US Army Corps of Engineers®

Papillion Creek and Tributaries Lakes, Nebraska

General Reevaluation Study

Appendix D
Structural Engineering

June 2021

Omaha District
Northwestern Division

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1. THE PAPILLION CREEK BASIN

1.1. Floodwall Locations

The Final Optimized Plan consists of two dams (DS10 and DS19) and a combination of floodwalls and levees along Little Papillion Creek as seen in Figure 1. For the purposes of this report, the terms right bank and left bank are relative to looking downstream. Hydrologic analyses provided the basis for identifying extents of stream reaches for evaluation. Damage reaches were simply indexed 1, 2, 3, etc., upstream to downstream for each watercourse. The first letter of the creek name was used to construct unique segment identifiers, such that LP1 represents Little Papillion Creek, reach 5.

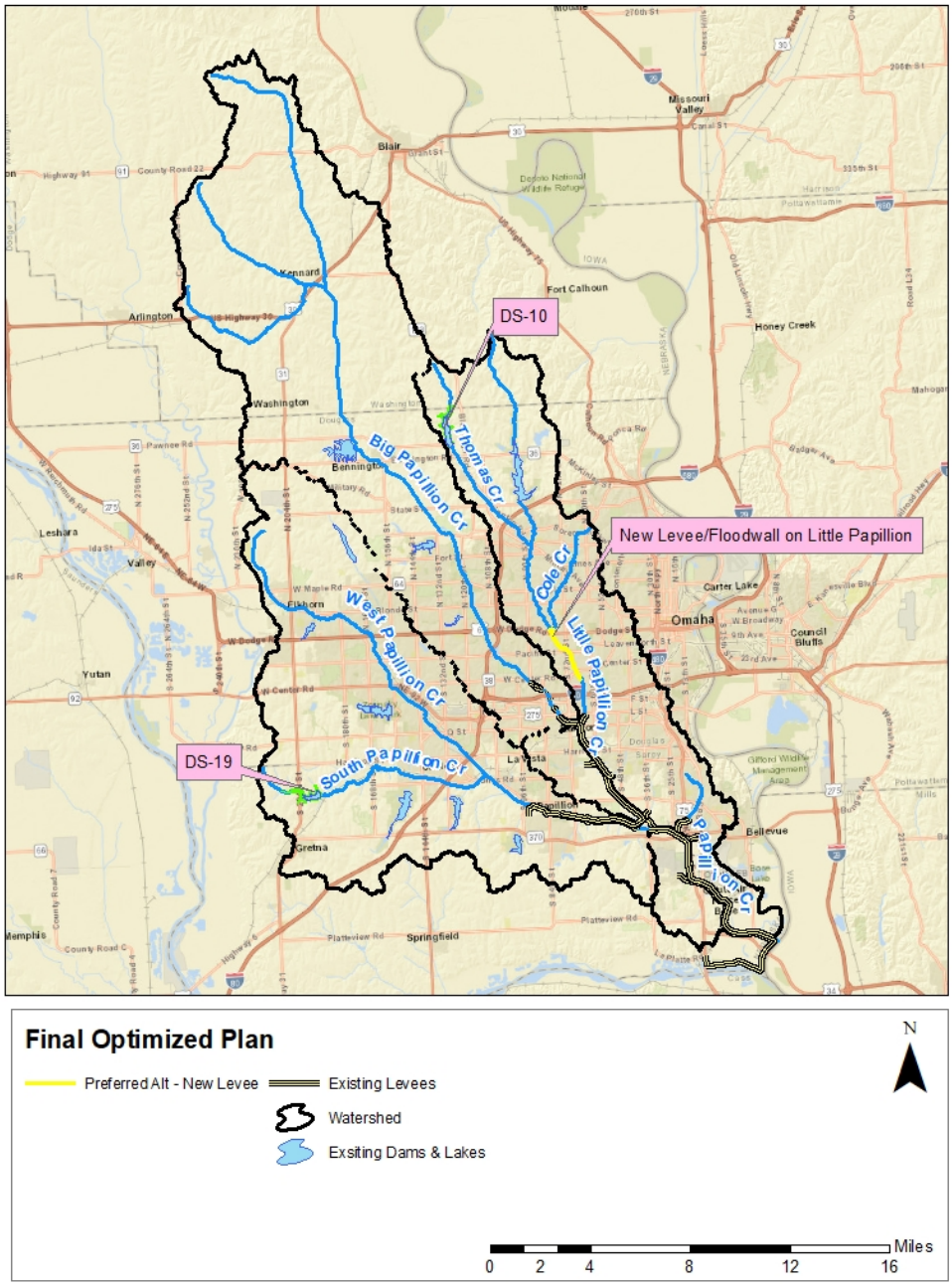

Figure 1: General locations of the preferred alternatives in the Final Optimized Plan

2. STRUCTURAL ELEMENTS

2.1. General

The baselines for floodwalls and levees are determined based on both steady and unsteady flow models provided by the Hydraulics section. Floodwalls are chosen over levee sections at locations close to buildings where more than one foot of height raise is required. More information about this optimization process can be found in Appendix C: Geotechnical Analysis.

The four primary floodwall locations considered in the feasibility study are the Little Papillion Creek between Western Avenue and the confluence of the Big and Little Papillion Creeks (corresponding to damage reaches LP5-LP12), the Big Papillion Creek between the Railroad Bridge downstream of I-80 and L Street (corresponding to damage reach BP7), and the West Papillion Creek between 149th Street and Millard Avenue (corresponding to damage reaches WP3-4).

In addition to the height above grade provided in the following sections, floodwalls will also need to extend below grade to the frost penetration depth of 4 feet. The floodwalls are to be reinforced concrete T-walls with a typical footing width of 12 feet with stem height that varies per floodwall segment. The floodwall dimensions will likely require barriers and/or keys as further analysis is performed.

There are nineteen road, railroad, and pedestrian crossings where the current bridge elevation is lower than the floodwall or levee height, with an average overtopping height of 3 feet and a maximum overtopping height of 5.5 feet. In order to prevent floodwaters from breaching the flood protection system, closure structures will be required at these crossings. The most cost-effective method of protecting these crossings would be the temporary installation of closure structures such as HESCO-style gabion barriers; however, the hydrologic analysis for the design flood scenarios has shown that there is typically less than an hour's duration between peak rainfall and peak flow at each of these crossings. This places tremendous risk on the levee sponsor for deploying and installing any temporary flood measures. It was assumed for the feasibility analysis that the sponsor did not have the capabilities to manually install temporary flood measures at each of these crossings prior to overtopping. The costs and traffic impacts associated with raising the road crossings would exceed the cost parameters of this feasibility study.

The primary closure structure option that satisfies the rapid response time requirements and satisfies cost requirements is the installation of a self-deployed closure structure which is activated either through floatation during a flood event or by stream pressures. Self-deployed closure structures are proprietary mechanisms that are typically used to protect critical structures such as hospitals from flood events. These self-deployed structures would need to be designed for the vehicular loading and flood loading as described per each crossing. Additionally, the self-deploying structures would need to be regularly maintained to ensure operability during a flood scenario.

There is inherent risk to relying on self-deployed closure structures during a flood event for a number of factors including but not limited to poor performance from vehicle-related damages,

debris compaction, road-salt induced corrosion and a relatively unproven performance history (self-deployed structures are relatively new flood protection devices). As an alternative to using self-deployed structures, it may be possible to raise or remove some pedestrian trail bridges to improve robustness of the flood protection system. Additionally, the installation of manually deployable structures such as rolling gates or swing gates over roadway structures would improve system robustness during a flood event and would have similar cost implications as self-deployed structures. There are, however, two primary risks associated with manual deployable structures that include operational error from either poor maintenance or inadequate response time to deploy prior to flooding. Therefore, before either of these alternatives can be seriously considered it is recommended that a reaction time study be performed by the sponsor to determine which bridge/road crossings could be manually closed prior to flood overtopping. While the feasibility analysis assumed that self-deployed structures provide the best level of protection due to deploy-time and cost constraints, it is recommended that other flood protection measures be used or at least considered on as many road and pedestrian crossings where they can still satisfy reaction and cost parameters.

The feasibility report did not consider the implication of a vehicular warning system during a major flood event. Regardless if either self-deployed structures or manually deployed structures are used, it is recommended that an electronic warning system be installed at each major road crossing to prevent vehicular damage to the closure structure.

2.2. Little Papillion Creek

The structural alternatives along Little Papillion Creek include floodwall construction on both the left and right banks, between Western Avenue and the confluence of the Saddle and the Little Papillion Creeks. This area corresponds to damage reaches LP5- LP8. Three levee elevations were evaluated in the optimization process. These elevations correspond to the Energy Grade Line (EGL) elevation of the 1% Annual Exceedance Probability (AEP) event plus zero feet, plus three feet, and plus five feet to account for uncertainty. Ultimately, 1% AEP plus 3 feet was chosen since it had the best Benefit-to-Cost Ratio (BCR). This will provide average height increases ranging from 2.6 feet to 9.8 feet. Closure structures will be installed at crossings between Cass Street and Mercy Road.

2.2.1. Western Avenue to Cass Street

This reach corresponds to the upstream portion of damage reach LP5. An aerial view can be seen in Figure 2 with the combined floodwall and levee course in magenta. The scope includes 2,233 feet on the right bank and 109 feet of floodwall on the left bank, tying past the confluence with Cole Creek. These floodwalls rise an average of 4.6 feet on the left bank and 2.6 feet on the right bank. Closure structures will be required on the right bank at Cass Street.

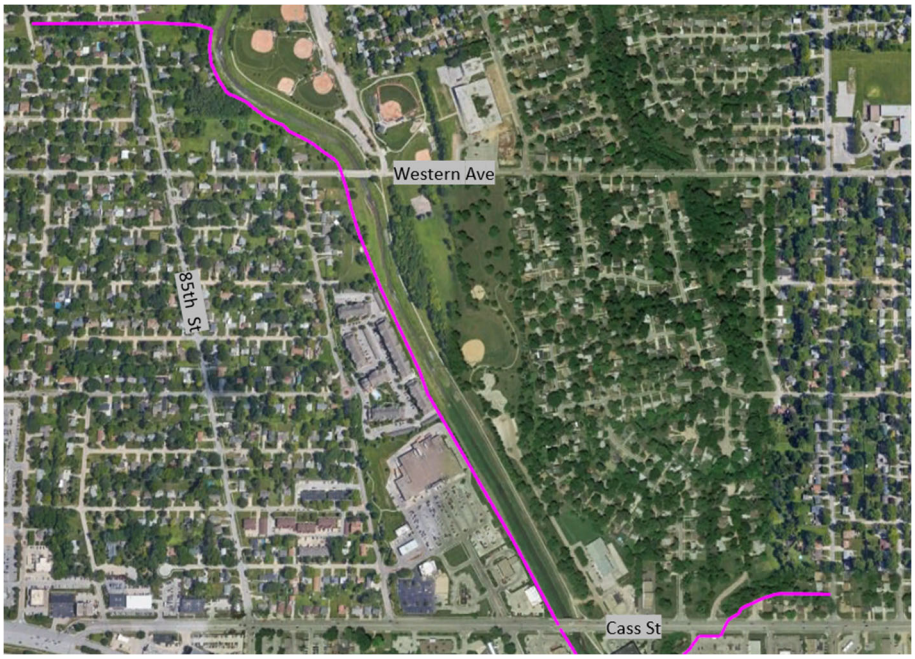

Figure 2: Aerial photo of Western Avenue to Cass Street

2.2.2. Cass Street to Dodge Street

This reach corresponds to the downstream portion of damage reach LP5. An aerial view can be seen in Figure 3 with the combined floodwall and levee footprints in magenta. The scope includes 1,309 feet of floodwall on the left bank (following Cole Creek) and 1,442 feet on the right bank. These floodwalls rise an average of 4.9 feet on the left bank and 3.5 feet on the right bank. Closure structures will be required on both banks at Dodge Street. Considering the average traffic volume over the Dodge Street Bridge, using a manually deployable closure structure like a slide gate could reduce long-term maintenance costs.

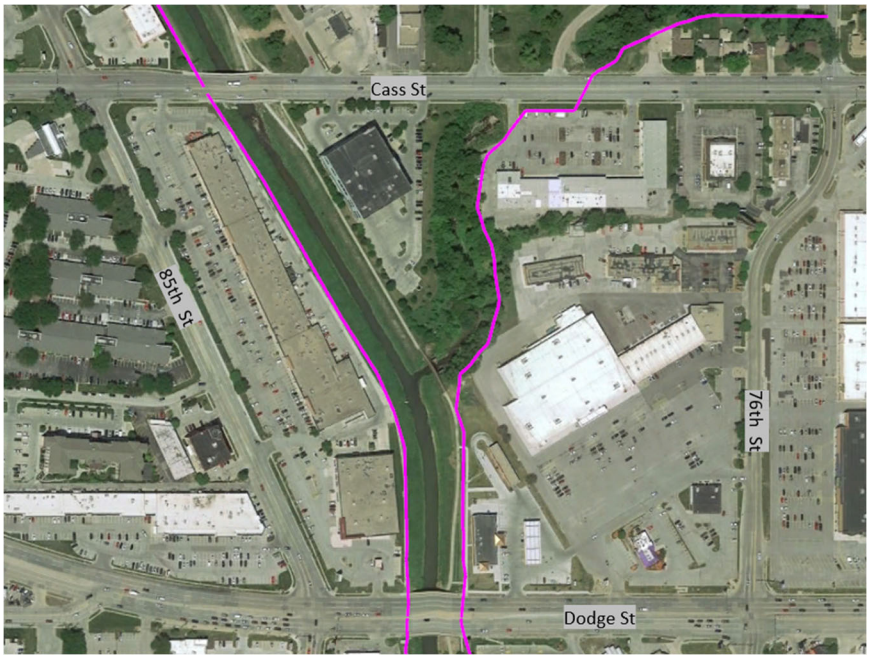

Figure 3: Aerial photo of Cass Street to Dodge Street

2.2.3. Dodge Street to 72nd Street

This reach corresponds to the upstream portion of damage reach LP6. The structural scope for this reach has 3,340 feet of floodwalls on the left bank and 4,831 feet of floodwalls on the right bank. An aerial view can be seen in Figure 4 with the combined floodwall and levee footprint in magenta. These floodwalls will have an average height of 3.7 feet and 5.1 feet on the left and right banks, respectively. Closure structures will be needed at Pedestrian Bridge 5 and 72nd Street. Considering the average traffic volume over the 72nd Street Bridge, using a manually deployable closure structure like a slide gate could reduce long-term maintenance costs.

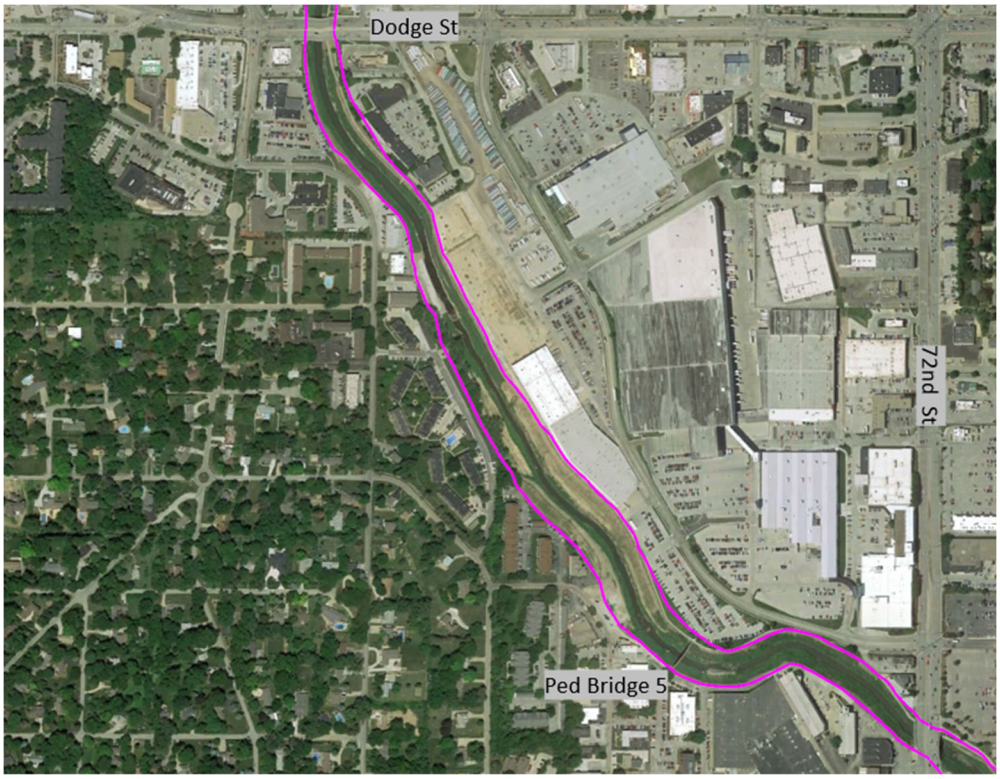

Figure 4: Aerial photo of Dodge Street to 72nd Street

2.2.4. 72nd Street to Pacific Street

This reach corresponds to the downstream portion of damage reach LP6. This reach can be seen in Figure 5. It consists of 1,027 feet of floodwall on the left bank and 711 feet of floodwall on the right bank, which will have an average height of 6.1 and 4.5 feet, respectively. Closure structures will be needed on both banks at Pacific Street.

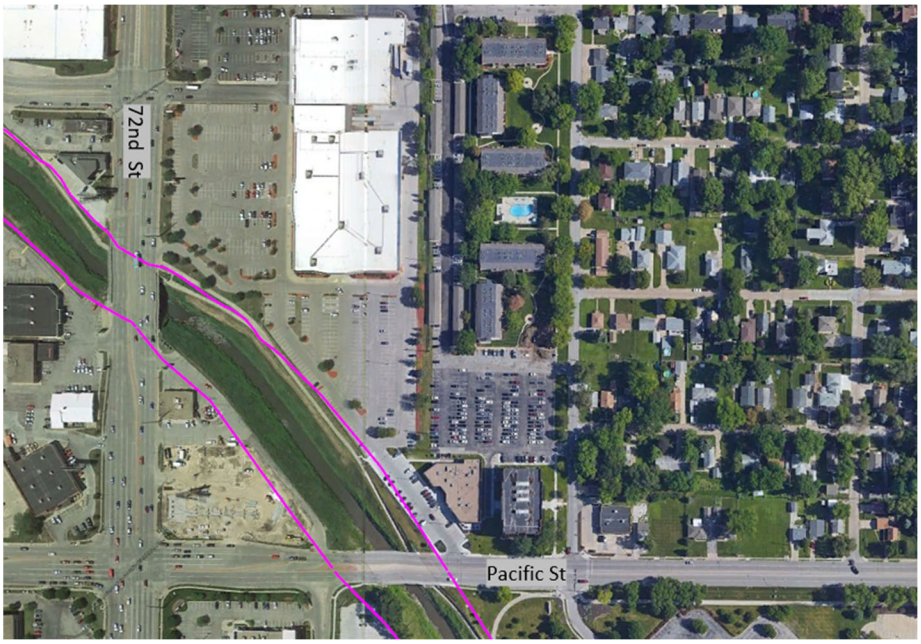

Figure 5: Aerial photo of 72nd Street to Pacific Street

2.2.5. Pacific Street to Mercy Road

This reach corresponds to damage reach LP7. The structural part of this alternative has 2,130 feet of floodwall on the left bank with an average height of 5.7 feet. Closure structures will be needed at the two pedestrian bridges in this reach (Ped Bridges 1 and 2). Raising or removing some of the pedestrian bridges will reduce the number of closures required. Pedestrian Bridge 3, which crossed Little Papillion Creek about 375 feet south of Pine Street, was removed during the St. Mary's College renovations in 2020.

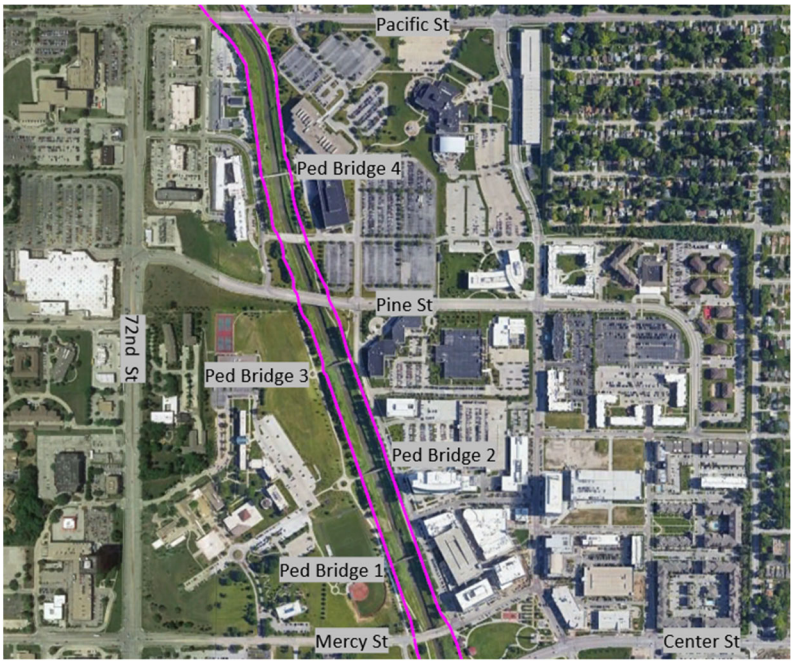

Figure 6: Aerial photo of Pacific Street to Mercy Road

2.2.6. Mercy Road to Saddle Creek Confluence

This reach corresponds to the upstream portion of damage reach LP8. This reach, with the baseline of floodwalls and levees in magenta, can be seen in Figure 7. The structural part of the alternative has 860 feet of floodwall on the left bank with an average height of 9.8 feet. Closure structures will be needed on both banks at Mercy Road.

Figure 7: Aerial photo of Mercy Road to the Saddle Creek Confluence

2.3. Dam Site 10

An earthen dam is to be constructed at Dam Site 10, on Thomas Creek east of Bennington, NE. This dam is to be a dry dam - which means the dam will only retain water during a high-water event (see Figure 8). The dam outlet conduit is to be a concrete box culvert with a 7-foot rise and an 8-foot span (see Figure 9). The class of the conduit is to be based on the surrounding soil.

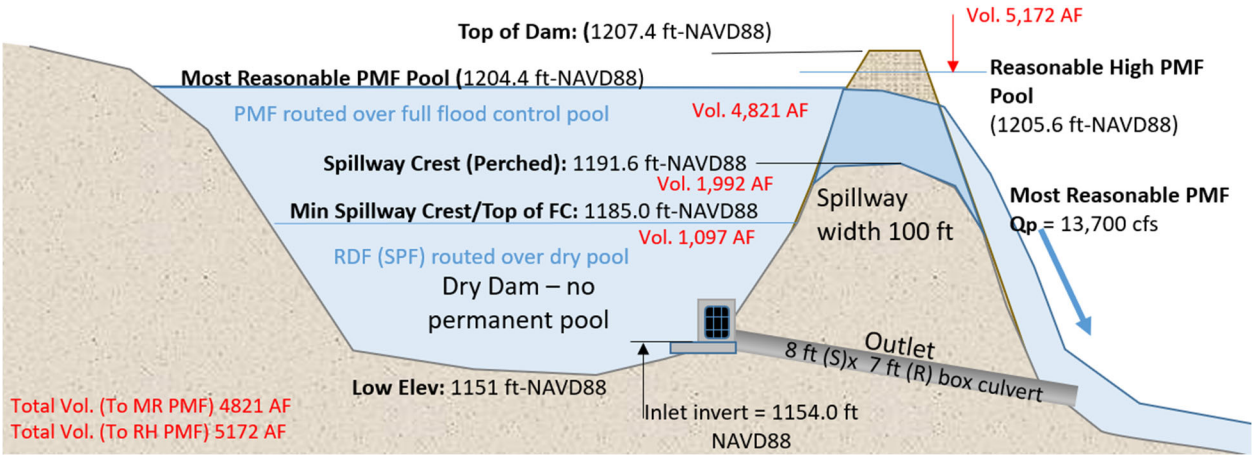

Figure 8: DS10 Hydraulic Diagram

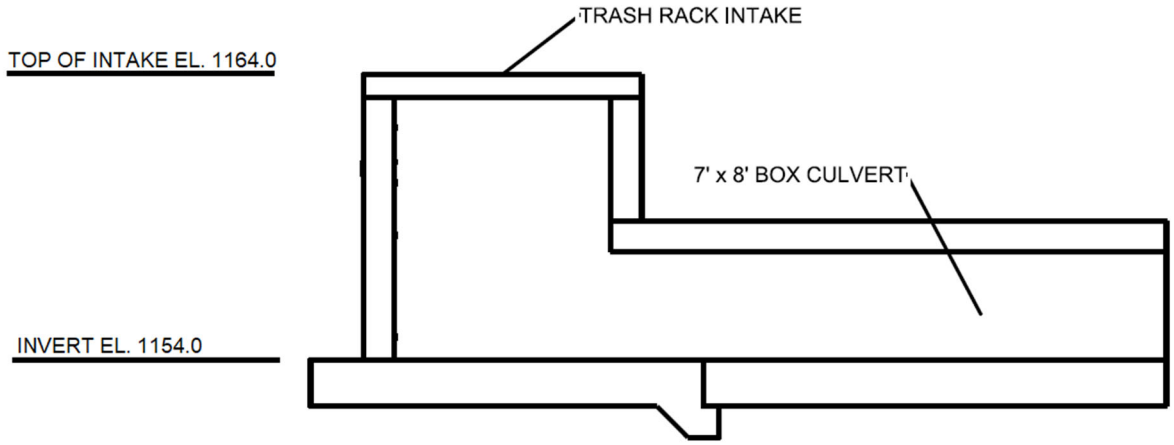

Figure 9: DS10 Intake Structure and Conduit

2.4. Dam Site 19

An earthen dam is to be constructed at Dam Site 19, on the South Papillion Creek north of Gretna, NE. This dam is to be a wet dam - which means the dam will retain water year-round (see Figure 10). The dam outlet works will consist of an intake structure and an outlet conduit. The intake structure is a reinforced concrete box shaft with metal trash racks protecting the openings. Two 6-foot wide by 5.5 feet tall low-flow openings are to be at a 1164 ft MSL elevation. The dam outlet conduit is to be a reinforced concrete pipe with an internal diameter of 6 feet (see Figure 11). The class of the culvert is to be based on the surrounding soil.

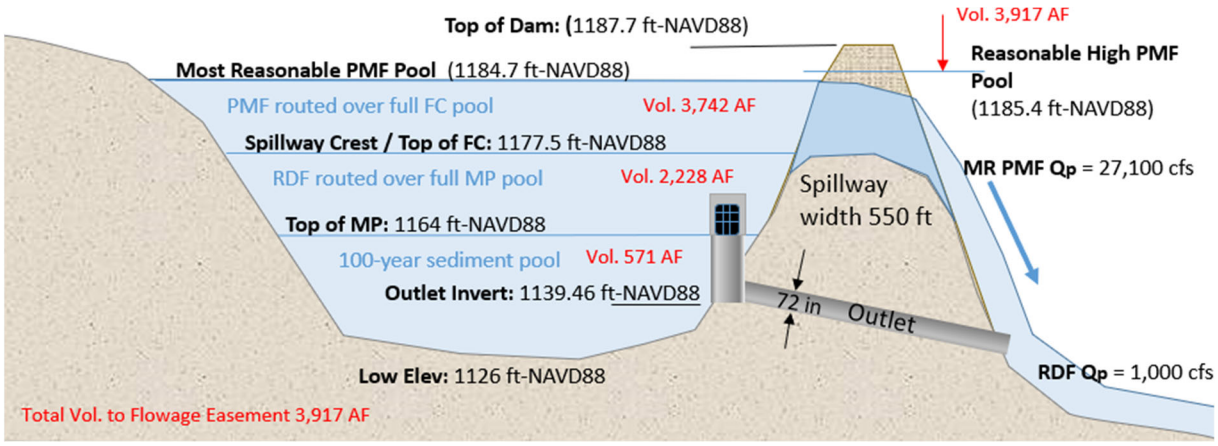

Figure 10: DS19 Hydraulic Diagram

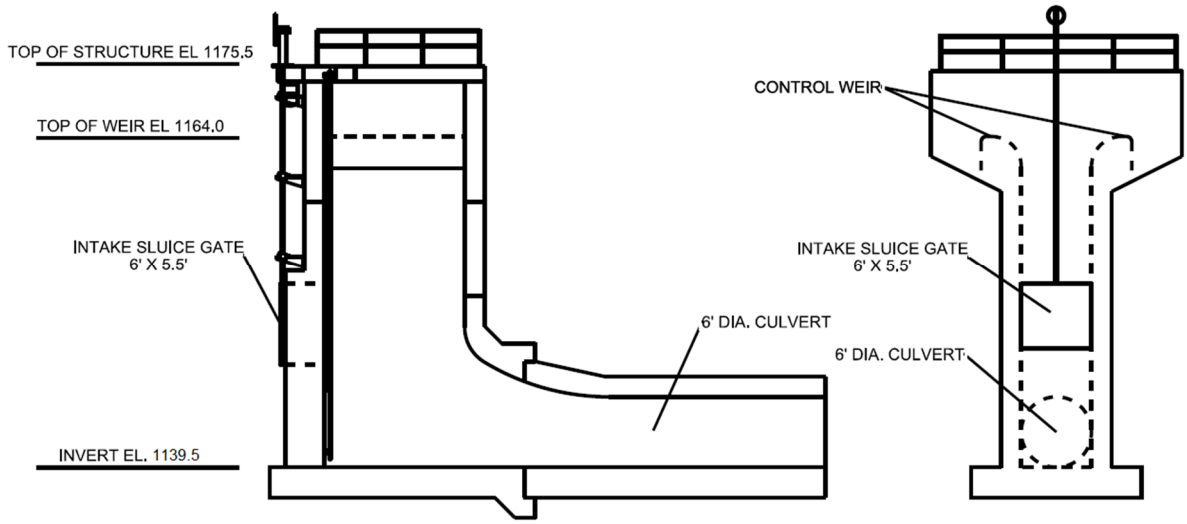

Figure 11: DS19 Outlet Structure and Conduit

3. ELIMINATED ALTERNATIVES

Several alternatives along Big Papillion Creek (BP) and West Papillion Creek (WP) were also considered as can be seen in Figure 12. After analysis, these alternatives had a Benefit-to-Cost Ratio (BCR) of less than one (i.e. more cost than benefit) and were eliminated from consideration.

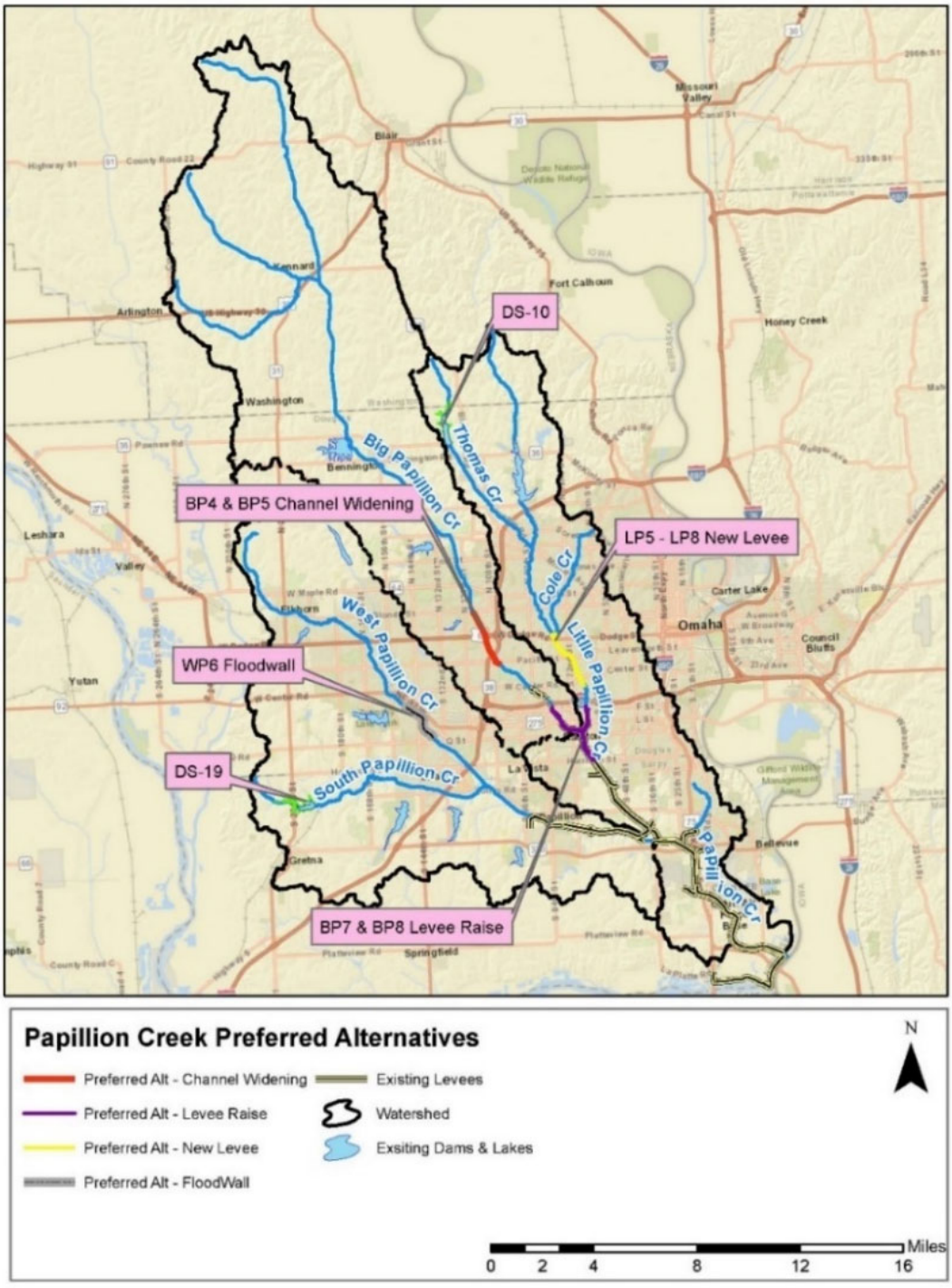

Figure 12: General locations of the preferred alternatives in the Tentatively Selected Plan

3.1. Big Papillion Creek

The structural alternatives along Big Papillion Creek consisted of floodwall construction as well as closure structures in between the railroad bridge south of I-80 and Q Street. The floodwall heights are based on the EGL for a 1% AEP flood event. This will provide average height increases ranging from 4.0 feet to 7.3 feet.

3.1.1. Railroad Bridge south of I-80 to L Street

This reach corresponds to the upstream portion of damage reach BP7. See Figure 13 for an aerial overview. This area would require the construction of 2135 feet of floodwalls on the left bank and 3208 feet on the right bank. These floodwalls would have an average height of 4.8 feet on the left bank and 4.2 feet on the right bank. Closure structures are required on the right bank at the L Street crossing.

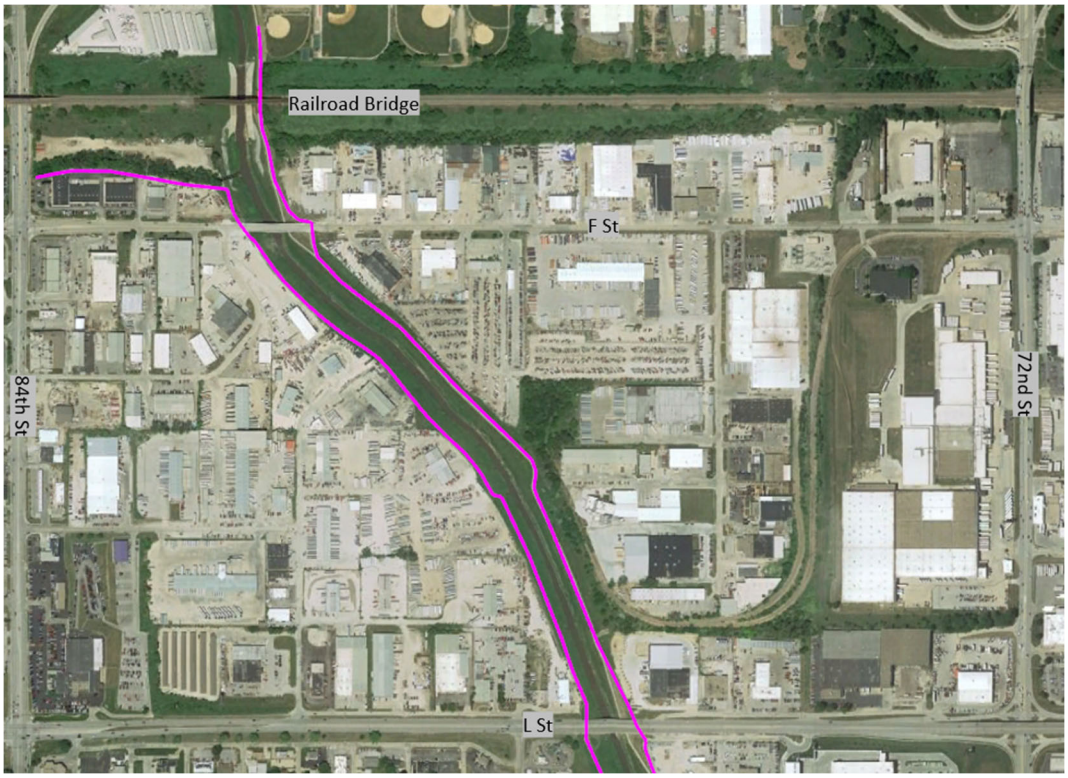

Figure 13: Aerial photo for L Street to Q Street

3.1.2. L Street to Q Street

This reach corresponds to the downstream portion of damage reach BP7. See Figure 14 for an aerial overview. This area would require the construction of 1240 feet of floodwalls on the left bank and 1367 feet on the right bank. These floodwalls would have an average height of 4.0 feet on the left bank and 4.2 feet on the right bank. Closure structures are required at the 72nd and Q Street crossings.

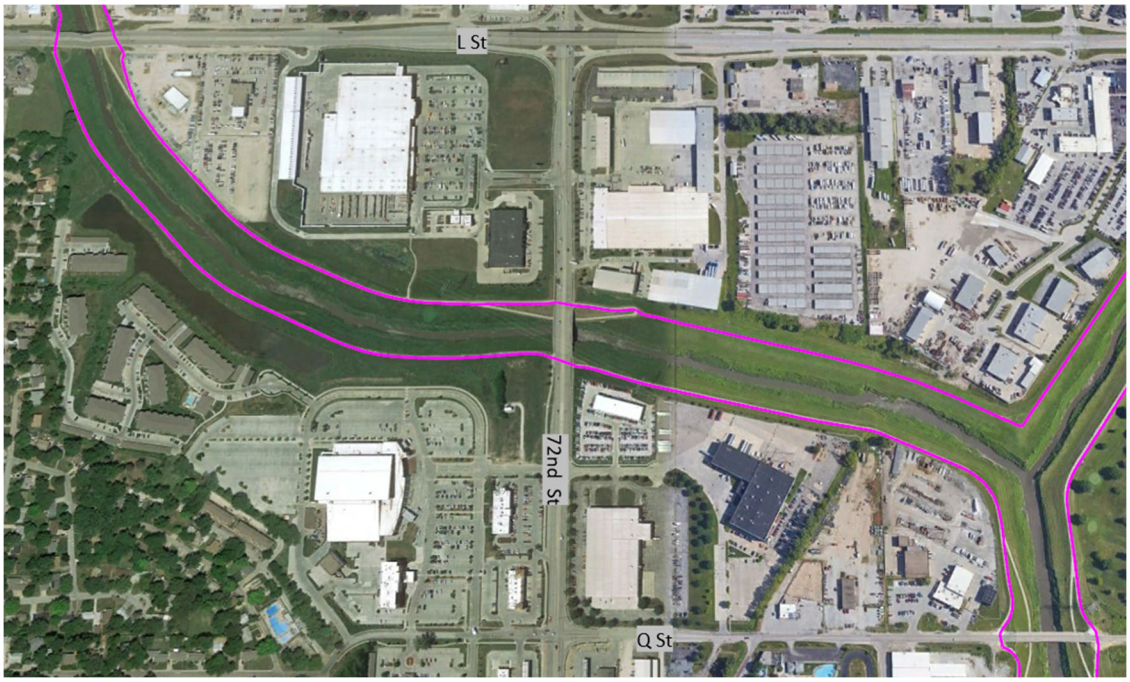

Figure 14: Aerial photo for L Street to Q Street

3.1.3. Q Street to Harrison Street

This reach corresponds to the damage reach BP8 (seen in Figure 15). This area only uses levees on both banks. However, closure structures are required at the Railroad Bridge and the right bank at the Harrison Street crossing.

Figure 15: Aerial photo for Q St to Harrison St

3.1.4. Little Papillion Railroad Bridge to L Street

One part of Little Papillion Creek is incorporated with the Big Papillion Creek segments based on hydrologic analyses. These analyses indicate affects reaching upstream from the confluence of the two creeks. This area corresponds to the downstream portion of damage reach LP8. The alternative for this area has 2838 feet of new floodwalls on the left bank and 1357 feet on the right bank. These floodwalls would have an average height of 7.3 feet on the left bank and 5.8 feet on the right bank. Closure structures are required at the L Street crossing.

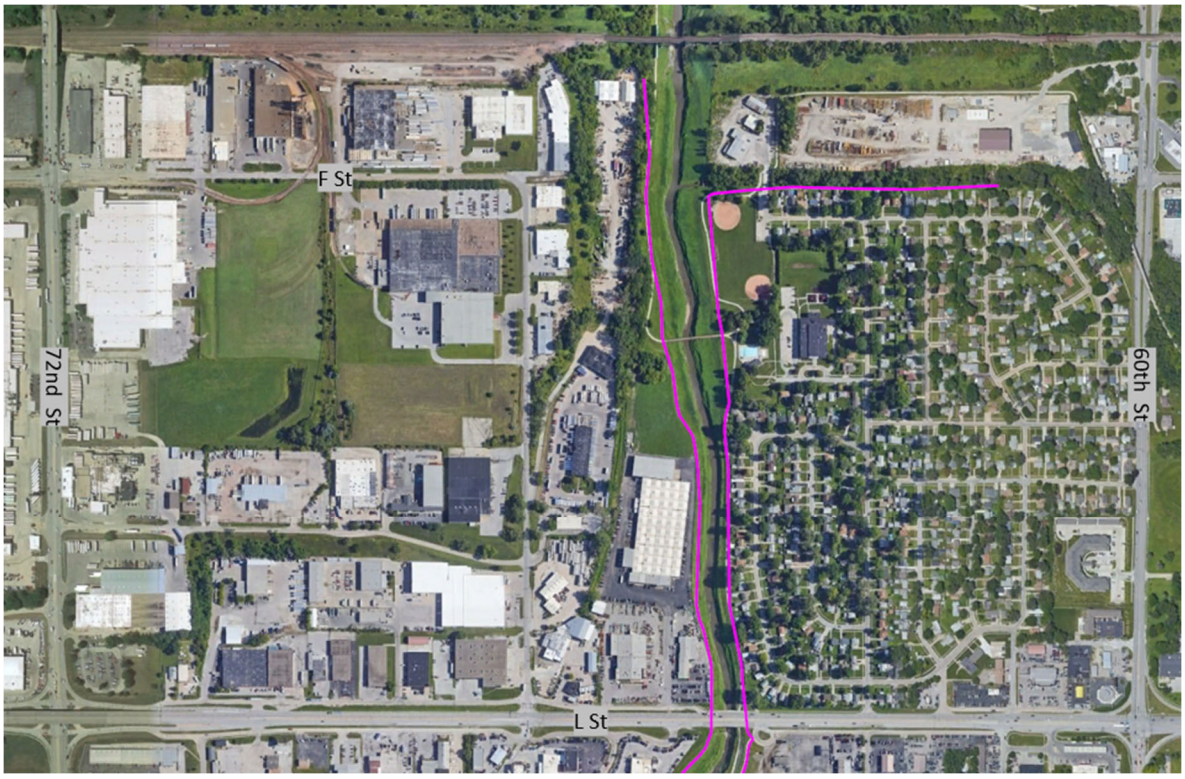

Figure 16: Aerial photo for Little Papillion Creek Railroad Bridge to the L Street

3.1.5. Big Papillion Creek Closure Structures

All the closure structures in the Big Papillion reaches are summarized in Table 1. Closure structures are either self-deploying closure structures or manually deployed closure structures.

Table 1: Closure Structures on Big Papillion Creek (1% AEP)

Crossing Name	Required Height (ft.)		Closure Structure Width (ft.)
	Left Bank	Right Bank	
L St	-	8.8	82.0
72nd St	0.8	0.8	83.0
Q St	4.0	3.2	40.0
Railroad Bridge	2.8	3.3	16.5
Harrison St	-	0.5	43.0
L St (Little Papillion)	7.8	5.0	81.6

3.2. West Papillion Creek

The alternatives along West Papillion Creek include height increases from 149th Street to Millard Avenue (corresponding to damage reaches WP3-WP4) on both banks. Floodwalls are incorporated as a refinement intended to reduce land acquisition costs on the landside of the levee. These alternatives were eliminated before the temporary closure structure alternative was eliminated. Consequently, all closures were sized as temporary HESCO structures. Should the alternatives along the West Papillion be considered again, the closure structures would need to be replaced with automatic closure structures. This replacement will negatively impact the West Papillion BCR. Like the Big Papillion Creek floodwalls, the West Papillion floodwall heights are based on the EGL from a 1% AEP flood event. This will provide average height increases ranging from 3.9 feet to 4.9 feet.

3.2.1. 149th Street to 144th Street

This reach corresponds to damage reach WP5. On the left bank, a combination of floodwalls and levees will be used, involving 3,115 feet of floodwall. The average wall height is 3.9 feet on the left bank. On the right bank, floodwalls will be used over a length of 3,903 feet. The average wall height on the right bank is 4.3 feet. An aerial photo of the reach is presented in Figure 17. Since the required heights are less than 3 feet, temporary closure structures were to be used at the 144th Street and 149th Street bridges.

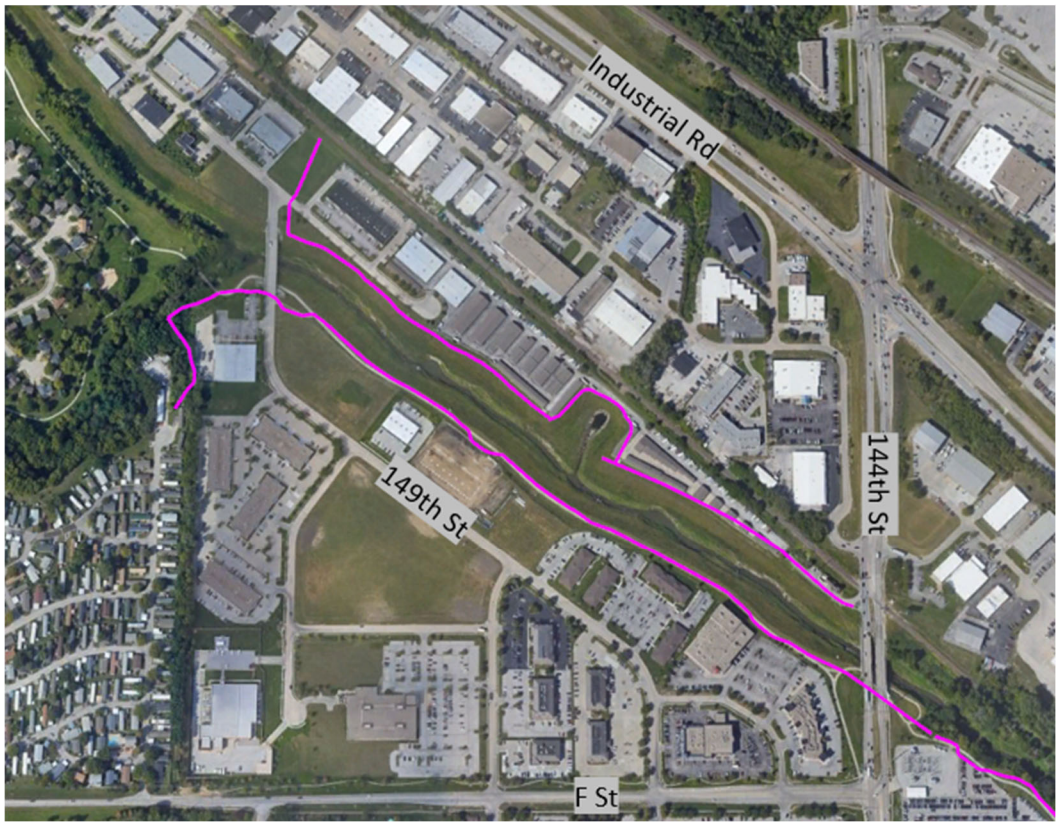

Figure 17: Aerial photo for 149th Street to 144th Street

3.2.2. 144th Street to Millard Avenue

This reach corresponds to damage reach WP6. On the left bank, a combination of floodwalls and levees will be used, involving 5,036 feet of floodwall. The average wall height is 4.9 feet on the left bank. On the right bank, a combination of floodwalls and levees will be used, involving 6,053 feet of floodwall. The average wall height is 4.5 feet on the right bank. An aerial photo of the reach is presented in Figure 18. Since the required height is less than 3 feet, the L Street Bridge was to be protected with temporary closure structures.

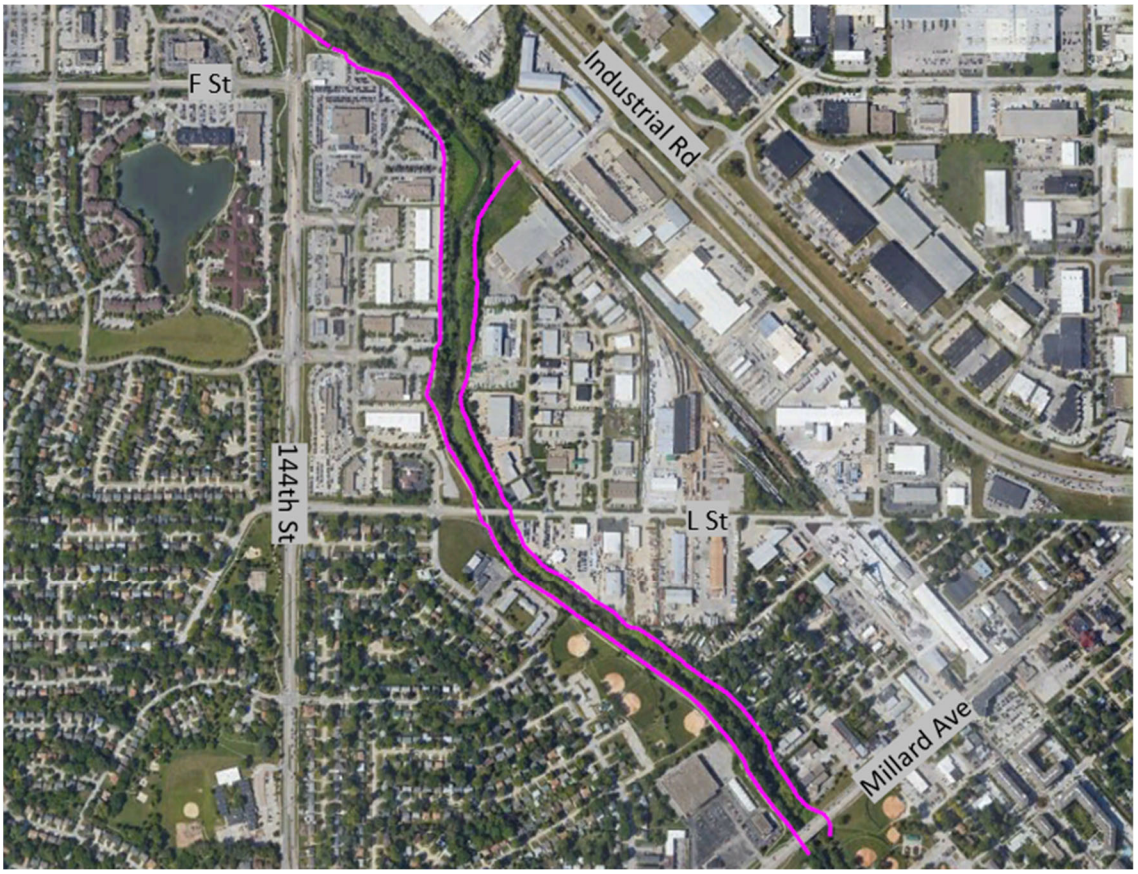

Figure 18: Aerial photo for 144th Street to Millard Avenue

3.2.3. West Papillion Creek Closure Structures

The closure structures along the West Papillion Creek alternative are summarized in Table 2. The required height is the higher of the two banks since this alternative was removed before the detailed closure structure analysis was completed.

Table 2: Closure Structures on West Papillion Creek (1% AEP)

Crossing Name	Required Height (ft.)	Bridge Width (ft.)
L Street	1.68	36
144th Street	0.78	100
149th Street	1.07	48

3.3. Dry Dam at DS19

A dry dam was considered at Dam Site 19. Structurally, this alternative would have only had a reinforced concrete inlet along with a concrete box culvert with a 5.5-foot rise and a 6-foot span (see Figure 19). The class of the conduit is to be based on the surrounding soil. Ultimately, the dry dam alternative was rejected due to lower BCR.

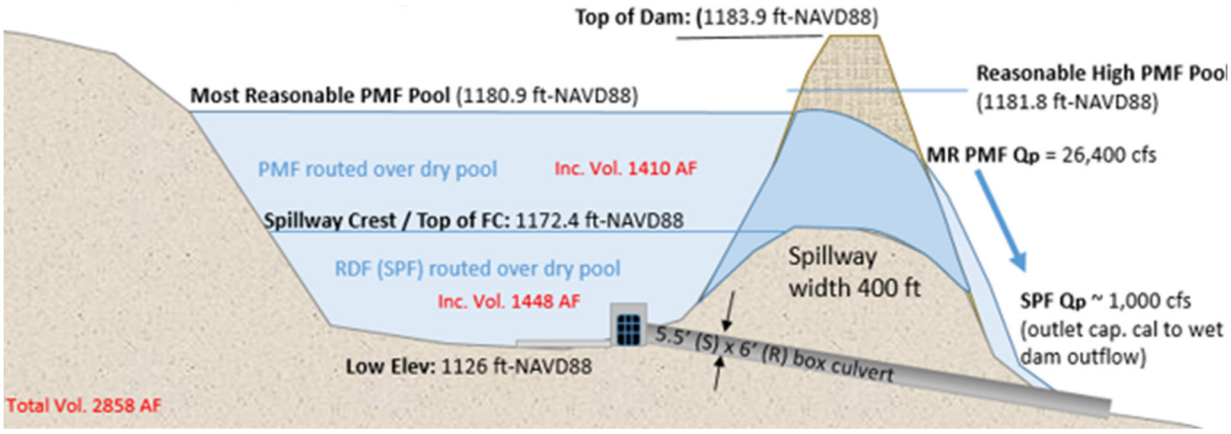

Figure 19: DS19 Dry Dam Alternative Hydraulic Diagram

4. STRUCTURAL INVENTORY

4.1. Quantity Estimates

4.1.1. Floodwall Summary Table by Reach

Estimated floodwall values for each reach are in Table 3**Error! Reference source not found.**. As noted in previous sections, the Big and West Papillion Creek alternatives were excluded from the final optimized proposal.

Table 3: Floodwall Summary by Reach

Creek		Little Papillion						Big Papillion				West Papillion	
Reach		LP5	LP5	LP6	LP6	LP7	L8	BP7	BP7	BP8	LP8	WP5	WP6
Location		Western Ave to Cass St	Cass St to Dodge St	Dodge St to 72nd St	72nd St to Pacific St	Pacific St to Mercy Rd	Mercy Rd to Little Papillion/Saddle Creek Confluence	Railroad Bridge (D/S of I-80) to L St	L St to Q St	Q St to Harrison St	Railroad Bridge (D/S of I-80) to L St (incl. w/ BP areas)	149th to 144th St	144th St to Millard Ave
Left Bank	Length (ft)	109	1309	3340	1027	2130	860	2135	1240	-	2838	3115	5036
Left Bank	Avg. Wall Height (ft)	4.6	4.9	3.7	6.1	5.7	9.8	4.8	4.0	-	7.3	3.9	4.9
Right Bank	Length (ft)	2233	1442	4831	711	-	-	3208	1367	-	1357	3903	6053
Right Bank	Avg. Wall Height (ft)	2.6	3.5	5.1	4.5	-	-	5.4	4.2	-	5.8	4.3	4.5
No. of Closures		1	1	2	1	2	1	1	2	2	1	2	1

4.1.2. Closure Structure List

Closure structures are required where a floodwall or levee is crossed by a bridge with a deck surface lower than the top of the floodwall or levee. Closure structures are either self-deploying closure structures or manually deployed closure structures. See Section 2.1 for more information. The closure structures required for the Little Papillion Creek Alternative are presented in Table 4, going upstream from Cass Street. The height of the levee closure structures is determined by the Energy Gradient Line plus an extra three feet.

Table 4: Closure Structures on Little Papillion Creek

Crossing Name	Required Height (ft.)		Closure Structure Width (ft.)
	Left Bank	Right Bank	
Cass St	-	1.8	78.5
Dodge St	2.4	2.0	109.3
Ped. Bridge 5	0.5	2.6	10.5
72nd St	5.5	5.2	114.0
Pacific St	3.8	3.0	74.5
Ped. Bridge 2	5.4	2.1	10.1
Ped. Bridge 1	1.0	-	9.5
Mercy Road	0.5	0.2	59.0

4.2. Potentially Effected Bridges in Project Area

There is a total of four bridges that currently do not possess the ability to pass flows from the design 100 yr flood +3 ft and would be partially submerged during such a scenario. These four bridges were likely designed for a different flood scenario based on their dates of construction, and it is unknown if they satisfy the minimum design structural capacity for the current design flood scenario in the project's absence. These four bridges in the project area are subjected to increased flood loadings of less than 1 foot from the proposed improvements, and it likewise unknown if the bridges satisfy minimum design capacity for the project design flood scenario. The potential negative impact of flows on these bridges in the study area needs further analysis both for current and future design load scenarios. If, as a result of further analysis, a bridge is raised or removed, then that bridge may not require closure structures.

Water surface elevations are increased moderately as a result of the project. In the baseline future 1% AEP flood, two pedestrian bridges as well as the Pacific and 72nd Street bridges are impacted. As a result of the project, the four bridges will be somewhat more impacted. These bridge impacts are summarized in Table 5. For clarity, values for the Water Surface Elevation (WSE) over the lower chord are omitted when the WSE is below the bridge. A discussion of both WSE and EGL can be found in the Hydraulics Appendix. The Bridge Minimum Low Chord Elevation is the lowest point on the underside of the bridge based on Papio-Missouri River NRD models.

Table 5: Bridges Crossing Little Papillion Creek					
Bridge Name	Bridge Min. Low Chord Elevation	Future 1% AEP Water Surface with Project	Future 1% AEP Water Surface w/o Project	WSE over Lower Chord with Project	WSE over Lower Chord w/o Project
Cass St	1041.52	1039.35	1038.85		
Dodge St	1039.50	1036.41	1035.57		
Ped. Bridge 5	1036.64	1035.69	1034.98		
72nd St	1030.20	1032.22	1031.64	5.49	4.78
Pacific St	1030.34	1030.66	1030.11	1.88	1.30
Ped. Bridge 4*	1032.78	1030.18	1029.59		
First Data Access	1031.17	1029.66	1029.01		
Pine St	1030.40	1029.22	1028.54		
Ped. Bridge 2	1022.93	1026.54	1025.53	5.73	5.40
Ped. Bridge 1	1025.24	1024.33	1023.70	1.30	0.29
Mercy Rd	1026.33	1020.49	1020.31		
67th St	1029.52	1021.50	1021.16		

*Pedestrian Bridge 3 (located ~375 feet south of Pine St) was removed during the feasibility study. Bridge numbering was retained for consistency.

References

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