On-Site	DPT-16-30	11/2/2016	0 - 1 ft	DPT-16-30-SO-00-01	N	0.12 J	20	1.0
On-Site	DPT-16-31	11/2/2016	0 - 1 ft	DPT-16-31-SO-00-01	N	< 0.33 U	5.9	0.26 J
On-Site	DPT-16-32	11/2/2016	0 - 1 ft	DPT-16-32-SO-00-01	N	< 0.35 U	10	0.24 J
On-Site	DPT-16-34	11/2/2016	0 - 1 ft	DPT-16-34-SO-00-01	N	< 0.33 U	80	8.9
On-Site	DPT-16-35	11/22/2016	0 - 1 ft	DPT-16-35-SO-00-01	N	0.21 J	28	12
On-Site	DPT-17-26	1/12/2017	0 - 1 ft	DPT-17-26-SO-00-01	N	< 0.36 U	0.25 J	0.22 J
On-Site	DPT-17-27	1/12/2017	0 - 1 ft	DPT-17-27-SO-00-01	N	< 0.36 U	< 0.60 U	0.25 J

Notes: µg/kg = micrograms per kilogram
bgs = Below ground surface
FD = Field duplicate sample
ft = Feet
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Table A-2 Sediment Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/kg)	PFOS (µg/kg)	PFOA (µg/kg)
On/Near Site (East of Bay Head Road)	SD-16-01	11/2/2016	SWSD-16-01-SD	N	< 0.37 U	1.7	0.23 J
On/Near Site (East of Bay Head Road)	SD-16-02	11/2/2016	SWSD-16-02-SD	N	< 0.69 U	5.1	< 0.69 U
On/Near Site (East of Bay Head Road)	SD-16-02	11/2/2016	SWSD-16-02-SD-DUP	FD	< 0.68 U	4.2	0.23 J
On/Near Site (East of Bay Head Road)	SD-16-03	11/2/2016	SWSD-16-03-SD	N	< 0.63 U	6.6	0.28 J
On/Near Site (East of Bay Head Road)	SD-16-04	11/2/2016	SWSD-16-04-SD	N	< 0.38 U	0.42 J	0.18 J
Off-Site (West of Bay Head Road)	SWSD-18-01	4/26/2018	SWSD-18-01-SD	N	< 0.38 U	12	1.2
Off-Site (West of Bay Head Road)	SWSD-18-01	11/19/2018	SD-18-01	N	< 0.84 U	0.42 J	< 0.95 U
Off-Site (West of Bay Head Road)	SWSD-18-02	4/26/2018	SWSD-18-02-SD	N	< 0.59 U	44	3.7
Off-Site (West of Bay Head Road)	SWSD-18-02	11/19/2018	SD-18-02	N	< 1.2 U	15	1.4 J
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SD	N	0.28 J	31 J	3.7 J
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SD-DUP	FD	< 0.91 UJ	28 J	4.5 J
Off-Site (West of Bay Head Road)	SWSD-18-03	11/20/2018	SD-18-03	N	< 2.4 UJ	24 J	3.4 J
Off-Site (West of Bay Head Road)	SWSD-18-03	11/20/2018	SD-18-03-DUP	FD	< 2.2 UJ	8.9 J	2.3 J
Off-Site (West of Bay Head Road)	SWSD-18-04	4/26/2018	SWSD-18-04-SD	N	< 0.76 UJ	19 J	2.4 J
Off-Site (West of Bay Head Road)	SWSD-18-04	11/20/2018	SD-18-04	N	< 3.7 UJ	8.3 J	< 4.2 UJ
Off-Site (West of Bay Head Road)	SWSD-18-05	4/26/2018	SWSD-18-05-SD	N	< 1.5 UJ	18 J	1.2 J
Off-Site (West of Bay Head Road)	SWSD-18-05	11/19/2018	SD-18-05	N	< 3.0 UJ	5.1 J	< 3.4 UJ
Off-Site (West of Bay Head Road)	SWSD-18-06	11/20/2018	SD-18-06	N	< 0.80 U	14	1.4
Off-Site (West of Bay Head Road)	SWSD-18-07	11/20/2018	SD-18-07	N	< 0.72 U	1.7 J	< 0.81 U
Off-Site (West of Bay Head Road)	SWSD-18-07	11/20/2018	SD-18-07-DUP	FD	< 0.89 U	6.7 J	0.50 J
Off-Site (West of Bay Head Road)	SWSD-18-08	11/19/2018	SD-18-08	N	< 1.4 U	0.59 J	< 1.6 U
Off-Site (West of Bay Head Road)	SWSD-18-09	11/19/2018	SD-18-09	N	< 0.85 U	0.36 J	< 0.96 U
Off-Site (West of Bay Head Road)	SWSD-18-10	11/19/2018	SD-18-10	N	< 0.91 U	0.32 J	< 1.0 U
Off-Site (West of Bay Head Road)	SWSD-18-11	11/19/2018	SD-18-11	N	< 2.6 UJ	4.4 J	< 3.0 UJ
Off-Site (West of Bay Head Road)	SWSD-18-12	11/19/2018	SD-18-12	N	< 3.7 UJ	5.3 J	< 4.2 UJ
Off-Site (West of Bay Head Road)	SWSD-18-13	11/19/2018	SD-18-13	N	< 2.4 UJ	1.5 J	< 2.7 UJ
Off-Site (West of Bay Head Road)	SWSD-18-13	11/19/2018	SD-18-13-DUP	FD	< 2.5 UJ	1.2 J	< 2.8 UJ
Off-Site (West of Bay Head Road)	SWSD-18-14	11/19/2018	SD-18-14	N	< 2.5 UJ	1.0 J	0.93 J
Off-Site (West of Bay Head Road)	SWSD-18-15	11/19/2018	SD-18-15	N	< 2.1 UJ	0.86 J	< 2.4 UJ
Off-Site (West of Bay Head Road)	SWSD-18-16	11/19/2018	SD-18-16	N	< 2.8 UJ	2.1 J	< 3.2 UJ
Off-Site (West of Bay Head Road)	SWSD-18-17	11/19/2018	SD-18-17	N	< 3.4 UJ	3.5 J	< 3.8 UJ
Off-Site (West of Bay Head Road)	SWSD-18-18	11/19/2018	SD-18-18	N	< 0.93 U	0.50 J	< 1.0 U
Off-Site (West of Bay Head Road)	SWSD-18-19	11/19/2018	SD-18-19	N	< 0.93 U	0.37 J	< 1.1 U
Off-Site (West of Bay Head Road)	SWSD-18-20	11/19/2018	SD-18-20	N	< 1.1 U	0.62 J	< 1.2 U
Off-Site (West of Bay Head Road)	SWSD-18-21	11/19/2018	SD-18-21	N	< 3.3 UJ	2.7 J	< 3.8 UJ
Off-Site (West of Bay Head Road)	SWSD-18-22	11/19/2018	SD-18-22	N	< 4.1 UJ	< 4.5 UJ	< 4.7 UJ
Off-Site (West of Bay Head Road)	SWSD-18-23	11/19/2018	SD-18-23	N	< 4.6 UJ	4.7 J	< 5.3 UJ
Off-Site (West of Bay Head Road)	SWSD-18-24	11/20/2018	SD-18-24	N	< 1.5 U	2.2	< 1.6 U

Notes: µg/kg = micrograms per kilogram
FD = Field duplicate sample
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Table A-3 Surface Water Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
On/Near Site (East of Bay Head Road)	SW-16-01	12/5/2016	SW-16-01-SW	N	0.020	0.27	0.023
On/Near Site (East of Bay Head Road)	SW-16-02	12/5/2016	SW-16-02-SW	N	0.0084	0.12	0.042
On/Near Site (East of Bay Head Road)	SW-16-02	12/5/2016	SW-16-02-SW-DUP	FD	0.0089	0.12	0.041
Off-Site (West of Bay Head Road)	SWSD-18-01	4/26/2018	SWSD-18-01-SW	N	0.0076	0.18	0.055
Off-Site (West of Bay Head Road)	SWSD-18-01	11/19/2018	SW-18-01-H	N	0.0075 J	0.12	0.041
Off-Site (West of Bay Head Road)	SWSD-18-02	4/26/2018	SWSD-18-02-SW	N	0.029	0.66 J	0.43 J
Off-Site (West of Bay Head Road)	SWSD-18-02	11/19/2018	SW-18-02-H	N	0.017 J	0.3	0.26
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SW	N	0.057	0.4 J	0.49 J
Off-Site (West of Bay Head Road)	SWSD-18-03	4/26/2018	SWSD-18-03-SW-DUP	FD	0.054	0.55 J	0.53 J
Off-Site (West of Bay Head Road)	SWSD-18-03	11/19/2018	SW-18-03-H	N	0.026 J	0.21	0.26
Off-Site (West of Bay Head Road)	SWSD-18-03	11/20/2018	SW-18-03-L	N	0.031	0.27	0.36
Off-Site (West of Bay Head Road)	SWSD-18-04	4/26/2018	SWSD-18-04-SW	N	0.031	0.27	0.26
Off-Site (West of Bay Head Road)	SWSD-18-04	11/19/2018	SW-18-04-H	N	0.0019	0.0043	0.0046
Off-Site (West of Bay Head Road)	SWSD-18-04	11/20/2018	SW-18-04-L	N	0.016	0.075	0.11
Off-Site (West of Bay Head Road)	SWSD-18-05	4/26/2018	SWSD-18-05-SW	N	0.015	0.14	0.13
Off-Site (West of Bay Head Road)	SWSD-18-05	11/19/2018	SW-18-05-H	N	0.0017 J	0.0039	0.0037
Off-Site (West of Bay Head Road)	SWSD-18-05	11/19/2018	SW-18-05-H-DUP	FD	0.0015 J	0.0035	0.0038
Off-Site (West of Bay Head Road)	SWSD-18-05	11/20/2018	SW-18-05-L	N	0.014	0.087	0.1
Off-Site (West of Bay Head Road)	SWSD-18-05	11/20/2018	SW-18-05-L-DUP	FD	0.015	0.082	0.1
Off-Site (West of Bay Head Road)	SWSD-18-06	11/20/2018	SW-18-06	N	0.0084	0.13	0.057
Off-Site (West of Bay Head Road)	SWSD-18-07	11/20/2018	SW-18-07	N	0.0092	0.15	0.073
Off-Site (West of Bay Head Road)	SWSD-18-08	11/19/2018	SW-18-08-H	N	0.0019	0.0045	0.0049
Off-Site (West of Bay Head Road)	SWSD-18-08	11/20/2018	SW-18-08-L	N	0.0040	0.014	0.017
Off-Site (West of Bay Head Road)	SWSD-18-09	11/19/2018	SW-18-09-H	N	0.0026 J	0.0069	0.0073
Off-Site (West of Bay Head Road)	SWSD-18-09	11/20/2018	SW-18-09-L	N	0.0038	0.011	0.011
Off-Site (West of Bay Head Road)	SWSD-18-10	11/19/2018	SW-18-10-H	N	0.0021	0.0064	0.0066
Off-Site (West of Bay Head Road)	SWSD-18-10	11/20/2018	SW-18-10-L	N	0.0068	0.029	0.039
Off-Site (West of Bay Head Road)	SWSD-18-11	11/19/2018	SW-18-11-H	N	0.0016 J	0.0032	0.0033
Off-Site (West of Bay Head Road)	SWSD-18-11	11/20/2018	SW-18-11-L	N	0.0091 J	0.046	0.059
Off-Site (West of Bay Head Road)	SWSD-18-11	11/20/2018	SW-18-11-L-DUP	FD	0.0091	0.047	0.058
Off-Site (West of Bay Head Road)	SWSD-18-12	11/19/2018	SW-18-12-H	N	0.0017	0.0047	0.0042
Off-Site (West of Bay Head Road)	SWSD-18-12	11/20/2018	SW-18-12-L	N	0.012	0.081	0.081
Off-Site (West of Bay Head Road)	SWSD-18-13	11/19/2018	SW-18-13-H	N	0.0019 J	0.017	0.0059
Off-Site (West of Bay Head Road)	SWSD-18-13	11/20/2018	SW-18-13-L	N	0.0032	0.0078	0.0093
Off-Site (West of Bay Head Road)	SWSD-18-14	11/19/2018	SW-18-14-H	N	0.0020 J	0.0048	0.0056
Off-Site (West of Bay Head Road)	SWSD-18-14	11/20/2018	SW-18-14-L	N	0.0040	0.014	0.017
Off-Site (West of Bay Head Road)	SWSD-18-15	11/19/2018	SW-18-15-H	N	0.0017 J	0.0045	0.0047
Off-Site (West of Bay Head Road)	SWSD-18-15	11/20/2018	SW-18-15-L	N	0.0050	0.02	0.024
Off-Site (West of Bay Head Road)	SWSD-18-15	11/20/2018	SW-18-15-L-DUP	FD	0.0049	0.019	0.024
Off-Site (West of Bay Head Road)	SWSD-18-16	11/19/2018	SW-18-16-H	N	0.0018	0.0044	0.0046

Table A-3 Surface Water Sampling Results
Per- and polyfluoroalkyl Substances (PFAS)
Former Bay Head Road Annex
Anne Arundel County, Maryland

Location Description	Location ID	Collection Date	Sample ID	Sample Type Code	PFBS (µg/L)	PFOS (µg/L)	PFOA (µg/L)
Off-Site (West of Bay Head Road)	SWSD-18-16	11/20/2018	SW-18-16-L	N	0.0052	0.018	0.023
Off-Site (West of Bay Head Road)	SWSD-18-17	11/19/2018	SW-18-17-H	N	0.0018	0.0042	0.0044
Off-Site (West of Bay Head Road)	SWSD-18-17	11/20/2018	SW-18-17-L	N	0.0056	0.02	0.028
Off-Site (West of Bay Head Road)	SWSD-18-18	11/19/2018	SW-18-18-H	N	0.0024	0.0074	0.0081
Off-Site (West of Bay Head Road)	SWSD-18-18	11/20/2018	SW-18-18-L	N	0.0028	0.0067	0.0078
Off-Site (West of Bay Head Road)	SWSD-18-19	11/19/2018	SW-18-19-H	N	0.0025	0.0079	0.0092
Off-Site (West of Bay Head Road)	SWSD-18-19	11/20/2018	SW-18-19-L	N	0.0032	0.0070	0.0080
Off-Site (West of Bay Head Road)	SWSD-18-20	11/19/2018	SW-18-20-H	N	0.0031	0.012 J	0.013 J
Off-Site (West of Bay Head Road)	SWSD-18-20	11/19/2018	SW-18-20-H-DUP	FD	0.0023	0.0065 J	0.0082 J
Off-Site (West of Bay Head Road)	SWSD-18-20	11/20/2018	SW-18-20-L	N	0.0033	0.0090	0.011
Off-Site (West of Bay Head Road)	SWSD-18-21	11/19/2018	SW-18-21-H	N	0.0024	0.0064	0.0076
Off-Site (West of Bay Head Road)	SWSD-18-21	11/20/2018	SW-18-21-L	N	0.0028 J	0.017	0.0088
Off-Site (West of Bay Head Road)	SWSD-18-22	11/19/2018	SW-18-22-H	N	0.0023	0.0059	0.0065
Off-Site (West of Bay Head Road)	SWSD-18-22	11/20/2018	SW-18-22-L	N	0.0031	0.025	0.013
Off-Site (West of Bay Head Road)	SWSD-18-23	11/19/2018	SW-18-23-H	N	0.0020	0.0053	0.0055
Off-Site (West of Bay Head Road)	SWSD-18-23	11/20/2018	SW-18-23-L	N	0.0072	0.039	0.044
Off-Site (West of Bay Head Road)	SWSD-18-24	11/20/2018	SW-18-24	N	0.028	0.057	0.058

Notes: µg/L = micrograms per liter
FD = Field duplicate sample
N = Normal sample
PFBS = Perfluorobutanesulfonic Acid
PFOS = Perfluorooctane Sulfonate
PFOA = Perfluorooctanoic Acid

Data Validation Qualifiers: J = Analyte positively detected but value is an approximate concentration.
J+ = Analyte positively detected but value is an approximate concentration, potentially biased high.
J- = Analyte positively detected but value is approximate concentration, potentially biased low.
U = Analyte was not detected above the reported quantitation limit.
UJ = Analyte was not detected; and the reported quantitation limit is approximate.

Attachment B
Photographic Log – Off-Site Creeks and Little Magothy River

Client Name: NAVFAC Naval Facilities Engineering Command NAVFAC WASHINGTON	**Site Location:** **ANNAPOLIS, MARYLAND**	**Project No.** **605883971**

Photo No.	**Date:**
1	**4-17-18**

Description:

View of the southeast end of the Little Magothy River through the upstream wetland area, looking northwest

Photo No.	**Date:**
2	**4-17-18**

Description:

View of the wetland area up-gradient of the southeast end of the Little Magothy upriver, looking southeast

Photo No. 3

Date: 4-17-18

Description:

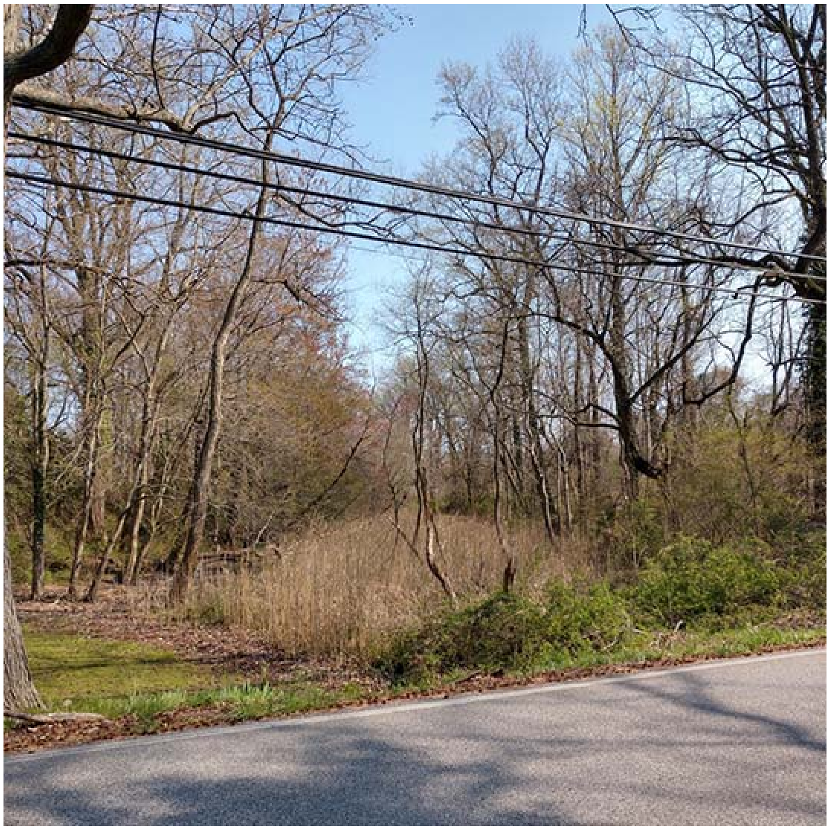
View of the wetland area up-gradient of the southeast end of the Little Magothy upriver, from the western shore, looking north

Photo No. 4

Date: 4-19-18

Description:

View of the stormwater accumulation area north of the site and adjacent to Bay Head Road, which drains into the unnamed tributary flowing from the site looking southeast



Client Name: NAVFAC Naval Facilities Engineering Command NAVFAC WASHINGTON	**Site Location:** **ANNAPOLIS, MARYLAND**	**Project No.** **605883971**

Photo No. **5**	**Date:** **4-19-18**

Description:

View of the unnamed tributary flowing from the site approximately 25 feet downstream of (i.e., northwest) and adjacent to Bay Head Road, looking northwest

Photo No. **6**	**Date:** **4-19-18**

Description:

View of the unnamed tributary flowing from the site approximately 50 feet downstream (i.e., northwest) from Bay Head Road, looking northwest

Attachment C
ProUCL Output

TABLE C1
SURFACE SOIL PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.18/21/2019 8:38:53 AM
From File	Input_SurfSoil.xls
Full Precision	OFF
Confidence Coefficient	95%
umber of Bootstrap Operations	2000

Perfluorooctanesulfonic Acid (PFOS)

General Statistics

Total Number of Observations	12	Number of Distinct Observations	12
Number of Detects	11	Number of Non-Detects	1
Number of Distinct Detects	11	Number of Distinct Non-Detects	1
Minimum Detect	0.25	Minimum Non-Detect	0.6
Maximum Detect	170	Maximum Non-Detect	0.6
Variance Detects	2447	Percent Non-Detects	8.333%
Mean Detects	36.37	SD Detects	49.46
Median Detects	20	CV Detects	1.36
Skewness Detects	2.358	Kurtosis Detects	5.835
Mean of Logged Detects	2.74	SD of Logged Detects	1.688

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.689	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.305	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.251	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	33.36	KM Standard Error of Mean	14
KM SD	46.24	95% KM (BCA) UCL	58.65
95% KM (t) UCL	58.5	95% KM (Percentile Bootstrap) UCL	57.13
95% KM (z) UCL	56.39	95% KM Bootstrap t UCL	107.9
90% KM Chebyshev UCL	75.36	95% KM Chebyshev UCL	94.39
97.5% KM Chebyshev UCL	120.8	99% KM Chebyshev UCL	172.7

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.301	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.766	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.149	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.266	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.707	k star (bias corrected MLE)	0.575
Theta hat (MLE)	51.44	Theta star (bias corrected MLE)	63.27
nu hat (MLE)	15.55	nu star (bias corrected)	12.65
Mean (detects)	36.37		

TABLE C1

SURFACE SOIL PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	33.34
Maximum	170	Median	16
SD	48.32	CV	1.449
k hat (MLE)	0.466	k star (bias corrected MLE)	0.405
Theta hat (MLE)	71.57	Theta star (bias corrected MLE)	82.33
nu hat (MLE)	11.18	nu star (bias corrected)	9.718
Adjusted Level of Significance (β)	0.029		
Approximate Chi Square Value (9.72, α)	3.767	Adjusted Chi Square Value (9.72, β)	3.222
95% Gamma Approximate UCL (use when n>=50)	86.02	95% Gamma Adjusted UCL (use when n<50)	100.6

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	33.36	SD (KM)	46.24
Variance (KM)	2138	SE of Mean (KM)	14
k hat (KM)	0.52	k star (KM)	0.446
nu hat (KM)	12.49	nu star (KM)	10.7
theta hat (KM)	64.11	theta star (KM)	74.82
80% gamma percentile (KM)	54.41	90% gamma percentile (KM)	92.35
95% gamma percentile (KM)	133.5	99% gamma percentile (KM)	235.7

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (10.70, α)	4.384	Adjusted Chi Square Value (10.70, β)	3.786
95% Gamma Approximate KM-UCL (use when n>=50)	81.42	95% Gamma Adjusted KM-UCL (use when n<50)	94.27

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.895	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.193	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.251	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	33.4	Mean in Log Scale	2.493
SD in Original Scale	48.27	SD in Log Scale	1.822
95% t UCL (assumes normality of ROS data)	58.43	95% Percentile Bootstrap UCL	56.36
95% BCA Bootstrap UCL	67.73	95% Bootstrap t UCL	107.3
95% H-UCL (Log ROS)	787.3		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	2.396	KM Geo Mean	10.98
KM SD (logged)	1.917	95% Critical H Value (KM-Log)	4.781
KM Standard Error of Mean (logged)	0.58	95% H-UCL (KM -Log)	1093
KM SD (logged)	1.917	95% Critical H Value (KM-Log)	4.781
KM Standard Error of Mean (logged)	0.58		

TABLE C1

SURFACE SOIL PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	33.36	Mean in Log Scale	2.411
SD in Original Scale	48.3	SD in Log Scale	1.971
95% t UCL (Assumes normality)	58.4	95% H-Stat UCL	1432

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Gamma Distributed at 5% Significance Level

Suggested UCL to Use

95% KM Bootstrap t UCL	107.9	sted KM-UCL (use when k<=1 and 15 < n < 50 but k<=1)	94.27

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 9:27:09 AM
From File	ProUCL Input.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

PFOS-All

General Statistics

Total Number of Observations	48	Number of Distinct Observations	42
		Number of Missing Observations	0
Minimum	3.2	Mean	76.63
Maximum	660	Median	15.5
SD	136.3	Std. Error of Mean	19.67
Coefficient of Variation	1.779	Skewness	2.85

Normal GOF Test

Shapiro Wilk Test Statistic	0.595	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.295	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	109.6	95% Adjusted-CLT UCL (Chen-1995)	117.6
		95% Modified-t UCL (Johnson-1978)	111

Gamma GOF Test

A-D Test Statistic	2.976	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.812	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.223	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.135	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.521	k star (bias corrected MLE)	0.503
Theta hat (MLE)	147	Theta star (bias corrected MLE)	152.5
nu hat (MLE)	50.04	nu star (bias corrected)	48.25
MLE Mean (bias corrected)	76.63	MLE Sd (bias corrected)	108.1
		Approximate Chi Square Value (0.05)	33.31
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	32.92

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	111	95% Adjusted Gamma UCL (use when n<50)	112.3

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.892	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.947	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.15	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.127	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.163	Mean of logged Data	3.128
Maximum of Logged Data	6.492	SD of logged Data	1.542

Assuming Lognormal Distribution

95% H-UCL	146.7	90% Chebyshev (MVUE) UCL	134.8
95% Chebyshev (MVUE) UCL	163.6	97.5% Chebyshev (MVUE) UCL	203.6
99% Chebyshev (MVUE) UCL	282		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	109	95% Jackknife UCL	109.6
95% Standard Bootstrap UCL	108.7	95% Bootstrap-t UCL	127.6
95% Hall's Bootstrap UCL	137.2	95% Percentile Bootstrap UCL	111.1
95% BCA Bootstrap UCL	118.1		
90% Chebyshev(Mean, Sd) UCL	135.7	95% Chebyshev(Mean, Sd) UCL	162.4
97.5% Chebyshev(Mean, Sd) UCL	199.5	99% Chebyshev(Mean, Sd) UCL	272.4

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	162.4

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

PFOA-All

General Statistics

Total Number of Observations	48	Number of Distinct Observations	42
		Number of Missing Observations	0
Minimum	3.3	Mean	67.39
Maximum	530	Median	13
SD	117.9	Std. Error of Mean	17.02
Coefficient of Variation	1.749	Skewness	2.54

Normal GOF Test

Shapiro Wilk Test Statistic	0.593	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.299	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level	

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	95.94	95% Adjusted-CLT UCL (Chen-1995)	102
		95% Modified-t UCL (Johnson-1978)	96.98

Gamma GOF Test

A-D Test Statistic	3.071	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.809	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.207	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.135	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

TABLE C2

SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Gamma Statistics

k hat (MLE)	0.553	k star (bias corrected MLE)	0.532
Theta hat (MLE)	121.9	Theta star (bias corrected MLE)	126.6
nu hat (MLE)	53.09	nu star (bias corrected)	51.1
MLE Mean (bias corrected)	67.39	MLE Sd (bias corrected)	92.37
		Approximate Chi Square Value (0.05)	35.68
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	35.28

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	96.5	95% Adjusted Gamma UCL (use when n<50)	97.6

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.896	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.158	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.194	Mean of logged Data	3.079
Maximum of Logged Data	6.273	SD of logged Data	1.463

Assuming Lognormal Distribution

95% H-UCL	117.3	90% Chebyshev (MVUE) UCL	111.2
95% Chebyshev (MVUE) UCL	134	97.5% Chebyshev (MVUE) UCL	165.8
99% Chebyshev (MVUE) UCL	228.1		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	95.38	95% Jackknife UCL	95.94
95% Standard Bootstrap UCL	95.38	95% Bootstrap-t UCL	108.9
95% Hall's Bootstrap UCL	100.3	95% Percentile Bootstrap UCL	96.81
95% BCA Bootstrap UCL	103.2		
90% Chebyshev(Mean, Sd) UCL	118.4	95% Chebyshev(Mean, Sd) UCL	141.6
97.5% Chebyshev(Mean, Sd) UCL	173.7	99% Chebyshev(Mean, Sd) UCL	236.7

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	141.6

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

PFBS-All

General Statistics

Total Number of Observations	48	Number of Distinct Observations	35
		Number of Missing Observations	0
Minimum	1.6	Mean	8.671
Maximum	57	Median	3.55
SD	11.03	Std. Error of Mean	1.592
Coefficient of Variation	1.272	Skewness	2.494

Normal GOF Test

Shapiro Wilk Test Statistic	0.668	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.261	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	11.34	95% Adjusted-CLT UCL (Chen-1995)	11.9
		95% Modified-t UCL (Johnson-1978)	11.44

Gamma GOF Test

A-D Test Statistic	2.778	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.778	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.203	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.131	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.054	k star (bias corrected MLE)	1.002
Theta hat (MLE)	8.229	Theta star (bias corrected MLE)	8.656
nu hat (MLE)	101.2	nu star (bias corrected)	96.17
MLE Mean (bias corrected)	8.671	MLE Sd (bias corrected)	8.663
		Approximate Chi Square Value (0.05)	74.55
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	73.96

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	11.19	95% Adjusted Gamma UCL (use when n<50)	11.27

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.888	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.166	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.47	Mean of logged Data	1.615
Maximum of Logged Data	4.043	SD of logged Data	0.984

Assuming Lognormal Distribution

95% H-UCL	11.39	90% Chebyshev (MVUE) UCL	12.06
95% Chebyshev (MVUE) UCL	13.88	97.5% Chebyshev (MVUE) UCL	16.4
99% Chebyshev (MVUE) UCL	21.36		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

TABLE C2

SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Nonparametric Distribution Free UCLs

95% CLT UCL	11.29	95% Jackknife UCL	11.34
95% Standard Bootstrap UCL	11.23	95% Bootstrap-t UCL	12.44
95% Hall's Bootstrap UCL	12.55	95% Percentile Bootstrap UCL	11.31
95% BCA Bootstrap UCL	11.77		
90% Chebyshev(Mean, Sd) UCL	13.45	95% Chebyshev(Mean, Sd) UCL	15.61
97.5% Chebyshev(Mean, Sd) UCL	18.61	99% Chebyshev(Mean, Sd) UCL	24.51

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	15.61

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

PFOS-NT

General Statistics

Total Number of Observations	10	Number of Distinct Observations	10
		Number of Missing Observations	0
Minimum	57	Mean	262.7
Maximum	660	Median	195
SD	195.6	Std. Error of Mean	61.86
Coefficient of Variation	0.745	Skewness	1.306

Normal GOF Test

Shapiro Wilk Test Statistic	0.846	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.842	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.224	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.262	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	376.1	95% Adjusted-CLT UCL (Chen-1995)	391.8
		95% Modified-t UCL (Johnson-1978)	380.4

Gamma GOF Test

A-D Test Statistic	0.296	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.735	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.139	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.269	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.274	k star (bias corrected MLE)	1.659
Theta hat (MLE)	115.5	Theta star (bias corrected MLE)	158.4
nu hat (MLE)	45.48	nu star (bias corrected)	33.17
MLE Mean (bias corrected)	262.7	MLE Sd (bias corrected)	204
		Approximate Chi Square Value (0.05)	21
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	19.34

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	414.9	95% Adjusted Gamma UCL (use when n<50)	450.7

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.974	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.127	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Lognormal Statistics

Minimum of Logged Data	4.043	Mean of logged Data	5.335
Maximum of Logged Data	6.492	SD of logged Data	0.731

Assuming Lognormal Distribution

95% H-UCL	509	90% Chebyshev (MVUE) UCL	450.7
95% Chebyshev (MVUE) UCL	535.9	97.5% Chebyshev (MVUE) UCL	654.2
99% Chebyshev (MVUE) UCL	886.5		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	364.5	95% Jackknife UCL	376.1
95% Standard Bootstrap UCL	358.2	95% Bootstrap-t UCL	506.2
95% Hall's Bootstrap UCL	1001	95% Percentile Bootstrap UCL	365
95% BCA Bootstrap UCL	377		
90% Chebyshev(Mean, Sd) UCL	448.3	95% Chebyshev(Mean, Sd) UCL	532.4
97.5% Chebyshev(Mean, Sd) UCL	649	99% Chebyshev(Mean, Sd) UCL	878.2

Suggested UCL to Use

95% Student's-t UCL	376.1

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

PFOA-NT

General Statistics

Total Number of Observations	10	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	41	Mean	212.4
Maximum	530	Median	166.5
SD	181.4	Std. Error of Mean	57.36
Coefficient of Variation	0.854	Skewness	0.621

Normal GOF Test

Shapiro Wilk Test Statistic	0.848	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.842	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.279	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.262	Data Not Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	317.5	95% Adjusted-CLT UCL (Chen-1995)	318.8
		95% Modified-t UCL (Johnson-1978)	319.4

Gamma GOF Test

A-D Test Statistic	0.755	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.742	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.273	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.272	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Gamma Statistics

k hat (MLE)	1.354	k star (bias corrected MLE)	1.015
Theta hat (MLE)	156.8	Theta star (bias corrected MLE)	209.3
nu hat (MLE)	27.09	nu star (bias corrected)	20.29
MLE Mean (bias corrected)	212.4	MLE Sd (bias corrected)	210.9
		Approximate Chi Square Value (0.05)	11.07
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	9.904

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	389.4	95% Adjusted Gamma UCL (use when n<50)	435.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.848	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.243	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.714	Mean of logged Data	4.946
Maximum of Logged Data	6.273	SD of logged Data	1.004

Assuming Lognormal Distribution

95% H-UCL	659.9	90% Chebyshev (MVUE) UCL	435
95% Chebyshev (MVUE) UCL	533.5	97.5% Chebyshev (MVUE) UCL	670.3
99% Chebyshev (MVUE) UCL	938.8		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	306.7	95% Jackknife UCL	317.5
95% Standard Bootstrap UCL	302	95% Bootstrap-t UCL	339.3
95% Hall's Bootstrap UCL	306.7	95% Percentile Bootstrap UCL	305.4
95% BCA Bootstrap UCL	305.8		
90% Chebyshev(Mean, Sd) UCL	384.5	95% Chebyshev(Mean, Sd) UCL	462.4
97.5% Chebyshev(Mean, Sd) UCL	570.6	99% Chebyshev(Mean, Sd) UCL	783.1

Suggested UCL to Use

95% Student's-t UCL	317.5

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

PFBS-NT

General Statistics

Total Number of Observations	10	Number of Distinct Observations	10
		Number of Missing Observations	0
Minimum	7.5	Mean	22.07
Maximum	57	Median	21.5
SD	15.63	Std. Error of Mean	4.942
Coefficient of Variation	0.708	Skewness	1.2

Normal GOF Test

Shapiro Wilk Test Statistic	0.848	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.842	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.195	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.262	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	31.13	95% Adjusted-CLT UCL (Chen-1995)	32.2
		95% Modified-t UCL (Johnson-1978)	31.44

Gamma GOF Test

A-D Test Statistic	0.541	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.734	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.226	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.269	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.342	k star (bias corrected MLE)	1.706
Theta hat (MLE)	9.422	Theta star (bias corrected MLE)	12.93
nu hat (MLE)	46.85	nu star (bias corrected)	34.13
MLE Mean (bias corrected)	22.07	MLE Sd (bias corrected)	16.9
		Approximate Chi Square Value (0.05)	21.77
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	20.07

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	34.6	95% Adjusted Gamma UCL (use when n<50)	37.54

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.886	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.214	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.015	Mean of logged Data	2.866
Maximum of Logged Data	4.043	SD of logged Data	0.724

Assuming Lognormal Distribution

95% H-UCL	42.5	90% Chebyshev (MVUE) UCL	37.83
95% Chebyshev (MVUE) UCL	44.95	97.5% Chebyshev (MVUE) UCL	54.82
99% Chebyshev (MVUE) UCL	74.21		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

TABLE C2

SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Nonparametric Distribution Free UCLs

95% CLT UCL	30.2	95% Jackknife UCL	31.13
95% Standard Bootstrap UCL	29.74	95% Bootstrap-t UCL	34.1
95% Hall's Bootstrap UCL	34.9	95% Percentile Bootstrap UCL	29.74
95% BCA Bootstrap UCL	32.55		
90% Chebyshev(Mean, Sd) UCL	36.9	95% Chebyshev(Mean, Sd) UCL	43.61
97.5% Chebyshev(Mean, Sd) UCL	52.93	99% Chebyshev(Mean, Sd) UCL	71.25

Suggested UCL to Use

95% Student's-t UCL	31.13

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

PFOS-TH

General Statistics

Total Number of Observations	18	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	3.2	Mean	6.317
Maximum	17	Median	5.05
SD	3.352	Std. Error of Mean	0.79
Coefficient of Variation	0.531	Skewness	2.317

Normal GOF Test

Shapiro Wilk Test Statistic	0.729	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.212	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.202	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	7.691	95% Adjusted-CLT UCL (Chen-1995)	8.077
		95% Modified-t UCL (Johnson-1978)	7.763

Gamma GOF Test

A-D Test Statistic	0.999	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.743	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.181	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.204	Detected data appear Gamma Distributed at 5% Significance Level

Detected data follow Appr. Gamma Distribution at 5% Significance Level

Gamma Statistics

k hat (MLE)	5.517	k star (bias corrected MLE)	4.635
Theta hat (MLE)	1.145	Theta star (bias corrected MLE)	1.363
nu hat (MLE)	198.6	nu star (bias corrected)	166.8
MLE Mean (bias corrected)	6.317	MLE Sd (bias corrected)	2.934
		Approximate Chi Square Value (0.05)	138
Adjusted Level of Significance	0.0357	Adjusted Chi Square Value	135.5

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	7.638	95% Adjusted Gamma UCL (use when n<50)	7.78

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.897	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.17	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.202	Data appear Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Lognormal Statistics

Minimum of Logged Data	1.163	Mean of logged Data	1.75
Maximum of Logged Data	2.833	SD of logged Data	0.412

Assuming Lognormal Distribution

95% H-UCL	7.605	90% Chebyshev (MVUE) UCL	8.091
95% Chebyshev (MVUE) UCL	8.934	97.5% Chebyshev (MVUE) UCL	10.1
99% Chebyshev (MVUE) UCL	12.4		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	7.616	95% Jackknife UCL	7.691
95% Standard Bootstrap UCL	7.578	95% Bootstrap-t UCL	9.224
95% Hall's Bootstrap UCL	14.24	95% Percentile Bootstrap UCL	7.689
95% BCA Bootstrap UCL	8.289		
90% Chebyshev(Mean, Sd) UCL	8.687	95% Chebyshev(Mean, Sd) UCL	9.76
97.5% Chebyshev(Mean, Sd) UCL	11.25	99% Chebyshev(Mean, Sd) UCL	14.18

Suggested UCL to Use

95% Adjusted Gamma UCL	7.78

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

PFOA-TH

General Statistics

Total Number of Observations	18	Number of Distinct Observations	17
		Number of Missing Observations	0
Minimum	3.3	Mean	6.1
Maximum	13	Median	5.55
SD	2.345	Std. Error of Mean	0.553
Coefficient of Variation	0.384	Skewness	1.612

Normal GOF Test

Shapiro Wilk Test Statistic	0.868	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.145	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.202	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	7.062	95% Adjusted-CLT UCL (Chen-1995)	7.234
		95% Modified-t UCL (Johnson-1978)	7.097

Gamma GOF Test

A-D Test Statistic	0.359	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.138	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.204	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	8.643	k star (bias corrected MLE)	7.24
Theta hat (MLE)	0.706	Theta star (bias corrected MLE)	0.843
nu hat (MLE)	311.2	nu star (bias corrected)	260.6
MLE Mean (bias corrected)	6.1	MLE Sd (bias corrected)	2.267
		Approximate Chi Square Value (0.05)	224.3
Adjusted Level of Significance	0.0357	Adjusted Chi Square Value	221

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	7.09	95% Adjusted Gamma UCL (use when n<50)	7.194

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.969	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.124	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.202	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.194	Mean of logged Data	1.749
Maximum of Logged Data	2.565	SD of logged Data	0.342

Assuming Lognormal Distribution

95% H-UCL	7.13	90% Chebyshev (MVUE) UCL	7.573
95% Chebyshev (MVUE) UCL	8.25	97.5% Chebyshev (MVUE) UCL	9.19
99% Chebyshev (MVUE) UCL	11.04		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	7.009	95% Jackknife UCL	7.062
95% Standard Bootstrap UCL	6.991	95% Bootstrap-t UCL	7.457
95% Hall's Bootstrap UCL	7.726	95% Percentile Bootstrap UCL	7.017
95% BCA Bootstrap UCL	7.217		
90% Chebyshev(Mean, Sd) UCL	7.758	95% Chebyshev(Mean, Sd) UCL	8.509
97.5% Chebyshev(Mean, Sd) UCL	9.552	99% Chebyshev(Mean, Sd) UCL	11.6

Suggested UCL to Use

95% Student's-t UCL	7.062

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

PFBS-TH

General Statistics

Total Number of Observations	18	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	1.6	Mean	2.078
Maximum	3.1	Median	1.95
SD	0.396	Std. Error of Mean	0.0934
Coefficient of Variation	0.191	Skewness	1.097

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Normal GOF Test

Shapiro Wilk Test Statistic	0.9	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.189	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.202	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	2.24	95% Adjusted-CLT UCL (Chen-1995)	2.257
		95% Modified-t UCL (Johnson-1978)	2.244

Gamma GOF Test

A-D Test Statistic	0.539	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.739	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.172	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.203	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	31.74	k star (bias corrected MLE)	26.48
Theta hat (MLE)	0.0655	Theta star (bias corrected MLE)	0.0785
nu hat (MLE)	1143	nu star (bias corrected)	953.4
MLE Mean (bias corrected)	2.078	MLE Sd (bias corrected)	0.404
		Approximate Chi Square Value (0.05)	882.8
Adjusted Level of Significance	0.0357	Adjusted Chi Square Value	876.2

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	2.244	95% Adjusted Gamma UCL (use when n<50)	2.261

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.935	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.161	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.202	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.47	Mean of logged Data	0.715
Maximum of Logged Data	1.131	SD of logged Data	0.18

Assuming Lognormal Distribution

95% H-UCL	2.246	90% Chebyshev (MVUE) UCL	2.342
95% Chebyshev (MVUE) UCL	2.462	97.5% Chebyshev (MVUE) UCL	2.629
99% Chebyshev (MVUE) UCL	2.956		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	2.231	95% Jackknife UCL	2.24
95% Standard Bootstrap UCL	2.225	95% Bootstrap-t UCL	2.279
95% Hall's Bootstrap UCL	2.284	95% Percentile Bootstrap UCL	2.244
95% BCA Bootstrap UCL	2.239		
90% Chebyshev(Mean, Sd) UCL	2.358	95% Chebyshev(Mean, Sd) UCL	2.485
97.5% Chebyshev(Mean, Sd) UCL	2.661	99% Chebyshev(Mean, Sd) UCL	3.007

Suggested UCL to Use

95% Student's-t UCL	2.24

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

PFOS-TL

General Statistics

Total Number of Observations	18	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	6.7	Mean	29.31
Maximum	87	Median	19
SD	26.18	Std. Error of Mean	6.171
Coefficient of Variation	0.893	Skewness	1.374

Normal GOF Test

Shapiro Wilk Test Statistic	0.783	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.25	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.202	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	40.04	95% Adjusted-CLT UCL (Chen-1995)	41.59
		95% Modified-t UCL (Johnson-1978)	40.37

Gamma GOF Test

A-D Test Statistic	0.654	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.755	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.186	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.207	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.639	k star (bias corrected MLE)	1.403
Theta hat (MLE)	17.88	Theta star (bias corrected MLE)	20.89
nu hat (MLE)	59	nu star (bias corrected)	50.5
MLE Mean (bias corrected)	29.31	MLE Sd (bias corrected)	24.74
		Approximate Chi Square Value (0.05)	35.18
Adjusted Level of Significance	0.0357	Adjusted Chi Square Value	33.96

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	42.06	95% Adjusted Gamma UCL (use when n<50)	43.58

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.939	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.134	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.202	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.902	Mean of logged Data	3.043
Maximum of Logged Data	4.466	SD of logged Data	0.828

Assuming Lognormal Distribution

95% H-UCL	47.82	90% Chebyshev (MVUE) UCL	47.1
95% Chebyshev (MVUE) UCL	55.38	97.5% Chebyshev (MVUE) UCL	66.87
99% Chebyshev (MVUE) UCL	89.44		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Nonparametric Distribution Free UCLs

95% CLT UCL	39.46	95% Jackknife UCL	40.04
95% Standard Bootstrap UCL	39.16	95% Bootstrap-t UCL	43.77
95% Hall's Bootstrap UCL	39.04	95% Percentile Bootstrap UCL	39.48
95% BCA Bootstrap UCL	41.39		
90% Chebyshev(Mean, Sd) UCL	47.82	95% Chebyshev(Mean, Sd) UCL	56.21
97.5% Chebyshev(Mean, Sd) UCL	67.85	99% Chebyshev(Mean, Sd) UCL	90.71

Suggested UCL to Use

95% Adjusted Gamma UCL	43.58

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

PFOA-TL

General Statistics

Total Number of Observations	18	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	7.8	Mean	33.94
Maximum	110	Median	20
SD	32.57	Std. Error of Mean	7.677
Coefficient of Variation	0.96	Skewness	1.413

Normal GOF Test

Shapiro Wilk Test Statistic	0.781	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.239	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.202	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	47.29	95% Adjusted-CLT UCL (Chen-1995)	49.3
		95% Modified-t UCL (Johnson-1978)	47.72

Gamma GOF Test

A-D Test Statistic	0.756	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.758	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.173	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.208	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.428	k star (bias corrected MLE)	1.227
Theta hat (MLE)	23.76	Theta star (bias corrected MLE)	27.65
nu hat (MLE)	51.42	nu star (bias corrected)	44.19
MLE Mean (bias corrected)	33.94	MLE Sd (bias corrected)	30.63
		Approximate Chi Square Value (0.05)	29.94
Adjusted Level of Significance	0.0357	Adjusted Chi Square Value	28.82

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	50.09	95% Adjusted Gamma UCL (use when n<50)	52.04

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.918	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.133	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.202	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.054	Mean of logged Data	3.135
Maximum of Logged Data	4.7	SD of logged Data	0.889

Assuming Lognormal Distribution

95% H-UCL	58.32	90% Chebyshev (MVUE) UCL	55.96
95% Chebyshev (MVUE) UCL	66.29	97.5% Chebyshev (MVUE) UCL	80.61
99% Chebyshev (MVUE) UCL	108.8		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	46.57	95% Jackknife UCL	47.29
95% Standard Bootstrap UCL	46.28	95% Bootstrap-t UCL	53.29
95% Hall's Bootstrap UCL	48.52	95% Percentile Bootstrap UCL	47.72
95% BCA Bootstrap UCL	47.63		
90% Chebyshev(Mean, Sd) UCL	56.97	95% Chebyshev(Mean, Sd) UCL	67.4
97.5% Chebyshev(Mean, Sd) UCL	81.88	99% Chebyshev(Mean, Sd) UCL	110.3

Suggested UCL to Use

95% Adjusted Gamma UCL	52.04

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

PFBS-TL

General Statistics

Total Number of Observations	18	Number of Distinct Observations	15
		Number of Missing Observations	0
Minimum	2.8	Mean	6.228
Maximum	16	Median	4.5
SD	4.16	Std. Error of Mean	0.981
Coefficient of Variation	0.668	Skewness	1.465

Normal GOF Test

Shapiro Wilk Test Statistic	0.782	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.227	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.202	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	7.934	95% Adjusted-CLT UCL (Chen-1995)	8.203
		95% Modified-t UCL (Johnson-1978)	7.99

Gamma GOF Test

A-D Test Statistic	0.955	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.745	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.202	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.205	Detected data appear Gamma Distributed at 5% Significance Level

Detected data follow Appr. Gamma Distribution at 5% Significance Level

TABLE C2
SURFACE WATER PROUCL UCL OUTPUT
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Gamma Statistics

k hat (MLE)	3.1	k star (bias corrected MLE)	2.62
Theta hat (MLE)	2.009	Theta star (bias corrected MLE)	2.377
nu hat (MLE)	111.6	nu star (bias corrected)	94.32
MLE Mean (bias corrected)	6.228	MLE Sd (bias corrected)	3.848
		Approximate Chi Square Value (0.05)	72.92
Adjusted Level of Significance	0.0357	Adjusted Chi Square Value	71.12

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	8.055	95% Adjusted Gamma UCL (use when n<50)	8.26

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.891	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.897	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.184	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.202	Data appear Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.03	Mean of logged Data	1.659
Maximum of Logged Data	2.773	SD of logged Data	0.57

Assuming Lognormal Distribution

95% H-UCL	8.257	90% Chebyshev (MVUE) UCL	8.695
95% Chebyshev (MVUE) UCL	9.862	97.5% Chebyshev (MVUE) UCL	11.48
99% Chebyshev (MVUE) UCL	14.66		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	7.841	95% Jackknife UCL	7.934
95% Standard Bootstrap UCL	7.8	95% Bootstrap-t UCL	8.785
95% Hall's Bootstrap UCL	8.262	95% Percentile Bootstrap UCL	7.967
95% BCA Bootstrap UCL	8.183		
90% Chebyshev(Mean, Sd) UCL	9.17	95% Chebyshev(Mean, Sd) UCL	10.5
97.5% Chebyshev(Mean, Sd) UCL	12.35	99% Chebyshev(Mean, Sd) UCL	15.98

Suggested UCL to Use

95% Adjusted Gamma UCL	8.26

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

TABLE C3

SURFACE SOIL PROUCL UCL OUTPUT WITH OUTLIERS REMOVED
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.110/1/2019 1:06:19 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

PFOS-NoMax

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
Number of Detects	10	Number of Non-Detects	1
Number of Distinct Detects	10	Number of Distinct Non-Detects	1
Minimum Detect	0.25	Minimum Non-Detect	0.6
Maximum Detect	80	Maximum Non-Detect	0.6
Variance Detects	535.9	Percent Non-Detects	9.091%
Mean Detects	23.01	SD Detects	23.15
Median Detects	16	CV Detects	1.006
Skewness Detects	1.854	Kurtosis Detects	4.052
Mean of Logged Detects	2.501	SD of Logged Detects	1.57

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.818	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.842	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.215	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.262	Detected Data appear Normal at 5% Significance Level

Detected Data appear Approximate Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	20.94	KM Standard Error of Mean	6.972
KM SD	21.94	95% KM (BCA) UCL	33.38
95% KM (t) UCL	33.57	95% KM (Percentile Bootstrap) UCL	33.41
95% KM (z) UCL	32.4	95% KM Bootstrap t UCL	41.13
90% KM Chebyshev UCL	41.85	95% KM Chebyshev UCL	51.33
97.5% KM Chebyshev UCL	64.48	99% KM Chebyshev UCL	90.31

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.269	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.751	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.145	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.274	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.918	k star (bias corrected MLE)	0.709
Theta hat (MLE)	25.06	Theta star (bias corrected MLE)	32.43
nu hat (MLE)	18.36	nu star (bias corrected)	14.19
Mean (detects)	23.01		

TABLE C3
SURFACE SOIL PROUCL UCL OUTPUT WITH OUTLIERS REMOVED
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	20.91
Maximum	80	Median	12
SD	23.03	CV	1.101
k hat (MLE)	0.531	k star (bias corrected MLE)	0.447
Theta hat (MLE)	39.41	Theta star (bias corrected MLE)	46.83
nu hat (MLE)	11.68	nu star (bias corrected)	9.825
Adjusted Level of Significance (β)	0.0278		
Approximate Chi Square Value (9.83, α)	3.833	Adjusted Chi Square Value (9.83, β)	3.246
95% Gamma Approximate UCL (use when n>=50)	53.61	95% Gamma Adjusted UCL (use when n<50)	63.3

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	20.94	SD (KM)	21.94
Variance (KM)	481.2	SE of Mean (KM)	6.972
k hat (KM)	0.911	k star (KM)	0.723
nu hat (KM)	20.04	nu star (KM)	15.91
theta hat (KM)	22.99	theta star (KM)	28.96
80% gamma percentile (KM)	34.38	90% gamma percentile (KM)	52.15
95% gamma percentile (KM)	70.43	99% gamma percentile (KM)	114

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (15.91, α)	7.897	Adjusted Chi Square Value (15.91, β)	6.996
95% Gamma Approximate KM-UCL (use when n>=50)	42.17	95% Gamma Adjusted KM-UCL (use when n<50)	47.61

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.838	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.842	Detected Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.222	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.262	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Approximate Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	20.99	Mean in Log Scale	2.261
SD in Original Scale	22.95	SD in Log Scale	1.688
95% t UCL (assumes normality of ROS data)	33.54	95% Percentile Bootstrap UCL	32.65
95% BCA Bootstrap UCL	36.07	95% Bootstrap t UCL	43.58
95% H-UCL (Log ROS)	427.6		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	2.147	KM Geo Mean	8.561
KM SD (logged)	1.807	95% Critical H Value (KM-Log)	4.715
KM Standard Error of Mean (logged)	0.574	95% H-UCL (KM -Log)	647.5
KM SD (logged)	1.807	95% Critical H Value (KM-Log)	4.715
KM Standard Error of Mean (logged)	0.574		

TABLE C3
SURFACE SOIL PROUCL UCL OUTPUT WITH OUTLIERS REMOVED
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	20.94	Mean in Log Scale	2.164
SD in Original Scale	23	SD in Log Scale	1.861
95% t UCL (Assumes normality)	33.51	95% H-Stat UCL	849.2

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	33.57

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

PFOS-No2Max

General Statistics

Total Number of Observations	10	Number of Distinct Observations	10
Number of Detects	9	Number of Non-Detects	1
Number of Distinct Detects	9	Number of Distinct Non-Detects	1
Minimum Detect	0.25	Minimum Non-Detect	0.6
Maximum Detect	38	Maximum Non-Detect	0.6
Variance Detects	151.7	Percent Non-Detects	10%
Mean Detects	16.67	SD Detects	12.32
Median Detects	12	CV Detects	0.739
Skewness Detects	0.494	Kurtosis Detects	-0.762
Mean of Logged Detects	2.292	SD of Logged Detects	1.51

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.948	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.203	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.274	Detected Data appear Normal at 5% Significance Level

Detected Data appear Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	15.03	KM Standard Error of Mean	4.047
KM SD	12.07	95% KM (BCA) UCL	21.15
95% KM (t) UCL	22.45	95% KM (Percentile Bootstrap) UCL	21.53
95% KM (z) UCL	21.69	95% KM Bootstrap t UCL	23.18
90% KM Chebyshev UCL	27.17	95% KM Chebyshev UCL	32.67
97.5% KM Chebyshev UCL	40.31	99% KM Chebyshev UCL	55.3

TABLE C3
SURFACE SOIL PROUCL UCL OUTPUT WITH OUTLIERS REMOVED
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.418	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.742	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.175	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.286	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.094	k star (bias corrected MLE)	0.803
Theta hat (MLE)	15.24	Theta star (bias corrected MLE)	20.75
nu hat (MLE)	19.69	nu star (bias corrected)	14.46
Mean (detects)	16.67		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)
For such situations, GROS method may yield incorrect values of UCLs and BTVs
This is especially true when the sample size is small.
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.25	Mean	15.19
Maximum	38	Median	11
SD	12.52	CV	0.824
k hat (MLE)	0.972	k star (bias corrected MLE)	0.747
Theta hat (MLE)	15.63	Theta star (bias corrected MLE)	20.34
nu hat (MLE)	19.43	nu star (bias corrected)	14.94
Adjusted Level of Significance (β)	0.0267		
Approximate Chi Square Value (14.94, α)	7.218	Adjusted Chi Square Value (14.94, β)	6.308
95% Gamma Approximate UCL (use when n>=50)	31.44	95% Gamma Adjusted UCL (use when n<50)	35.97

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	15.03	SD (KM)	12.07
Variance (KM)	145.6	SE of Mean (KM)	4.047
k hat (KM)	1.551	k star (KM)	1.153
nu hat (KM)	31.03	nu star (KM)	23.05
theta hat (KM)	9.688	theta star (KM)	13.04
80% gamma percentile (KM)	23.89	90% gamma percentile (KM)	33.42
95% gamma percentile (KM)	42.84	99% gamma percentile (KM)	64.49

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (23.05, α)	13.13	Adjusted Chi Square Value (23.05, β)	11.85
95% Gamma Approximate KM-UCL (use when n>=50)	26.39	95% Gamma Adjusted KM-UCL (use when n<50)	29.24

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.77	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Detected Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.255	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.274	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Approximate Lognormal at 5% Significance Level

TABLE C3
SURFACE SOIL PROUCL UCL OUTPUT WITH OUTLIERS REMOVED
ECOLOGICAL RISK ASSESSMENT
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	15.09	Mean in Log Scale	2.051
SD in Original Scale	12.64	SD in Log Scale	1.614
95% t UCL (assumes normality of ROS data)	22.42	95% Percentile Bootstrap UCL	21.65
95% BCA Bootstrap UCL	21.79	95% Bootstrap t UCL	23.61
95% H-UCL (Log ROS)	317.5		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	1.924	KM Geo Mean	6.846
KM SD (logged)	1.744	95% Critical H Value (KM-Log)	4.781
KM Standard Error of Mean (logged)	0.585	95% H-UCL (KM -Log)	504.5
KM SD (logged)	1.744	95% Critical H Value (KM-Log)	4.781
KM Standard Error of Mean (logged)	0.585		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	15.04	Mean in Log Scale	1.942
SD in Original Scale	12.71	SD in Log Scale	1.802
95% t UCL (Assumes normality)	22.4	95% H-Stat UCL	680

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	22.45

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Attachment D
Tier 2, Step 3a Food Web Models and HQs for PFOS

TABLE D1

WILDLIFE EXPOSURE FACTORS
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Receptor Species	Body Weight (kg)	Assumed Diet Fraction of diet as %; Amount as kg_{ww}/day				Food Ingestion Rate (kg_{dw}/day)	Food Ingestion Rate (kg_{ww}/day)	Fraction Sediment in Diet (%) Amount as kg_{dw}/day	Water Intake Rate (kg/day)	Home Range (km)	Seasonal Use Factor (unitless)	Area Use Factor (unitless)
		Units	Fish TL 2/3	Fish TL 3/4	Aquatic and Benthic Invertebrates							
Birds												
Great Blue Heron (*Ardea herodias*)	2.336 (a)	% kg_{ww}/day	-- --	100% 0.5812 (b)	-- -- (b)	0.1453 (c)	0.5812 (d)	-- -- (e)	0.1042 (f)	5.3 (g)	1 (h)	0.13 (i)
Belted kingfisher (*Megaceryle alcyon*)	0.1473 (a)	% kg_{ww}/day	50% 0.0465 (b)	30% 0.0279 (b)	20% 0.03100 (b)	0.0233 (c)	0.1054 (d)	2% 0.0005 (e)	0.0164 (f)	1.16 (g)	1 (h)	0.59 (i)
Osprey (Pandion haliaetus)	1.629 (a)	% kg_{ww}/day	-- --	100% 0.4576 (b)	-- --	0.1144 (c)	0.4576 (d)	-- -- (e)	0.0818 (f)	11.5 (g)	1 (h)	0.059 (i)
Mammals												
Otter (Lutra canadensis)	7.990 (a)	% kg_{ww}/day	35% (b) 0.3621	45% 0.4656 (b)	20% 0.3449 (b)	0.2586 (c)	1.1725 (d)	9.4% 0.0243 (e)	0.643 (f)	31 (g)	1 (h)	0.022 (i)
Mink *(Neovison vison)*	1.020 (a)	% kg_{ww}/day	34% (b) 0.0761	33% 0.0738 (b)	33% 0.1230 (b)	0.0559 (c)	0.2729 (d)	9.4% 0.0053 (e)	0.101 (f)	2.24 (g)	1 (h)	0.30 (i)

General Notes:

Food ingestion rates are wet weight for food items and dry weight for sediment/soil ingestion. As needed, rate may be converted.
Ingested abiotic media (i.e., soil or sediment) is in addition to 100% of dietary ingestion.
See individual organism notes for source, units, and conversion.
Moisture content of food items assumed to be as follows: 75% for fish and 85% for aquatic and benthic invertebrates (USEPA, 1993).

BW - Body Weight
COPC - Constituent of Potential Concern
dw - Dry Weight
FIR - Food Ingestion Rate
kg - Kilogram
km - Kilometer
TL - Trophic Level
USEPA - United States Environmental Protection Agency
WIR - Water Ingestion Rate (1 L of water has weight of 1 kg)
ww - Wet Weight

Footnotes for individual species parameters and assumptions presented on next pages.

TABLE D1

WILDLIFE EXPOSURE FACTORS
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Notes for Great Blue Heron (*Ardea herodias*):

(a) Average body weight of adult male and female herons (USEPA, 1993).
(b) Diet assumed to be exclusively fish (TL 3/4).
(c) Food ingestion rate calculated using algorithm for carnivorous birds developed by Nagy, 2001 [FIR (g_{dw}/day) = $0.849*BW^{0.663}$].
(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

$$FIR_{ww} = \text{Sum } \{[(\text{Proportion of food}_i \text{ in diet}) \times (FIR_{dw})] / (1\text{-moisture content}_i)\}$$

(e) Fraction set to 0%. Assumption for wading bird based on best professional judgement and ingestion of TL 3/4 fish.
(f) Water ingestion rate calculated using algorithm for all birds developed by USEPA, 1993 [WIR (kg/day) = $0.059*BW^{0.67}$].
(g) Average adult foraging distance from colony based on studies conducted in riverine & coastal areas in South Dakota and North Carolina (USEPA, 1993).
(h) Great blue heron assumed to be present and actively foraging year-round.
(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

Notes for Belted Kingfisher (*Megaceryle alcyon*):

(a) Average body weight of adult male and female kingfishers (USEPA, 1993).
(b) Diet assumed to be exclusively fish and benthic invertebrates, dietary percentages based on professional judgement and EPA 1993.
(c) Food ingestion rate calculated using algorithm for carnivorous birds developed by Nagy, 2001 [FIR (g_{dw}/day) = $0.849*BW^{0.663}$].
(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

$$FIR_{ww} = \text{Sum } \{[(\text{Proportion of food}_i \text{ in diet}) \times (FIR_{dw})] / (1\text{-moisture content}_i)\}$$

(e) Fraction set to 2%. Assumption for kingfisher based on best professional judgement and ingestion of invertebrates, and TL 2/3 and 3/4 fish.
(f) Water ingestion rate calculated using algorithm for all birds developed by USEPA, 1993 [WIR (kg/day) = $0.059*BW^{0.67}$].
(g) Average territory (km shoreline) based on studies conducted in streams in Pennsylvania and Ohio (USEPA, 1993).
(h) Belted kingfisher assumed to be present and actively foraging year-round.
(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

Notes for Osprey (P*andion haliaetus*):

(a) Average body weight of adult male and female osprey (USEPA, 1993).
(b) Diet assumed to be exclusively fish (TL 3/4).
(c) Food ingestion rate calculated using algorithm for carnivorous birds developed by Nagy, 2001 [FIR (gdw/day) = 0.849*BW0.663].
(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

$$FIR_{ww} = \text{Sum } \{[(\text{Proportion of food}_i \text{ in diet}) \times (FIR_{dw})] / (1\text{-moisture content}_i)\}$$

(e) Fraction set to 0%. Assumption for osprey based on best professional judgement and ingestion of TL 3/4 fish.
(f) Water ingestion rate calculated using algorithm for all birds developed by USEPA, 1993 [WIR (kg/day) = $0.059*BW^{0.67}$].
(g) Average territory radius (km) doubled to generate full linear range (diameter) based on studies conducted in lakes and coastal/bay area in Minnesota. Nova Scotia and NW Ca
(h) Osprey assumed to be present and actively foraging year-round.
(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

TABLE D1

WILDLIFE EXPOSURE FACTORS
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

Notes for Otter

(a) Average body weight of adult male and female river otters (USEPA, 1993).
(b) Diet assumed to be exclusively fish and benthic invertebrates, dietary percentages based on professional judgement and EPA 1993.
(c) Food ingestion rate calculated using algorithm for mammals developed by Nagy, 2001 [FIR (gdw/day) = 0.323*BW0.744].
(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

$$FIR_{ww} = \text{Sum }\{[(\text{Proportion of food}_i \text{ in diet}) \times (FIR_{dw})] / (1\text{-moisture content}_i)\}$$

(e) The incidental soil ingestion rate is based on the value identified by Beyer (1994) for the surrogate species used, raccoon.
(f) Water ingestion rate calculated using algorithm for all mammals developed by USEPA, 1993 [WIR (kg/day) = 0.099*BW0.90] using average body weight.
(g) Average adult female home range (km river) for river drainages in Idaho (USEPA, 1993).
(h) Otter assumed to be present and actively foraging year-round.
(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

Notes for Mink

(a) Average body weight of adult male and female mink in Michigan and Montana (USEPA, 1993).
(b) A diet consisting of 33% invertebrates, and 67% fish was selected.
(c) Food ingestion rate calculated using algorithm for mammals developed by Nagy, 2001 [FIR (gdw/day) = 0.323*BW0.744].
(d) Dry weight food ingestion rate converted to wet weight food ingestion rate:

$$FIR_{ww} = \text{Sum }\{[(\text{Proportion of food}_i \text{ in diet}) \times (FIR_{dw})] / (1\text{-moisture content}_i)\}$$

(e) The incidental soil ingestion rate is based on the value identified by Beyer (1994) for the surrogate species used, raccoon.
(f) Water ingestion rate calculated using algorithm for all mammals developed by USEPA, 1993 [WIR (kg/day) = 0.099*BW0.90] using average body weight.
(g) Average adult home range for stream habitats in Sweden (USEPA, 1993).
(h) Otter assumed to be present and actively foraging year-round.
(i) The AUF was calculated by dividing the length of the sampled (off-site) tributary (2,235 feet or 0.6812 km) by the receptor home range.

TABLE D2

SEDIMENT, SURFACE WATER, AND FISH TISSUE CONCENTRATIONS
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

	Measured Media Concentrations (a)		**Estimated Invertebrate Tissue Concentrations**		**Estimated Fish Tissue Concentrations**			
	Sediment 95% UCL (ug/L)	**Surface Water 95% UCL (ug/L)**	**Water-to-TL2 Invertebrate BCF**	**TL2 Invertebrate Tissue EPC (ug/kg$_{ww}$)**	**Fish BAF (Water + Diet)**		**Fish Tissue EPC**	
							TL2/3	**TL3/4**
COPC					**TL 2/3 Fish**	**TL3/4 Fish**	**(ug/kg$_{ww}$)**	
PFOS	13.1	0.162	1,100 (b)	179	6,513 (c)	10,120 (d)	1058	1643

Notes:

95% UCL - 95% Upper Confidence Limit of the Arithmetic Mean
BAF = Bioaccumulation Factor
BCF = Bioconcentration Factor
COPC - Constituent of Potential Concern
EPC - Exposure Point Concentration

kg - Kilogram
L - Liter
ug - Microgram
PFOS - Perfluorooctanesulfonic Acid
ww - Wet Weight

(a) Surface water average EPCs are based on the 95% Upper Confidence Limit of the "All 2018 Surface Water Data", which were calculated using ProUCL 5.1. See Table 3 of ERA.

(b) Average BCF calculated based on BCFs (n=2) obtained from the following sources: Kannan et al. 2005 and Houde et al. 2008 (cited in Concawe 2016). See Table 6 of ERA.

(c) Geomean BAF calculated based on BAFs obtained or derived from the following sources: Kannan et al. 2005, Houde et al. 2008 (as cited in Concawe 2016), and MDCH 2015. See Table 6 of ERA.

(d) Geomean BAF calculated based on BAFs obrainted or derived from the following sources: Kannan et al. 2005, Houde et al. 2008 (as cited in Concawe 2016), MDCH 2015, and Martin 2004 (as cited in Franklin 2015). See Table 6 of ERA.

TABLE D3

TOXICITY REFERENCE VALUES
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

			NOAEL-based TRVs		LOAEL-based TRVs	
COPC	**Source**	**Target Species**	**NOAEL (ug/kg_{bw}/day)**	**NOAEL Test Endpoint**	**Test LOAEL (ug/kg_{bw}/day)**	**LOAEL Test Endpoint**
PFAS						
PFOS	(a)	Mammal	100	Reproduction	400	Reproduction
PFOS	(b)	Bird	77	Reproduction	770	Reproduction

Notes:
BW - Body Weight
COPC - Constituent of Potential Concern
kg - Kilogram
LOAEL - Lowest Observed Adverse Effects Level
ug - Microgram
NOAEL - No Observed Adverse Effects Level
PFAS - Poly- and Perfluoroalkyl Substances
PFOS - Perfluorooctanesulfonic Acid
TRV - Toxicity Reference Value

(a) Mammalian TRVs obtained from the following sources: RIVM 2010; Environment Canada 2006; Stahl et al. 2011; and Dietz et al. 2015
(b) Avian TRVs obtained from the following source: Newsted et al. 2005

TABLE D4

POTENTIAL RISKS TO THE GREAT BLUE HERON
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

ASSUMPTIONS FOR THE GREAT BLUE HERON	
Body Weight (kg)	2.3
Seasonal Use Factor	1
Area Use Factor	0.13
Water Consumption Rate (kg/day)	0.10
TL4 Fish Consumption Rate (kg_{ww}/day)	0.58

$$\text{Total Daily Dose} = \frac{\Sigma([IR_f \times C_f] + [IR_s \times C_s] + [IR_w \times C_w]) \times SUF \times AUF}{\text{Body Weight}}$$

Where:
IR_f = Ingestion rate of food (kg/day)
IR_s = Incidental ingestion rate of sediment (kg/day)
IR_w = Ingestion rate of water (L/day)
C_f = Concentration of COPC in food (ug/kg)
C_s= Concentration of COPC in sediment (ug/kg)
C_w = Concentration of COPC in water (ug/L)
SUF = Seasonal Use Factor (fraction of time receptor spends within exposure area)

Notes:
BW - Body Weight
COPC - Constituent of Potential Concern
EPC - Exposure Point Concentration
HQ - Hazard Quotient (Dose/TRV)
kg - Kilogram
L - Liter
LOAEL - Lowest Observed Adverse Effects Level
ug - Microgram
NOAEL - No Observed Adverse Effects Level
PFAS - Poly- and Perfluoroalkyl Substances
PFOS - Perfluorooctanesulfonic Acid
TRV - Toxicity Reference Value
95% UCL - 95% Upper Confidence Limit of the Arithmetic Mean
ww - Wet Weight

HQs above 1 are bolded and highlighted.

SUPPORTING CALCULATIONS

COPC	Media Concentrations		Potential Daily Dose (ug/kg_{bw}/day)			NOAEL-based TRV (ug/kg_{bw}/day)	NOAEL-based HQ	LOAEL-based TRV (ug/kg_{bw}/day)	LOAEL-based HQ
	Fish TL4 (ug/kg_{ww})	Surface Water 95% UCL (ug/L)	Fish TL4	Surface Water	Total				
PFAS									
PFOS	1643	0.162	52.5	0.000931	52.5	77	0.68	770	0.068

TABLE D5
POTENTIAL RISKS TO THE BELTED KINGFISHER
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

ASSUMPTIONS FOR THE BELTED KINGFISHER	
Body Weight (kg)	0.15
Seasonal Use Factor	1
Area Use Factor	0.59
Sediment Consumption Rate (kg_{dw}/day)	0.0005
Water Consumption Rate (kg/day)	0.016
Invertebrate Consumption Rate (kg_{ww}/day)	0.0310
TL3 Fish Consumption Rate (kg_{ww}/day)	0.0465
TL4 Fish Consumption Rate (kg_{ww}/day)	0.028

$$\text{Total Daily Dose} = \frac{\Sigma([IR_f \times C_f] + [IR_s \times C_s] + [IR_w \times C_w]) \times SUF \times AUF}{\text{Body Weight}}$$

Where:
IR_f = Ingestion rate of food (kg/day)
IR_s = Incidental ingestion rate of sediment (kg/day)
IR_w = Ingestion rate of water (L/day)
C_f = Concentration of COPC in food (ug/kg)
C_s= Concentration of COPC in sediment (ug/kg)
C_w = Concentration of COPC in water (ug/L)
SUF = Seasonal Use Factor (fraction of time receptor spends within exposure area)
AUF = Area use factor (ratio of the receptor's home range relative to the size of exposure area)

Notes:
BW - Body Weight
COPC - Constituent of Potential Concern
EPC - Exposure Point Concentration
HQ - Hazard Quotient (Dose/TRV)
kg - Kilogram
L - Liter
LOAEL - Lowest Observed Adverse Effects Level
ug - Microgram
NOAEL - No Observed Adverse Effects Level
PFAS - Poly- and Perfluoroalkyl Substances
PFOS - Perfluorooctanesulfonic Acid
TRV - Toxicity Reference Value
95% UCL - 95% Upper Confidence Limit of the Arithmetic Mean
ww - Wet Weight

HQs above 1 are bolded and highlighted.

SUPPORTING CALCULATIONS

	Media Concentrations					Potential Daily Dose (ug/kg_{bw}/day)									
COPC	Fish TL3 (ug/kg_{ww})	Fish TL4 (ug/kg_{ww})	Invertebrate (ug/kg_{ww})	Surface Water 95% UCL (ug/L)	Sediment 95% UCL (ug/L)	Fish TL3	Fish TL4	Invertebrate	Surface Water	Sediment	Total	NOAEL-based TRV (ug/kg_{bw}/day)	NOAEL-based HQ	LOAEL-based TRV (ug/kg_{bw}/day)	LOAEL-based HQ
PFOS	1058	1643	179	0.162	13.1	196	183	22.1	0.0106	0.0242	401	77	**5**	770	0.5

TABLE D6

POTENTIAL RISKS TO THE OSPREY

ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

ASSUMPTIONS FOR THE OSPREY	
Body Weight (kg)	1.63
Seasonal Use Factor	1
Area Use Factor	0.059
Water Consumption Rate (kg/day)	0.082
TL4 Fish Consumption Rate (kg$_{ww}$/day)	0.46

$$\text{Total Daily Dose} = \frac{\Sigma([IR_f \times C_f] + [IR_s \times C_s] + [IR_w \times C_w]) \times SUF \times AUF}{\text{Body Weight}}$$

Where:
IR_f = Ingestion rate of food (kg/day)
IR_s = Incidental ingestion rate of sediment (kg/day)
IR_w = Ingestion rate of water (L/day)
C_f = Concentration of COPC in food (ug/kg)
C_s= Concentration of COPC in sediment (ug/kg)
C_w = Concentration of COPC in water (ug/L)
SUF = Seasonal Use Factor(fraction of time receptor spends within exposure area)

Notes:
BW - Body Weight
COPC - Constituent of Potential Concern
EPC - Exposure Point Concentration
HQ - Hazard Quotient (Dose/TRV)
kg - Kilogram
L - Liter
LOAEL - Lowest Observed Adverse Effects Level
ug - Microgram
NOAEL - No Observed Adverse Effects Level
PFAS - Poly- and Perfluoroalkyl Substances
PFOS - Perfluorooctanesulfonic Acid
TRV - Toxicity Reference Value
95% UCL - 95% Upper Confidence Limit of the Arithmetic Mean
ww - Wet Weight

HQs above 1 are bolded and highlighted.

SUPPORTING CALCULATIONS

COPC	Media Concentrations		Potential Daily Dose (ug/kg$_{bw}$/day)			NOAEL-based TRV (ug/kg$_{bw}$/day)	NOAEL-based HQ	LOAEL-based TRV (ug/kg$_{bw}$/day)	LOAEL-based HQ
	Fish TL4 (ug/kg$_{ww}$)	Surface Water 95% UCL (ug/L)	Fish TL4	Surface Water	Total				
PFAS									
PFOS	1643	0.162	27.4	0.000485	27.4	77	0.36	770	0.036

TABLE D7

POTENTIAL RISKS TO THE OTTER
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

ASSUMPTIONS FOR THE OTTER	
Body Weight (kg)	8.0
Seasonal Use Factor	1
Area Use Factor	0.022
Sediment Consumption Rate (kg_{dw}/day)	0.024
Water Consumption Rate (kg/day)	0.64
Invertebrate Consumption Rate (kg_{ww}/day)	0.34
TL3 Fish Consumption Rate (kg_{ww}/day)	0.36
TL4 Fish Consumption Rate (kg_{ww}/day)	0.47

$$\text{Total Daily Dose} = \frac{\Sigma([IR_f \times C_f] + [IR_s \times C_s] + [IR_w \times C_w]) \times SUF \times AUF}{\text{Body Weight}}$$

Where:
IR_f = Ingestion rate of food (kg/day)
IR_s = Incidental ingestion rate of sediment (kg/day)
IR_w = Ingestion rate of water (L/day)
C_f = Concentration of COPC in food (ug/kg)
C_s= Concentration of COPC in sediment (ug/kg)
C_w = Concentration of COPC in water (ug/L)
SUF = Seasonal Use Factor(fraction of time receptor spends within exposure area)
AUF = Area use factor (ratio of the receptor’s home range relative to the size of exposure area)

Notes:
BW - Body Weight
COPC - Constituent of Potential Concern
EPC - Exposure Point Concentration
HQ - Hazard Quotient (Dose/TRV)
kg - Kilogram
L - Liter
LOAEL - Lowest Observed Adverse Effects Level
ug - Microgram
NOAEL - No Observed Adverse Effects Level
PFAS - Poly- and Perfluoroalkyl Substances
PFOS - Perfluorooctanesulfonic Acid
TRV - Toxicity Reference Value
95% UCL - 95% Upper Confidence Limit of the Arithmetic Mean
ww - Wet Weight

HQs above 1 are bolded and highlighted.

SUPPORTING CALCULATIONS

COPC	Media Concentrations					Potential Daily Dose (ug/kg_{bw}/day)						NOAEL-based TRV (ug/kg_{bw}/day)	NOAEL-based HQ	LOAEL-based TRV (ug/kg_{bw}/day)	LOAEL-based HQ
	Fish TL3 (ug/kg_{ww})	Fish TL4 (ug/kg_{ww})	Invertebrate (ug/kg_{ww})	Surface Water 95% UCL (ug/L)	Sediment 95% UCL (ug/L)	Fish TL3	Fish TL4	Invertebrate	Surface Water	Sediment	Total				
PFAS															
PFOS	1058	1643	179	0.162	13.1	1.05	2.10	0.169	0.000287	0.000874	3.3	100	0.03	400	0.008

TABLE D8

POTENTIAL RISKS TO THE MINK

ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL

FORMER BAY HEAD ROAD ANNEX (BHRA)

ANNAPOLIS, MARYLAND

ASSUMPTIONS FOR THE MINK	
Body Weight (kg)	1.0
Seasonal Use Factor	1
Area Use Factor	0.30
Sediment Consumption Rate (kg_{dw}/day)	0.0053
Water Consumption Rate (kg/day)	0.10
Invertebrate Consumption Rate (kg_{ww}/day)	0.12
TL3 Fish Consumption Rate (kg_{ww}/day)	0.076
TL4 Fish Consumption Rate (kg_{ww}/day)	0.074

$$\text{Total Daily Dose} = \frac{\Sigma([IR_f \times C_f] + [IR_s \times C_s] + [IR_w \times C_w]) \times SUF \times AUF}{\text{Body Weight}}$$

Where:

IR_f = Ingestion rate of food (kg/day)

IR_s = Incidental ingestion rate of sediment (kg/day)

IR_w = Ingestion rate of water (L/day)

C_f = Concentration of COPC in food (ug/kg)

C_s= Concentration of COPC in sediment (ug/kg)

C_w = Concentration of COPC in water (ug/L)

SUF = Seasonal Use Factor(fraction of time receptor spends within exposure area)

AUF = Area use factor (ratio of the receptor's home range relative to the size of exposure area)

Notes:

BW - Body Weight
COPC - Constituent of Potential Concern
EPC - Exposure Point Concentration
HQ - Hazard Quotient (Dose/TRV)
kg - Kilogram
L - Liter
LOAEL - Lowest Observed Adverse Effects Lev
ww - Wet Weight

ug - Microgram
NOAEL - No Observed Adverse Effects Level
PFAS - Poly- and Perfluoroalkyl Substances
PFOS - Perfluorooctanesulfonic Acid
TRV - Toxicity Reference Value
95% UCL - 95% Upper Confidence Limit of the Arithmetic Mean

HQs above 1 are bolded and highlighted.

SUPPORTING CALCULATIONS

COPC	Media Concentrations					Potential Daily Dose (ug/kg_{bw}/day)									
	Fish TL3 (ug/kg_{ww})	Fish TL4 (ug/kg_{ww})	Invertebrate (ug/kg_{ww})	Surface Water 95% UCL (ug/L)	Sediment 95% UCL (ug/L)	Fish TL3	Fish TL4	Invertebrate	Surface Water	Sediment	Total	NOAEL-based TRV (ug/kg_{bw}/day)	NOAEL-based HQ	LOAEL-based TRV (ug/kg_{bw}/day)	LOAEL-based HQ
PFAS															
PFOS	1058	1643	179	0.162	13.1	24	36.2	6.55	0.00488	0.0205	67	100	0.7	400	0.17

TABLE D9

SUMMARY OF POTENTIAL RISKS TO WILDLIFE
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

HQs for Potential PFOS Exposure (95% UCL Abiotic Media)									
Great Blue Heron		Belted kingfisher		Osprey		Otter		Mink	
NOAEL-based HQ	LOAEL-based HQ	NOAEL-based HQ	LOAEL-based HQ	NOAEL-based HQ	LOAEL-based HQ	NOAEL-based HQ	LOAEL-based HQ	NOAEL-based HQ	LOAEL-based HQ
0.68	0.068	**5.2**	0.52	0.36	0.036	0.033	0.0083	0.67	0.17

Notes:
HQs above 1 are bolded and highlighted.

95% UCL - 95% Upper Confidence Limit of the Arithmetic Mean
HQ - Hazard Quotient (Dose/TRV)
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level
PFOS - Perfluorooctanesulfonic Acid

TABLE D10

SITE-SPECIFIC SCREENING VALUE FOR THE BELTED KINGFISHER
ECOLOGICAL RISK ASSESSMENT FOOD WEB MODEL
FORMER BAY HEAD ROAD ANNEX (BHRA)
ANNAPOLIS, MARYLAND

ASSUMPTIONS FOR THE BELTED KINGFISHER	
Body Weight (kg)	0.15
Seasonal Use Factor	1
Area Use Factor	0.59
Water Consumption Rate (kg/day)	0.016
Ingestion Rate of Food (kg_{ww}/day)	0.11

$$\text{Surface Water SL} = \frac{\text{Toxicity Reference Value x Body Weight}}{\text{SUF x AUF x }([IR_f \times ([BCF_{TL2} \text{ x PF}] + [BAF_{TL2/3} \text{ x PF}] + [BAF_{TL3/4} \text{ x PF}])] + IR_w)}.$$

Where:
IR_f = Ingestion rate of food (kg/day)
IR_w = Ingestion rate of water (L/day)
BCF_{TL2} = Water to trophic level 2 invertebrate bioconcentration factor (L/kg_{ww})
$BAF_{TL2/3}$ = Trophic level 2/3 fish bioaccumulation factor (L/kg_{ww})
$BAF_{TL3/4}$ = Trophic level 2/3 fish bioaccumulation factor (L/kg_{ww})
SUF = Seasonal Use Factor (fraction of time receptor spends within exposure area)
AUF = Area use factor (ratio of the receptor's home range relative to the size of exposure area)

Notes:
BAF = Bioaccumulation Factor
BCF = Bioconcentration Factor
COPC - Constituent of Potential Concern
kg - Kilogram
L - Liter
LOAEL - Lowest Observed Adverse Effects Level
PF = Proportion of Food Item
PFOS - Perfluorooctanesulfonic Acid
SL = Screening Level (Site-Specific)
TRV - Toxicity Reference Value
ug - Microgram
ww - Wet Weight

SUPPORTING CALCULATIONS

COPC	Dietary Inputs						LOAEL-based TRV (ug/kg_{bw}/day)	Surface Water Screening Level (ug/L)
	TL 2/3 Fish BAF (water+diet) (L/kg_{ww})	TL 2/3 Fish PF (unitless)	TL 3/4 Fish BAF (water+diet) (ug/kg_{ww})	TL 3/4 Fish PF (unitless)	Water to Invertebrate BCF (L/kg_{ww})	Invertebrate PF (unitless)		
PFOS	6,513	0.50	10,120	0.30	1,100	0.20	770	0.28

TABLE D11
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