Figure D-16
Utilities Details: Map 8

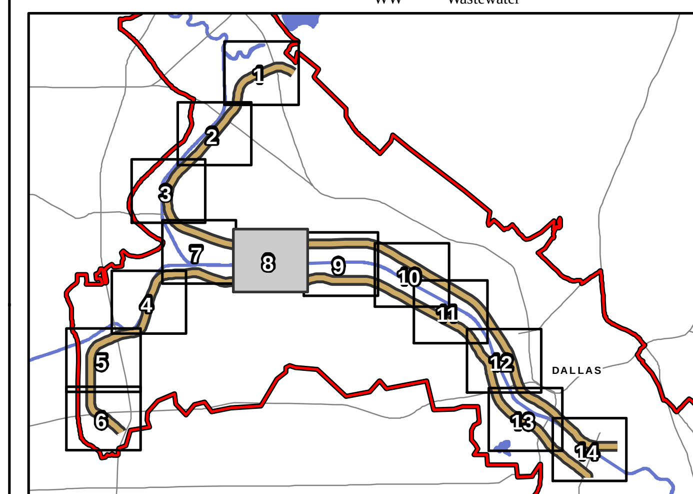
LEGEND

Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

Key

CRI&P	Chicago, Rock Island and Pacific Railroad
Ex.	Existing
HP	High Pressure
IH	Interstate Highway
IP	Intermediate Pressure
KV	Kilovolt
OH	Overhead
SH	State Highway
SFB	Suspended From Bridge
UG	Underground
WW	Wastewater



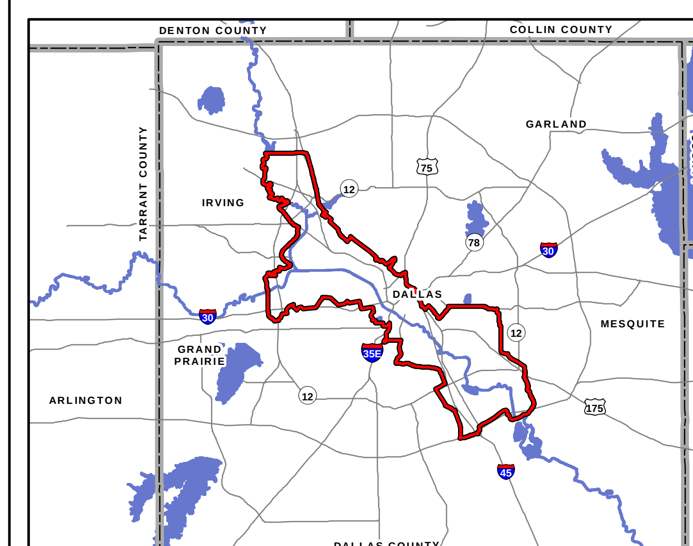


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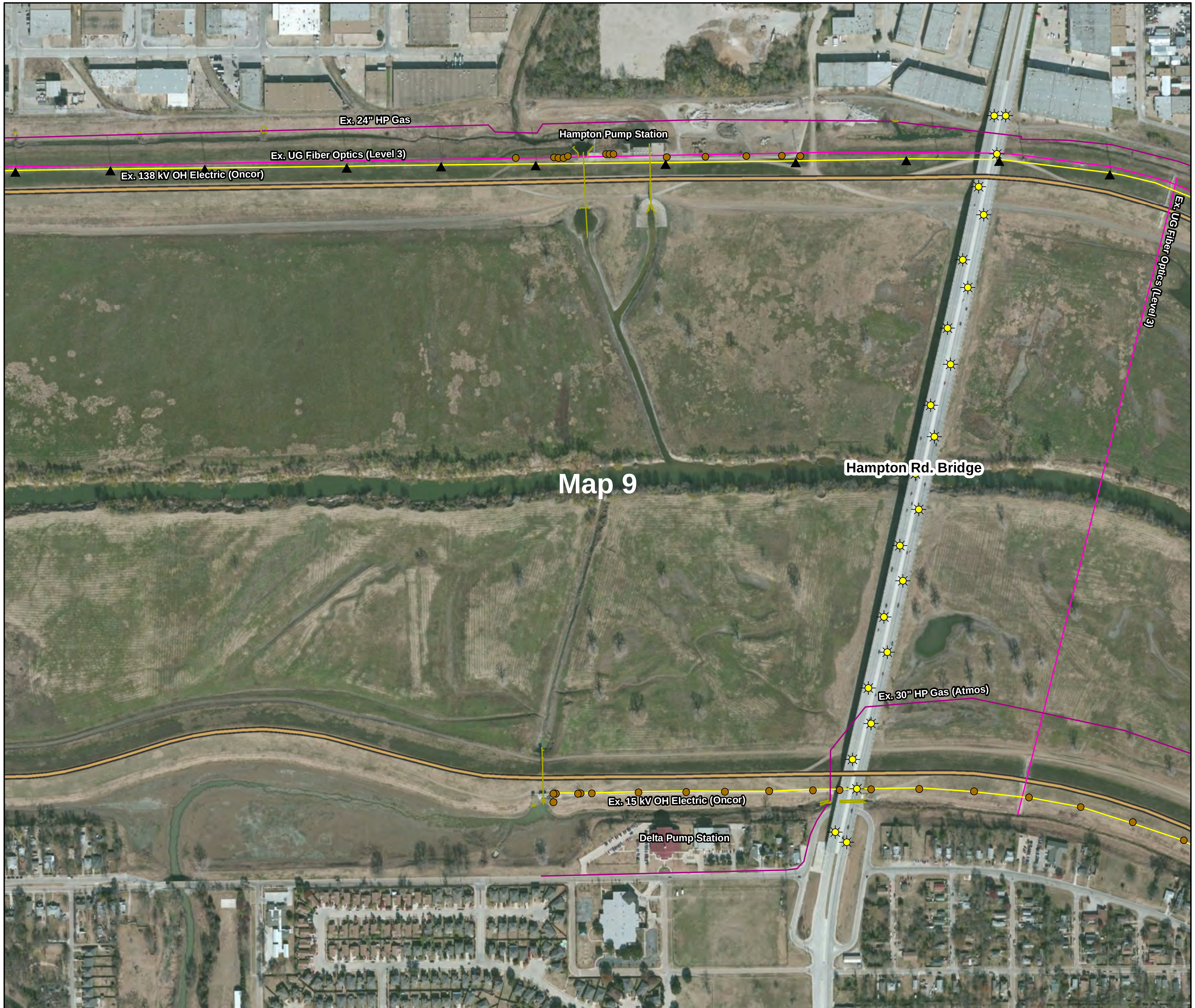
Figure D-17
Utilities Details: Map 9



LEGEND

Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
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SFB	Suspended From Bridge
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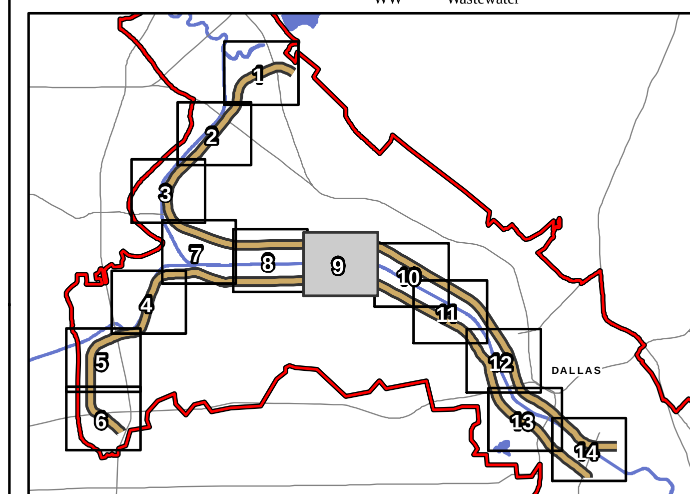
WW	Wastewater



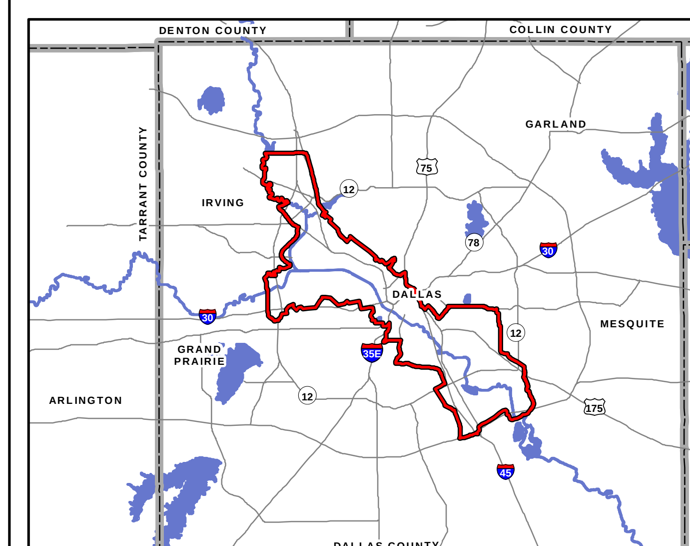


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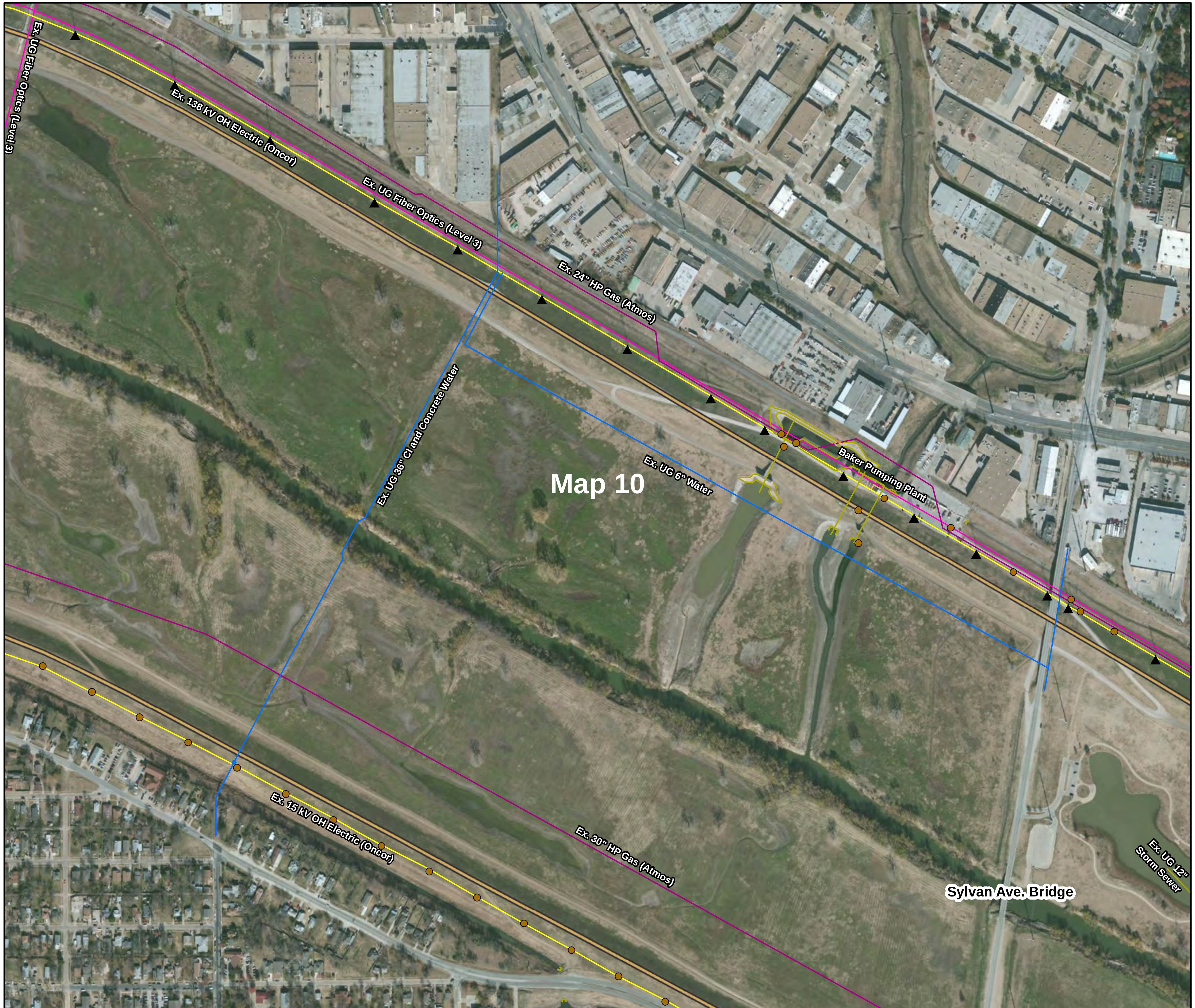
Figure D-18
Utilities Details: Map 10



LEGEND

Utility Lines

- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

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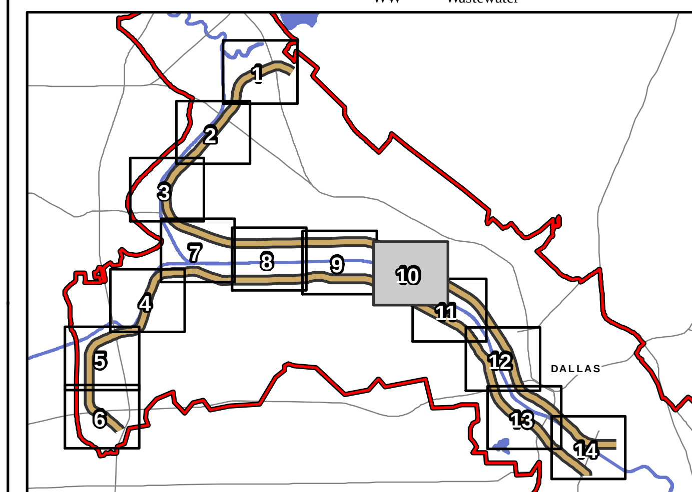
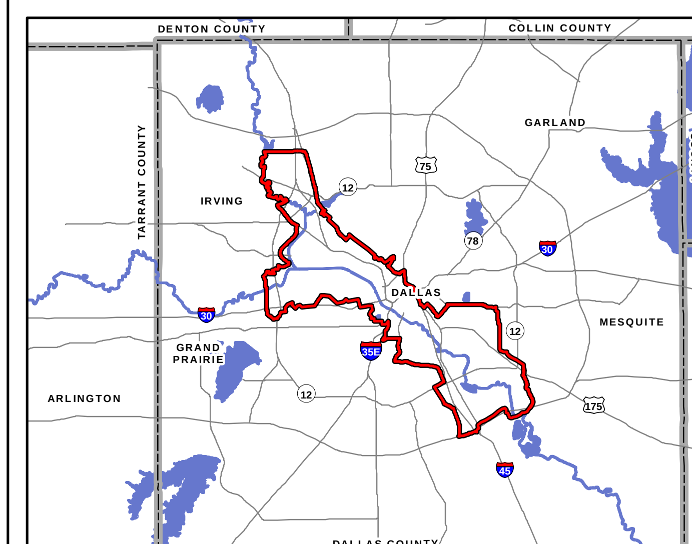
WW	Wastewater





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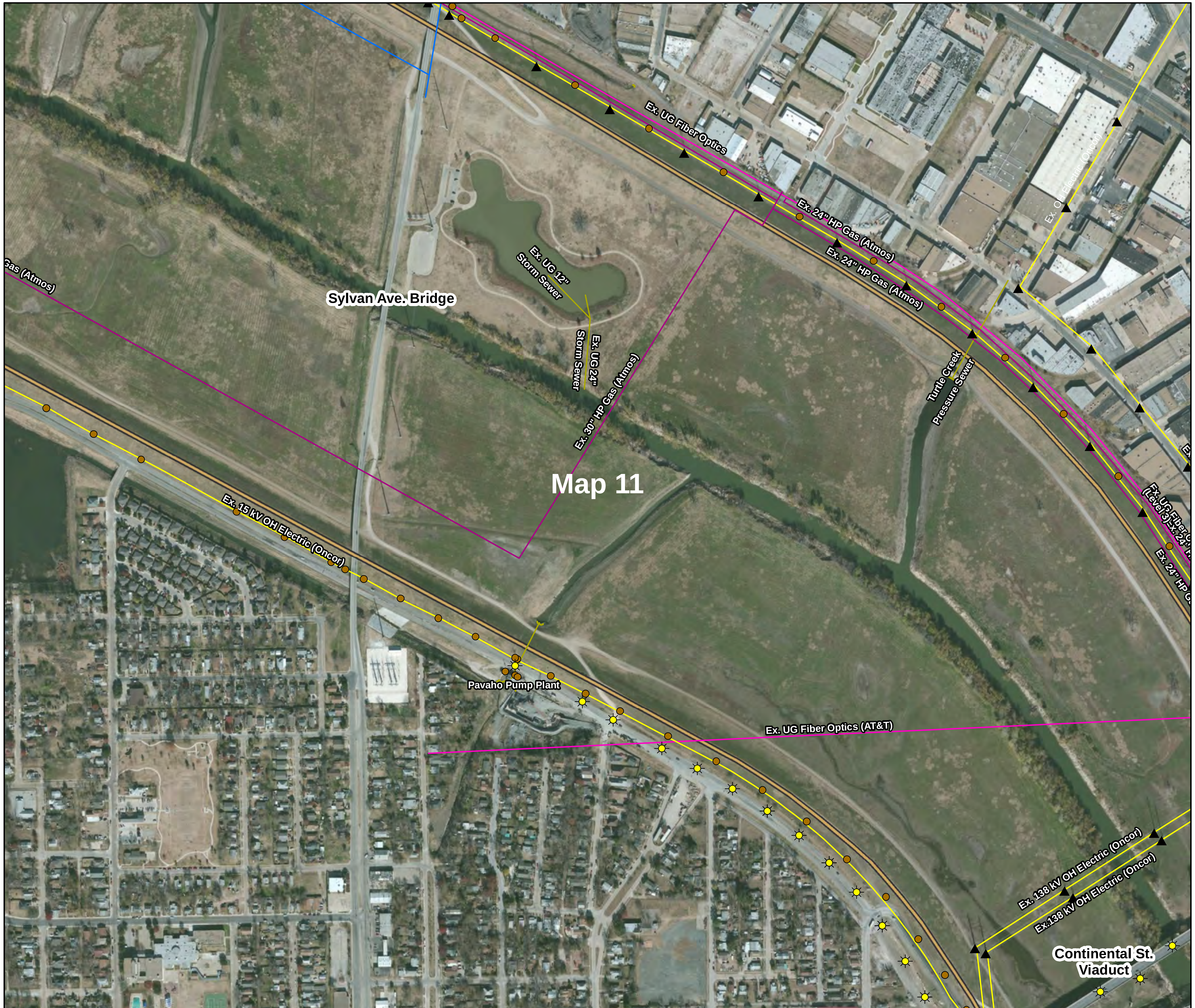

Figure D-19
Utilities Details: Map 11

LEGEND

Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

Key

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Ex.	Existing
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IH	Interstate Highway
IP	Intermediate Pressure
KV	Kilovolt
OH	Overhead
SH	State Highway
SFB	Suspended From Bridge
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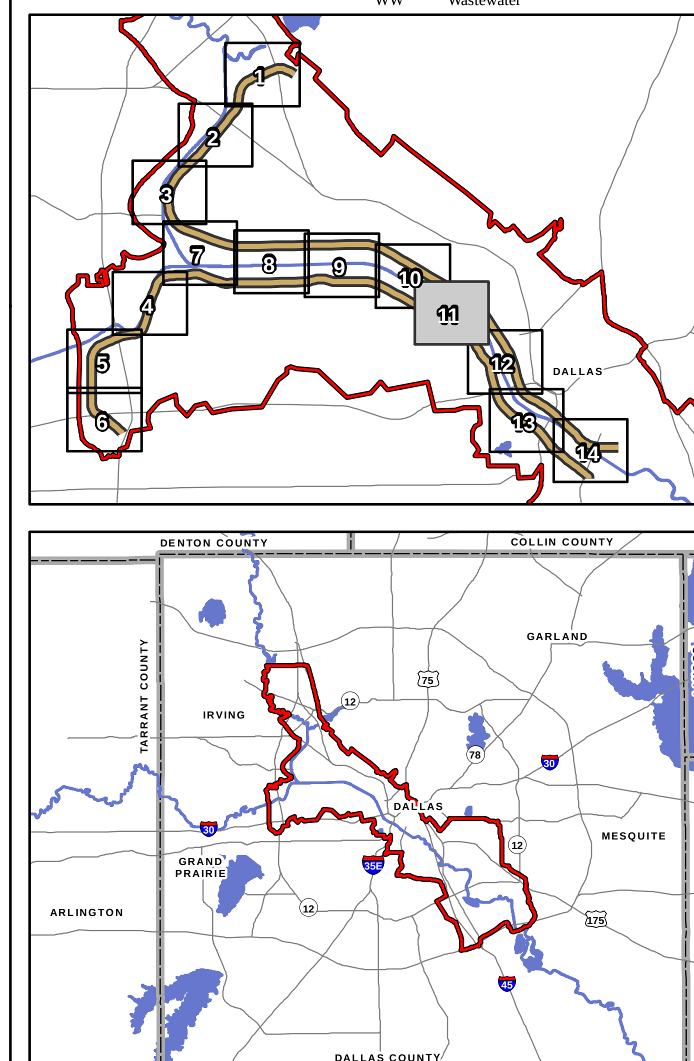

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Figure D-20
Utilities Details: Map 12

LEGEND

Utility Lines

- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

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IH	Interstate Highway
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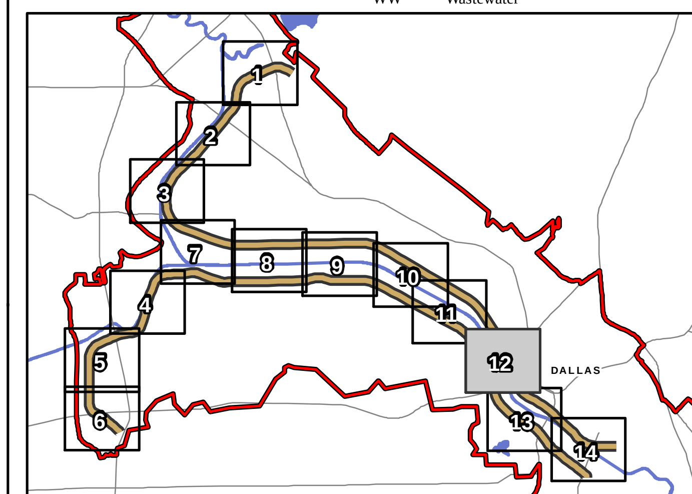
KV	Kilovolt
OH	Overhead
SH	State Highway
SFB	Suspended From Bridge
UG	Underground
WW	Wastewater



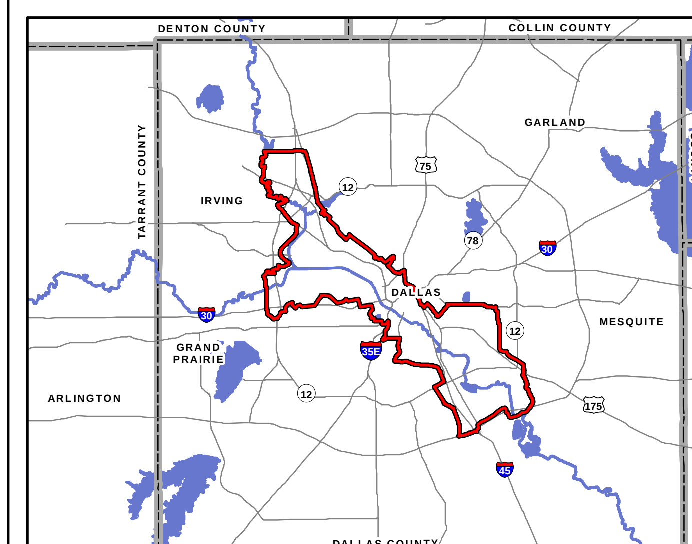


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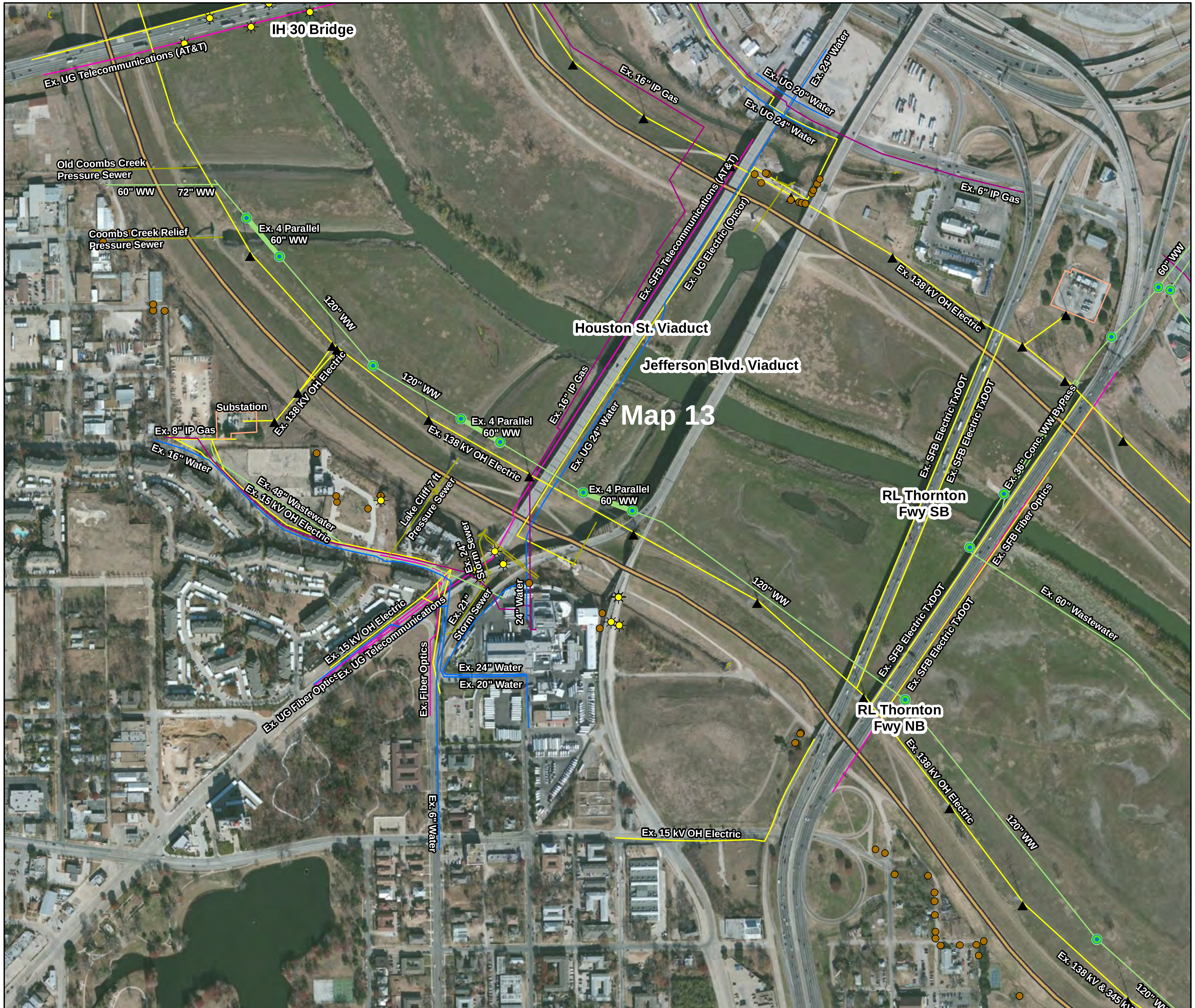
Figure D-21
Utilities Details: Map 13



LEGEND

Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
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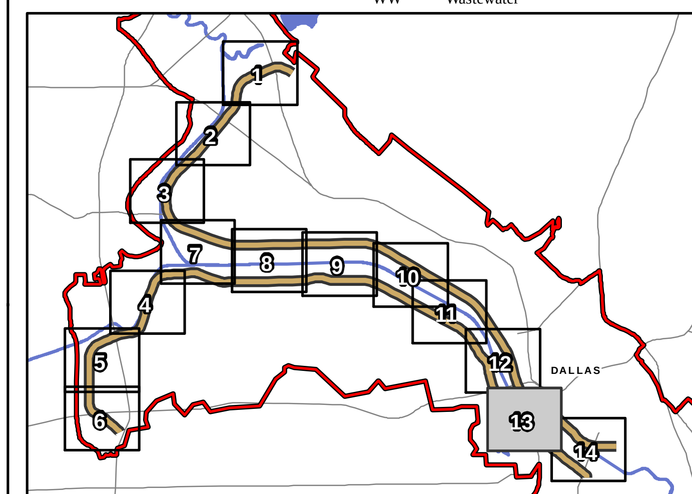

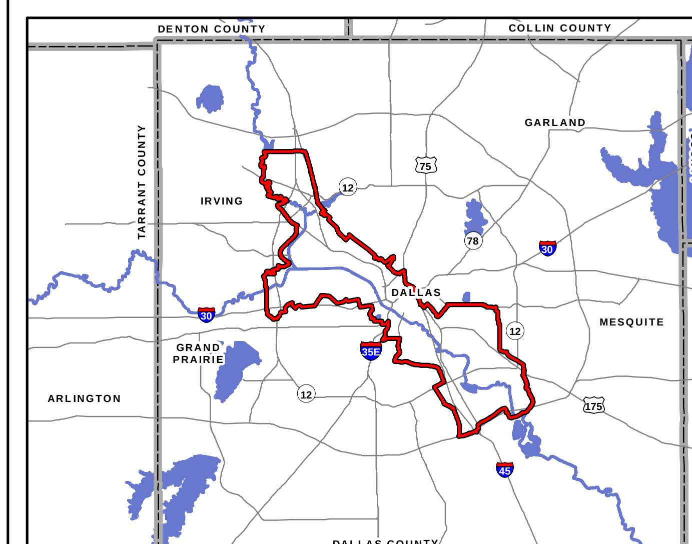

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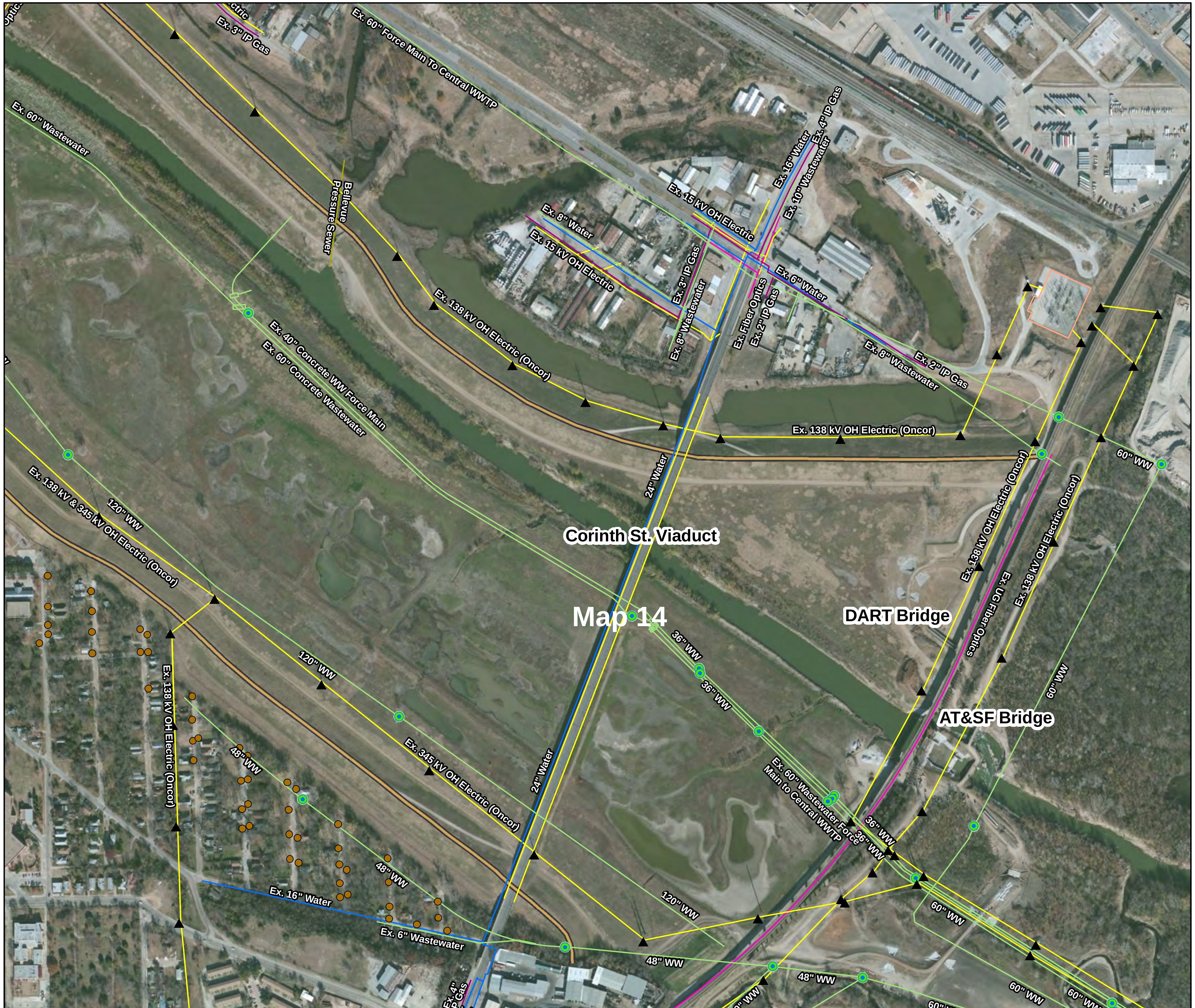
Figure D-22
Utilities Details: Map 14



LEGEND

Utility Lines	
Electrical	Dallas Floodway Levee System Levee Crest
Electrical Substation	Manhole
Communication	Exterior Light
Wastewater	Power Pole
Sewer	Transmission Tower
Natural Gas	
Petroluem	
Water	
Abandoned Oil and Gas	

Key

CRI&P	Chicago, Rock Island and Pacific Railroad
Ex.	Existing
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IH	Interstate Highway
IP	Intermediate Pressure
KV	Kilovolt
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SH	State Highway
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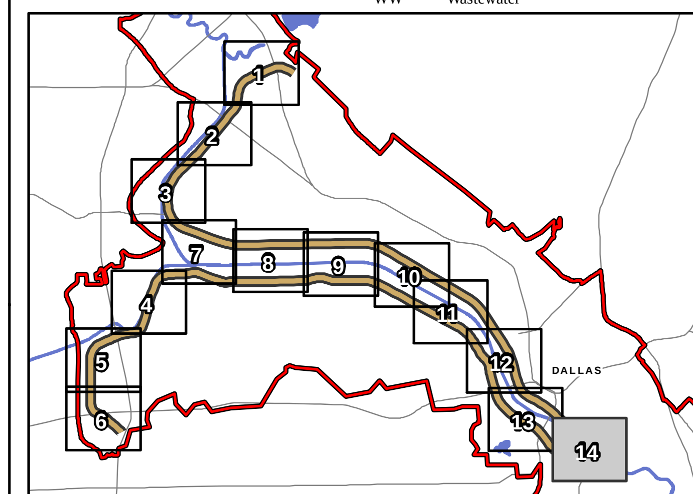

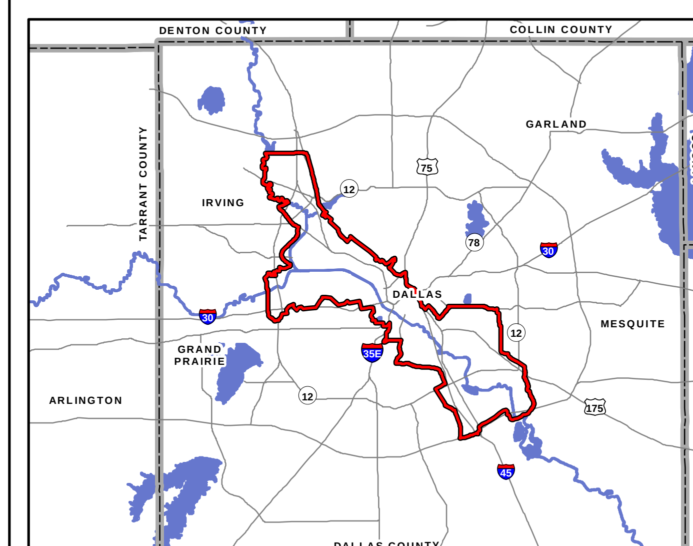

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2.0 THE CITY OF DALLAS' BALANCED VISION AND INTERIOR DRAINAGE PLANS

Current stages of the study put forth in the following sections were done in accordance with Engineering Regulation (ER) 1110-2-1150 "Engineering and Design for Civil Works Project". Chapter 13 of this ER discusses the scope of the engineering feasibility study. It authorizes and provides guidance for the basis of the engineering and engineering outputs that are created as part of the feasibility study for a given Civil Works Project. The following sections discuss the feasibility analysis of the City of Dallas' BVP and IDP for WRDA compliance. The City of Dallas as the non-federal sponsor has goals for the Dallas Floodway Levee System that consist of flood risk management, ecosystem restoration, and recreation objectives. The WRDA Project is selected from a FRM component that is determined through NED analysis. The analysis concludes with a recommended USACE FRM Plan. The FRM Plan is then combined with the City of Dallas' preference for flatter side slopes on the riverside slope of the levee, the goals and features of the BVP, and the features of the IDP to create the overall comprehensive plan for the Dallas Floodway. From this comprehensive plan, the WRDA plan will be selected.

The development of the FRM plan is discussed in Section 2.2 with NED analysis used as the basis for determining the plan. The FRM plan is further refined and discussed in Section 2.3 based on further modeling and analysis of the system. The BVP is then discussed in detail with each of its features discussed in separate sections. All of the BVP features are discussed in their relation to other features of the Floodway and the technical soundness of their individual designs. Summary sections at the end of the feature discuss the technical soundness of the individual and suggest a path forward in future design. The IDP is discussed similarly with each feature of the proposed project discussed individually with a summary section describing technical soundness of the feature. These features are also referenced throughout the remainder of the report in their relation to Comprehensive Analysis.

The creation of the FRM plan, integration of the side slope flattening measures, BVP features, and IDP improvements is discussed in the following sections based on the criteria set forth in Section 2.1.

2.1 Evaluation of the Local Sponsor Plan with MDFP Criteria

The Recommended Plan for the Modified Dallas Floodway Project (MDFP) for Section 5141 of WRDA 2007, requires the construction and implementation of its comprising features to be technically sound and environmentally acceptable. Environmentally acceptable is accomplished through the National Environmental Policy Act (NEPA) process, and is not part of the scope of this appendix. This appendix focuses on the civil and structural definitions of technically sound. Section 2.1.1 provides the criteria of technically sound as it relates to a civil site design evaluation. These criteria are used throughout the report as the basis for the evaluation of the various features for determining the viability of the proposed projects. All evaluated plans, aside from the NED FRM Plan and Side Slope Flattening Plan, were developed by the City of Dallas and its contractors. They are incorporated into this report with limited changes from their original scope outlined by the City of Dallas.

2.1.1 Technically Sound

The Dallas Floodway project consists of many different features within the footprint of the Dallas Floodway Levee System including the BVP, IDP, bridges, environmental mitigation projects, the Trinity Parkway, and USACE FRM Plans. Some of these features have the potential to be included as a part of the MDFP Plan, while other features were evaluated as part of the Comprehensive Analysis and will be implemented and constructed pending Section 408 approval. Some of the MDFP features will be a part of cost share by USACE, while Section 408 approval items are not part of the total project cost and will not be cost shared. The various features and components of the MDFP and Comprehensive Analysis projects were evaluated against the technically sound criteria. This analysis ensured the proposed local projects meet USACE engineering and safety standards, are compatible with the proposed Comprehensive Analysis project features, and would not have significant adverse effects on the functioning of the existing Dallas Floodway Levee System. The overarching goal of the MDFP evaluation was to determine technical soundness in order to progress from the current Feasibility Phase to the PED Phase of the project.

To be technically sound, the feature must meet the criteria that follow. A technically sound feature is constructible and positively interfaces with adjacent Dallas Floodway Levee System features. The feature is designed to meet minimum USACE and all other relevant design criteria. This includes SWF Pamphlet, SWFP 1150-2-1, which describes “Criteria for Construction within the Limits of Existing Federal Flood Protection Projects” and ETL-10-2-571” Guidelines for Landscape Planting and Vegetation Management at Levees Floodwalls, Embankment Dams, and Appurtenant Structures.” The feature is consistent with standard engineering practice. A technically sound determination is independent of design optimization; further development of the plan could derive a better design approach to the individual feature. A technically sound feature achieves the intent of the given feature within the context of the overall project goals.

For many of the MDFP features, technically sound from a feature’s long term sustainability and performance is not part of the scope of this Appendix. The intent of the analysis of the MDFP features for technical soundness is to ensure, from a civil site design and structural standpoint that the features work geometrically in both horizontal and vertical planes. Functionality of each feature has been analyzed within the context of the above technically sound definition and is described in further sections of this appendix.

At the end of the discussion of each feature a summary and conclusions section will identify whether the features met the technically sound criteria established for the review. It was determined that in the event the review identified a design issue, a risk informed decision was made whether further feasibility level design was required or whether the design could be considered technically sound and the design issue could remedied in future design phases.

2.2 Flood Risk Management Plan Development

In the formulation of the Flood Risk Management (FRM) Plan, several structural measures were evaluated based on the results of the Risk Assessment. The Risk Assessment identified several key failure mechanisms and were evaluated based upon the overall risk of the failure mode. Based upon risk thresholds, alternatives that exceeded these thresholds were identified for further analysis. These alternatives are discussed in the following sections and were evaluated based upon NED and their reduction to life safety risk. This evaluation determined the final FRM plan through coordinated analysis by several disciplines with the final selected plan discussed in Section 2.2.6.

2.2.1 Alternatives Considered

Chapter 3 of the main report describes the plan formulation and economics for the FRM plan in greater detail. The full array of alternatives developed including non-structural measures, structural measures eliminated from consideration, planning criteria, economic results of the study, and other pertinent plan formulation information are also described in Chapter 3. Quantities and cost estimates for alternatives plans were developed in support of the FRM plan formulation efforts. The Risk Assessment identified unacceptable risks for overtopping and associated embankment erosion of the East and West Levees resulting from greater than the Standard Project Flood (SPF). The SPF has since been re-categorized to indicate the 277,000 cubic feet per second flood. The Risk Assessment also identified backwater erosion piping of a sand layer connected to the river and exposed in a land-side sump resulting from at or greater than the water surface level. The alternative plans that were considered to address these risks include the No Action Plan, raising the existing East and West levees, armoring the levees to strengthen against breach, and seepage mitigation. Removal of the existing AT&SF Railroad Bridge was also included as a stand-alone alternative and in combination with levee raise alternatives. These alternatives are discussed below.

2.2.1.1 No Action Plan

Fundamental to any analysis is the No Action Plan. Adoption of this alternative for FRM implies acceptance of the costs and adverse effects of continued flooding. Appendix E and the main report contain the Flood Damage Analysis of the No Action Plan. The No Action Plan would be recommended only when no other solutions are feasible or when environmental damage would be irreparable. The No Action Plan also establishes the conditions against which other alternatives are compared against. It is often referred to as the "Future Without-Project Condition".

2.2.1.2 Removal of AT&SF Railroad Bridge

The historical AT&SF Railroad Bridge is located at the far downstream end of the project area. It parallels and is adjacent to the DART Bridge. The AT&SF Railroad Bridge was taken out of service and abandoned as a railroad bridge in the 1990s when the DART system purchased the bridge and right-of-way and constructed a new light rail system bridge parallel to the old bridge. The AT&SF facility extends approximately 3,000 feet across the Floodway. There are actually two separate lengths of AT&SF Bridge in the Floodway, which are separated by approximately 450 linear feet of earthen railroad embankment. The bridges are approximately 23 feet high and include numerous types of construction. Most of the bridge length consists of wooden trestle construction. However, a steel truss clear span bridge crosses the main river channel. There is also approximately 660 linear feet of concrete railroad bridge.

The City of Dallas has proposed and completed the construction of a hike and bike trail that incorporates the truss clear span bridge and includes architectural details that reflect the design of the existing bridge. The AT&SF removal plans would maintain these features referred to as the Santa Fe Trestle Trail. The AT&SF Railroad Bridge removal would include demolition and removal of 900 linear feet of wooden trestle ballast-deck bridge, demolition and removal of 100 linear feet of wooden trestle open deck bridge, and demolition and removal of 660 linear feet of concrete ballast-deck bridge. The AT&SF Railroad Bridge removal would also include removal of approximately 970 linear feet of earthen railroad embankment. See Sheet CD101 for a schematic and location of bridge removal elements.

2.2.2 Probable Failure Mode #2 – Overtopping and Subsequent Breach

2.2.2.1 Levee Height Modification (Levee Raise)

Overtopping with breach was one of the potential failure modes identified in the risk assessment to be at an unacceptable level of risk. To mitigate this risk, it was decided that a levee raise in the low spots, as determined by evaluating the current levee crest height against the proposed flow water surface elevation, would be an acceptable solution. The raise locations and heights are based upon using a steady state analysis with the removal of the AT&SF Bridge. See Figures D-1 through D-6.

Initial Template: 4H:1V Side Slopes

The initial template is shown in Figure D-23. This template included a 16-foot levee crest width with 4H:1V slopes. The design suggestion was to tie into the protected side crest of the levee at the 4:1 slope with the majority of work to be completed on the river side of the levee system. The existing access road that is on the crest of the levee was determined to be unsuitable material for use as part of a levee raise. As recommended, the top two feet of the levee crest will be excavated and removed at any location where a levee raise is considered.

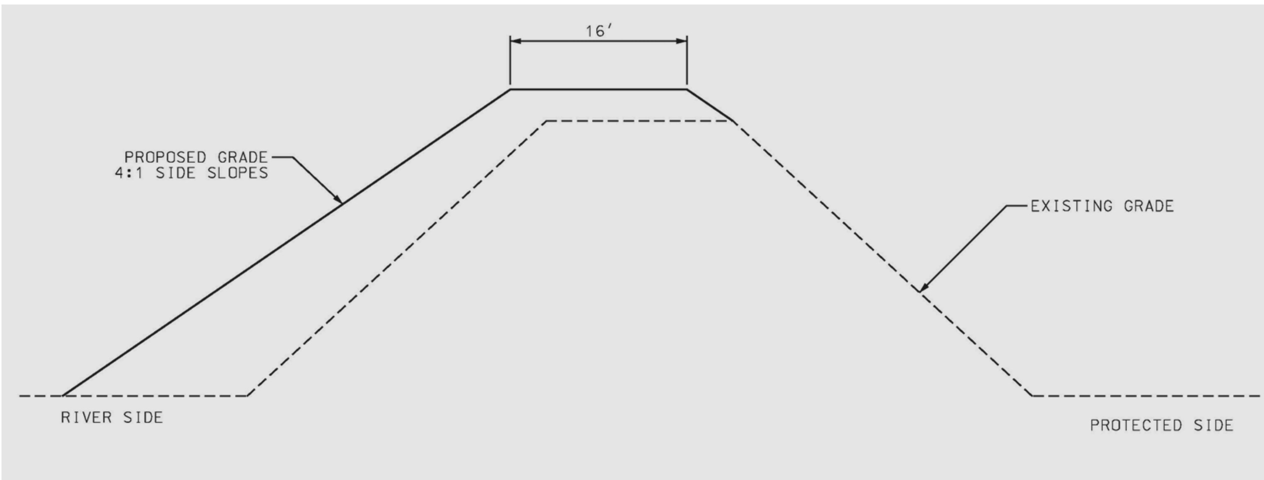

Figure D-23 Levee Raise Template 4H:1V Side Slopes

The proposed roadway section of the new access road is 10' wide with a crushed limestone aggregate depth of 8". Beneath the limestone a geo-textile liner will be placed as part of the road structure. The proposed roadway cross section is shown in Figure D-24. The new access road will tie into the existing roadway on either side of the levee raise. The proposed access road will have a three foot buffer on either side based upon the geometry of the levee cross section. The height of the levee access road will be flush with the crest of the levee, which will be considered the levee height.

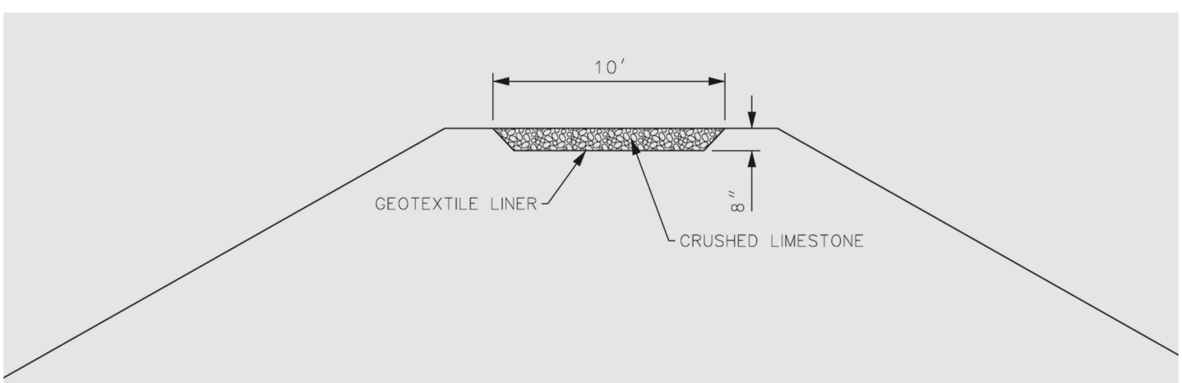

Figure D-24 Initial Access Road Cross Section

Quantities were calculated based on the two templates shown in Figures D-23 and D-24 for the 260,000 cubic feet per second (cfs), 277K, and 302K cfs flows, with respect to their water surface elevations, as an initial assessment for amount of work. The quantities were estimated using the average end area method, with cross sections at no more than 1,000 feet apart. This produced relatively rough quantities, shown in Table D-2, which were then used to inform further plan formulation. Only fill earthwork quantities, in cubic yards (CY), and seeding acreage were calculated in this iteration. The applicable reaches to be raised were determined based upon estimating the starting and ending stations from Figures D-1 through D-6. The reaches associated with each flow are shown in Table D-5.

Table D-2. Initial Quantities for 260K, 277K, and 302K cfs Flows

East Levee Quantities				
Flow Amount (cfs)	*Earthwork*	*Unit*	*Seeding*	*Unit*
260K	20,289	CY	0.44	ACRE
277K	196,013	CY	4.17	ACRE
302K	671,699	CY	11.58	ACRE
West Levee Quantities				
Flow Amount (cfs)	*Earthwork*	*Unit*	*Seeding*	*Unit*
260K	-	CY	0.00	ACRE
277K	90,270	CY	1.90	ACRE
302K	570,638	CY	8.94	ACRE

The second iteration of quantities was more refined after analyzing the rough quantities shown above. The same template of 4H:1V side-slopes was utilized (Figure D-23); however, the cross sections for the average end area methodology were computed at smaller intervals, leading to a greater detail in quantities computation. The average cross section distance was 200 feet as compared to the 1,000 foot cross sections for the previous iteration. The results from the NED on the initial quantities and cost calculations indicated the optimized solution was between the 260K cfs and 277K cfs levee raise. Therefore, levee raise quantities were analyzed at five different flows centered on the 269K cfs water surface elevation for this iteration of quantity determination. Quantities were computed to equal a minimum levee height for the 260K, 265K, 269K, 273K, and 277K cfs water surface elevations.

Quantities were calculated for excavation of the existing access road, earthen fill for the levee raise, a new crushed limestone access road with a geo-textile liner, scarification of the existing levee, and seeding for the new surface of the levee. Earthen fill quantities include the amount of material excavated from the removal of the existing access road and are minus the volume of new access road that will be constructed. Scarification along the flat portions of the levee profile, the levee crest and past the toe of the levee, were determined to be 6-inches deep. A volume in CY was calculated for this quantity. Scarification on the side slopes of the levee were calculated based on a 10 foot wide step excavation method. To increase efficiency in quantities calculations, it was determined that, on average, the amount of excavation necessary for scarification on the side slopes was approximately 1.33 times the length of the side slope. This approximation method was used to determine a volume, in CY, of the scarification along the side slopes of the levee. Calculation of the new road crushed limestone and geo-textile liner was done by using the linear footage of the levee raise distance. For instance, a 400 foot long levee raise was multiplied by the 10 foot wide road and 8” deep aggregate road to determine the volume of crushed limestone required.

The quantities associated with the second iteration of calculations are shown in Table D-3. The applicable reaches were identified with the use of Figures D-1 to D-6 and are shown in Table D-5.

Table D-3. Quantities for 260K, 265K, 269K, 273K, and 277K cfs Flows

Item	*Unit*	**East Levee Quantities**				
		260K	*265K*	*269K*	*273K*	*277K*
LEVEE RAISE VOLUME	CY	10,974	16,909	45,245	183,459	425,458
REMOVE EXIST. LEVEE ROAD	CY	1,046	2,525	6,792	18,902	28,529
SCARIFICATION ON FLAT SURFACE (6 inch" DEPTH)	CY	635	1,255	3,538	8,212	10,473
SCARIFICATION ON SLOPE (MIN. 10' WIDE STEP EXCAVATION)	CY	3,229	4,028	11,539	20,452	37,368
SEEDING AREA	ACRE	2.30	3.53	10.94	18.02	31.39
NEW ROAD 8" CRUSHED LIMESTONE	CY	247	469	1,210	2,914	3,902
GEOTEXTILE ROAD LINER	SY	1,259	2,393	6,170	14,859	19,896
Item	*Unit*	**West Levee Quantities**				
		260K	*265K*	*269K*	*273K*	*277K*
LEVEE RAISE VOLUME	CY	-	-	10,081	59,082	106,149
REMOVE EXIST. LEVEE ROAD	CY	-	-	2,312	7,377	12,031
SCARIFICATION ON FLAT SURFACE (6" DEPTH)	CY	-	-	995	4,239	7,049
SCARIFICATION ON SLOPE (MIN. 10' WIDE STEP EXCAVATION)	CY	-	-	2,800	13,720	24,725
SEEDING AREA	ACRE	-	-	2.54	12.31	21.98
NEW ROAD 8" CRUSHED LIMESTONE	CY	-	-	469	1,432	2,247
GEOTEXTILE ROAD LINER	SY	-	-	2,393	7,304	11,459

<u>Revised Template with 3H:1V Side Slopes</u>

The final report for the Value Engineering Study suggested several ideas on how to reduce the costs associated with raising the levee in order to potentially allow for an increase in levee design height. Using a smaller crest width and using steeper, 3H:1V, side slopes were put forth as viable alternatives to reducing the amount of fill associated with a levee raise. Based upon maneuverability and mobility concerns, the crest width was decided to remain a constant 16 feet to match the existing design crest width of the levee. It was determined that 3H:1V side slopes would be considered as a potential cost reduction technique that would lead to an increase in design capacity of the levee system.

For further information on decisions regarding slope remediation, see Appendix B. Appendix B Paragraphs 11 and 12 discuss the geo aspects of 4H:1V versus 3H:1V slopes. In addition, Probable Failure Mode (PFM) 13B in the final Risk Assessment addresses this issue.

The criteria for a levee raise remained the same for this iteration as in iterations discussed in Section 2.2.2.1, except for the proposed levee side slopes. See sheet C-501 for the proposed levee template with 3H:1V side slopes.

The specific quantities calculated for this revised levee template were the same as those shown in Table D-3. The road surface shown in Figure D-24 remained constant in this iteration of quantities. The assumptions for scarification, road surface, and excavation are the same as those of the 4H:1V side slope calculations shown in Table D-3. The quantities were determined using a modified average end area methodology with cross sections every 200 feet. In contrast to previous estimations, the formula for quantities was modified slightly to more accurately reflect the quantity being estimated. The pyramidal volume calculation was utilized where one of the two values used in the average end area methodology was equal to zero. For instance if the area of excavation at cross section 1+00 is equal to 60 square feet (SF) and the area of excavation at the next cross section 3+00 is zero, a conventional approach is a volume of 6,000 cubic feet (CF).

Average End Area Method

$$V = \frac{A_1 + A_2}{3} * L = \frac{60 + 0}{2} * (300 - 100) = 6000\ CF$$

However, using the pyramidal method in this instance, a volume of 4000 CF is calculated.

Modified Average End Area Method, Where One Value Equals Zero

$$V = \frac{A_1}{3} * L = \frac{60}{3} * (300 - 100) = 4000\ CF$$

This is a more accurate assessment of volume calculations in areas where a quantity equals zero. It leads to a lesser quantity that is more representative of actual conditions.

In this iteration, quantities were developed at 3H:1V side slopes for the water surface elevations of the 277K and 289K cfs flows. The quantities determined for a levee raise to contain these two flows are shown in Table D-4. The reaches evaluated for this quantities assessment were determined with the use of Figures D-1 through D-6 and are shown in Table D-5.

Table D-4. Quantities for 277K and 289K cfs Flows with 3H:1V Side Slopes

Item	*Unit*	East Levee	
		277K	*289K*
LEVEE RAISE VOLUME	CY	41,578	95,081
REMOVE EXIST. LEVEE ROAD	CY	25,804	46,486
SCARIFICATION ON FLAT SURFACE (6" DEPTH)	CY	7,353	16,290
SCARIFICATION ON SLOPE (MIN. 10' WIDE STEP EXCAVATION)	CY	6,391	14,346
SEEDING AREA	ACRE	14.72	31.56
NEW ROAD 8" CRUSHED LIMESTONE	CY	3,902	6,642
GEOTEXTILE ROAD LINER	SY	19,896	33,874

Item	*Unit*	**West Levee**	
		277K	*289K*
LEVEE RAISE VOLUME	CY	20,078	75,971
REMOVE EXIST. LEVEE ROAD	CY	10,155	34,533
SCARIFICATION ON FLAT SURFACE (6" DEPTH)	CY	3,925	12,598
SCARIFICATION ON SLOPE (MIN. 10' WIDE STEP EXCAVATION)	CY	5,234	20,427
SEEDING AREA	ACRE	8.53	28.71
NEW ROAD 8" CRUSHED LIMESTONE	CY	2,247	5,136
GEOTEXTILE ROAD LINER	SY	11,459	26,192

Earthen Levee Raise Assumptions and Preliminary Design Considerations

Levee heights for the levee raise alternatives are based on the hydraulic models for the entire Dallas Floodway study area. The hydraulic stations used in the hydraulic models were correlated to the levee baseline stations by overlaying the two stationing systems in plan-view using MicroStation CADD software. The water surface elevations in the hydraulic models could then be used to build proposed profiles for the levee raise alternatives.

The steady state hydraulic models with the demolition of the AT&SF Bridge created by the district were translated into graphical representations of the existing levee and the water surface elevations of the various flows. These graphs were used in determining the start and end stationing of the levee raise areas. The height of the levee raise was also determined from these graphical representations of the levee and water surface. The stationing was approximated to the nearest 100 feet in river stationing, converted to the nearest 100 feet in levee stationing, and then used in quantities calculations. There is a margin of error associated with this conversion from river to levee stationing as there is no direct correlation or mathematical representation that can be used. There is also a variability associated with the levee height raise determination as this was also approximated from the same graphical representation. The low spots that were identified in the existing levee for potential levee raise for the water surface elevation at each flow are shown with levee and river stationing in Table D-5. See attached plan set for corresponding stationing locations from the table. See Figures D-1 through D-6 for water surface elevations plotted against a profile of the existing levee crest height.

The existing crushed limestone access road will be removed prior to raising the top of impervious material on the levees and a new gravel road will be constructed after the impervious material has reached the design grade. The excavation of the existing pervious access road will consist of removing the top two feet of the levee crest. A finished crest width of 16 feet will be maintained to match the original design width of the levees. The new crushed limestone access road will be included as part of the levee raise height. A variety of techniques may be required to raise the levees at the bridges. Refer to the discussion on bridges in Section 2.2.5 for more details.

Table D-5: Levee and River Stationing for Raising East and West Levees

Flow (cfs)	East Levee and Elm Fork Levee						West Levee and West Fork Levee					
	Levee Stationing		Main River Stationing		Elm Fork Stationing		Levee Stationing		Main River Stationing		West Fork Stationing	
	Begin Sta.	End Sta.	Begin Sta.	End Sta.	Begin Sta.	End Sta.	Begin Sta.	End Sta.	Begin Sta.	End Sta.	Begin Sta.	End Sta.
260K	117+00	119+00	1185+00	1187+00								
	226+00	232+00	1286+00	1292+00								
	292+00	294+00	1348+00	1350+00								
265K	117+00	119+00	1185+00	1187+00								
	226+00	232+00	1286+00	1292+00								
	283+00	294+00	1340+00	1350+00								
269K	116+00	119+00	1184+00	1187+00			158+00	162+00	1246+00	1251+00		
	162+00	164+00	1227+00	1229+00			171+00	182+00	1262+00	1274+00		
	172+00	189+00	1237+00	1252+00			298+00	302+00	1396+00	1400+00		
	224+00	233+00	1284+00	1293+00								
	248+00	250+00	1308+00	1310+00								
	279+00	295+00	1336+00	1351+00								
273K	81+00	82+00	1142+00	1143+00			157+00	163+00	1245+00	1252+00		
	116+00	119+00	1183+00	1187+00			168+00	183+00	1258+00	1275+00		
	155+00	165+00	1222+00	1230+00			190+00	204+00	1282+00	1295+00		
	173+00	201+00	1237+00	1261+00			209+00	219+00	1300+00	1311+00		
	208+00	217+00	1268+00	1277+00			293+00	306+00	1392+00	1405+00		
	227+00	235+00	1287+00	1295+00								
	248+00	251+00	1308+00	1311+00								
	279+00	295+00	1336+00	1351+00								
	492+00	532+00			90+00	130+00						
277K	81+00	82+00	1142+00	1143+00			157+00	164+00	1245+00	1253+00		
	116+00	119+00	1184+00	1187+00			166+00	185+00	1256+00	1277+00		
	155+00	165+00	1222+00	1230+00			186+00	221+00	1278+00	1313+00		
	172+00	235+00	1237+00	1295+00			249+00	259+00	1345+00	1356+00		
	248+00	252+00	1308+00	1312+00			286+00	306+00	1385+00	1405+00		
	277+00	295+00	1335+00	1351+00								
	338+00	344+00	1391+00	1397+00								
	480+00	533+00			77+00	132+00						
289K	81+00	84+00	1142+00	1144+00			156+00	248+00	1244+00	1343+00		
	116+00	119+00	1183+00	1187+00			249+00	272+00	1344+00	1371+00		
	154+00	235+00	1221+00	1295+00			275+00	306+00	1374+00	1405+00		
	247+00	319+00	1307+00	1372+00			409+00	437+00			32+00	61+00
	330+00	352+00	1383+00	1405+00			493+00	527+00			118+00	135+00
	477+00	545+00			73+00	143+00						
	547+00	567+00			145+00	161+00						
302K	81+00	101+00	1142+00	1162+00			60+00	62+00	1152+00	1154+00		
	116+00	121+00	1184+00	119+00			122+00	125+00	1206+00	1209+00		
	153+00	235+00	1220+00	1295+00			156+00	308+00	1244+00	1407+00		
	238+00	354+00	1298+00	14+07			335+00	339+00	1434+00	1438+00		
	475+00	623+00			69+00	202+00	376+00	384+00	1473+00	1481+00		
							407+00	453+00			27+00	76+00
							463+00	527+00			83+00	135+00

Earthwork quantities were computed by average end area method using MicroStation CADD and GEOPAK design software. The areas in the average end area methodology were computed using cross sections created from a TIN file of the East and West levees. See Section 1.2 of this appendix for information on the existing surveyed levee surface. These areas were then entered into a Microsoft Excel spreadsheet that calculated the various quantities based upon equations for the average end area methodology. Raising the levee by placing fill to the river side requires a small offset in the levee crown. The higher the levee is raised, the more offset is required. The existing levee ground surface contains many irregularities which must be considered during design. Irregularities in the existing ground surface are one of the factors in determining the appropriate amount of levee crest offset. The fill placement for the levee raise alternatives was reduced to the extent possible by adjusting the offset of the proposed levee crown to provide the best overall fit with the existing levee geometry. The earthwork quantities for the preliminary design of levee raise alternatives did not include additional fill height for settlement.

Additional design and quantity estimation for levee settlement is not required. Levee settlement has occurred with this existing levee system since it was originally built in the 1920s and strengthened by the Corps in the 1950s. Based on the age of the levee system and the compressibility characteristics of the underlying clay and weathered shale, it is reasonable to conclude that at least 90% of the settlement has occurred. Although additional settlement caused by the Recommended Plan is estimated to be negligible, as the project moves into future design phase (PED) additional levee stability and settlement analysis will be required. The cost and schedule risk analysis provides a risk rating of “high” for the levee quantity estimates. The overall risk rating is an input in the cost and schedule risk analysis that develops contingencies for the total project cost. Any design refinements for levee settlement would be minor, and would not affect the total project cost estimate including contingencies. After the design and construction of the levees the maintenance of the levee height for the new levee crest will be a matter of operation and maintenance by the project sponsor.

<u>Borrow Area Locations and Depths</u>

The cost estimates were prepared with the assumption that the earthen borrow material for the levees would come from on site in the overbank region of the Floodway. The borrow areas would be just upstream of Inwood Avenue/Hampton Road for the East Levee and just upstream of Westmoreland Road for the West Levee. Depths of excavation in the borrow areas were determined based on analysis of suitable material and minimizing environmental impact. It is assumed that the haul distance for the levee embankment material would range up to approximately 12 miles round trip. The assumed locations of the borrow areas considered in the formulation of the FRM plans and used for cost estimating purposes are shown in Figure D-25.

The basic assumptions for the determination for the borrow areas included input from geotechnical and environmental resource specialists. The environmental resource specialists identified the least environmentally significant areas that potentially could be used as borrow sites. The geotechnical specialist provided an evaluation of suitable material for the levee raise. The common areas between these two outlines became the maximum extents of the borrow areas. It was determined that it was more significant to decrease the footprint of the borrow areas by making the borrow areas deeper than to make a shallower depth of borrow with a larger footprint.

US Army Corps of Engineers
Fort Worth District

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

ENGINEERING/ CONSTRUCTION DIVISION DESIGN BRANCH

Designed by: C. CHINI	Date:	Rev.
Dwn by: C. CHINI	Sol No.	
Reviewed by:	Contr No.	
Submitted by:	File name: Plot date: 8/1/2013 Plot scale:	

DALLAS FLOODWAY LEVEE STUDY
DALLAS, TEXAS

FIGURE D-25
APPROXIMATE LOCATIONS OF BORROW PITS

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Critical criteria associated with determining the extents of the borrow sites include the following:

1. 10 foot maximum excavation depth for suitable material to avoid ground water
2. 6-8 feet is the ideal maximum depth for the borrow areas, limit the 10 foot excavation depth to the center areas of the borrow pits.
3. The top 1 foot of soil in the borrow pit is determined to be unsuitable levee fill material and will be removed and replaced back in the borrow areas following excavation.
4. Borrow areas shall be no closer than 200 feet from the toe of the levee.
5. Borrow areas shall be no closer than 50-100 feet from the river channel.
6. Borrow areas shall not enter into any right of way of a bridge.

Additionally, a bulk factor of 20 percent was assumed for hauling the material to the levee raise site, and a compaction loss of 20 percent was assumed from in situ to construction of the levees.

The borrow pit cross section is modeled after the wetland cells located in the Dallas Floodway Extension project. The middle section of the excavated borrow pit has a maximum depth of 10 feet with a width of 100 feet. From the middle section, the borrow pit stair-steps up to a larger plateau of 4 foot depth that extends the remaining width of the borrow pit before tying into the existing grade. The cross section of the borrow pit is shown on sheet C-502.

In determining the volume associated with the borrow pit, the modified average end area method was utilized at 100 foot cross sections. Because the width of the borrow pit is not constant, the width of the 4 foot deep excavated zone was considered the variable in the cross sectional geometry. The calculations below determine the relationship between the cross section length and the area of the cross section. This calculation was used in the average end area methodology for determining the possible extent of suitable excavation area for each cross section.

$$L = 100 + 18 + 18 + 16 + 16 + 2w = 2w + 168\ LF$$

$$w = \frac{L}{2} - 84\ LF$$

$$AREA = 2 * \left(16 * \frac{4}{2}\right) + 2 * 4w + 2 * \left(\frac{(4 + 10)}{2} * 18\right) + 100 * 10 = 8w + 1316\ SF$$

$$AREA = 8 * \left(\frac{L}{2} - 84\right) + 1316 = 4L + 644\ SF$$

The cross sectional area was determined to be 4 times the length of the cross section plus a constant 644 square feet. Utilizing this cross sectional geometry a footprint of two borrow pit areas, one on each side of the river for better accessibility during construction, was determined. The acreage of the East Borrow Pit and West Borrow Pit are 22.20 acres and 16.41 acres, respectively. Table D-6 outlines the total materials that are generated for each borrow pit and the combined materials.

Table D-6. Borrow Pit Materials

Item		*Unit*	*West Borrow Pit*	*East Borrow Pit*	*Totals*
Borrow Pit Surface Area		SF	714,905	967,175	**1,682,080**
Borrow Pit Surface Area		ACRE	16.41	22.20	**38.62**
Usable Material	**Excavated Volume**	CY	100,759	121,431	**222,190**
	Excavated Volume (With 20% Bulk)	CY	120,911	145,717	**266,628**
Unusable Material*	**Excavated Volume**	CY	25,209	31,519	**56,728**
	Excavated Volume (With 20% Bulk)	CY	30,251	37,823	**68,074**

Note: *Unusable Material is defined as the top one (1) foot of soil on the borrow site. This soil will be replaced after excavation is complete.

2.2.2.2 Levee Armoring

A second measure to address overtopping with breach is armoring to control the breach. When the water overtops the levee, there is a risk that the velocity and shear stresses associated with the water flowing down the protected side of the levee will cause enough erosion to induce a breach in the levee. To mitigate this risk, there are two potential solutions that were considered. It is plausible that the levee can be raised to a sufficient height, where the risk of overtopping and subsequent breach falls within tolerable limits. This solution is evaluated with the levee raise associated with an overtopping without breach. The secondary solution is to sufficiently reinforce the protected side of the levee so that erosion is minimal and the risk of breach is neutralized to within acceptable limits. Reinforcing or armoring of the levee was investigated as a potential mitigation technique. All armoring of the levee was assumed to be done on the existing contours of the levee. For the purposes of economic analysis, the levee armoring alternative was considered independent of the levee raise alternative.

<u>Base Line Condition for Armoring</u>

Initially, to achieve a baseline condition for armoring, quantities were calculated for armoring the entire levee system. This includes the East and West Levees as well as the Elm and West Fork Levees. The template proposed for armoring the levees is shown in Figure D-26.

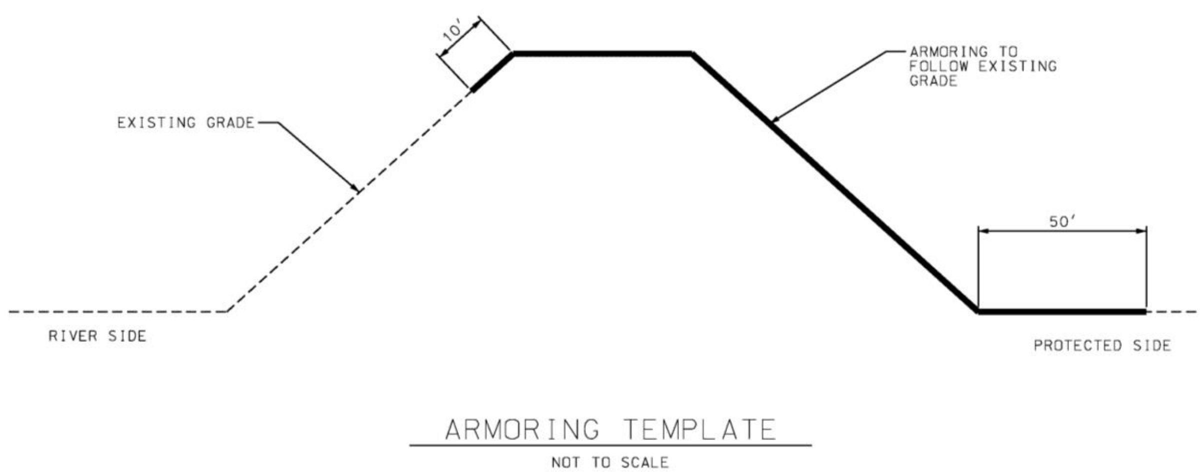


Figure D-26 Existing Levee Armoring Template

The template describes the armoring material beginning 10 feet down the riverside slope from the riverside crest of the levee. The armoring area would then extend across the crest of the levee, down the protected side slope from the levee, and ending after extending 50 feet past the protected side toe of the levee. The location and lengths of the armoring material were decided in order to mitigate the effects of a hydraulic jump occurring at the toe of the protected side of the levee. The material for armoring the levee was identified as an Articulated Concrete Block mat. The concrete blocks have some open gaps and are cabled together to create some flexibility in order to conform to the existing ground surface.

The quantities computed for the whole length of the levees were determined in plan-view. The levee toe on the protected side of the levee was identified and moved parallel 50 feet away from the levee. The levee crest on the river side was also identified and then moved parallel in plan-view 10 feet towards the river. These two bounds were connected linearly on the upstream and downstream end of the levee creating a polygon. The polygon was exported to a two dimensional file where the area was calculated for both the East and West Levee. The quantities for armoring are shown in Table D-7. The quantities did not take into account any contouring of the levee as all calculations were done in plan-view.

Table D-7. Quantities for Armoring All Reaches of Levees

	Armoring Quantity	*Unit*
East Levee and Elm Fork	1,180,836	SY
West Levee and West Fork	549,557	SY

Armoring in the Low Spots

The second iteration of quantities for armoring was done in more focused areas along the East and West Levee. Armoring quantities were calculated using the water surface elevations for the 255K cfs, 260K, 265K, 269K, 273K, 277K, 289K, and 302K cfs flow levels. Each water surface elevation was overlain on a profile of the existing levee crest. Low spots were identified as any point where the existing levee profile had a lower elevation than the water surface elevation for the flow analyzed. See Figures D-1 through D-6 for profiles of water surface elevations and existing levee crest heights. These locations for armoring correspond, for the most part, with areas that were identified for a levee raise. One notable exception occurs at the 269K cfs flow alternative on the Elm Fork Levee, reach 495+00 to 530+00 (levee stationing). This reach was determined to be a low spot that merited armoring; however, the height differential for a levee raise was considered negligible (less than 2 inches). Therefore, armoring was the only alternative considered for this low spot. Table D-8 identifies the linear locations along the levee where armoring was calculated for each flows. Stationing is shown in Levee Stationing with corresponding River Stationing.

The same criteria used in the base line condition for armoring (Section 2.2.3.1) were utilized for armoring quantity determination in this iteration, see Figure D-26. To create a more refined and accurate quantity for armoring, the armoring quantities were computed using cross sectional views of the levee to take into account the contours of the levee. An adapted average end area methodology was used to compute the quantity needed for the armoring of the levee. Since the end result of the calculations was an area not a volume, the entry into the calculation was a linear footage of armoring along the cross section. This is utilizing the same concept that is used to determine the area of a trapezoid, also known as a trapezoidal methodology.

Table D-8: Levee and River Stationing for Armoring East and West Levees

Flow (cfs)	East Levee and Elm Fork Levee						West Levee and West Fork Levee					
	Levee Stationing		Main River Stationing		Elm Fork Stationing		Levee Stationing		Main River Stationing		West Fork Stationing	
	Begin Sta.	End Sta.	Begin Sta.	End Sta.	Begin Sta.	End Sta.	Begin Sta.	End Sta.	Begin Sta.	End Sta.	Begin Sta.	End Sta.
255K	117+00	119+00	1185+00	1187+00								
	227+00	232+00	1289+00	1292+00								
	292+00	294+00	1348+00	1350+00								
260K	117+00	119+00	1185+00	1187+00								
	226+00	232+00	1286+00	1292+00								
	292+00	294+00	1348+00	1350+00								
265K	117+00	119+00	1185+00	1187+00								
	226+00	232+00	1286+00	1292+00								
	283+00	294+00	1340+00	1350+00								
269K	116+00	119+00	1184+00	1187+00			158+00	162+00	1246+00	1251+00		
	162+00	164+00	1227+00	1229+00			171+00	182+00	1262+00	1274+00		
	172+00	189+00	1237+00	1252+00			298+00	302+00	1396+00	1400+00		
	224+00	233+00	1284+00	1293+00								
	248+00	250+00	1308+00	1310+00								
	279+00	295+00	1336+00	1351+00								
	495+00	530+00			93+00	128+00						
273K	81+00	82+00	1142+00	1143+00			157+00	163+00	1245+00	1252+00		
	116+00	119+00	1183+00	1187+00			168+00	183+00	1258+00	1275+00		
	155+00	165+00	1222+00	1230+00			190+00	204+00	1282+00	1295+00		
	173+00	201+00	1237+00	1261+00			209+00	219+00	1300+00	1311+00		
	208+00	217+00	1268+00	1277+00			293+00	306+00	1392+00	1405+00		
	227+00	235+00	1287+00	1295+00								
	248+00	251+00	1308+00	1311+00								
	279+00	295+00	1336+00	1351+00								
	492+00	532+00			90+00	130+00						
277K	81+00	82+00	1142+00	1143+00			157+00	164+00	1245+00	1253+00		
	116+00	119+00	1184+00	1187+00			166+00	185+00	1256+00	1277+00		
	155+00	165+00	1222+00	1230+00			186+00	221+00	1278+00	1313+00		
	172+00	235+00	1237+00	1295+00			249+00	259+00	1345+00	1356+00		
	248+00	252+00	1308+00	1312+00			286+00	306+00	1385+00	1405+00		
	277+00	295+00	1335+00	1351+00								
	338+00	344+00	1391+00	1397+00								
	480+00	533+00			77+00	132+00						
289K	81+00	84+00	1142+00	1144+00			156+00	248+00	1244+00	1343+00		
	116+00	119+00	1183+00	1187+00			249+00	272+00	1344+00	1371+00		
	154+00	235+00	1221+00	1295+00			275+00	306+00	1374+00	1405+00		
	247+00	319+00	1307+00	1372+00			409+00	437+00			32+00	61+00
	330+00	352+00	1383+00	1405+00			493+00	527+00			118+00	135+00
	477+00	545+00			73+00	143+00						
	547+00	567+00			145+00	161+00						
302K	81+00	101+00	1142+00	1162+00			60+00	62+00	1152+00	1154+00		
	116+00	121+00	1184+00	119+00			122+00	125+00	1206+00	1209+00		
	153+00	235+00	1220+00	1295+00			156+00	308+00	1244+00	1407+00		
	238+00	354+00	1298+00	14+07			335+00	339+00	1434+00	1438+00		
	475+00	623+00			69+00	202+00	376+00	384+00	1473+00	1481+00		
							407+00	453+00			27+00	76+00
							463+00	527+00			83+00	135+00

Cross sections were evaluated at approximately every 200 feet along the area in question, see Table D-8. The existing levee topography was used to determine the length of the armoring on the cross section. In accordance with Figure D-26, the armoring extended 50 feet from the protected toe of the levee and approximately 10 feet down from the crest of the levee on the river side. By averaging the length of armoring on neighboring cross sections and multiplying them by the length between the cross sections, an approximate area of armoring was calculated. These final areas for the East and West Levees, including the Elm Fork and West Fork Levee, are shown in Table D-9.

The material assumed in quantities calculation was an Articulated Concrete Block as it was determined to be a conservative approach to providing the most protection from erosion.

Table D-9. Quantities for Armoring up to Water Surface Elevations

Item	*Unit*	**East Levee**							
		255K	*260K*	*265K*	*269K*	*273K*	*277K*	*289K*	*302K*
ARMORING AREA	SY	16,540	18,561	37,656	198,989	271,617	373,255	742,063	1,032,289
Item	*Unit*	**West Levee**							
		255K	*260K*	*265K*	*269K*	*273K*	*277K*	*289K*	*302K*
ARMORING AREA	SY	-	-	-	35,962	122,775	197,640	497,151	672,238

Armoring Assumptions and Preliminary Design Considerations

Levee heights for the armoring alternatives are based on the hydraulic models for the entire Dallas Floodway study area. The hydraulic stations used in the hydraulic models were correlated to the levee baseline stations by overlaying the two stationing systems in plan-view using MicroStation CADD software. The water surface elevations in the hydraulic models could then be used to build proposed profiles for the levee raise alternatives.

The hydraulic models created by the district were translated into graphical representations of the existing levee and the water surface elevations of the various flows. These graphs were used in determining the start and end stationing of the levee armoring areas. The stationing was approximated to the nearest 100 feet in river stationing, converted to the nearest 100 feet in levee stationing, and then used in quantities calculations. There is a margin of error associated with this conversion from river to levee stationing as there is no direct correlation or mathematical representation that can be used. See the attached plan set for corresponding stationing locations from the table. See Figures D-1 through D-6 for water surface elevations plotted against a profile of the existing levee crest height.

Armoring quantities were computed by a trapezoidal method using MicroStation CADD and GEOPAK design software. The lengths in the trapezoidal methodology were computed using cross sections created from a TIN file of the East and West Levees. See Section 1.2 of this appendix for information on the surveyed levee surface. These areas were then entered into a Microsoft Excel spreadsheet that calculated the quantities for armoring based upon equations for the trapezoidal methodology. The existing levee ground surface contains many irregularities which must be considered during design. In some locations along the protected side of the East and West Levee there is a water collection area or sump. Runoff from neighboring communities is collected in these areas and pumped over the levee into the river. At times, it is difficult to determine where the toe of the levee is and where the sump begins. As a result of this, there is variability with regards to the levee armoring template. Defining 50 feet from the protected side toe becomes problematic in certain areas. It was determined that an assumption be made that the levee toe occurs at the top of the sump and not at the bottom of the sump area. The 50 foot of armoring the extended into the sump area and may or may not reach the lowest elevation of the sump, depending upon the width of the sump area. This is to be further refined during the design stages of project development if the plan is to be carried forward as part of a selected plan.

2.2.3 Seepage at the Levee Foundation

The final probable failure mechanism evaluated for risk reduction by structural measures, as identified in the Risk Assessment, was seepage at the levee foundation. This failure mechanism was near the tolerable risk limits and, therefore, needed to be evaluated from an engineering standpoint.

2.2.3.1 Preliminary Mitigation Techniques

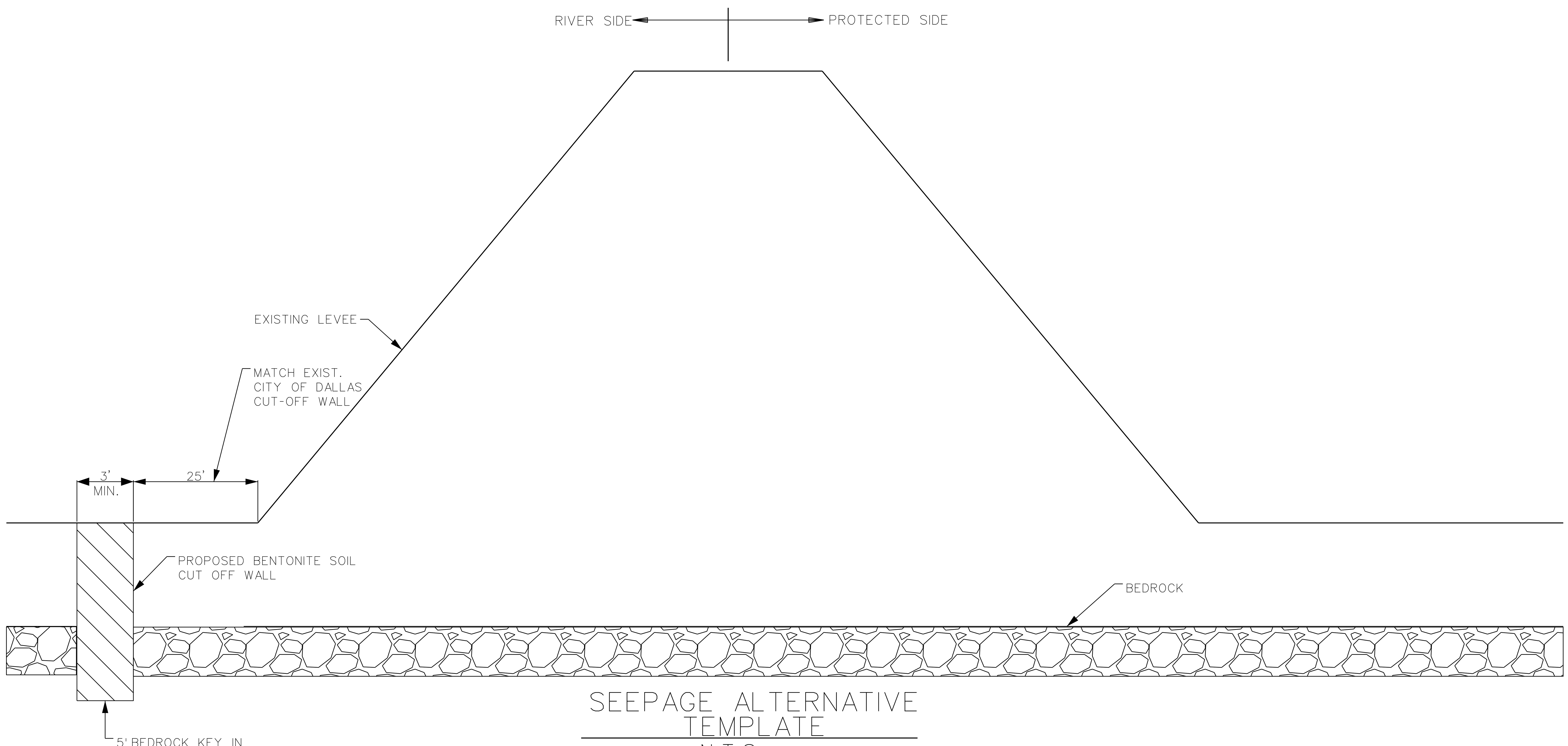
Originally, two mechanisms for reducing seepage at the levee foundation were evaluated. A cut-off wall was proposed at the toe of the river side of the levee. This three foot wide cut-off wall will be composed of a soil bentonite mixture and would tie into the bedrock under the levee with a key-in depth of 5 feet. The extent of the cut-off wall was determined through geotechnical evaluation of the borings in the Dallas Floodway project area. See Appendix B for geotechnical criteria for cut-off wall extent determinations. The initial proposed cut-off wall is shown in Figure D-27.

The second structural measure evaluated was a sand seepage blanket on the protected side of the levee. A three foot thick sand seepage blanket will be put in place on the dry side of the levee. The width of the sand seepage blanket will be approximately 300 feet. The length or extents of the application of the sand seepage blanket would be the same as for the cut-off wall. The two measures were considered independently of each other and would not be used in conjunction with the other measure. The seepage blanket detail is shown in Figure D-28.

2.2.3.2 Final Proposed Mitigation Techniques

After the Risk Assessment and Value Engineering processes (see Chapter 3 of the main report), it was determined that the seepage cut-off wall would be the most effective and economic way of reducing seepage at the levee foundation. The seepage blanket was ruled out based upon real estate concerns and concerns regarding the reduction of the volume in the sump areas on the protected side of the levees.

The seepage cut-off wall was further refined to include a clay cap that was 9 feet wide by 3 feet thick centered above the cut-off wall. The clay cap extends along the entire length of the cut-off wall. Quantities were determined for this final alternative only. The City of Dallas has previously put in place two cut-off walls on the interior of the levee system, one along the East Levee and one along the West Levee. The City of Dallas' cut-off wall runs along the East Levee from station 285+00 to 442+00 for a total of 15,700 feet or approximately 2.97 miles. The City of Dallas cut-off wall along the West Levee extends from levee station 3+00 to 29+00 for a total of 2,600 feet or 0.49 mile. The distance of the cut-off wall from the riverside toe of the levee varies. The center line of the cut-off wall for this analysis was assumed to be approximately 25 feet from the riverside toe. The proposed cut-off walls will match the existing cut-off walls put in place by the City of Dallas with respect to the distance from the toe of the levee. On the West Levee, the proposed cut-off wall abuts the City of Dallas' cut off wall on either side. The bedrock layer that is to be keyed into was identified as either a shale layer or limestone layer. See Figure D-29 for the seepage cut-off wall template that includes a clay cap.



SEEPAGE ALTERNATIVE TEMPLATE

N.T.S.

US Army Corps of Engineers
Fort Worth District

Designed by: C. CHINI
Dwn by: C. CHINI
Reviewed by: D. DANG
Submitted by: DAVID C. BROWN, P.E. CHIEF, CIVIL SECTION
Plot date: 4/18/2013

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

ENGINEERING/ CONSTRUCTION DIVISION DESIGN BRANCH

DALLAS FLOODWAY LEVEE STUDY
DALLAS, TEXAS

FIGURE D-27
CUT-OFF WALL WITH NO CLAY CAP

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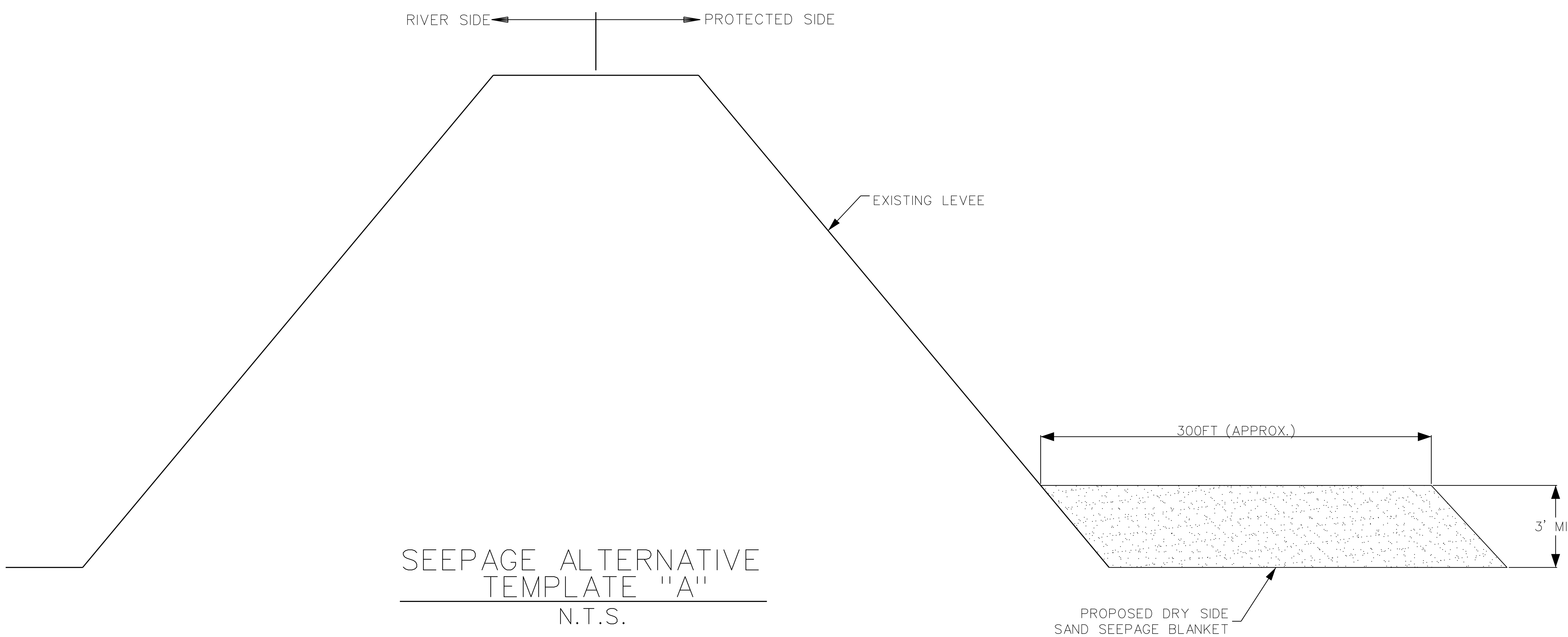

SEEPAGE ALTERNATIVE TEMPLATE "A"

N.T.S.

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Fort Worth District

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

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Reviewed by: D. DANG
Submitted by: DAVID C. BROWN, P.E. CHIEF, CIVIL SECTION

Plot date: 4/18/2013

DALLAS FLOODWAY LEVEE STUDY
DALLAS, TEXAS

FIGURE D-28
SEEPAGE BLANKET

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NOT FOR CONSTRUCTION; SCALED FOR TABLOID PRINTS (11x17)

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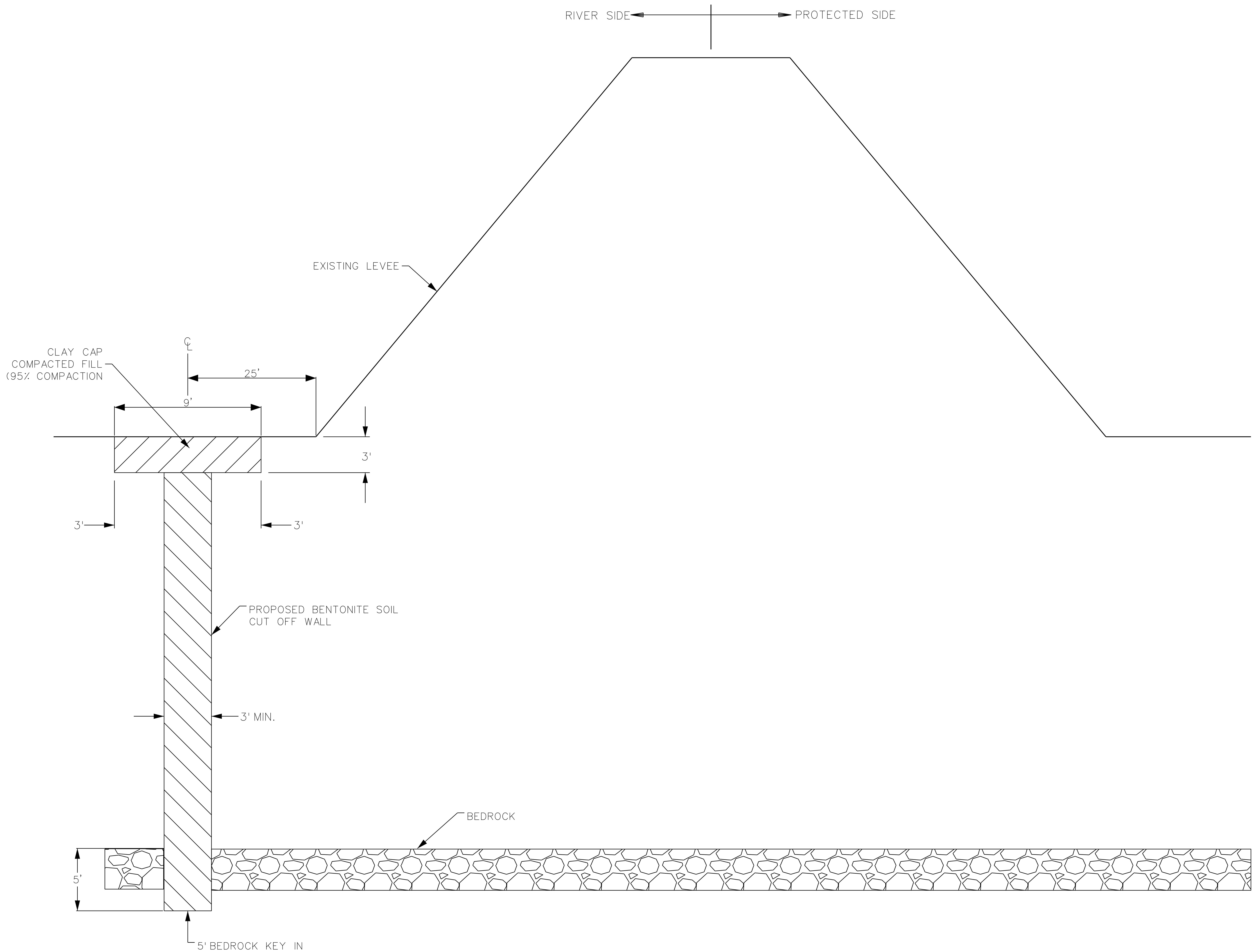
US Army Corps of Engineers
Fort Worth District



TYPICAL SECTION CUTOFF WALL

N.T.S.

Designed by: C. CHINI	Date:
Dwn by: C. CHINI	Sol No.
Reviewed by: D. DANG	Contr No.
Submitted by: DAVID C. BROWN, P.E. CHIEF, CIVIL SECTION	Plot date: 4/18/2013

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ENGINEERING/ CONSTRUCTION DIVISION DESIGN BRANCH

DALLAS FLOODWAY LEVEE STUDY
DALLAS, TEXAS

FIGURE D-29
CUT-OFF WALL WITH CLAY CAP

Sheet reference number:

DESIGN FILE: DF-D-29.dgn

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It was determined that three different construction techniques could be utilized to build the entire extents of the cut-off wall. The first construction technique was to be utilized for a cut-off wall of depth less than 40 feet. Another technique was to be used for cut-off walls greater than 40 feet in depth. The third construction method will occur where a proposed cut-off wall extends under the IH-35 corridor crossing the Elm Fork Levee. This expanse of cut-off wall would need to be jet-grouted to achieve the desired projection without adversely affecting the major roadway.

The quantities are based on the template shown in Figure D-29, the existing ground surface elevations used in previous exercises, and the records of borings in the area. Borings near the locations where cut-off walls would be installed were identified to get an understanding of the bedrock depth along the reach of the cut-off wall. The average end area method was utilized to determine the quantities of cut-off wall that would be needed for each of the construction methods individually. The depth to bedrock was determined via cross sections at every 200 feet along the length of the cut-off wall using the top of ground elevation and interpolating between borings for the bedrock depth. The cut-off wall extends from three feet below surface elevation, to allow for the clay cap, down five feet below the top of bedrock.

Quantities determined for seepage cut-off walls are shown in Table D-10. The total length of cut-off wall comes to 5,054 feet on the East and Elm Fork Levees and 19,320 feet on the West and West Fork Levees. This leads to a combined length of 24,744 feet or 4.69 miles. The depth of the cut-off wall ranges from 44 to 73 feet on the East and Elm Fork Levees and 10 to 62 feet on the West Levee. On the East Levee, the jet-grouted length of cut-off wall was assumed to go to a depth of five feet into the bedrock; however, the top of the cut off wall was determined to be at the toe of the embankment on either side of IH-35. This section of cut-off wall was not required to have a clay cap.

Table D-10. Quantities Seepage Mitigation Cut-Off Walls

East Levee and Elm Fork				
Item	*Depth (feet)*	*Unit*	*Clay Cap*	*Cut-Off Wall*
Total Volume All Reaches		**CY**	**5,054**	**33,364**
Reach 459+00 to 468+00	46 - 58	CY	900	4,999
Reach 531+00 to 551+00	66 - 73	CY	2,000	14,718
Reach 585+50 to 611+04	44 - 59	CY	2,154	12,051
Reach 585+50 to 611+04 (Jet Grout Under I35E) (350 LF)	56 - 59	CY	0	1,596
West Levee and West Fork				
Item	*Depth (feet)*	*Unit*	*Clay Cap*	*Cut-Off Wall*
Total Volume All Reaches		**CY**	**19,320**	**66,261**
Reach 0+00 to 10+00	20 - 21	CY	1,000	1,932
Reach 29+00 to 67+50	20 - 32	CY	2,600	5,572
Reach 29+00 to 67+50	42 - 70	CY	1,250	6,954
Reach 117+50 to 135+50	15 - 40	CY	600	2,202
Reach 117+50 to 135+51	40 - 52	CY	1,200	5,091
Reach 160+00 to 195+50	10 - 25	CY	3,550	6,085
Reach 329+50 to 346+00	53 - 61	CY	1,650	9,826
Reach 390+00 to 409+00	53 - 62	CY	1,900	11,114
Reach 435+50 to 444+00	10 - 35	CY	850	2,099
Reach 450+50 to 480+70	15 - 30	CY	2,300	4,336
Reach 450+50 to 480+70	40 - 56	CY	720	3,555
Reach 530+00 to 547+00	40 - 47	CY	1,700	7,495

2.2.3.3 Seepage Mitigation Assumptions and Preliminary Design Considerations

Cut-off wall quantities were determined using the MicroStation CADD and GEOPAK software. The average end area methodology was used with the assumption that the area of the cut-off wall for each cross section equaled the depth of the cut-off wall, including the key-in to bedrock, less the clay cap, multiplied times the three foot width of the cut-off wall. Cross sections for quantities calculations were cut at approximately every 200 feet utilizing the same TIN files for ground surface generation as in previous (armoring and levee raise) quantities generation.

Boring data was provided with a boring model detailing the location and identification of each boring in the Dallas Floodway Levee System. HNTB boring data was predominantly used as well as some older boring data. Due to the large reaches calling for cut-off walls and the relatively limited amount of borings some interpolation had to be done to determine bedrock depth. The borings used in delineating the depth to bedrock were not just located on the riverside of the levee. Interpolation between borings was attempted to be limited to 300-500 feet wherever possible. The depth to bedrock had a high variability along the identified areas for cut-off walls which causes the potential for high deviation in quantities calculations. In some locations, borings had not reached a depth of bedrock. In these areas, there is a potential that the bedrock depth is much greater than initially considered using interpolation between neighboring borings.

It was determined that limiting the length between borings for interpolation was the best solution for reducing the risk associated with the design and construction of this project feature. Further investigation would need to be complete during the design phases of project development in order to more accurately reflect the quantities of material needed for construction. Multiple borings along the planned reaches of the cut-off walls would need to be complete to reduce the risk of quantity generation and gain a more accurate depiction of the actual subsurface strata prior to final design and cost estimation.

2.2.4 Bridge Assumptions

Refer to Table D-1 for water surface elevations for the 277K cfs flow, with and without the AT&SF Bridge in place, including the low bridge chord and bridge deck elevations for all bridges crossing the Dallas Floodway Levees. For the purposes of reducing the number of tables, the 289K cfs water surface elevation is assumed to be roughly 1 foot above the 277K cfs flow. The 302K cfs flow is considered to be approximately 2 feet above the water surface elevation of the 277K cfs flow. It was assumed that a low beam elevation less than 3 inches below the water surface elevation would be considered a probable margin of error; therefore, no bridge sealing would need to be completed at the respective flow level.

The following bridges are scheduled to be replaced by other entities and were not considered as constraints to raising the levees (i.e. the new replacement bridges are included in the future without-project condition). These are indicated on Table D-1 by highlighting the respective rows in green:

1. IH-30 Eastbound, Westbound, and entrance and exit ramps
2. IH-35 Northbound and Southbound (R.L. Thornton Freeway)
3. Sylvan

The following bridges will not be impacted by the levee raise due to their current height:

1. DART Bridge on the downstream end of Dallas Floodway
2. Jefferson
3. Houston on the East Levee
4. Margaret Hunt Hill Bridge

5. Hampton/Inwood
6. DART Old Bridge on Elm Fork
7. DART New Bridge on Elm Fork
8. Zang
9. Westmoreland on the West Levee
10. Loop 12

Tables D-11 through D-13 show which bridges have low beam elevations lower than the proposed levee crest elevations for the respective water surface elevation alternative. Three different bridge crossing scenarios/configurations were identified. The crossing scenarios are as follows and identified in Tables D-11 through D-13. See sections 2.2.5.1 through 2.2.5.3 for more information regarding the design solutions/scenarios for each affected bridge by configuration.

A. Bridge beams/deck spanning the levee
B. Bridge Abutment at/within the levee
C. Special case of Houston Bridge at West Levee.

Table D-11. Bridge Crossings Impacted at 277K cfs Flow Water Surface Elevation

East Levee				
Bridge Name	*Bridge Crossing Type*	*277K Water Surface Elev. (feet)*	*277K WSE (With AT&SF Bridge Removal) (feet)*	*Low Beam Elev. (feet)*
Corinth	A	425.45	424.46	424.00
Commerce*	B	429.03	428.28	428.54
U. P. R.R.	B	429.60	428.96	428.61
Continental*	A	430.04	429.43	429.20
SH-356	B	436.03	435.73	434.31
West Levee				
Bridge Name	*Bridge Crossing Type*	*277K Water Surface Elev. (feet)*	*277K WSE (With AT&SF Bridge Removal) (feet)*	*Low Beam Elev. (feet)*
Corinth*	A	425.45	424.46	424.37
Houston	C	427.30	426.41	418.50

*Bridge modification is only necessary at this water surface elevation with the AT&SF bridge still in place

Table D-12. Additional Bridge Crossings Impacted at 289K cfs Flow Water Surface Elevation

East Levee				
Bridge Name	*Bridge Crossing Type*	*277K Water Surface Elev. (feet)****	*277K WSE (With AT&SF Bridge Removal) (feet)****	*Low Beam Elev. (feet)*
Commerce**	B	429.03	428.28	428.54
SH-183*	B	437.04	436.77	437.67
West Levee				
Bridge Name	*Bridge Crossing Type*	*277K Water Surface Elev. (feet) ****	*277K WSE (With AT&SF Bridge Removal) (feet) ****	*Low Beam Elev. (feet)*
U.P. R.R.*	B	429.60	428.96	430.22
Continental	B	430.04	429.43	430.00

*Bridge modification is only necessary at this water surface elevation with the AT&SF bridge still in place
**Bridge modification is added only for water surface elevations after the AT&SF Bridge is removed
***Add one foot in water surface elevation for approximate correlation between 277K cfs flow and 289K cfs flow

Table D-13. Additional Bridge Crossings Impacted at 302K cfs Flow Water Surface Elevation

East Levee				
Bridge Name	*Bridge Crossing Type*	*277K Water Surface Elev. (feet)****	*277K WSE (With AT&SF Bridge Removal) (feet)****	*Low Beam Elev. (feet)*
Shady Grove/ E. Irving Blvd	B	435.98	435.67	436.94
SH-183**	A	437.04	436.77	437.67
Westmoreland*	B	433.98	433.59	435.71
West Levee				
Bridge Name	*Bridge Crossing Type*	*277K Water Surface Elev. (feet) ****	*277K WSE (With AT&SF Bridge Removal) (feet) ****	*Low Beam Elev. (feet)*
Commerce*	B	429.03	428.28	430.15
U. P. R.R.**	B	429.60	428.96	430.22
Singleton	B	438.74	438.46	440.00

*Bridge modification is only necessary at this water surface elevation with the AT&SF Bridge still in place
**Bridge modification is added only for water surface elevations after the AT&SF Bridge is removed
***Add two feet in water surface elevation for approximate correlation between 277K cfs flow and 289K cfs flow

The problems associated with these crossing configurations and the proposed solutions are discussed below.

2.2.4.1 Bridge Beams/Deck Spanning the Levee

Some bridges cross the levee crest, with the bridge abutments located on the land side, some distance from the levee. Although these bridges cross the levee, most also have piers positioned within the levee. Some levee raise alternatives would require the levees to be raised above the low beam elevation of these bridges. It was not considered feasible to raise the bridges, so alternative solutions were considered for the purpose of comparing and screening the preliminary levee raise plans. Various alternatives were considered and a concept was chosen to use for preliminary cost estimating purposes. The concept chosen consists of a structural cap to be constructed on top of the levee crown under select bridges, which would be individually designed for each bridge. The structural cap concept was chosen primarily because it would not require additional piers to penetrate deep into the levee. Other alternative solutions may be considered in greater detail beyond the NED plan identification process. The levee cap concept would initially require excavating the upper portion of the earthen levee from beneath a bridge to provide room to work. Then a structural cap of controlled low strength material (CLSM) would be formed and placed. The structural cap would be so configured as to fit between and around the bridge beams, leaving enough space to allow the beams to move freely. The gaps between the cap and the beams would then be filled with an elastomeric substance, which would allow the beams freedom of movement but would prevent seepage during a flood event. Sketches of this concept are shown in Figures D-30, D-31, and D-32. It is assumed that this configuration would only be subject to relatively low head pressures during very infrequent events due to the placement near the top of the levee profile. It is understood that this concept may not represent the solution that is chosen during the final analysis. Another possible solution would consist of constructing a structural wall within the levee, which could act as a bridge support while also preventing seepage through the levee. However, this concept would be more expensive than the CLSM cap concept.

The CLSM levee cap has been proposed for the following bridges, which have beams that span across one or both levees:

1. Corinth
2. Continental
3. SH-183/Carpenter

2.2.4.2 Bridge Abutment at/within the Levee

Some bridges have abutments near or at the levee crest. These bridges allow the possibility of reconfiguring the levees on the land side of the abutments to provide a levee raise without modifying the bridge. However, some alteration of the roadway bridge approaches may be necessary. For example, construction of cutoff walls that extend through the bridge approaches (along the levee and perpendicular to the bridge) may be necessary to prevent the possibility of seepage. These details have not been developed for the preliminary alternatives. However, during the detailed design phase of the study, it should be possible to resolve these design issues with conventional design solutions.

The following bridges have this configuration:

1. Commerce
2. U.P. R.R.
3. Continental
4. Westmoreland, East Levee interface
5. Shady Grove/East Irving
6. SH-356/Irving
7. Singleton

2.2.4.3 Houston Street at the West Levee

The deck of the historical Houston Street Bridge (elevation 424.47) is approximately 3 feet below the 277K cfs flow water surface elevation with the AT&SF Bridge in place and about 2 feet below the same water surface elevation with the Bridge removed where it crosses the West Levee. The team assumed that using sandbags would be sufficient for all flows detailed in Tables D-11 through D-13 except for the 302K cfs water surface elevation where the AT&SF Bridge is still in place. In this case, a floodwall would need to be constructed to retain the projected water surface elevation.

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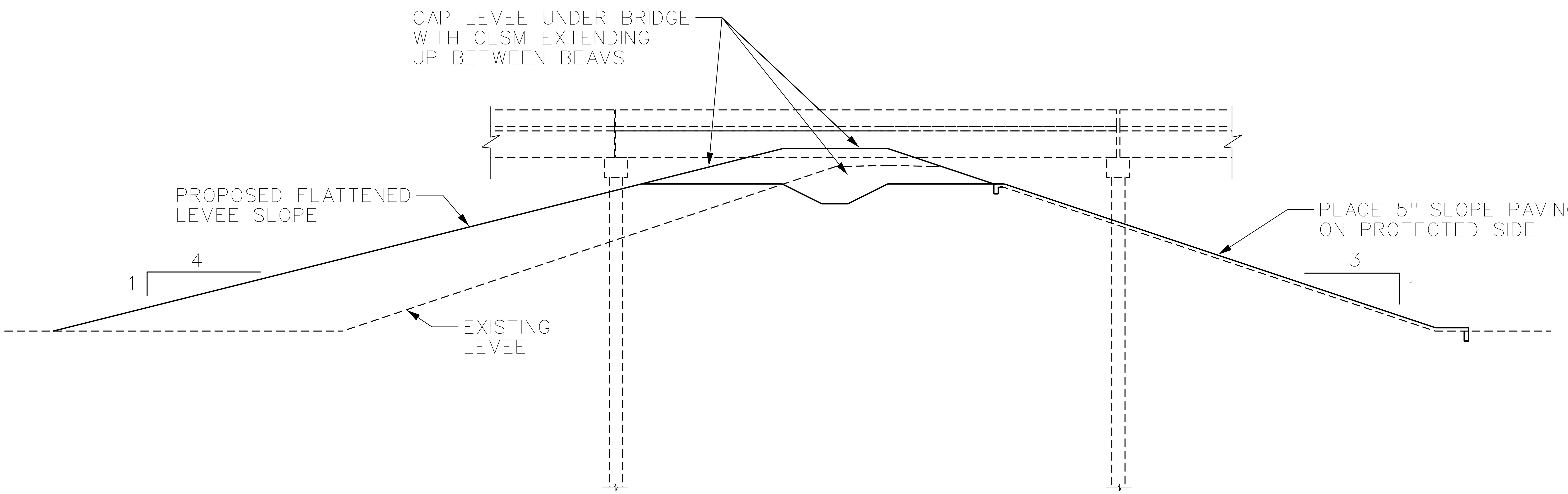

LEVEE CAP UNDER BRIDGES

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Fort Worth District

Symbol	Description	Tracking No.	Action	Date

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Dwn by: | Sol No. xxxxxx-xx-x-xxxx
Reviewed by: | Contr No.
Submitted by: DAVID G. BROWN, P.E. CHIEF, CIVIL SECTION | File name: | Plot date: 4/18/2013 | Plot scale:

U.S. ARMY ENGINEER DISTRICT,
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FORT WORTH, TEXAS

ENGINEERING/
CONSTRUCTION DIVISION
DESIGN BRANCH

DALLAS FLOODWAY
TRINITY RIVER, TEXAS
FEASIBILITY STUDY
FIGURE D-30
LEVEE CAP UNDER BRIDGES

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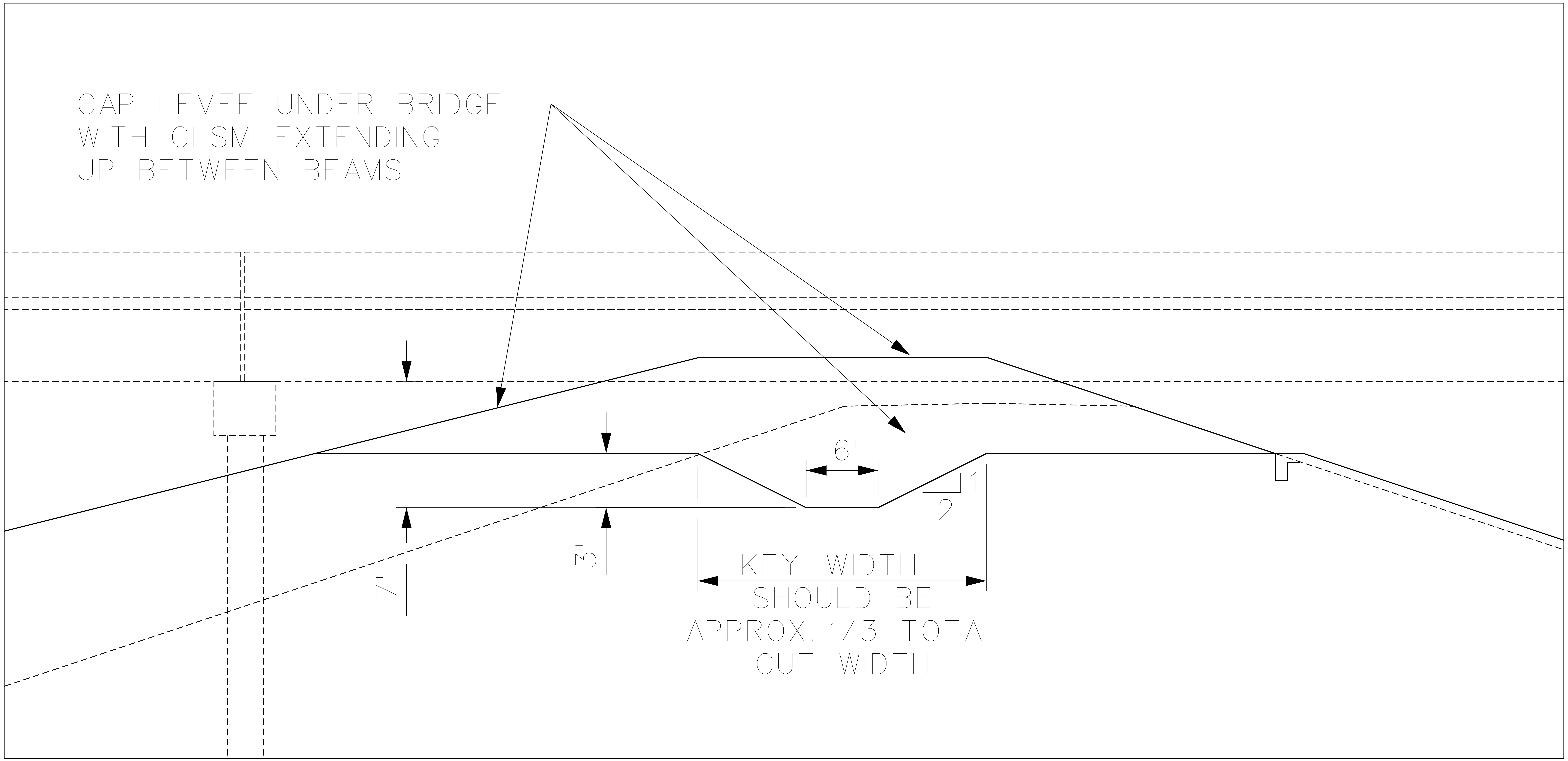

DETAIL OF LEVEE CAP

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CONSTRUCTION DIVISION
DESIGN BRANCH

Submitted by:
DAVID C. BROWN, P.E.
CHIEF, CIVIL SECTION

DALLAS FLOODWAY
TRINITY RIVER, TEXAS
FEASIBILITY STUDY
FIGURE D-31
LEVEE CAP DETAIL

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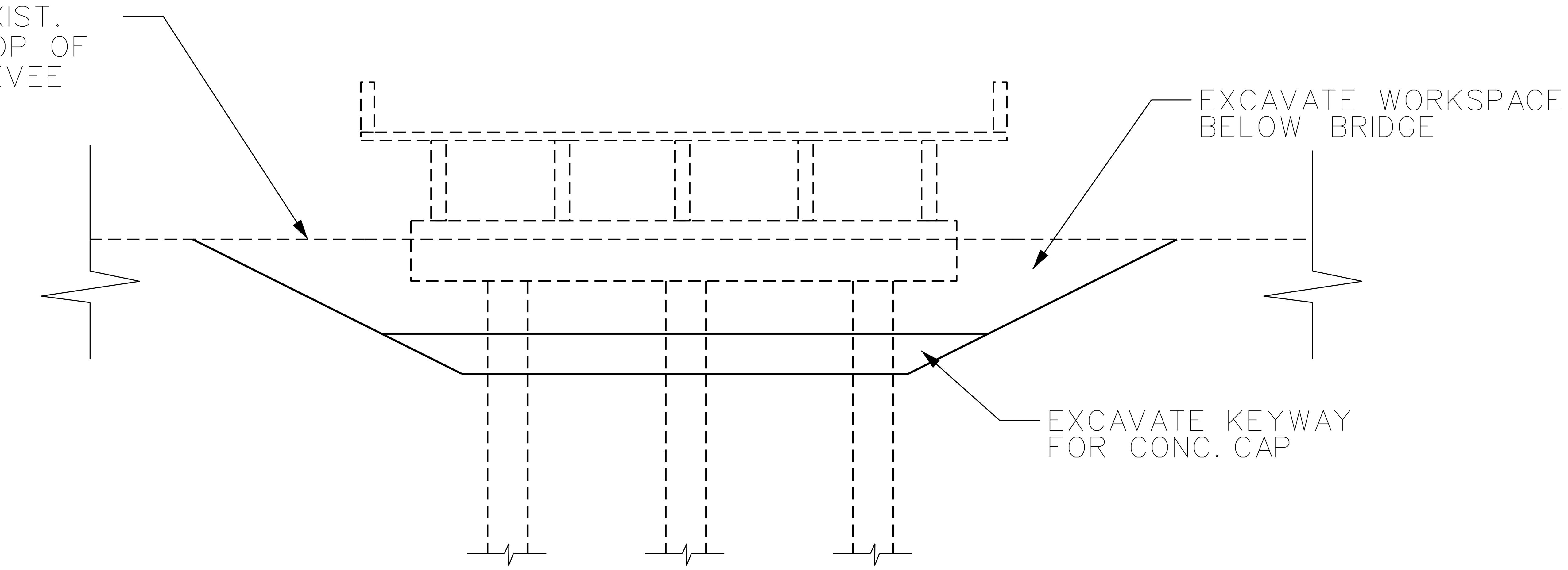

STAGE 1

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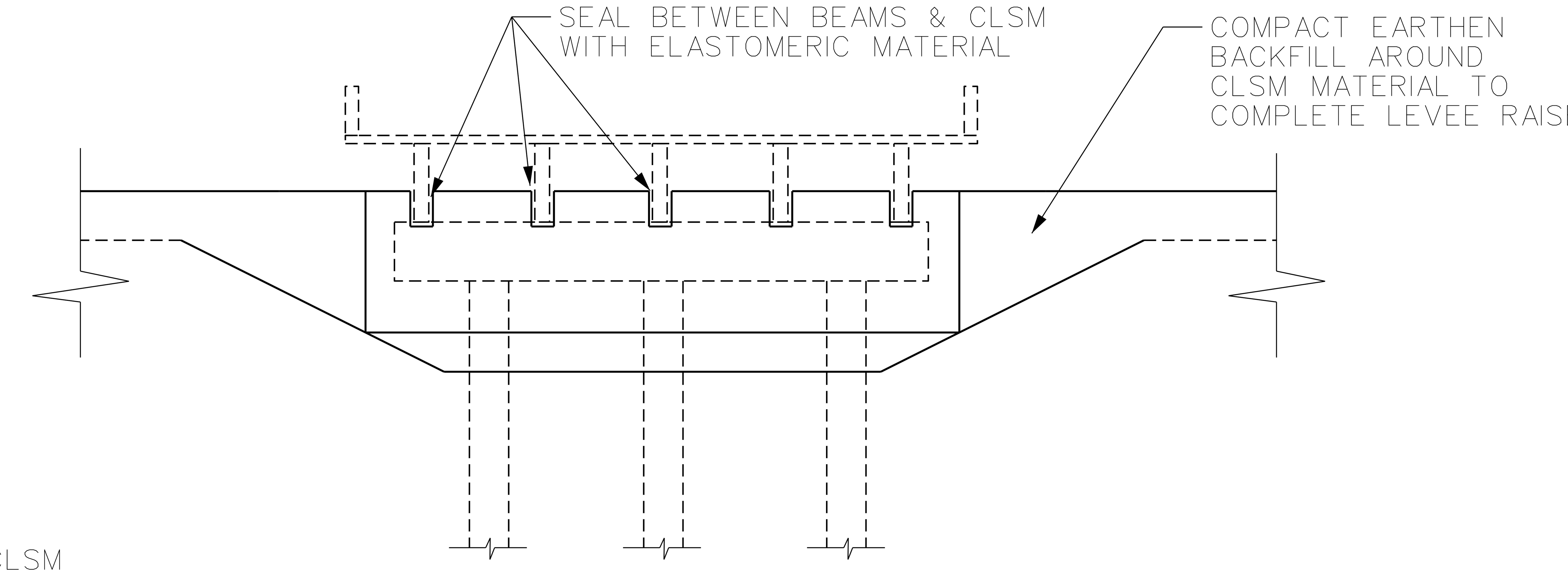

STAGE 3

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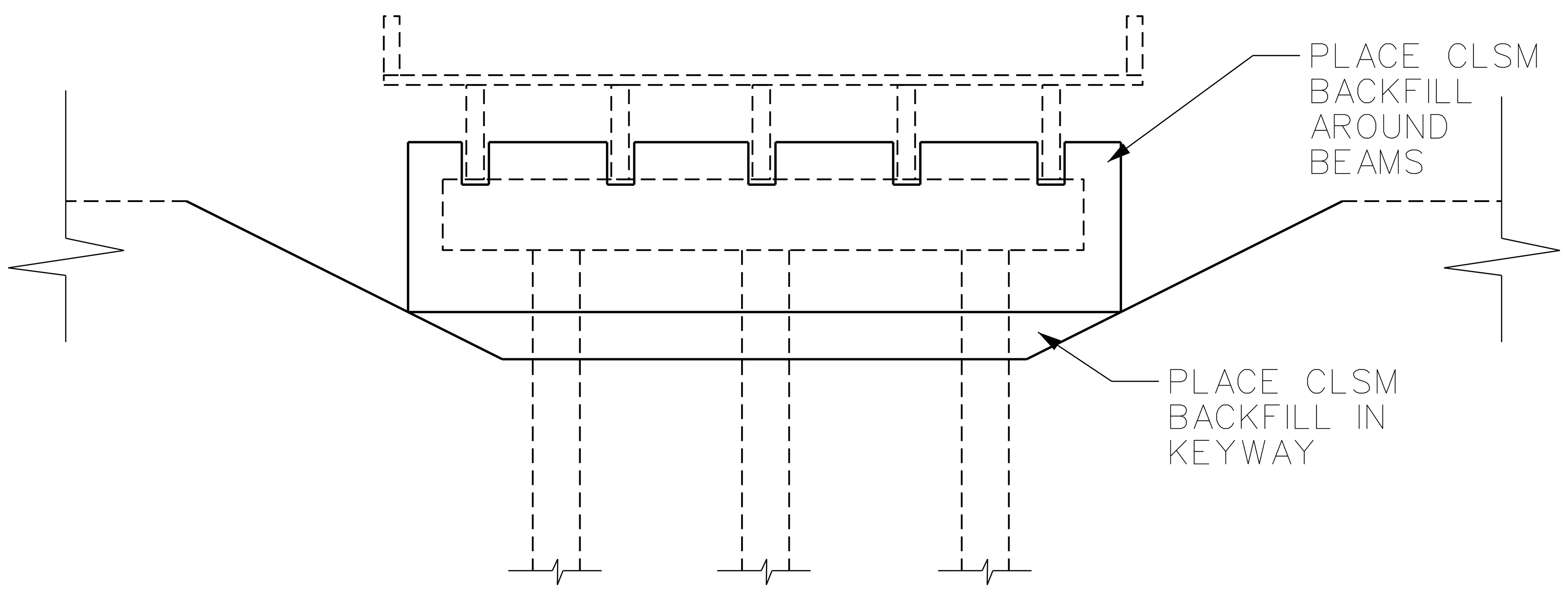

STAGE 2

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FORT WORTH, TEXAS

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Designed by: | Dwn by: | Reviewed by: | Submitted by: DAVID C. BROWN, P.E. CHIEF, CIVIL SECTION

Date: xxx xx | Sol No. xxxxxx-xx-x-xxxx | Contr No. | Plot date: 8/1/2013 | Plot scale:

Rev.

Symbol | Description | Tracking No. | Action | Date

DALLAS FLOODWAY
TRINITY RIVER, TEXAS
FEASIBILITY STUDY
FIGURE D-32
LEVEE CAP UNDER BRIDGES
WORK PHASES

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2.2.4.4 Bridge-Levee Interface

Portions of bottom chords of several bridges are below the water surface elevation corresponding to the 277K cfs flow with AT&SF Bridge removed. This is indicated as negative freeboard by Table D-1 and Table D-14. It may be possible that accumulated storm debris during a maximum flood event could induce drag and buoyant forces of sufficient magnitude to displace the bridge at the levee. If a bridge is displaced from its support the proposed raised levee under the bridge or the seal proposed between the levee and the bridge could be compromised. This could result in a localized notch or weir in the levee crest. Whether this is possible is dependent on several factors; the velocity of flow, the duration of the rise in water surface elevation, the volume of debris, and the method of anchorage of the bridge superstructure to the support.

Table D-14. Flow Velocity and Duration of Contact at Bridge Crossings Impacted at 277K cfs Flow Water Surface Elevation

East Levee											
				Baseline				*With AT&SF Bridge Removed*			
Bridge Name	*River*	*Station*	*Low Beam Elev.*	*Velocity (feet /sec)*[1]	*Duration (hrs)*	*277k W.S. (Steady Flow)*	*Low Beam Free-board*	*Velocity (feet/sec)*	*Duration*	*277k W.S. (Steady Flow)*	*Low Beam Free-board*
Corinth	Main Stem	109983	424.00	2.5	3.2	425.45	-1.45	--[2]	--[2]	424.46	-0.46
Commerce	Main Stem	120729	428.54	--[2]	--[2]	429.03	-0.49	--[3]	--[3]	428.28	0.26
U.P. R.R.	Main Stem	121623	428.61	3	1	429.6	-0.99	--[2]	--[2]	428.96	-0.35
Continental	Main Stem	122860	429.20	--[2]	--[2]	430.04	-0.84	--[2]	--[2]	429.43	-0.23
SH-356	Elm Fork	4792.5	434.31	1.5	5.8	436.03	-1.72	1.5	5.7	435.73	-1.42
West Levee											
				Baseline				*With AT&SF Bridge Removed*			
Bridge Name	*River*	*Station*	*Low Beam Elev.*	*Velocity (feet /sec)*[1]	*Duration (hrs)*	*277k W.S. (Steady Flow)*	*Low Beam Free-board*	*Velocity (feet/sec)*	*Duration*	*277k W.S. (Steady Flow)*	*Low Beam Free-board*
Corinth	Main Stem	109983	424.37	--[2]	--[2]	425.45	-1.08	--[2]	--[2]	424.46	-0.09
Houston	Main Stem	116214	418.50	2.5	16.8	427.3	-8.8	2.5	16.4	426.41	-7.91
Continental	Main Stem	122860	430.00	--[2]	--[2]	430.04	-0.04	--[3]	--[3]	429.43	0.57

[1]Velocity estimate obtained from flow distribution feature in steady flow HEC-RAS. The value was taken 50 feet from the bridge abutment and is rounded to the nearest 0.5feet/sec. Velocities are similar between steady flow and unsteady flow models.
[2]Water surface does not reach low beam elevation in unsteady flow model.
[3]Water surface does not reach low beam elevation in steady flow model.

At this time no stability analysis has been performed for any of these bridges; all impacted bridges except Houston Bridge might have the potential to withstand a 277K cfs flooding event. It should be noted that although the flood event will carry debris and the volume of debris is indeterminate, the velocity is reduced at the channel edges on the levees in comparison to the velocity at mid channel. Also, the duration of the event where bottoms of beams are submerged is rather brief. Preliminary analysis of the flood characteristics indicates the velocity adjacent to the levees is in the range of 1.5 to 3 feet per second. It also indicates that the duration of the event is in the range of 1 hour to 6 hours, except for Houston Bridge, which is indicated to be 16.4 to 16.8 hours. In discussion of risk, the PDT has determined the probability of developing a significant debris mass during the peak flow and duration that, except for Houston Bridge, the risk to the levees might be minimal. The concern at the Houston Street Bridge is the 277K cfs flood event would cause a breach of the West Levee.

The risk assessment (Appendix C) took the elevations of the bridge decks into account. No credible failure modes for the levee were identified based on debris loading and subsequent failure of a bridge structure. The failure mode for erosion of a bridge pier was deemed to be not significant and was not carried forward for risk analysis. A risk informed decision was made to accept the low risk of bridge failure based on the outcome of the Risk Assessment and develop the bridge seal plans in PED as appropriate.

2.2.5 Summary and Conclusions

The results of the FRM plan development and subsequent NED analysis concluded that USACE's FRM plan would consist of two components: a levee raise to meet the 277K cfs flow water surface elevation and the removal of portions of the AT&SF Bridge and earthen berm. The levee raise will be completed using 3H:1V side slopes in accordance with the final iteration of quantity modeling. Armoring of the levee and cut-off walls were determined infeasible. Utility relocations and bridge sealing plans are to be further developed in future stages of the study and in project design. The final FRM plan including affected utilities and the selected bridge sealing plan is discussed in Section 2.3 regarding the refining of the FRM plan.

Due to the use of 3H:1V side slopes in levee raises, the City of Dallas requested that flatter side slopes be carried forward into the next phase of the study to aid in operation and maintenance. Under the side slope flattening plan, the riverward side slopes of the entire levee system would be flattened to a 4H:1V side slope. This flattening is already in place along some parts of the levee, predominantly at the downstream end of the levee system. The design and feasibility of this proposal is discussed further in Section 2.4. This design preference is carried forward as a City of Dallas preferred plan and is part of the overall FRM plan, but not part of the NED Plan developed by USACE.

2.3 FRM Plan Refinement

The first added segment in the evaluation of the City of Dallas' BVP and IDP Plans was determined to be the FRM. This plan was determined based on NED analysis of the various probable modes of failure identified in the Risk Assessment. This selection process is described in more detail in Section 2.2 of this appendix.

The FRM plan was identified to have two major components as part of the design. This included a levee raise in the low spots of the levee to match the water surface elevation of a 277,000 cfs flow. Additionally, plans were developed to remove portions of the AT&SF trestle bridge including earthen berms, wooden trestles, and spans of steel supported railroad deck.

In order to be consistent with other disciplines, the survey adopted for use in this refinement of the FRM Plan was slightly different than the survey used in previous study iterations. The survey includes both levees and the area in between the East and West Levees including bathymetry data for the Main Stem of the Trinity River. The Elm and West Fork survey showed topographic information extending from the sumps on the landside of the levee past the respective river fork, but no bathymetry data was available. The survey information used is based off the 1991 Survey done of the Floodway with updates in 2000. This is to match the data in the HEC-RAS models. Further updates of the survey are available; however, they are not used in the current stage of the study to ensure a baseline comparison is set through all studies.

2.3.1 277K cfs Levee Raise

The preliminary locations for the levee raise to meet the 277K cfs water surface elevation were developed based on plots generated from a steady state analysis HEC-RAS model as described in Section 2.2.2. This method required the conversion between USACE Levee Stationing and River Stationing based upon a graphical output. In order to reduce error and further refine the levee raises, a water surface elevation based upon levee stationing was needed.

Based on constructability, it was assumed that a levee raise of less than 6 inches, unless connected to a larger section of levee raise, would not be a part of the FRM Plan. These locations would utilize temporary localized flood fighting measures. These areas can be seen on the profile sheets C-201 through C-209 and are called out as such on the individual sheets.

During the plan refinement, GEOPAK site software was used to create the models for determining quantities and impact areas. Initially with this process, an original model was created using the assumptions in Section 2.2 for the levee raise. This model was used to generate preliminary impacts for construction and for the Environmental Impact Statement. This included the borrow pits. Based on further investigation of the requirements for the levee raise, new assumptions were required that contradicted the initial assumptions in Section 2.2. Specifically, this is in regards to the use of the eight inches of crushed limestone access road as part of the effective levee height. The assumption changed to no longer include the levee road, proposed or existing, in the effective levee height for FRM Plan development. An additional model was needed that showed greatly expanded impact areas and material quantities for FRM. The initial model and its quantities are not discussed in this appendix. The new model overrides all aspects of the original model, and the new model is discussed in detail in the following sections.

2.3.1.1 Risk Register and Change in Scope

In the development of the FRM Plan, Section 2.2, several base assumptions were used to generate quantities and to determine scope of work. The road surface template shown in Figure D-24 assumed that the crushed gravel road surface could be considered part of the effective levee height. Due to a change in assumptions, this is no longer the case. The crushed limestone road cannot be considered part of the overall levee height and has been placed on the top of the effective levee as shown in Figure D-33.

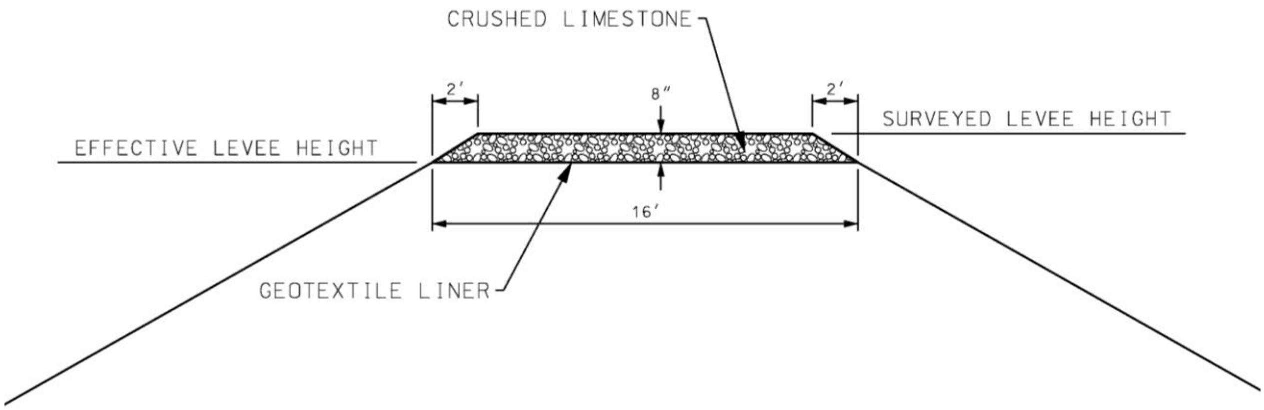


Figure D-33 Revised Proposed Access Road Cross Section

Figure D-33 shows the top of the effective levee below the road base and the surveyed top of levee at the crest of the access road. The logical progression of this determination carried over to the existing conditions of the levee and its access road. Based upon a revisited look at the geotechnical borings in the crest of the levee, the existing levee access road was determined to be at a depth of eight inches below the surveyed top of levee. This is a change from the initial assumption of two feet of excavation and will be reflected in the revised excavation quantities.

In previous exercises used to develop the FRM Plan, the surveyed top of levee was assumed to be the effective levee height. The survey was superimposed onto the projected water surface elevation for the various flow rates and the reaches for levee raise were identified. However, the reconsideration of effective levee height caused a revisiting of the levee raise reaches, which was the consequence listed in the original risk register. The effective levee height of the existing levee is eight inches below the surveyed levee height. Therefore, the profile of the existing levee was offset vertically down eight inches to best estimate the effective levee height. This caused a substantial increase in area to be raised as part of the 277K levee raise.

2.3.1.2 Revised Quantities and NED Plan Formulation

There were concerns that this change in effective levee height and the resultant increase in levee raises and quantities would change the results for NED analysis used in the formulation of the FRM Plan. To determine an estimate on the potential impacts to the NED determination of the FRM Plan, an initial scaling of values to determine approximate quantities for the revised 277K levee raise. Using the quantities in Table D-4, an interpolation between the 277K cfs and 289K cfs levee raise was used to generate quantities (Table D-15). The 289K cfs water surface elevation is approximately one foot above the 277K cfs water surface elevation. The difference between the old 277K levee raise and the revised assumptions is an eight inch difference. Interpolation was done between these two estimated quantities in Table D-4 assuming a levee template in the shape of a trapezoid with a constant slope of 3H:1V on the side slopes and a levee crest width of 16 feet.

These approximations of quantities are very rough and were used to determine the effects on NED plan formulation only. It was assumed that a revised quantity calculation for the new FRM plan would take place for cost purposes.

Table D-15. Scaled 277K Levee Raise Quantities from Table D-4

Item	*Unit*	East Levee		
		277K	*277K Revised*	*Percent Change From Table D-4*
LEVEE RAISE VOLUME	CY	41,578	**49,699**	20%
REMOVE EXIST. LEVEE ROAD	CY	25,804	**12,678**	-51%
SCARIFICATION ON FLAT SURFACE (6" DEPTH)	CY	7,353	**11,636**	58%
SCARIFICATION ON SLOPE (MIN. 10' WIDE STEP EXCAVATION)	CY	6,391	**14,346**	124%
SEEDING AREA	ACRE	14.72	**31.56**	114%
NEW ROAD 8" CRUSHED LIMESTONE	CY	3,902	**6,642**	70%
GEOTEXTILE ROAD LINER	SY	19,896	**33,984**	71%
Item	*Unit*	**West Levee**		
		277K	*277K Revised*	*Percent Change From Table D-4*
LEVEE RAISE VOLUME	CY	20,078	**40,824**	103%
REMOVE EXIST. LEVEE ROAD	CY	10,155	**9,418**	-7%
SCARIFICATION ON FLAT SURFACE (6" DEPTH)	CY	3,925	**9,000**	129%
SCARIFICATION ON SLOPE (MIN. 10' WIDE STEP EXCAVATION)	CY	5,234	**20,427**	290%
SEEDING AREA	ACRE	8.53	**28.71**	237%
NEW ROAD 8" CRUSHED LIMESTONE	CY	2,247	**5,136**	129%
GEOTEXTILE ROAD LINER	SY	11,459	**26,192**	129%

These quantities generated a rough cost that showed a substantial increase in project costs between the old and revised 277K levee raises. At this point, the 277K levee raise was the only quantity estimated as there has not been another data point created (302K cfs levee raise with 3H:1V side slopes) to determine the resultant effects on the 289K levee raise. By only changing the quantities and costs for the 277K cfs levee raise, the NED plan formulation looked to shift to the 289K cfs levee raise being the preferred plan. However, further analysis showed that the scope of the 289K cfs levee raise increased significantly as well. By raising the projected 277K cfs water surface elevation one foot vertically, an approximate 289K cfs water surface elevation was superimposed on the effective levee height. Revised lengths for both the 277K and 289K cfs water surface elevations were determined using this overlay of the effective levee height. The revised levee raise lengths for each water surface elevation are shown in Table D-16 as compared to the original levee raise impacts used to generate quantities in Table D-4.

Table D-16. Revised Levee Raise Lengths from Initial NED Plan Formulation

East Levee		
	277K cfs	*289K cfs*
NED Impacted Length (LF)	15,800	26,900
New Assumption Impacted Length (LF)	25,740	33,005
Percent Increase	63%	23%
West Levee		
	277K cfs	*289K cfs*
NED Impacted Length (LF)	9,100	20,800
New Assumption Impacted Length (LF)	23,529	36,567
Percent Increase	159%	76%

Table D-16 shows that there is a significant increase in the revised 289K cfs levee raise compared to the initial assumptions in NED plan formulation. The levee raises analyzed in the NED plan formulation were reanalyzed from a cost perspective to determine whether the formulation would change. Based on the changes, the 277K cfs levee raises remains the NED Plan and no additional formulation was required.

2.3.1.3 277K cfs Water Surface Elevation

Original data for water surface elevations were based upon river stationing for the Main Stem of the Trinity River and the West and Elm Forks. To correlate the water surface elevation data to East and West Levee Stationing, the pattern lines used in the creation of the HEC-RAS model were utilized to create cross sections based upon the levee center line. Each cross section had a designated water surface elevation based upon its river stationing number. By determining where the pattern line for the cross section intersected each levee center line, a correlation between East and West Levee stationing and river stationing was determined.

The data was converted using a combination of the Bentley MicroStation and GEOPAK Site products. Data was exported using functions within the GEOPAK program and was edited in Microsoft Excel.

A GEOPAK input file was then created for the Main Stem East Levee, Main Stem West Levee, West Fork, and Elm Fork. This input file prescribed the creation of a profile where the 277K cfs water surface elevation was the vertical data and the horizontal data, and the stationing of the levee. These profiles are shown juxtaposed against the existing levee surface on profile (surveyed and effective levee height) sheets C-201 through C-209 on the accompanying plan set.

2.3.1.4 Quantities

In order to generate a more accurate cost estimate to use for the NED plan, quantities for the 277K cfs levee raise were redeveloped. Using the base survey information from the 1991 survey, a model was created to determine the material needs for raising the low spots of the levee. The model of the new levee surface was created using Bentley GEOPAK Site. Based upon the levee reaches identified using the effective levee height shown by the profiles on sheets C-201 through C-209, a model was created to excavate the top of levee in all required areas to a depth of eight inches. This was based off the identified levee center line. These sections of cut were then evaluated using GEOPAK for volume needs. The returned volume was used as the removal volume for the existing road and the surface area of the element was utilized as the area of scarification on a flat surface. This area of scarification was then multiplied by a factor of 6 inches to determine a volume in CY of scarification on a flat surface.

This excavation model was exported and used as the base surface for the levee raise model. The levee raise model was created using GEOPAK and forces the levee raise using break lines from the protected side edge of the excavation up to the required height to meet the water surface elevation of the 277K cfs flow. This model ties back into the side slopes of the levee at a 3H:1V slope and includes a 16 foot levee crest that is consistent with previous models. This model only generates quantities up to the effective levee height. The volume analysis tool in GEOPAK was used for each reach to determine the levee raise fill requirement. The resultant surface area of the element after the subtraction of the levee excavation surface area was used to determine the side slope scarification. This value was multiplied by a factor of 0.75 feet per square yard to determine the side slope scarification volume. This was based off of an estimation of previous quantity iterations.

Following the generation of this model for effective levee height, a final model was generated to show surveyed levee height. This model assumes that an eight inch layer of crushed limestone extends from crest to crest on the effective levee height. GEOPAK is able to export values of volume and surface area to determine the proper quantities of crushed limestone and Geotextile liner required for the road surface per Figure D-33.

The total change shown in Table D-17 compares the combine quantity of the main stem and fork to the corresponding 277K quantity in Table D-4. The quantities shown in Table D-4 are based off of an average end area methodology used to generate a baseline cost for analysis. Scarification volume is compared to the total scarification volume (flat and sloped) that is shown in Table D-4. A negative change indicates that the revised quantities shown in Table D-18 are decreased from those in Table D-4. A positive change indicates an increase in quantity. These estimation techniques are based upon previous iterations of quantity generation for this site and utilize the information computed in the GEOPAK Site Modeler for the modeled levee raise.

Table D-17. Comprehensive Analysis 277K cfs Levee Raise Quantities

		East Levee			West Levee		
	Unit	*Main Stem*	*Elm Fork*	*Change from Table D-4*	*Main Stem*	*West Fork*	*Change from Table D-4*
Length	**LF**	17,845	7,895	62.9%	14,594	8,935	158.6%
Existing Road Cut Volume	**CY**	5,502	4,089	-62.8%	4,221	3,245	-23.9%
New Crushed Limestone Road	**CY**	7,050	3,119	160.6%	5,705	2,382	259.9%
Geotextile Liner	**SY**	31,724	14,036	130.0%	25,673	10,720	217.59%
Net Fill	**CY**	21,082	12,852	-18.38%	35,163	6,030	96.16%
Seeding	**ACRE**	0.96	0.57	-90.2%	1.50	0.06	-81.71%
Scarification Volume	**CY**	17,529	9,982	100.2%	29,029	8,521	309.99%

While the impacted length of the levee increased for both the East and West levees, there was a decrease in the net fill quantities associated with the East Levee. This is due to the large reduction in road excavation volume. In the initial FRM quantity generation, it was assumed that two-feet of excavation was required to remove all existing road material. This excavated material was then replaced by suitable material with only eight inches of crushed limestone for the road structure. In this iteration of quantity generation, only the top eight inches of existing levee was excavated prior to levee raises. This significantly reduces the amount of fill material required in any given reach, which led to the overall reduction in fill material.

2.3.1.5 Levee Improvements under Bridges Scheduled to be Replaced

There are a few low spots in the levee that occur under bridges that are scheduled to be replaced. The identified areas included only the locations that were completely contained under a bridge deck. There were other bridges scheduled to be replaced that require minor work done underneath, however, the extents of the section to be raised extended beyond the limits of the bridge deck significantly. The locations identified occur on the East Levee at the crossings of IH-35E and IH-30. These quantities are included as part of the overall quantities of the project as shown in Table D-18.

The work under the relocated bridges would need to be coordinated with the Horseshoe Project for replacing the bridge in order to minimize construction time and decrease construction costs for the NED Plan. The quantities associated with these specific areas are broken out in the table below. They represent a relatively small portion of the work to be done in relation to the overall levee raise scope. Table D-18 lists the combined levee work that will need to be completed as part of the raise under both the IH-35E and IH-30 bridges.

Table D-18. Quantities for Levee Raise under Bridges Scheduled for Replacement

	Unit	*East Levee Subset*
Length	LF	439
Existing Road Cut Volume	CY	139
New Crushed Limestone Road	CY	173
Geotextile Liner	SY	780
Net Fill	CY	716
Seeding	ACRE	0.01
Scarification Volume	CY	1,001

2.3.1.6 Borrow Pits

The borrow locations, assumptions, and cross sections for the levee raise material mostly remained the same as in previous exercises, see Section 2.2.2.4. In this instance, however, the borrow pit was modeled as part of the overall levee system in order to create an accurate surface for future models to build upon. Additionally, it was assumed that all borrow material would come from one borrow pit between the West Levee and the Trinity River. This is to reduce the footprint of the borrow pits by including them within the footprint of the proposed West Dallas Lake as part of the City's BVP. See Section 2.5.3.3 for information on the location of West Dallas Lake. Additionally, the width of the deepest, middle portion of the borrow pit was expanded to minimize impact area. The width of the modeled borrow pit in this iteration of quantity development was determined to be 180 linear feet. The modeling was done using GEOPAK Site Modeling software. Compaction and bulking factors were both assumed for estimation purposes to be 20% from in situ conditions. The information related to borrow pit calculations is shown in Table D-19. The overall footprint of the borrow pits are shown on sheet CG103 to CG104.

Table D-19. FRM Plan Refinement of Levee Raise Borrow Pits

Borrow Pit Quantities (Revised FRM Levee Raise)			
Total Fill Required	**In Place**	CY	75,127
	With 20% Compaction Factor	CY	**93,909**
Total Borrow Pit Area		SF	486,541
Total Borrow Pit Area		ACRE	11.17
Total Material Excavated		CY	107,395
Total Unusable Material	**Excavated Volume**	CY	19,020
	Excavated Volume with 20% Bulk	CY	22,824
Total Usable Material	**Excavated Volume**	CY	**94,452**
	Excavated Volume with 20% Bulk	CY	113,342
Difference: Excavated Usable Material (No Bulk)-Required Fill (With Compaction Factor)		CY	**543**

2.3.2 AT&SF Railroad Bridge Modification

As described in Section 2.2.1.2, the AT&SF Bridge consists of a combination of wooden trestles, earthen embankments, and sections of concrete supported railway. The City of Dallas has built a biking trail incorporating portions of the wooden trestle to preserve the historical significance. The remainder of the bridge including the earthen embankments will be removed as part of the USACE FRM Plan. The earthen berms and other existing bridge features are located at the far downstream end of the Dallas Floodway Levee System. A significant hydraulic impact on the Floodway can be seen in the removal of these features, especially considering the debris collection these features generate.

2.3.2.1 Earthen Berm Removal

Two earthen berms are proposed to be removed as part of the AT&SF Bridge removal plan. One berm is located in the center of the Floodway on the south side of the Trinity River. The second berm extends out from the high ground of the West Levee and juts into the Floodway. These two berms were assumed to be completely demolished down to surrounding grade. Assumptions on drainage were made to ensure the removal of these berms did not create additional low spots that could pose hydraulic or geotechnical issues. The berm removals were modeled using the GEOPAK software and was included as part of the final FRM plan grading plan and surface file. The surface was graded to minimize impact while trying to match existing features as closely as possible.

2.3.2.2 Quantities calculations

The original quantities for demolition are discussed in Section 2.2.1.2. Values were cross checked with current survey and aerial data and remained constant. The only quantity that was recalculated was the earthen berm. These two berms were originally calculated using the average end area method. These quantities were refined in accuracy using GEOPAK. As part of the GEOPAK Site modeling software, earthwork quantities were calculated through the analysis tools. A 20% bulking factor was assumed in order to be consistent with previous borrow pit calculations. Table D-20 shows the quantity breakdown for each berm and the net volume of material to be removed as part of the AT&SF Bridge removal.

Table D-20. AT&SF Bridge Earthen Berm Removal

Description	*Net Volume (CY)*	*Net Volume with 20% Bulk (CY)*
Middle Berm	21887	**26,264**
West Berm	22046	**26,455**
Total		**52,719**

It is also assumed that the quantity of material removed from these locations is unsuitable fill for levee raise and slope flattening work. Therefore, pending further testing for geotechnical suitability and environmental considerations, the quantity of material will be disposed of in a landfill location. The earthen material is assumed to be free from any contaminants that would limit the usage of the material and restrict the disposal sites.

2.3.3 Utilities

The current FRM plan entails the raising of the levee in low spots to match the water surface elevation for the 277K cfs flow and the removal of certain portions of the AT&SF Bridge. The levee raise is vertically minimal in the scope of utilities. At this stage of the project, there are also no utilities identified that would be affected by the earthen berm removal of the AT&SF Bridge. The FRM plan does not require major utility work that would add significant costs to the scope of work.

2.3.4 Bridge Work

As a result of the increased capacity of the levee, the increased maximum water surface elevation comes into contact with several bridges. As part of the FRM Plan, it is important to mitigate the risks associated with bridges having low chords or bridge decks below the proposed water surface elevation. The determination of affected bridges and solutions based on bridge type and water surface elevation are described in Section 2.2.5. This section is a summary of the bridge modifications due to the selected FRM Plan.

Due to the projected water surface elevation from the FRM Plan, there are four bridge-levee interfaces that require some sort of structural solution to mitigate potential risks. There is one bridge crossing of the levees that have Scenario A: bridge beams/deck spanning the levee (Corinth East Levee), and two bridges with Scenario B: bridge abutment at/within levee (Union Pacific Railroad East Levee, SH-356 East Levee). For further detail on the bridge impacts, reference Table D-11 and Section 2.2.5.1 and 2.2.5.2. Figures D-30, D-31, and D-32 show schematics and typical details for the bridge sealing plans.

The final bridge levee interface involves Scenario C of Houston Bridge at the West Levee. Houston Bridge is a historic bridge that, at the West Levee, has a bridge deck significantly lower than the top of the abutting levee. The levee was built around the bridge and rises above the bridge deck. At the 277,000 cfs flood water surface elevation, it was determined that a non-permanent measure would be the best flood fighting technique during this flood condition. Sand bags or other temporary flood wall is the suggested flood fighting technique at the intersection of Houston Street and the West Levee. During flood fighting operations and potential evacuations from the City of Dallas' low lying areas, Houston Street would not be accessible or a viable evacuation route. It will be important to block both sides of bridge via traffic barriers and proper traffic control/notification devices during flood stages approaching the 277k cfs flood event.

2.3.5 Flood Risk Management Plan Conclusions

The FRM Plan proposed and designed at the current study level has no major conflicts with other portions of the Dallas Floodway Levee System. The AT&SF Bridge berm removal needs to be further refined with updated survey information in later design phases to incorporate changes that may have resulted from the construction of the Santa Fe Trestle Trail, see Section 3.2.4. The removal of the earthen berm on the West Levee could be reduced based upon the design of the Trestle Trail. This would only reduce quantities and costs and poses no overall risk to the project and its cost estimate. The levee raise to match the 277K cfs flood event water surface elevation as well as the AT&SF Bridge removal is technically sound.

2.4 City Preference of Slope Flattening

The current side slopes of the levee range in grade from approximately 2.8H:1V to 4H:1V. The existing 4H:1V side slopes occur mainly on the downstream sides of the East and West and Levee. The levees in areas steeper than 4H:1V have a history of slides that pose large operational and maintenance costs to the City of Dallas in addition to a safety risk during routine operations. In order to address these potential issues, the City of Dallas proposed flattening the riverward side slopes at every point on both the East and West Levees. This would include both the Elm and West Forks. The side slopes on the river side of the levee would be flattened to achieve a 4H:1V slope.

2.4.1 Modeling Process

The modeling of the proposed levee surface with flattened side slopes was completed using GEOPAK Site modeling software. The base surface model used to start the grading was the existing surface based off of the 1991 survey information, but included the 277,000 cubic feet per second FRM levee raise with 3H:1V side slopes, and AT&SF Bridge earthen berm removal portions of the project. The FRM levee raise included in this model is the original model created using GEOPAK prior to the change in assumptions regarding effective levee height. The assumption for inclusion of the existing and proposed gravel access road on the crest of the levee changed to exclude all gravel surfaces. However, this change in assumption will not overly affect the quantities generated for side slope flattening. It was assumed that all FRM work would be done prior to the side slope flattening in order to determine a proper baseline when it came to quantities and cost generation. Therefore, the surface generated from the output of the AT&SF earthen berm removal and levee raise modeling in GEOPAK was used as the existing conditions in the slope flattening scenarios.

In order to get a more accurate quantity determination, it was impossible just to run a template with 4:1 side slopes across the entire reach of both levees. The levee cross section varies substantially across the breadth of the Dallas Floodway Levee System. There is not a consistent slope along the riverward side of a cross section at any station along the levee system. This caused some problems as it was difficult to identify the break point where a slope increased from flatter than 25% to greater than 25% (4H:1V). To determine this breaking point, an additional program was used, Inroads Site Modeler. There is a function that allows for the display of minor contours based upon specific criteria; in this case, any minor contour that had a slope less than 25% was displayed. This enabled the user to draw a general outline of the breakpoint along the entire riverward length of both levees.

This outline of the breakpoints along each levee served as the starting point for the levee side slope flattening. For instance, the typical cross section of slope flattening shown in Figure D-34 describes the ideal starting point for levee slope work to occur. In reality, the slope work could begin at any point along the levee slope face. As shown in Figure D-35, the slope work can sometimes begin halfway down the riverward face of the levee side slope. These exhibits can both be seen on sheet C-501. In other words, only the areas that were steeper than 4H:1V (25%) were flattened. Areas that were at 25% or flatter were left untouched.

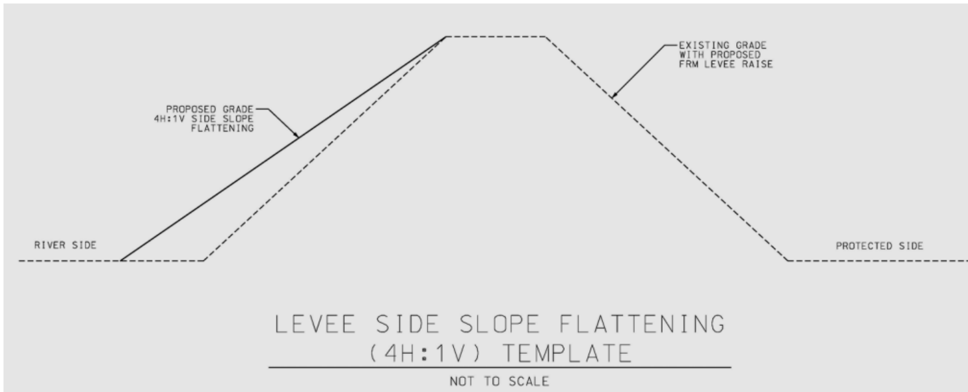


Figure D-34 Typical Side-Slope Flattening Template

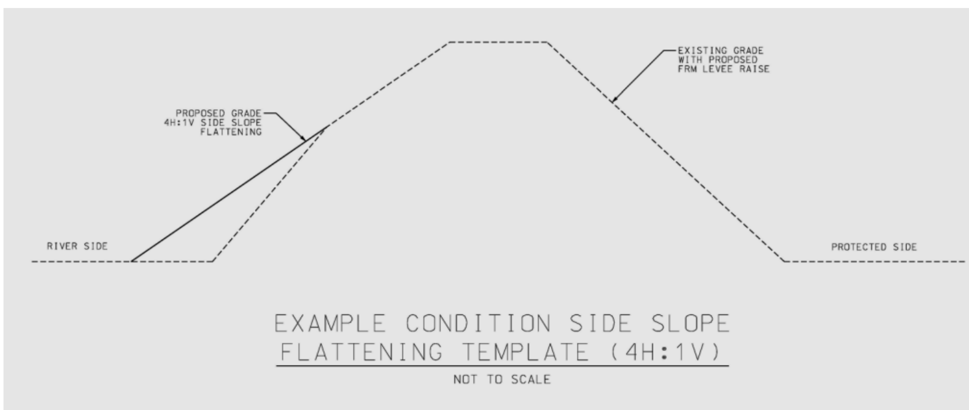


Figure D-35 Example Condition Side-Slope Flattening Template

Because of the variability of the existing slopes of the levee, some margin of error was considered in the levee slope flattening model. Existing side slopes from 25% to 27% were considered acceptable based on constructability. In some cases, there were areas of the levee side slope that create a convex portion of the levee with a flatter slope; yet, areas above and below this on the slope were too steep. In these cases, the flatter portion was considered a small cut area in order to create a smaller fill balance. This caused a fairly insignificant amount of cut for the levee flattening that can be seen as part of the quantities presented in Section 2.4.1.3.

The scope and breadth of the project and levee system created challenges in the creation of the digital terrain model and subsequent manipulation of the model for the Dallas Floodway Levee System. The base survey information including the interior of the levee system creates a very large file that was difficult to work with under certain conditions. As a result, several creative modeling liberties needed to be taken to ensure a model was properly created. The levee flattening model was created using four modeling files with two each for the East and West Levee. Each subsequent model built on the output of the previous model until a final model was developed to include the entire length of the levee system. As a result, some quantities may be slightly skewed. However, any errors are minimal based upon the overall scope and size of the project.

2.4.1.1 Levee Access Roads

As part of the levee system access roads crisscross the face of the levee to allow for access from the top of the levee to the Floodway. These access roads, predominantly, are located around bridges crossing the Floodway and near major outfall structures. The roads run diagonally across the face of the levee at a slope, typically, around 8% to 10% (8-10 foot rise every 100 feet). The access road has a minimum width of 16 feet, but varies across the Dallas Floodway Levee System and is designed to match the existing width. In most cases, the flattening of the side slope of the levee necessitated the reconstruction of the access roads to match the new contours of the face of the levee.

Several assumptions needed to be made in order to accurately construct the model with the revised levee access roads. First, it was assumed that the starting point of the access road at the top of the levee would remain constant. This assumption was used in an attempt to minimize the amount of fill needed to construct the levee side slope flattening. Next, as the levee side slope is flattened, the toe of the levee pushes outward towards the river. This flatter slope requires the alignment of the access road to rotate towards the interior of the levee system to maintain the proper slopes along the face of the levee. Further assumptions included, attempting to maintain the existing slope of the access road in place in the new road alignment with no road being steeper than a 10% grade.

The re-grading of the access roads posed some potential conflicts to some of the existing features of the Dallas Floodway Levee System. Specifically, clearance under bridges may be in question at some access roads that go under bridges crossing the levees. By flattening the levee side slopes, the elevations along the face of the levee increase from what they were before. There is a potential that a significant levee flattening effort causing a change in elevation could make require the access road to move further down the face of the levee. Additionally, some access roads as they were rotated to accommodate with flattened levee slope may too closely approach existing outfall structures. This may not allow for proper vehicle maneuvering and inhibit access roads from being navigated and used effectively.

In places where clearance or interference with existing structures is determined in the design phase to be an issue, the access road can be moved to ensure adequate vertical clearance and maneuvering room is required. By moving the access road further downstream or upstream the levee, depending on the direction the road is pointing, the alignment of the road can satisfy all engineering requirements. This would not add a significant amount of fill material and the change would be negligible in the overall scope of the project. In places where conflicts occur, matching the end points of the existing access roads with the end points of the new alignment will alleviate potential conflicts with minimal costs and quantities. This was not evaluated in the current stages of the project development, but will be evaluated during design and preconstruction phases.

2.4.1.2 Exhibits and State of Existing Levees

The limits of grading for the 4H:1V side slope flattening along with the limits for the Borrow Pits (discussed in Section 2.4.1.4, below) are shown on sheets CG100-CG107. The sheets show the grading limits and not the construction limits of the slope flattening work to be completed. Sheets CG100 through CG107 show several features including FRM measures. The exhibits also show some potential options for the levee slope flattening on the East Levee, which is discussed later in Section 2.4.3.2.

Additionally, these areas assume that the entire reach of both levees needs to be flattened. The City of Dallas has already completed some slope flattening to 4H:1V on the downstream ends of both levees. This would require less impact area to be affected. The exact extent of the existing slope flattening work is unknown based on the survey information that was used as the base conditions. For more information on existing slopes and current conditions of the levee, refer to Sections 1.2.2 and 1.2.2.1. The quantities calculations will reflect the fact that there is very little work on the downstream ends of the levees. The grading limits show the areas that will be 4H:1V but do not indicate the amount of work to be done. Minimal work is required on the downstream ends of the levees as a result of the existing work done by the City of Dallas and the quantities will reflect this. Further analysis of the existing state of the levees and subsequent reduction in impact area, as required, will be completed in future design phases in accordance with any new survey information.

2.4.1.3 Quantities

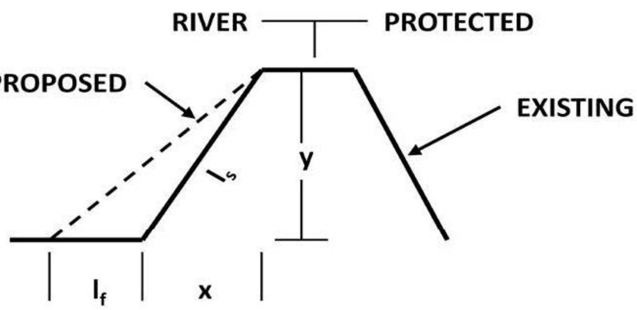
Quantities were calculated as a part of the modeling process to determine a cost estimate that would help in determining economic feasibility (life-cycle cost analysis). The site was modeled using GEOPAK software, which provides, upon request, the earthwork quantities as well as square footage of affected areas. However, in order to generate an accurate cost estimate, a few other quantities are required to be calculated and evaluated as part of the cost estimate. Access roads along the face of the levee, slope scarification for construction purposes, and seeding area were the additional major cost areas that needed to be evaluated. Additionally, utility relocations could have a potential effect on costs of the overall feature. Utility relocations and quantities are discussed in Section 2.4.4.

Earthwork cut and fill quantities were taken directly from the output of the GEOPAK modeling software. Estimates on the access roads along the face of the levee were measured based on the area of the service drive that was designed. The access road was assumed to have the same structure as that of the access road along the crest of the levee. See Figure D-33 for a typical cross section of the access road. Seeding area was assumed to be the area impacted less the area of the access roads to be put in place. The scarification value required some additional assumptions in its quantity generation. It was assumed that a majority of the scarification would be done along the slope of the levee. A formula was developed to determine the volume of scarification needed, based upon the length of the levee section and an estimated average slope of 3.4H:1V. See Figure D-36 for a detailed description of the determination of scarification based upon length of levee.

Also, as mentioned previously, some tolerance is required in construction so an existing slope at within 2-3% of desired final grade would be considered sufficiently flattened to satisfy the 4H:1V criteria presented by the City of Dallas. Therefore, some slopes, especially on the downstream end are shown to need flattening, when they are acceptable from the tolerance criteria presented. This would decrease the quantities to some extent and will be evaluated during design when more current survey information is available. The quantities generated from the analysis of this feature are presented in Table D-21.

Table D-21. Levee Side Slope Flattening Quantities

Item	*Unit*	*East Levee*	*West Levee*
Net Fill Volume	CY	608,872	510,697
Seeding Area	ACRE	144.18	129.26
Scarification Volume	CY	638,074	598,741
Crushed Limestone Road	CY	2,331	1,948
Geotextile Area	SY	10,491	8,766
Demolish and Remove Existing Concrete Riprap	CY	1248	647
Demolish and Remove Existing Rip Rap	SY	6,603	6,509
Class B Concrete Rip Rap, 5in Depth	CY	2,933	2,314



l_f = LENGTH OF SCARIFICATION ON FLAT GROUND

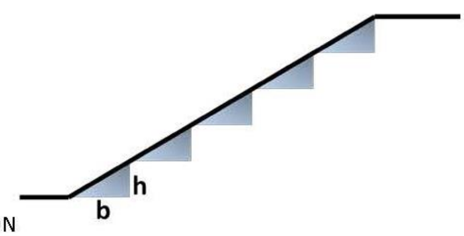
l_S = LENGTH OF SCARIFICATION ON SLOPED GROUND

* l_f AND RESULTANT SCARIFICATION IS DEEMED NEGLIGIBLE

y = AVERAGE RISE OF LEVEE $\approx 30'$

x = AVERAGE RUN OF THE LEVEE

$$\frac{x}{y} \approx \frac{3.4}{1} \quad THEREFORE\ x = 102'$$



SCARIFICATION AREA
ASSUME 20' WIDE SCARIFICATION STEPS
HEIGHT OF SCARIFICATION IS ABOUT 5.9'
ABOUT 5 TOTAL STEPS FOR FULL LEVEE SCARIFICATION

$$SCARIFICATION\ AREA = S_A = 5 * \frac{bh}{2} = 5 * \left(\frac{20 * 5.9}{2}\right) = 295\ ft^2$$

NORMALIZE S_A BASED ON SCARIFICATION LENGTH ON SIDE SLOPE

$$n = \frac{S_A}{l_S} \quad \left[\frac{ft^2}{ft}\right]$$

$$LENGHT\ OF\ LEVEE = L$$

$$TOTAL\ VOLUME\ OF\ SLOPE\ SCARIFICATION = V_S$$

$$V_S = L * l_S * n = l * S_A = 295 * L\ [ft^3]$$

Figure D-36 Scarification Estimation Process

2.4.1.4 Borrow Pits

Potential borrow material was evaluated to determine its suitability for use as part of levee construction. The criteria used to evaluate the potential borrow sites is discussed in Section 2.2.2.4. In addition to this criteria, the goal was to limit the impact of the borrow pit on the overall project efforts. Goals of the project, as determined by the BVP, include the construction of three different lakes in between the East and West Levee in the Dallas Floodway Levee System. To minimize impacts and to reduce redundancies in excavation, it was determined that material, ideally, would be taken from one of the three proposed lakes for use in the flattening of the levee side slopes. Therefore, the outline of the three lakes was superimposed upon the outline of the suitable borrow areas as identified previously. Only one lake, West Dallas Lake, contained suitable material for use in levee construction. Originally, a borrow pit on either side of the river to aid in construction, was proposed. Based upon the evaluation of the soil material, all material for levee slope flattening was concentrated in the areas affected by the West Dallas Lake.

To calculate volumes of borrow needed, the borrow pit was modeled using GEOPAK modeling software. It was assumed that all FRM levee raise construction had taken place. One of the borrow pits for the FRM levee raise overlaps with the footprint of the West Dallas Lake. Therefore, all material required for the construction of the levee raise feature, as discussed in Section 2.3.1.5, had already been accounted for in the existing model. In the creation of the borrow pit model, the suitable material footprint was draped on the existing surface and then offset horizontally 35 feet and vertically downward 10 feet to create a breakline, or bottom contour. This created a 3.5H:1V slope for the borrow pit, which mimics the slope of the proposed West Dallas Levee. As part of the borrow pit for this feature, part of the FRM borrow pit is filled back in to reduce the overall impact area of the borrow pits. This is accounted for in the net volume quantities that were computed for the borrow pit.

The existing grade at the location of the West Dallas Lake varies within a few feet of elevation 410 feet; therefore, the bottom elevation of the borrow pit varies slightly, as well. One of the criteria for suitable material, limits the extent of excavation for borrow material to 10 feet, so this is to be expected. As a result, the West Dallas Lake is only partly excavated; there remains a significant portion of excavation to be performed in order to complete the entire lake. As per the constraints, the borrow pit is split in two pieces on either side of North Westmoreland Road in order to avoid impacts of this feature to the bridge. The borrow pit footprints are shown on sheets CG103 to CG104. The quantities computed for the borrow areas are shown below in Table D-22. The over excavation of borrow material shown is considered negligible in the overall scope of borrow material.

Table D-22. Levee Side Slope Flattening Borrow Pits

Borrow Pit Quantities (Flatten Side Slopes to 4H:1V)			
Total Fill Required	**In Place**	CY	1,119,569
	With 20% Compaction Factor	CY	**1,399,461**
Total Borrow Pit Area		SF	4,597,514
Total Borrow Pit Area		ACRE	106.44
Total Material Excavated		CY	1,583,427
Total Unusable Material	**Excavated Volume**	CY	170,278
	Excavated Volume with 20% Bulk	CY	204,334
Total Usable Material	**Excavated Volume**	CY	**1,413,149**
	Excavated Volume with 20% Bulk	CY	1,695,779
Difference: Excavated Usable Material (No Bulk)-Required Fill (With Compaction Factor)		CY	**13,688**

2.4.2 Slope Stabilization under Bridges

Current conditions for slope stabilization under bridges vary widely across the Dallas Floodway Levee System. Some bridges have concrete rip rap, others have stone riprap, while other bridges have no slope stabilization measures underneath them at all. The City of Dallas has stated the hardships of maintaining ground cover on the areas underneath the bridges in order to increase slope stabilization. Their preference was to stabilize the slope using concrete revetment under all bridges. In accordance with the flattening of the side slopes along the entire length of both levees, the slopes under the bridges are to be adjusted accordingly. All existing revetment or riprap is to be demolished, the slope to be raised to 4H:1V and new concrete riprap is to be put in place. This is to create a uniform 4H:1V surface across the entire levee to improve operations and maintenance efforts.

2.4.2.1 Texas Department of Transportation Standard Concrete Riprap

The type of concrete riprap under the bridges should be in accordance with the Texas Department of Transportation (TxDOT). The standard riprap under bridges is 5 inch thick reinforced concrete. TxDOT's standard detail is included on sheet C-503.

2.4.2.2 Quantities

The City of Dallas requested that slope stabilization measures put in place on the riverside slope of the levee extend from the top to toe of the levee and ten feet outside the bridge deck. For existing quantities, it was assumed that existing slope stabilization measures satisfy the same dimensions. The square footage of the affected area was determined in plan-view based upon topographic information of the levee and aerial imagery depicting the edges of the bridge decks. The quantities for slope stabilization under bridges for the East and West Levees are shown in Table D-21.

2.4.3 Future Alternatives in Preconstruction Engineering and Design Phase

The current model and quantities reflect the preference to eventually flatten all levee side slopes to 4H:1V for operations and maintenance as well as recreational benefits. The Dallas Floodway Levee System contains approximately 22 miles of levees, therefore, this plan would be difficult to implement at one time. As a result, some potential modifications could be made to the implementation of the levee side slope flattening plan. These items came about through discussions with the City of Dallas and through observations made on the general phasing of projects.

2.4.3.1 Initially Flatten Slopes to 4H:1V Only in Areas Affected by FRM Levee Raises

The FRM plan proposed by USACE includes several distinct areas along both levees that are identified to be raised to match the water surface elevation of the 277K cfs flood conditions. These areas compromise of low spots along the levees where the water surface elevation of the proposed 277K cfs flood event exceeds the existing elevation of the top of levee. These levee raises consist of removing the top eight inches of the levee and benching in along the existing slope to accommodate the appropriate levee raise with 3H:1V side slopes. Raising the levee in these areas requires significant mobilization and impacts large portions of the levee crest and side slopes. In order to mitigate levee construction time and eliminate redundant construction techniques, the City of Dallas proposed the flattening of the levee side slopes, initially, only in the areas affected by the 277K cfs levee raise.

With this plan, as part of the construction of the levee raise, the side slopes would be flattened to 4H:1V. Separate models for the FRM plan and the side slope flattening would be created to determine quantities for each feature. This would enable proper cost generation and cost sharing procedures to be evaluated. In some cases, there are levee raises that are separated by a short distance. The areas in between these features would also be included as part of the levee raise in order to reduce the number of undulations in the levee slope. This proposal would also include the realignment and construction of any access roads along the face of the levee that would be affected by the slope flattening and levee raise.

During the current stages of this study, this proposal was not evaluated with respect to quantities and costs. This idea will be evaluated as part of construction phasing in future phases of design.

2.4.3.2 Levee Side Slope Flattening as Impacted by the Trinity Parkway Bench

Current proposals and designs call for an earthen berm to be constructed along the riverside face of the East Levee in order to support the Trinity Parkway; see Section 3.2.1 for more information. This proposed toll way will enter the levee system just upstream from Hampton Road and exit the levee system at the far downstream end before continuing into the Dallas Floodway Extension project area. The Trinity Parkway, and its interface with the BVP, is discussed further in Section 3.2.1.

The proposed earthen Trinity Parkway bench construction begins just downstream of Hampton Road along the East Levee and begins within a few feet of the top of the levee. This berm extends downstream slowly decreasing in its vertical location along the slope of the levee before exiting the Dallas Floodway proper at a fairly minor elevation along the face of the East Levee. The berm is interrupted in a few locations where the Trinity Parkway becomes a bridge extending over an existing feature of the Floodway. This generally occurs at existing outfall structures and channels along the East Levee.

The proposed 4H:1V levee side slope flattening plan includes the entire stretch of the East Levee where it interfaces with the Trinity Parkway less the areas already flattened to an acceptable slope. The primary purpose of the levee side slope flattening was to reduce operation and maintenance costs, specifically mowing and slides along the riverward face of the levee. In locations where the Parkway's bench extends a significant distance up the face of the levee, these operation and maintenance requirements will be virtually nonexistent. Therefore, it is possible to remove these areas, or significantly reduce the amount of work being done, from the side slope flattening plan as they will be covered up by the Trinity Parkway berm. In locations where a bridge supports the Trinity Parkway instead of berm, the slope flattening plan would proceed as necessary to ensure an acceptable slope. The locations where a slope flattening plan may not be necessary or can be significantly reduced are shown on sheets CG100 through CG107. The areas in question are differentiated on the sheets through a different hatching pattern.

With this plan, the interface of the retaining walls for the Trinity Parkway Bench where a bridge begins and ends and the extension of the levee slope during flattening would have to be further evaluated. See Figure D-36. During this phase of the study, no quantities have been developed to show the potential reduction in costs this plan would offer. Further implementation of this plan would be evaluated in future stages of design as a costs saving and construction phasing issue.

2.4.4 Utilities

There are several outfall structures that are affected by flattening the side slopes of the levee. These areas are noted on sheets CG101 through CG107. The conflict with the side slope flattening and the outfall structure is fairly easily resolved. The side slope flattening pushes the levee toe towards the river and, in these cases, encroaches into the outfall areas. Some of these outfall structures already have designs to be fixed in accordance with the BVP. The BVP is a proposed plan to bring recreation benefits to the interior of the Dallas Floodway Levee System including a relocated river, lakes, wetlands, and recreation fields. This project and its features are discussed in greater detail in Section 2.5. These outfall structures include the Dallas Branch, Woodall Rodgers, and Belleview storm drains. The BVP extends the outfall pipes to interact with the relocated river channel and be concurrent with the proposals for lakes within the

Floodway. Other outfall structures that are affected include those associated with pump stations. These outfall structures will be fixed as part of the IDP, see Section 2.6.

There are a few outfall structures affected by the slope flattening proposal, and subsequent extension of the levee toe, that are not part of other features and their design plans. These outfall structures include Old Coombs Creek, Coombs Creek, Turtle Creek, Nobles Branch Sump, and Eagle Ford Sump. The associated costs and quantities for the extension of the outfall structures for these features is solely related to the proposal to flatten all riverward levee side slopes to 4H:1V. Table D-23 details each outfall structure that is affected by the plan and the approximate length the outfall pipe needs to be extended to satisfy the design constraints of the project. These values are approximate and will be reevaluated in the design phase. There are East Levee pressure sewer modifications; however, they are included as features of the BVP and Trinity Parkway.

Table D-23. Required Utility Relocations for 4H:1V Side Slope Flattening

Outfall Structure	*Line Type*	*Pipe Size*	*Material*	*Pipe Extension Length (Linear Feet)*
Old Coombs Creek	Pressure Sewer	4 – 9'x10' Box Culverts	Reinforced Conc.	50
Coombs Creek	Pressure Sewer	96" Pipe	Reinforced Conc.	20
Turtle Creek	Pressure Sewer	4 – 9'x11' Box Culvers	Reinforced Conc.	50
Nobles Branch Sump	Gravity Line	60" Pipe	Reinforced Conc.	50
Eagle Ford Sump	Gravity Line	2 – 54"x54" Box Culvers	Reinforced Conc.	50

At this stage of the study there was limited survey data available to determine exact quantities and costs for the utility relocations. At this juncture, the new outfall structures were not designed. In further stages of the design process, it is recommended that more accurate survey information of these outfall structures be recorded and proper design commence at that point. These utility relocations are minor and no overall negative effect is expected on the resulting project.

2.4.5 Side Slope Flattening Conclusions

The existing levee riverward side slopes vary widely across the breadth of the Dallas Floodway Levee System. They also vary across a single cross section with the slope rarely remaining constant down the face of the levee. The variance in slopes, especially steeper slopes, has created an operations and maintenance challenge that the City of Dallas would like to mitigate. Steep and uneven side slopes create challenges with mowing equipment and drives up the mowing contract cost. It is also a safety issue the City of Dallas is trying to address. The goal of the side slope flattening plan is to minimize operation and maintenances costs for mowing and fixing slides, as well as increasing the safety of these operations. There are few issues that need to be addressed in further design stages. Although there are issues with the impact of the levee flattening on the Trinity Parkway Bench, utility extensions, and the interaction with the IDP (discussed further in Section 2.6) the issues can be remedied in future design phases.

2.5 Balanced Vision Plan

The BVP is a project developed by the City of Dallas to utilize the area between the East and West Levee in the Dallas Floodway Levee System for the purposes of recreation and environmental restoration, while maintaining the primary purpose of flood control. The proposed plan consists of three lakes, the river relocation plans, wetlands, recreation fields, and various other hardscape and landscape features. The river is to be relocated to provide a more natural sinuosity as well as allow for the lakes to be put in place.

More information on the Trinity River Relocation Project is discussed in detail in documentation created by the City of Dallas and its contractors; a summary is presented below in Section 2.5.2. Three lakes are planned as part of the BVP: West Dallas Lake, Urban Lake, and Natural Lake. West Dallas Lake is located the furthest upstream and is between the relocated river channel and West Levee, spanning underneath and on either side of N. Westmoreland Road. Natural Lake and Urban Lake are further downstream on the opposite side of the river. The proposed lakes have more specific documentation in the BVP plan prepared by the City of Dallas with a summary located below in Section 2.5.3. In addition to the river channel realignment and proposed lakes, other features include wetlands, utility relocations, recreation fields, and various other features designed to enhance and fully utilize the space. These features are discussed below with more specific information provided in the City of Dallas' reports.

The City of Dallas has proposed two separate plans for the BVP. The use of either plan is contingent on the construction of the future Trinity Parkway by the NTTA. The Trinity Parkway is a proposed tollway that will be constructed via berms and bridges on the riverside slope of the East Levee for a distance of approximately 5.8 miles. This proposed feature is discussed further as part of the Comprehensive Analysis plan in Section 3.2.1. However, this feature is not a part of the BVP or MDFP Plan. The City of Dallas' two versions of the BVP are contingent on the Trinity Parkway being built. The "with" Parkway BVP design assumes that the Trinity Parkway will be constructed. The second, the "with-out" Parkway BVP design assumes that the Trinity Parkway will not be constructed in the Floodway. This does not preclude the future construction of the Trinity Parkway as a Section 408 project.

The BVP and the Trinity Parkway share many of the same features, including the three lakes, the Trinity River Relocation Project, and many of the same features bordering the River and the West Levee. With the many commonalities, there are several changes between the two plans as a result of the Trinity Parkway either being in place or not. In the BVP With Parkway, the parkway borders the Natural and Urban Lakes before exiting upstream prior to the Hampton Pump Station. The Without Parkway BVP has more room for other features as a result of the space vacated by the Trinity Parkway. Trails and park roads have more room to meander; access roads between the two plans are different to accommodate the Trinity Parkway feature. The proposed Hampton Wetlands is expanded in the Without Parkway Model towards the East Levee. The downtown overlook area downstream of Commerce Street is different between the two models as well. The eastern edge of Natural Lake is also slightly modified to allow for the bench as part of the Trinity Parkway. These features and any other minor discrepancies between the two plans are broken out in the following sections where needed to illustrate individual features as they are evaluated for technical soundness.

From an evaluation standpoint, the BVP is assumed to be constructed immediately following the construction of the FRM and Slope Flattening alternatives. In the case of the With Parkway BVP Plan for evaluation purposes, it is assumed that the Trinity Parkway is already in place. IDP features or other local projects not already constructed, see Section 3.2, are assumed, for the purposes of evaluation only, not to be in place prior to the BVP. For analysis on how these projects fit with the BVP plans, see their respective sections in the report. The various features were evaluated using the CS100 sheets.

2.5.1 Balanced Vision Plan Feature Categorization

The Dallas Floodway Levee System is required to convey the USACE SPF; this flood has been categorized to a flow volume of 277K cubic feet per second (future flows). Features required to convey the SPF includes all of the features proposed within the Dallas Floodway, such as the BVP features, FRM components and IDP items. The BVP is comprised of many features with varying degrees of intricacy and importance to the overall Floodway function. Designing all the park features to withstand the maximum design flood will be extremely costly and is, for the most part, unnecessary. The proposed design philosophy considers the cost-benefit ratio of each park element with regards to level of protection. Level of protection is determined by the flood event's magnitude upon which design criteria for the individual feature is based. The designers have divided the designed features into four categories based on levels of protection that have different levels of risk, cost, repairs, and operational significance. The following flood recurrence intervals for design purposes were based on original assumptions of an SPF equaling the 800-year flood event. Since the feasibility level design was developed, the SPF return interval has changed from approximately the 800-year to about 2,500 years (or 0.04% ACE). Revisions to the return interval have been made, and may cause a revision of the design flood events for each of the four categories. It is recommended that further refinement of this plan use flows and water surface elevations to describe design criteria. The features discussed in this section are further discussed in the following sections on the BVP and are shown on sheets CS101-CS118.

Category 1 features are park survival elements that are critical in defining the operation of the Dallas Floodway Levee System as a whole. They determine the geometry of the Floodway and affect hydraulic conveyance during flood events. Major structural damage to these elements could result in reduced or failed performance of the Dallas Floodway during flood events. Category 1 features are designed to survive flood events with flood recurrence intervals up to and including the 800-year event. Since the feasibility level design was developed, the SPF return interval has changed from approximately the 800-year to about 2,500 years (or 0.04% ACE). The goal of the element's design is to have it remain in place, without significant structural damages post flood event. In addition, these features will still need to be usable park destinations, requiring only minor maintenance and repairs following a flood event. Category 1 features that have been identified include the Central Island Berm and its features, separating the Natural and Urban Lakes, and the West Dallas Lake berm, separating the lake from the Trinity River, and its features. The berms are discussed more in Section 2.5.3.4. Other Category 1 features include the Woodall Rodgers, Dallas Branch, and Belleview storm drain outfalls. See Section 2.5.8 for further detail about the relocation of these pressure storm sewers. During any flood event some damage to the park survival elements is expected and will still require minor repairs. These issues will included the lake lining systems along the lake embankments of the lakes due to localized scour and erosive forces where local eddies will cause scouring and erosion.

Category 2 features are critical park features or elements that are necessary for public safety and operation of the park following flood events. Major damages would make these park destinations inoperable after a flood event, subsequently requiring the closure of the park areas for extended periods while maintenance is performed. Category 2 critical park features include flood management and conveyance structures, such as the Urban Lake outfall channel structures, Natural and Urban Lake isthmus, West Dallas Lake pump station, gates, and electrical systems required to manage flood flows and conveyance during normal operating conditions. See section 2.5.3.5 for further information on the West Dallas Lake Pump Station. Additional Category 2 features include water supply for the lakes, lake lining systems, utilities crossing the Floodway underneath the lakes, and the Urban Lake promenade. These features and park elements are to be designed for flood events with flood recurrence intervals greater than the 100-year event.

Category 3 features are non-critical park features that, if damaged or lost, would severely impact activities and programs within the Dallas Floodway. These includes features such as amphitheaters, boating safety features throughout the lakes, primary vehicle access throughout the park, and sanitation or public health features that, in the event of failure, cannot be easily replaced or may result in the release of pollutants to the lakes or Trinity River. Category 3 features will be designed for flood recurrence intervals ranging from 50-years up to the 100-year event, depending on the specific feature and design cost.

Category 4 features are considered to be non-critical park features or elements that, if damaged or lost, would not greatly affect park activities. These could be replaced at a small cost and include aesthetic features (vegetation, trees, or non-structural rock work), minor supporting infrastructure (benches and picnic tables), secondary pedestrian walks, and park lighting. Category 4 features will be designed for flood recurrence intervals ranging from 25-years up to the 50-year event, depending on the feature, park operations, and its cost impacts when damaged.

2.5.2 River Relocation

The Trinity River Relocation Project begins upstream at the confluence of the West Fork and Elm Fork of the Trinity River, extending downstream approximately 8.0 miles, merging with the existing river channel near Corinth Avenue. The Relocation Project has primarily four goals as part of the BVP: flood control, environmental restoration, recreation, and transportation. For the flood control aspect of the BVP, the realigned Trinity River was designed to avoid changes in water surface elevation associated with the 100-year discharge and the SPF, also known as the 277,000 cfs flood, while maintaining adequate design conveyance of 13,000 cfs and interior storm drain discharge outfall of 20,000 cfs. The environmental restoration goal was achieved through the creation of more natural riverine habitat that more closely mimics the original Trinity River. The recreation goal of the BVP was integrated into the channel design through geometric changes that improve accessibility of channel banks, facilitate safe passage through the river, and improve the aesthetics in and along the realigned Trinity River, as they interface with and protect critical park features within the BVP. The transportation goal was addressed through the accommodation of existing and future bridge pier design, while also allowing for the future design of the Trinity Parkway along the East Levee of the Dallas Floodway. These four major goals for the Trinity River Relocation Project as stated in the BVP are the major motivating factors driving the relocation of the river.

In addition to the four major goals addressed in the BVP, there are five physical and biological characteristics used to direct the channel realignment and ecosystem restoration design. The first focus involved diversifying in-channel hydraulic and sediment transport patterns by increasing the sinuosity of the channel alignment. This would then improve habitat and add variance to the complexity of the channel geometry and profile. Secondly, the proposed design varies habitat gradients along the channel banks through milder channel bank side slopes, providing a diverse range of habitat conditions and vegetation gradients along the banks of the realigned Trinity River. Another characteristic of the proposed channel design maintains natural undulations and variance found in the channel bed profile, following the average longitudinal profile slope through the River, while still facilitating more natural scour and deposition patterns around the newly created meander bends. The channel design will also enable a diverse riparian vegetation plan that would re-establish and optimize the establishment of natural vegetative growth patterns found along the Trinity River. The increased riparian vegetation also contributes to the reduction of bank erosion. An additional characteristic used in the channel design was to create and connect floodplain habitat through the use of gradually sloped banks and high terraces near the top of the channel. This will improve connection by creating more natural elevation gradients between the channel and floodplain during high flows, while combining the proposed floodplain wetlands with other features of the BVP projects. The final design criteria necessitated that the relocated Trinity River would act as an overflow for the BVP Lakes (West Dallas Lake, Urban Lake and Natural Lake) through the use of weirs. These five physical and biological design criteria along with the four BVP goals provided the basis for the channel design and Trinity River Relocation plans.

2.5.2.1 Channel Geometry

The preliminary horizontal channel alignment, channel design cross sections, and profile are designed with the intent to maintain consistency with the location of other BVP features, while maintaining the flood protection functions of the channel and providing more geomorphically stable channel conditions. The intent is to accommodate proposed features within the floodplain, facilitate expected channel recreational use, and enhance riparian habitat.

There are several parameters for a preliminary channel cross sections identified to meet the aforementioned intent. The channel bottom width will remain at least 50 feet wide and will be widened in certain regions to improve transitions with elements of the floodplain park design. The geometry of the designed channel will also enable low-flow on the floodplain bench elevation at normal depth for flows of 500 cfs, floodplain bench slopes and landscape terrace sides slopes at 20:1 or flatter, for adequate drainage and transitions, and channel bank side slopes between floodplain benches and channel inverts or between floodplain benches and top of bank to be a maximum of 3:1 side slopes on the outside and 4H:1V on the insides of meander bends. The channel slopes will have bank treatments to prevent lateral migration and erosion. The channel profile design is intended to preserve the existing average slope of 0.00023 feet/feet and to rely on natural geomorphic process to produce a diverse longitudinal profile over time. Constructed pools were also added to the cross sections and profiles to improve the initial ecological impact and the fish and bird habitat diversity. Pools are located in meander bends with preliminary pool design depths averaging depths of 2.6 feet with a standard deviation of 1.6 feet and pool lengths of 375 feet with a standard deviation of 221 feet.

The channel geometry can be further identified through the cross sections that are depicted on the Trinity River relocation plan set that accompanied the river relocation report. These are preliminary cross sections that were generated by the City of Dallas' contractor as part of the development of the BVP. Select cross sections are shown on Sheets C-301 to C-306; however, a more detailed cross section set can be found in the Trinity River Relocation Plan put together by the City of Dallas and its contractors.

2.5.2.2 Main and Discharge Channel Design

The current realignment report for the Trinity River contains recommendations for channel lining with Type I and Type II slope treatments. These treatments are defined; however, it is unclear whether their scope and application is adequate for maintaining channel integrity. A technical review of the geomorphology report by USACE geomorphology experts revealed several suggestions for improving the long and short term stability of the river channel, and the discharge channels flowing into it.

The current slope protection and armoring plan had some concerns regarding the suitability of materials and extent to which the channel was protected. Both sides of the river on an added curve need to be armored and the use of vegetated mats without toe armoring is not advised. Vegetation, by itself, was not considered to be a viable short term solution for river bank stability. Contingency plans need to be developed during design to account for vegetation wash outs caused by a storm event. Vegetative efforts will provide long term stability of the bank; however, until the root systems are fully developed, they do not provide the level of protection for which they are designed.

Additionally, the discharge channels from the various storm drains and pump stations entering the Trinity River were a concern for erosion and stream bank stability. As part of the final design of the Trinity River, it is recommended that these outfall channels approach and intersect the relocated Trinity River at an angle that provides low turbulence. The outfall channels would approach the river at a smaller angle than currently designed. It is also recommended that increased sinuosity, riffle structures, or vegetation be added to the discharge channels to mimic the Trinity River.

There is a final concern with regards to the island between Oxbow Lake and the main Trinity River channel. The armoring and proposed vegetation on the separating island is not adequately defined and supported. Further design of this feature is necessary to determine its long term functionality and response over time with consistent flooding and inundation.

None of these issues was determined to be a fatal flaw and all items can be addressed to their fullest extend in the design phase of the Dallas Floodway Project.

2.5.2.3 Constraints and Design Features

Several constraints are imposed on the Trinity River Relocation project as a result of its interface with several other features including, bridges, lakes, levees, and recreation features. The first constraint is a required offset of 150 feet offset from the expected future riverside toe of the improved levees, slope flattening and levee raising. Design of the channel alignment, geometry, or both were adjusted accordingly to ensure the realigned channel excavation limits are outside the 150 foot offset from the future USACE improved riverside levee toes. The preliminary Trinity River relocation is also designed to coordinate with floodplain park features such as proposed trails, roads, bridges, playing fields, lakes, and the whitewater course. This preliminary design minimizes the need for costly bridge pier modifications by transitioning smoothly back into the existing channel at Westmoreland, Hampton, Sylvan, and Corinth bridges. The relocated channel will realign with the existing river channel a minimum distance of 500 feet upstream and downstream of a bridge. This is required to prevent excessive contractions or expansions in cross-sectional area that could lead to erosion or sediment deposition problems around the bridge.

An oxbow feature, labeled Oxbow Lake on the attached plan set, is also implemented just upstream of the Corinth Bridge to help meet environmental restoration and recreation objectives of the project. The oxbow will only be connected to the Trinity River at flows above 5,740 cfs. This oxbow is part of both the Trinity River relocation and the Corinth wetlands. It is a part of a larger environmental restoration and wetland restoration effort on the part of the project.

At the Trinity River design flow of 13,000 cfs, velocities range from 1 to 4 feet per second with channel shear stresses below 0.20 pounds per square feet (psf) except at IH-30 and around bridge piers. These locations have velocities that exceed 8 feet per second and shear stresses can exceed 6 psf. At locations were velocity and shear stresses exceed acceptable ranges, slope treatments Type II and Type III with riprap foundations are used to prevent bank erosion and failure, while also maintaining the environmental and aesthetic value of the channel banks. Type II bank treatments use live staking fascines and re-vegetation above the foundation. Type II bank treatment is used in areas of higher velocity and shear stress, typically along the outsides of meander bends or where minor erosion of the of the upper elevations of channel banks might be acceptable, but later channel migration would impact sensitive project features. Type III bank treatment uses limestone blocks and vegetated coir soil lifts with live staking between the joints and vegetated coir erosion control fabric above the riprap foundation. This is used in areas with higher velocity and shear stress where lateral channel migration is not acceptable.

2.5.2.4 Conclusions and Design Suggestions

The current design for the BVP including the Trinity River Relocation is at a 35% submittal. It is understood that the design is not final and will be refined in further submittals before final construction documents are submitted. The intent of this narrative is to describe some of the problems that may arise from the implementation of the current plan. The river relocation is being evaluated from a constructability perspective and not from a long term geomorphic or geotechnical review. For further evaluation on the Trinity River Relocation Project with respect to geotechnical or hydraulics and hydrological standpoint, see the respective appendices for each discipline.

Because of the sinuosity of channel geometry the Trinity River Relocation will require modifications to existing outfall location of storm drainage features such as storm drain gravity flow outfall channels. This is partly addressed in Section 2.5.7 about utilities. Current grading plans for the Trinity River Relocation show rerouted channels for outfall. Although some of the IDP projects show no grading for an outfall structure, the grading plans could be developed in the future design phase. In addition, the existing outfall channels are left in their existing state and not backfilled. According to the intent of the designer, the channels will be backfilled with a suitable material when the outfall structure is extended or reconfigured. Grading in these locations should match the existing top of bank and allow for positive drainage towards the nearest lake or the relocated river. It is imperative that low spots that would result from not backfilling the existing channel be removed through proper grading. Ponding in these areas could create low spots leading to additional risks from seepage due to their proximity to the levee toe.

The Trinity River Relocation Project begins upstream at the confluence of the Elm and West Fork of the Trinity River and extends downstream until the relocated channel merges back into the existing Trinity River channel at Corinth Street. Current river alignments and grading shown in submittals do not properly show the design of proper transitions to the main channel of the Trinity River or to the Elm and West Forks. The intent of the channel realignment is to transition seamlessly from the forks to the existing channel upstream for Corinth St. These transitions are not appropriately designed at the current project stage and need to be corrected in order to preclude serious erosion or sedimentation issues. A longer transition is preferable on the upstream end where the Elm and West Forks converge. It is recommended that both banks of the forks be graded to appropriately merge the two channel geometries together. Updated bathymetry data is needed in the areas where the relocated Trinity River realigns with existing channels to progress in the stages of design and implementation.

There are various locations along the proposed river channel alignment where the top of bank is above existing grade. This creates problems regarding drainage in these areas. The surrounding area and features are intended to drain into the Trinity River which proves impossible with the difference in elevation and the presence of no outfall channels in the design. In addition, this effectively acts like an earthen levee, which if designs stay consistent, would have to be designed and evaluated to retain water in some cases up to two or three feet above the surrounding grade. It is recommended that future grading plans consider the drainage issue and ensure that all features tie into existing grade properly. The intent of the drainage on the interior of the Floodway, except for approved wetlands, should be to have all runoff drain to a lake or the realigned river channel. Creating low spots between the levee toe and the river channel is not advised and could create potential ponding areas, which will affect drainage away from the slope and increase the risks of seepage at the levee toe.

Future designs also need to consider the integration of existing outfall channels into grading plan of the relocated river. Realigned outfall channels need to match existing grades of current outfall channels that are not being relocated and provide adequate transitions. This will alleviate potential sedimentation or erosion that will arise from turbulence in areas where existing and proposed channels are not properly interfaced. Proposed outfall channel geometry designs should reflect existing conditions in regard to flow levels in the in-place channel. Design analysis for all proposed channels should be submitted for review to ensure that no flow loss is seen with the new channel geometry.

In conclusion, there are several interface and integration issues that arise with the river relocation plan. The Trinity River interfaces with many different features and has to accommodate all existing channels and flow requirements, while still providing the necessary benefits for the BVP. Further discussion on interfacing with features is located in Section 2.5.9 regarding bridge pier modifications. Additionally, further discussion regarding proposed new bridges and future local projects is located in Section 3.2, specifically Section 3.2.6 on Sylvan Bridge has a few issues to be resolved. Although there are grading issues with the Trinity River Relocation, at this stage of design, the project is technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.3 Lakes

Key components of the BVP as prescribed by the City of Dallas will include the creation of three lakes within the Dallas Floodway. These three lakes are to be constructed between the East and West Levee and are accommodated by the relocation of the Trinity River. The configuration and geometry of the BVP lakes in Table D-24 were developed using GIS data which differ with the stated information based on the BVP City Reports. These two lakes are located on the downstream end of the Dallas Floodway Levee System and are between the East Levee and relocated Trinity River. West Dallas Lake is located further upstream from the other two lakes and between the West Levee and relocated Trinity River. The West Dallas Lake is approximately 1.5 miles long and ranges from 600 to 700 feet in width. The three lakes and their associated features are described in further detail in the sections below. In addition to these three constructed lakes, the existing Trammel Crow Lake will remain to create a total of four lakes within the Dallas Floodway Levee System. As part of the BVP there will be new amenities constructed along its perimeter. Trammel Crow Lake is discussed further in Section 2.5.3.6.

All of the newly constructed lakes will require the design to satisfy requirements for the mitigation of seepage, to ensure minimal damage during flood events, and to provide for future operations and maintenance duties. The proposed earthen berms between the lakes and the relocated Trinity River Channel shall meet an earthen dam design criteria and are described further in Section 2.5.3.4. Lake design elements are required to meet regulatory and operations goals which include overflow weirs, slope retention systems, erosion control systems, lake lining systems, berm penetrations, and lake drain lines.

The proposed lake lining system consists of a minimum 18-inch thick compacted clay liner to mitigate seepage into the subsurface soils by the lakes and better retain the water volume. The thickness of the clay liner can be increased to a depth of 30 inches where sandy materials are encountered. Treatment of the clay with lime or cement will be as necessary to determine suitable material properties. This is discussed further in the Geotechnical Appendix, Appendix B.

Since the BVP and proposed Lakes are within the active Dallas Floodway, all features will be subject to various water velocities and water shear stresses during a flood event. The depths of inundation during these flood events will vary and the forces associated with flood events need to be taken into consideration in the design for the sustainable functionality of the Floodway. The Floodway and its BVP components are designed to withstand various flood stages based on the category of feature, as described in Section 2.5.1. The feature has to be designed to accommodate both the depths of inundation during flood events and the flows that will carry trash and heavy debris through the Levee System.

One key component of the lake's functionality is the regular maintenance of the lake itself following flood events. Sedimentation and erosion are two important components of this maintenance feature. Presently, sedimentation is discussed in detail in the referenced reports with little mention of possible erosion fixes. Sedimentation in the lakes is projected to be remediated through the use of mechanical dredging equipment when the sediment reaches a depth of 2-3 feet. The time interval for this operation is projected every ten years as necessary. Multiple flood events are anticipated to be required for this condition to occur. When dredging the bottom of the lakes, it is important that the clay line remain intact to its full depth to maintain the integrity of the lake. Erosion remediation after flooding events, along with periodic inspections of the earthen berms surrounding the lakes, will be required and is not currently detailed in the referenced reports. This is an integral feature to discuss when determining technical soundness and will be included in future Operation and Maintenance manuals.

The overall concept of the BVP with its lakes is technically sound for feasibility design. Design integration issues can be addressed and accounted for in PED. A risk informed decision was made that corrections could be addressed in future design. Scour and erosion protection is provided in some locations; however, it is severely lacking in others and needs to be further evaluated. Even with scour and erosion protection, damages are anticipated to include localized scour at location where structures, foundations or other features create localized eddies. Pipes and structures at river outfall locations, including possible shallow utilities crossing under the lakes may require repair or maintenance due to excessive scour or erosion. Impact loads from large debris traveling downstream during a flood event may cause additional damage to exposed features along the promenade and other lake features.

Table D-24. Lake Descriptions

	West Dallas Lake	*Urban Lake*	*Natural Lake*
Surface Acres	130	86	57
Open Water (acres)	123	84	50
Fringe Wetland (acres)	7	2	7
Avg. Width (feet)	650	700	600
Avg. Depth (feet)	18	12	12
Avg. Length (feet)	8,500	7,000	4,600
Storage Volume (acre-feet)	1,730	1,020	630
Weirs (#)	2	1	1

2.5.3.1 Natural Lake

Natural Lake begins at the isthmus separating the Urban and Natural Lakes and extends downstream, with respect to the Trinity River, before ending approximately 2,200 feet north of the Houston Street Bridge. The downstream edge of Natural Lake is bounded by Cypress Pond and an earthen berm that separates the Lake with a bend in the realigned Trinity River. On average 60 million gallons per day of water will enter Natural Lake from the Dallas Water Utility Central Wastewater Treatment Plant (CWWTP). The clean effluent discharge will be pumped upstream from CWWTP in a 60 inch diameter pipe to the 70 foot diameter outlet structure located at the south end of Natural Lake. This effluent will flow through Natural Lake, into Urban Lake through the isthmus, before eventually discharging into the Trinity River. Natural Lake and its features can be seen on sheets CS100-CS118.

The current designs for Natural Lake prescribe floating wetlands, distributed throughout the Lake. These wetlands will help filter and purify the lake water. Natural Lake will also be equipped with a boat launch near the south end of the Lake with an accompanying vehicle parking area. Pedestrian trails and vehicular access roads surround the perimeter of the Lake, as well as Cypress Pond, see Section 2.5.3.8. The overflow weir is located between Jefferson Boulevard Bridge and Southbound R.L. Thornton Bridge (IH-35E).

During preliminary design submittal stages, the BVP design assumed the existing Able Pump station would be relocated from its current site to a site near the existing Belleview storm drain outfall. Currently, the Able Pump Station 65% design, submitted June 2013, does not call for the relocation of Able Pump Station to be such a large distance. The new Able Pump Station will be relocated approximately 120 feet north of the existing Able Pump Station and will remain between Houston and Jefferson Bridges.

The current design of the Natural Lake boundary is within the designated 150-foot buffer in the area near the new Able Pump Station. To maintain the 150-foot buffer, the Natural Lake would need to be shifted 30 feet towards the Trinity River. Coordination will be required between the designers for Able Pump Station and the BVP to ensure there will be no conflicts in the storm drain outfall location.

The two proposed layouts for the BVP include a With Parkway and Without Trinity Parkway design. These two design sets are separated by the intent to include the proposed Trinity Parkway, see Section 3.2.1, as part of the Dallas Floodway Levee System. The With Trinity Parkway alternative places the Trinity Parkway between and parallel to the riverside of the East Levee and Natural Lake. The With Parkway proposal involves the interaction between the Trinity Parkway and Natural Lake, while the Without Parkway proposal has direct interaction between Natural Lake and the East Levee of the Dallas Floodway. The grading plans for each alternative, regarding the interface between neighboring features, have not yet been fully developed. There is no definitive tie between Natural Lake and the East Levee or Trinity Parkway. The current modeling of these interfaces is discontinuous in certain places and does not yet reflect constructible conditions. In conclusion, the interaction between Natural Lake and the proposed Able Pump Station needs to be addressed in the next stages of Able Pump Station design to ensure the proper locations and design for the outfall structure of Able. Although there are issues with the grading interfaces between the Natural Lake and the Trinity Parkway the configuration of the Natural Lake is technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.3.2 Urban Lake

The Urban Lake begins approximately 4,000 feet downstream of Sylvan Bridge and is parallel to and located between the East Levee and the realigned Trinity River. The Urban Lake ends approximately 1,500 feet downstream of the Margaret McDermott (IH-30) Bridge where it abuts Natural Lake. The connection between Natural and Urban Lake is denoted as an isthmus. The current design intent is to have Natural Lake flow into Urban Lake as a water source. This creates a flow from the proposed Natural Lake to Urban Lake that is opposite the flow of the Trinity River. On average, 60 million gallons per day of water will supply Urban Lake from Natural Lake. The flow into Natural Lake is discussed in Section 2.5.3.1. Urban Lake and its features can be seen on sheets CS100-CS118.

Urban Lake’s major design features include an amphitheater with floating stage near the isthmus, a proposed fountain plaza, an Urban Lake outlet channel, a kayak loop, a marina, a skate park, a group pavilion area, pedestrian trails, and access roads. Bubbler fountains and lake aerators will be distributed throughout the Urban Lake to help aerate the water and enhance circulation for water quality purposes. The Urban Lake outfall channel is located at the north end of Urban Lake with a total length of 2,350 feet before discharging into the Trinity River. The outfall channel is designed to maintain a water channel bottom to convey the full outflow from Urban Lake to the Trinity River and will provide access for maintenance and sediment removal. Normal flow conditions will result in the discharge of 90 cfs through the outfall channel to provide safe passage for properly equipped novice boaters. A head gate will regulate the flow through the outlet channel, allowing up to 500 cfs of discharge to create white water attraction for intermediate and advanced boaters.

An overflow weir will be constructed between the Margaret Hunt Hill Bridge and the Union Pacific Railroad Bridge. The Urban Lake overflow weir will be approximately 400 feet in length parallel to Urban Lake with an average width, perpendicular to the Lake, of 250 feet. The top of crest for the overflow weir will be at an elevation of 403 feet above MSL. This top of crest is approximately 12 feet wide and used as a pedestrian trail with infrequent vehicle use for maintenance purposes. At the base of the overflow weir, two pressure storm sewers discharge into the Trinity River. These two pressure storm sewers are extensions of the Dallas Branch and Woodall Rodgers storm sewers. Pressure storm sewers are further discussed in Section 2.5.8.2. The capacity of the Dallas Branch storm drain system is anticipated to be 1,350 cubic feet per second, and the capacity of the Woodall Rodgers storm drain system is projected at 1,790 cfs. These two outfall structures enter the Trinity River directly under the overflow weir at varying angles. Also, under the Urban Lake overflow weir is a 3-foot diameter lake drain pipe with sluice gate and gate vault. This is to be used for periodic maintenance for drainage of Urban Lake and removal of sediment following a significant flood event. The proposed confluence of the Dallas Branch and Woodall Rodgers Pressure Sewer extensions are located directly underneath the Urban Lake overflow weir. During a storm event that overtops the overflow weir, it is expected that a significant portion of the projected capacity of the storm sewer will be discharging into the Trinity River coincidently. Three water sources discharging at a single point, with potential flooding in the Trinity River could create issues with the project's functionality due to major scour and erosion. The Urban Lake overflow weir with regards to the locations of the Dallas Branch and Woodall Rodgers pressure storm sewer outfall needs further evaluation in PED to ensure there are no localized erosion problems while discharging into the Trinity River. Potential remedies include armoring of the opposite bank of the Trinity River from the discharge locations or the staggered outfall locations of the storm sewers.

The two proposed layouts for the BVP include a With Parkway and Without Trinity Parkway design. These two design sets are separated by the intent to include the proposed Trinity Parkway, see Section 3.2.1, as part of the Dallas Floodway Levee System. The Trinity Parkway parallels the riverside of the East Levee for the extent of Urban Lake. The With Parkway proposal, therefore, involves the interaction between the Trinity Parkway and Urban Lake. The Without Parkway design proposal involves the interaction between Urban Lake and the East Levee of the Dallas Floodway. In either case, the grading plan that interfaces with the neighboring feature, whether it's the East Levee or Trinity Parkway, is not fully developed. There is no definitive tie into either the East Levee or Trinity Parkway. The current modeling of these interfaces is discontinuous in certain places and does not yet reflect constructible conditions.

In conclusion, the overflow weir structure in conjunction with the outfall of the two pressure storm sewer pipes needs to be evaluated further in PED to determine proper design. In addition to this issue, the grading plan interfacing with either the Trinity Parkway or East Levee, depending on the BVP design, needs to be developed. Although there are issues with the pressure sewer outfalls and the grading interfaces between the Urban Lake, Trinity Parkway, and the East Levee, the configuration of the Urban Lake is technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.3.3 West Dallas Lake

The West Dallas Lake begins just downstream of the confluence of the Elm Fork and West Fork of the Trinity River. It continues parallel to the West Levee, extending downstream past Westmoreland Bridge, and ending approximately 1,700 feet upstream from Hampton Bridge. Water will be supplied to the lake during overflow flood events, when the Trinity River stage exceeds an elevation of 405 feet above mean sea level (msl) via overflow weirs. The overflow weirs will allow for Trinity River flooding to overflow into West Dallas Lake. During conditions where the Trinity River is below the spillway overflow elevation, make-up water for seepage and evaporation losses will be supplied to the Lake with a water management system with water rights in mind by using a groundwater pump. The West Dallas Lake Pump Station is discussed further in Section 2.5.3.5.

Major West Dallas Lake recreational features include a seven-lane Olympic sized rowing course, a large amphitheater, a boat dock, floating wetlands, pedestrian and equestrian trails along the perimeter of the lake, and picnic areas. The purpose of the floating wetlands will be to help filter and purify the lake water. The floating wetlands will be anchored into the lake bottom with mooring blocks. The wetlands in conjunction with floating buoy strings will help define the rowing course. Two overflow weirs will be constructed on either sides of Westmoreland Bridge in conjunction with lake drain lines to be used for periodic maintenance and removal of sediment following significant flood events. Overflow weir No. 1 is located on the west side of Westmoreland Bridge and has a 32-foot wide crest at an elevation of 405 feet above msl. The approximate length of the overflow weir is 250 feet and approximate width of 175 feet. The second overflow weir is located on the east side of Westmoreland Bridge and will have similar crest widths, dimensions, and elevations to the other weir. The overflow weirs will be constructed of roller compacted concrete with the side slopes installed in a series of one-foot steps.

The attached plan set shows the features of the West Dallas Lake on sheets CS100 through CS118. The West Dallas Lake is required to have its top of bank at least 150 linear feet from the proposed West Levee Toe and create positive drainage between the levee and the lake. Current designs and grading plans are at a 35% submittal level and have no contours tying into existing grade. The existing West Levee toe has a depression that creates a drainage swale traveling parallel to the levee. The grading for the West Dallas Lake increases the depth of this drainage swale creating a large sump area. Further developments downstream of the West Dallas Lake impede the drainage of this sump area; therefore, it is imperative that the grading for the West Dallas Lake address the grading to drain issue between the Lake and the West Levee. The revised grading plan should have positive grading from the levee slope to the West Dallas Lake, which may cause the effective levee toe to be further up the face of the levee. This grading issue needs to be coordinated with the hydraulic model that governs development within the Dallas Floodway Levee System Although there are issues with the grading interfaces between the West Dallas Lake and the West Levee the configuration of the West Dallas Lake is technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.3.4 Lake Berms

The three lakes are separated from the Trinity River by fairly narrow strips of land. The area between the Natural and Urban Lakes and the Trinity River is referred to as the Central Island for planning purposes. There is also an earthen strip separating the West Dallas Lake and the Trinity River. This is simply referred to as the West Dallas Lake Berm. These features have been classified as critical park features or elements and are used to minimize flooding potential and ensure the separation of the Lakes and the Trinity River. These features are classified as Category 1 features (see Section 2.5.1 for more information). For more information and design criteria reference Final Lakes Design Report dated August 2009.

These lake berms vary in width and will generally consist of native clays. It is assumed that these native clays will come from suitable material on site within the Dallas Floodway Levee System. Unsuitable material for the berms will be removed and replaced with suitable fill material to complete the embankment to final grade. The typical section will include a maximum allowable slope on the riverside to be 4H:1V or 3H:1V in areas were the surface is protected with a riprap blanket and bedding material. These surface protection systems will only be allowed under bridges or in other areas generally obscured from view for aesthetic purposes. An emergency and maintenance vehicle access road will be paved and have a minimum width of 20 feet wide along the crest of the lake berms and will be a part of the park's primary trail system.

The most current design creates some issues with maintenance dealing with the earthen berms bordering all three lakes and with the Central Island berm separating Natural and Urban Lakes. If the berm embankments are overtopped by flood stages, this could result in a loss of top soil and vegetative cover along the berms. Larger and longer duration flood events may cause logjams at bridge piers leading to the formation of currents that may deflect flood flows causing erosion to the berms. Severe floods may result in the loss of the berms that impound the lakes and cause severe damage to all the lake and park features. It is recommended that armoring all berms with some sort of scour protection be evaluated to ensure proper erosion protection during the unpredictable flows and eddies during flood events. The lake berms are technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.3.5 West Dallas Lake Pump Station

The West Dallas Lake pump station was designed to maintain the normal pool elevation in the West Dallas Lake. The intent was to use the pump station to make up for the water demands taken from West Dallas Lake to include evaporation, seepage, park irrigation, and supply of the Pavaho Wetlands Project; see Section 3.2.2 for further information on the Pavaho Wetlands Project. The West Dallas Lake Pump Station is no longer proposed as currently design. The water source for the West Dallas Lake is expected to be from a groundwater source that does not conflict with water rights.

2.5.3.6 Trammel Crow Lake

Crow Lake is a small, 3-acre existing lake within the Dallas Floodway Levee System. It was constructed in the 1990s and is located on the north side of the existing Trinity River Channel, downstream from Sylvan Bridge. The proposed BVP includes Crow Lake as part of its design for the interior of the Floodway System. The BVP includes increased access to the lake with parking structures and paved access roads as the improvements surrounding the lakes.

There are no outstanding concerns with Crow Lake as the relocated Trinity River generally remains at its existing location as it passes Crow Lake. The only concern is the lack of grading between the relocated Trinity River and Trammel Crow. Because of the lack of grading, it is unclear as to the interaction between the Trinity River, Crow Lake, and the surrounding features. In addition, no grading is present for any of the proposed parking areas or access roads. During design, grading in this area will ensure positive drainage in the surrounding features and between the Lake and Trinity River. Although there are issues with the grading interfaces within the Trammel Crow Lake, BVP features and the Trinity Parkway the existing configuration of the Trammel Crow Lake is technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.3.7 Central Wastewater Treatment Plant Pipeline and Lower Lake Water Management

The CWWTP is located downstream of the main Dallas Floodway Levee System on the south side of the Trinity River in the Dallas Floodway Extension project area just upstream from IH-45. The DFE project is a USACE authorized project (currently in construction phase) located immediately downstream of the Dallas Floodway project area. The CWWTP is surrounded by a levee that borders portions of proposed Wetland Cell 'C' as part of the DFE Upper Chain of Wetlands (UCOW) Project. Currently, a 60 inch force main pumps water from Cadiz Pump station to CWWTP, a distance of about 2.7 miles. This pipeline runs parallel to the south edge of the UCOW before turning north and crossing the Trinity River around Corinth Street.

The current proposal is to use a portion of the clean effluent from CWWTP and segments of the existing Cadiz 60 inch Force Main to the proposed Natural Lake as part of the BVP. Approximately 7,200 linear feet of existing sanitary sewer force main will be repurposed and lined for clean effluent use. About 6,750 linear feet of new pipeline will be placed to connect the existing pipe to the pump station on the downstream end and Natural Lake on the upstream end. The 60 inch pipeline would pump approximately 60 million gallons per day from CWWTP to Natural Lake. The proposal is to modify the current pump station at CWWTP to pump effluent into a new 60 inch pipeline which would then merge with a relined 60 inch Cadiz Force Main. Just downstream of Corinth Street, the existing, relined 60 inch Cadiz Force Main would branch off to a new 60 inch pipe before crossing under the realigned Trinity River and emptying into Natural Lake.

Natural Lake would feature a reinforced effluent discharge structure in its southeastern corner. This outfall structure is not considered critical to park survival; however, it is important to the proper operation of the Natural and Urban Lake during normal conditions and following flood events. The structure would be designed for the 100-year flood event. For more information reference the Preliminary Design Report of the CWWTP Effluent Pump Station and 60 inch Alternate Discharge Line Improvements and the Final Lake Design Report. The preliminary plan view layout can be seen on sheet CU101 as an exhibit provided by the City of Dallas.

It is assumed that UCOW Cells A, B, and C will already be in place before the construction of the pipeline, as the design is currently approaching a 65% stage. The areas affected by UCOW will be reclassified as wetlands and contain ponds that will have continuous pool elevations of several feet. The current alignment of the 60 inch effluent pipe has a significant portion planned underneath Cell C of UCOW. Proposed access points appear in the center of Cell C's channel that will be continuously underwater. In addition to the current alignment under Cell C, another access point to the effluent line is planned for the intersection of the new pipeline and existing, relined Cadiz Force Main just downstream from Corinth Street. The current BVP plans have this area designated as wetlands with no access points to this location. Access to the 60 inch pipe is imperative for operation and maintenance. Current plans for the Upper Chain of Wetlands include a two-foot clay liner in all wetland areas to improve wetland quality. Coordination with regards to this design feature needs to occur if any areas of UCOW are disturbed in the construction of this pipeline.

The UCOW will pull water from the current lagoon supplied by the CWWTP and its effluent. During the construction of the CWWTP pipeline feeding Natural Lake, it is important to consider the effects on the water supply for the wetlands. The water demand for the wetlands is relatively small compared to that required by the Natural and Urban Lakes. However, it is important to ensure the continued proper functioning of these existing and planned features post construction of this water supply line. The current design and layout contains some issues in constructability and integration with other projects in the area. The current configuration of the CWWTP pipeline is technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.3.8 Cypress Pond

Cypress Pond is located just downstream from Natural Lake. It is not part of Natural Lake from a hydraulic standpoint; however, it provides an enhanced naturalistic environment with cypress trees designed to screen the Trinity Parkway from the opposite side of the park. Able Pump Station as well as runoff from the Trinity Parkway will supply water for the pond. Able Pump Station as well as the Belleview storm drain will be rerouted underneath Cypress pond to empty into the river, with a small portion of Able Pump Station routed into the pond, about 3 cfs. The Trinity Parkway runoff would have a peak flow of about 65 cfs.

Cypress Pond is a noncritical design component that will survive flood events of 25 to 50 years. It is designed as a shallow retention area with a maximum depth of four feet. The embankment surrounding the pond does not meet the definition of a dam structure because of its relative size, but will support an access and maintenance road. Armoring for the embankment has not been identified as a requirement at this stage of the design, but further analysis showing higher velocities may necessitate it based upon maintenance costs.

The Trinity Parkway borders Cypress Pond on the North and the relocated Trinity River has its south border. It extends from the downstream end of Natural Lake, as well. These spatial constraints restrict the Cypress Pond footprint from moving significantly. There are some slight grading and integration issues between the Cypress Pond and the Trinity River. This will require Cypress Pond to shift approximately 30 feet southward to eliminate any integration issues. The BVP designers are aware of this issue and it will be addressed in further stages of design. It is also recommended that a more detailed look be taken at armoring the embankment separating Cypress Pond and the Trinity River. With the expected 30 foot shift of the Cypress Pond towards the Trinity River, the shift may cause increased slopes to maintain proper storage volume in Cypress Pond. Where the Cypress Pond encroaches on the relocated Trinity River, it is recommended that armoring be considered as a necessary part of the design approach. Armoring in these areas will mitigate for erosion in high flow and overtopping scenarios and reduce the potential for embankment failure causing flooding and drainage issues. Although there are issues with potential erosion and overtopping due to high shear stress and velocities, the configuration of the Cypress Pond is technically sound for a feasibility design and issues could be remedied in future design.

Following the environmental review of the Cypress Ponds, it was determined the Cypress Ponds could not be built as proposed above. The Cypress Ponds was renamed the Forested Ponds and have the following features. Constructed Forested Ponds are proposed to bring shade and cooling to the heart of the Floodway, especially alongside the edge of the Urban Lake Promenade. They also would function as biofiltration areas capable of absorbing lake nutrients. These constructed wetland ponds would feature native bottomland hardwoods and other water-tolerant herbaceous plants capable of high rates of biofiltration.

Forested Ponds along the Urban Lake would be periodically filled with water from the bottom third of the Urban Lake. Pumped from the lake under the Promenade, lifted up and over the adjacent water wall, the water would first be aerated by the water wall and then further filtered by the ponds before finally returning to the Urban Lake. The wetland ponds would be approximately 5 feet in depth and be equipped with overflow mechanisms to prevent overtopping. Along the Natural Lake, the Forested Ponds would be designed to receive, retain and filter stormwater runoff from the bridge crossings proposed in other projects. Filtered water would return to the Natural Lake.

2.5.3.9 Lake Drain Lines

Lake drain lines are proposed for each of the three BVP Lakes. These lake drain lines would be used to drain the lake for periodic maintenance and to quickly remove high sediment water after a storm event. These lake drain lines are to be constructed with 30 to 36 inch steel pipes encased in concrete and extend under the proposed overflow weirs for each lake. One drain line each is proposed for the Urban and Natural Lake and two drain lines would be constructed at the West Dallas Lake. These lake drain features would be considered Category 2 features as part of the BVP.

The outflow gate will be comprised of an inlet two feet above the lake bottom and a low flow outlet at the lake bottom with manual operation. The sluice gate vault will be integrated into the overflow weir and will be closed under normal conditions. The main gate would allow a maximum drawdown of 2 feet per day and would allow the majority of the lake volumes to be drained between seven and ten days. The remaining volume of water would then drain through the manual lower sluice gate and would take an additional seven days to completely drain the lake.

Plan and profile views of these drain lines are not currently available at this stage of design. There are some initial design concerns based upon the description of these features in the Final Lakes Report dated August 2009. These lake drain lines will penetrate the earthen berms separating the lakes from the relocated Trinity River and would need to be designed accordingly and satisfy all applicable USACE criteria. Additionally, these drain lines, when used, will be operating at a high volume for a sustained period of time. The opposite bank of the relocated Trinity River will need to be reinforced for scour and erosion protection commensurate with this high level of sustained flows. There would also need to be measures to ensure that the outfall structure of the drain pipe is at a sufficient elevation to have enough water pressure head to drain the lake completely.

Additionally, two pressure storm sewer lines already converge at the Urban Lake overflow weir. See Section 2.5.8.2 for more information about these two lines. Adding an additional pipe, though used infrequently, further complicates the problems associated with this already congested area. This additional pipe creates another vector of flow and will increase the turbulence in this area of the river. There are design issues with lake drain lines and the pressure sewers, but the design is technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.4 Cut-off Walls

In determination of the potential issues that could arise from seepage, a 150-200 foot buffer from the proposed levee toe should be sufficient to reduce the seepage failure mechanism. The proposed levee toe includes any levee improvements to change the levee toe, including the flattening of the levee side slopes to 4H:1V. This design pushes out the existing levee toe towards the interior of the Floodway, see Section 2.4. The toe was evaluated to see if there was any overlap with proposed top of bank of river and lake features. There are no significant issues that arose from this evaluation based on a 200-foot distance from the toe of the levee. There are some concerns regarding the depth to which the lakes are being excavated. Specifically, the depth of excavation for West Dallas Lake is substantial at 24 feet from the existing grade. Further seepage analysis is needed at this location to determine appropriate offset distances for the depth of this lake. If the footprints of the river or lakes change to any extent, the cut-off wall option would have to be re-evaluated.

USACE conducted a risk assessment of the major BVP features including the Lakes and River Relocation. The risk assessment determined that there is one reach requiring a cut-off wall due to the River Relocation. The reach is located on the upstream portion of the main stem of the Trinity River along the East Levee. The cut-off wall will be located 10 to 30 feet in front of the river side toe similar to the City of Dallas 100-year cut-off wall configuration. The cut-off wall extension will have a depth of 20 to 40 feet. The cut-off wall will extend downstream from the existing City of Dallas cut-off wall to Continental Avenue Bridge. This is from approximately station 163+00 to station 285+00 along the East Levee for an approximate length of 12,200 feet or 2.31 miles. Details for a typical cut-off wall from the City of Dallas are shown on sheets C-506 and C-507. These details were used for quantity generation only and the final design of cut-off walls may change in future design phases of the project. They are shown to identify the intent of the cut-off wall in typical detail.

2.5.5 Hardscape Features

Hardscape features vary slightly between the two versions of the BVP. Hardscape features are defined as access roads, paths, parking structures, promenades, hard-court recreation feature, amphitheaters, etc. In the BVP without Trinity Parkway, the designs propose the construction of several access roads, parking structures, and paths within the proposed footprint of the Trinity Parkway. These variations are minor and there are no significant differences between the two proposed plans.

It is recommended that runoff from these hardscape areas be treated through low impact development best management practices. This will help maintain water quality as runoff from roads and parking areas drains into lakes and the Trinity River. There are several best management practices (BMP) that would be applicable in these scenarios. Bio-swales and other BMPs can not only help treat potentially polluted hardscape areas, it can also help eliminate erosion during storm water runoff events and subsequent drainage.

2.5.5.1 Access roads and Trails

Access roads, primary vehicle paths, and trails crisscross up and down the entire Dallas Floodway Levee System as part of the BVP. Primary vehicle paths and maintenance roads are used to access all features within the Dallas Floodway and are part of the overall flood-fighting and maintenance effort. These features need to be designed and graded appropriately so proper maintenance and access can be maintained for required vehicles. There is an equestrian trail located along the West Levee and pedestrian paths and bridges allowing access between features and across the realigned Trinity River. Currently, grading plans for trails and vehicle paths are not fully developed and will need to be addressed as part of future design efforts.

Access roads from outside the levees to the inside are located on the face of both the East and West Levees. These access roads are the only means of access to the features of the BVP. The roads add a significant amount of fill to the face of the levee and assurances need to be made that the integrity of the levee is not compromised through the use of material or construction technique. These access roads are not included as part of the grading plan. The access road grading plan is a significant hardscape feature that is not developed. These features add a significant amount of fill to the face of the levee, and the effective levee toe is pushed farther away from the levee. The design would require adherence to the 150-foot buffer from the levee toe and the Trinity River Relocation and Lakes footprint. It is suggested that the slopes of these access roads be no steeper than 20H:1V or 5% which could affect the current layout of the access roads to accommodate the length of road required to navigate down the face of the levee.

A revised grading plan will need to be made to ensure no negative effects occur from the design of these features. While the levee toe will extend somewhat with the inclusion of these features, it is not expected to impact the overall hydraulics of the Floodway system. The proper design of all the hardscape features will require the creation of a full grading plan that accommodates all features of the BVP. The hardscape features are technically sound for a feasibility design and the incomplete grading issues can be resolved in future design.

2.5.5.2 Industrial Boulevard Entry Plaza

The Industrial Boulevard Entry Plaza extends across the East Levee upstream from IH-30, providing access to the Urban Lake Promenade. This feature is not fully designed and developed at this stage. It is important that this feature accommodate the FRM Plan as well as the Trinity Parkway to ensure proper clearances and integration with the Dallas Floodway Levee System.

2.5.5.3 Parking Areas

Several parking areas are located throughout the Dallas Floodway BVP. These parking areas enable vehicle access to several of the unique features throughout the BVP. Current grading plans do not incorporate these features. These are relatively small features when compared to the overall BVP scope and can be included as designs progress in detail. It is imperative to include proper drainage for these parking areas to eliminate ponding and minimize maintenance costs.

While parking areas are throughout the park, it is important for these features to be coordinated with other projects in the area. Bridge pier modifications may create obstacles for parking structures to be coordinated around. In addition, the proposed and currently under construction Cadiz Street Pump Station and sanitary sewer improvements (also known as the East Bank-West Bank Interceptor project) include the construction of a below ground terminus structure that is 40-feet in diameter. This structure is located on the downstream edge of the IH-35E Bridge and in the area of a BVP proposed parking lot. This terminus is referred to in some documentation as a siphon. It is important that this siphon structure be coordinated with the design of the parking lot and surrounding access roads to ensure the footprint remains outside any proposed paving areas, while maintaining proper access for operations and maintenance.

These areas have little information about their design and drainage needs, but is technically sound for feasibility design and can be addressed and accounted for in PED. It is important that parking structures drain properly and navigate around other projects in the area.

2.5.6 Landscape Features

A major portion of the BVP is the landscape design. The landscape features include various recreation fields, wetlands, treed vegetated areas, and other parklands. These features are a critical portion of the BVP as they help ensure the hydraulic conductivity of the Floodway, have aesthetic value, and create areas for public enjoyment. The hydraulic conductivity of the Floodway is determined using the HEC-RAS model for the area to include various roughness coefficients describing the surface properties.

The recreation fields are located along the West Levee between the Pavaho Wetlands and West Dallas Lake. There are also a few recreation fields just upstream from West Dallas Lake. These recreation fields will be grass fields for use in sports. This will be a regularly maintained feature to ensure proper grass growth and grass length. The recreation fields are terraced and graded to drain with wetlands in the low spots between the fields and the relocated Trinity River. The recreation fields are adjoined to the side of the West Levee at varying elevations. There are no major issues associated with these fields. During the final design, it is important to make sure the fields drain away from the levee itself.

Wetlands of varying depths and types are across the proposed Dallas Floodway Levee System. These areas are specifically designed for various features and are described in more detail as part of the environmental appendix (Appendix F). The grading surrounding these wetlands needs to account for the amount of water these wetlands can contain during various flood events. Drainage away from these wetlands and towards a more suitable location may be required where large open areas can potentially drain into wetlands. This needs to be addressed in further design to ensure the integrity of the wetlands is kept.

As part of the wetlands and throughout the proposed BVP features, vegetation is used for aesthetics and part of hydraulic features. There are multiple current landscape plans that have conflicting depictions of the actual amount of vegetation to be used in certain areas. This is especially evident in the Corinth Wetlands, see Section 2.5.7. Tree spacing is not well defined in certain areas and can lead to inaccuracies pertaining to the hydraulic modeling of the system. It is important that the hydraulic modeling accurately represent proposed dense vegetation areas. As landscape designs are refined in future phases, the hydraulic modeling will be representative of the landscape features.

2.5.7 Corinth Wetlands

The Corinth Wetlands extend from Oxbow Lake, downstream between the relocated Trinity River and the West Levee. The intent of this feature is to expand the existing wetlands in that area. There are multiple landscape and grading plans for this area that all have varying descriptions and details of the amount and type of work to be completed in this area. Some plans show large amounts of landscape work including riparian woodland plantings. In addition, there are no grading contours present in this feature and the integration of existing wetlands, but is technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.8 Utilities

There are four major pressure storm sewers, various water lines and other utilities that are affected by the BVP as proposed by the City of Dallas. Four pressure storm sewers pass underneath the East Levee and discharge into the Trinity River. With the realignment of the Trinity River and the construction of three lakes as part of the BVP, these storm sewers need to be rerouted and extended to accommodate their new outfall location. The four pressure storm sewers are Belleview, Dallas Branch, Woodall Rodgers, and Turtle Creek. In addition, the BVP requires the relocation and modification of existing water mains crossing the Trinity River to accommodate the proposed lakes and Trinity River Relocation. The DWU water mains are currently under review as a local feature under Section 408. Additional discussion of the DWU water mains is in Section 3.2.9. Utility modifications and relocations are identified for cost estimating purposes. A final accounting of the required utility relocations for the Recommended Plan is provided in Section 4.1 of this appendix. The scope of the utility relocations described here assumes the Trinity Parkway is built prior to the BVP features.

2.5.8.1 Belleview Pressure Storm Sewer

The existing Belleview Outfall consists of a 16-foot diameter horseshoe pipe that discharges into an outfall channel before flowing into the Trinity River. The BVP as discussed in previous sections includes the relocation of the Trinity River and the creation of several lakes including Cypress Pond.

Current designs indicate that the existing pipe will be extended as part of the Trinity Parkway project. This will extend the length of pipe underneath the parkway berm, discharging into the Trinity River. Currently, there is some conflict in this location with the location of the Trinity Parkway and Trinity River. This is discussed fully in Section 3.2.1. Based on the current plans of the Trinity Parkway and BVP, the 16-foot horseshoe pipe will be extended from its current location approximately 640 feet in length to reach the relocated Trinity River. This length may change based on the actual final location of the outfall structure after the Trinity Parkway is built. Based on the drainage study for the Belleview System, it was determined that the final capacity of the pipe is approximately 2,400 cfs. No significant hydraulic head losses are anticipated due to friction; however, some capacity losses are anticipated due to sediment accumulation within the pipe. This issue will be part of the operations and maintenance of the Belleview Pressure Storm Sewer and will require periodic inspection and cleaning.

There are a couple issues with the current design of the outfall structure and location of the Belleview Pressure Storm Sewer. The 16 foot diameter pipe, when fully flowing with water, will have water discharging at a high elevation above the proposed Trinity River channel bottom. Additionally, the top of pipe is projected approximately four vertical feet above the crest of the bench in the river on the opposite side of the channel from the discharge point. This in combination with the large amount of flow, 2,400 cfs, creates a large potential for erosion of the opposite bank and for a significant distance downstream. This needs to be investigated further as the design process moves forward as it may negatively affect other features within the Floodway due to the forced erosion and subsequent re-channelization of the Trinity River. Erosion protection on the opposite slope across from the discharge location and for a distance downstream may help mitigate erosion on the opposite bank. Additionally, the realignment of the Belleview Storm Sewer pipe to create a smaller angle of intersection with the Trinity River may help reduce the eddying and turbulence that will arise from this confluence. Further options that may be explored involve the installation of a junction box and reducing the outfall structure to multiple smaller pipes to avoid the higher elevation of discharge.

If the Trinity Parkway is constructed after the BVP, the BVP will have to accommodate the full extension of this pipe from its current location. Additionally, coordination with Trinity Parkway designers is needed to ensure their initial discharge pipe extension is compatible with the BVP extension plans. There are design issues with the pressure sewers, but is technically sound for feasibility design and can be addressed and accounted for in PED.

2.5.8.2 Dallas Branch and Woodall Rodgers Pressure Storm Sewer

Preliminary BVP designs assume that the existing Dallas Branch and Woodall Rodgers pressure storm drain outfalls will be extended to accommodate the proposed Trinity Parkway roadway berm. The outfall structures will be extended but will retain the same outfall channel. The BVP design calls for further extension of the Dallas Branch and Woodall Rodgers pressure storm sewers. The outfall structures as built by the Trinity Parkway will be replaced by concrete junction boxes. The new pipes would extend off these junction boxes, traveling underneath Urban Lake, before discharging into the realigned Trinity River at the base of the Urban Lake overflow weir. This design plan, however, is contingent on the construction of the Trinity Parkway prior to the BVP. If the BVP is constructed prior to the Trinity Parkway, the extension of the two pressure storm sewers will have to be done entirely as part of the BVP design. It is assumed that a similar design will be used between the two BVP designs.

The current designs show conflicting pipe and discharge sizing for the Dallas Branch and Woodall Rodgers Pressure Storm Sewers. For instance, the Dallas Branch proposed extension detail the pipes to be box culverts of 4-5 feet by 10 feet in profile sheets. However, in plan view, the extensions and discharge structures describe a round pipe of 6–7 feet in diameter. Woodall Rodgers has a similar discrepancy where box culverts are shown in profile view, but plan view describes round pipes. These discrepancies must be remedied in future design stages to ensure compatibility with surrounding features as well as carrying capacity of the drain line.

The capacity of the Dallas Branch storm drain system is anticipated to be 1,350 cfs, and the capacity of the Woodall Rodgers storm drain system is anticipated at 1,790 cfs. As described in Section 2.5.3.2 regarding Urban Lake, the confluence of the Dallas Branch and Woodall Rodgers proposed storm drain outfall extension occurs at the base of the Urban Lake overflow weir into the Trinity River. This creates three different sources of discharge intersecting the Trinity River at different angles at approximately the same location. With this condition, eddying and scour of the Trinity River Bank and berm separating the Trinity River and Urban Lake is likely. This issue needs to be further analyzed during future design and may cause extra costs due to pressure storm sewer pipe rerouting and/or further scour and erosion protection. The criteria for technical soundness are not met; however, it is technically sound for feasibility design and can be addressed and accounted for in PED. Additionally, due to friction losses caused by lengthening the storm sewer pipes and minor losses with the addition of the junction boxes, the storm sewers may see a resultant reduced flow capacity that may impact the overall functionality of the storm drain system. This friction loss and minor loss issue needs to be evaluated in further design to ensure that the pressure storm sewer is experiencing no loss in functionality and that the pump for the sewer pipes is adequate to support any losses.

2.5.8.3 Turtle Creek Pressure Storm Sewer

In the Final Lakes Design Report, dated August 2009, it was discussed that the Trinity River relocation will shift the Trinity River to the east of the current outfall channel for the Turtle Creek Pressure Storm Sewer. Identified adjustments include modifying the channel length and armoring the area where the Turtle Creek outfall channel meets the Trinity River. The Trinity River relocation design report does not address these issues, specifically regarding the Turtle Creek outfall. Future design will ensure that all outfall channels intersecting the Trinity River are properly designed by each segment of the project.

2.5.8.4 Other Utilities Affected by the Balanced Vision Plan

The City of Dallas and their contractors for the BVP identified several utilities within the Dallas Floodway Levee System that needed to be relocated or were otherwise affected by the implementation of the BVP. The report is titled “Utility Adjustments and Relocations Design Report” dated September 2008. No as-built information was available for cross checking of this utility plan.

The BVP construction would require four underground Dallas Water Utility water mains to be relocated (see Section 3.2.9), five miscellaneous pipelines will be removed, and 13 underground and/or aerial franchise utilities will be need to be relocated. Design requirements should be updated to reflect the latest City of Dallas and USACE design standards. Utility surveys, utility easement, and right of way research will confirm exact locations and depths of utilities. Coordination efforts with franchise utilities and the City of Dallas will be conducted to ensure proper timetables and costs are maintained.

Additionally, the proposed Able Pump Station on the East Levee will discharge into the existing location of the Trinity River within the footprint of the proposed Natural Lake. For more information on Able Pump Station, see Section 2.6.1. The Natural Lake forces the Trinity River to be relocated towards the West Levee. In order to continue Able Pump Station’s discharge into the Trinity River, discharge pipes will need to pass under Natural Lake. It is the responsibility of the BVP to extend this discharge structure to the relocated Trinity River. Quantities for this extension were determined on a rough order of magnitude to create a cost estimate. The extension of the discharge structure included 3,200 linear feet (LF) of 114” welded steel pipe, 800 LF of 48” welded steel pipe, the demolition of the existing discharge structure, and the construction of a new discharge structure at the relocated Trinity River.

2.5.8.5 Utility Conclusions

Although there are issues with the current utility relocation design, it is technically sound for a feasibility design and issues could be remedied in future design. Future coordination with the Trinity Parkway and the construction order of the Parkway and BVP is a key component in the constructability of the feature. The angle at which outfall structures intersect the channel with such large flow rates should also be further evaluated to determine the possibility of their realignment to more closely match the velocity vectors of the Trinity River.

2.5.9 Bridge Pier Modification

The design for the BVP bridge pier modification is a 20% design submittal. This submittal details the impacts that the BVP improvements will have on the bridges crossing the Dallas Floodway Levee System. The report concluded that the following existing bridges required pier modifications:

Westmoreland/Mockingbird, Continental Avenue, Union Pacific Railroad, Commerce Street, Houston Street Viaduct, Jefferson Boulevard Viaduct, IH-35 Southbound, and IH-35-Northbound. Bridge pier modifications are required because either the relocated Trinity River affected different bridge piers than the existing channel, or a proposed BVP lake will submerge the once dry bridge pier. The existing bridge pier is then continuously exposed to water leading to possible erosion or scour issues, where it originally was only designed for infrequent flood intervals. The Hampton and Sylvan Bridges, located within the Dallas Floodway, are not part of the BVP bridge modification plan, because the realigned Trinity River keeps the same alignment as the existing Trinity River in these locations. Although the existing Hampton and Sylvan bridges piers remain under the same conditions post the realignment of the Trinity River, due diligence should include the examination of these bridges to ensure the existing flows and erosion conditions are able to withstand the hydraulic conditions. Table D-25 lists the various bridges that were addressed in the bridge pier modification plan submitted as part of the BVP. Table D-25 also lists other bridges that are either proposed or constructed that have not been identified as part of the original bridge pier modification plan or cost estimate. There are four separate bents for the new IH-30 (Margaret McDermott Bridge) Horseshoe Project. These four bents are the Westbound Frontage Road, Eastbound Frontage Road, Westbound Main Lanes with high occupancy vehicle (HOV) Lanes, and Eastbound Main Lanes. There are also five separate bents for the new IH-35E Horseshoe Project. The five bents are the Southbound and Northbound Main Lanes, HOV Lanes, and the Southbound and Northbound Collector Drives. All of these different bents of the Horseshoe Project need individual evaluation and modification based on the effects of the BVP. It is assumed that these costs for bridge pier modification will be incurred by the IH-30/35 Horseshoe Project.

Table D-25. Bridge Pier Modification Summary

Bridge Name	*Part Of BVP Modification*	*Lake Affected By*	*Affected By Trinity River Relocation*
Westmoreland	YES	WEST DALLAS	RIVER NOT RELOCATED
Continental	YES	URBAN	YES
Union Pacific Railroad	YES	URBAN	RIVER NOT RELOCATED
Commerce Street	YES	URBAN	YES
Houston Street Viaduct	YES	NATURAL	YES
Existing Jefferson Boulevard Viaduct	YES	NATURAL	YES
Existing IH 35E-SB	YES	NATURAL	YES
Existing IH 35E-NB	YES	NATURAL	YES
New Jefferson Boulevard (Future Project Not Under Design Currently)	NO	NATURAL - DESIGN HAS NOT BEGUN	UNKNOWN IF FUTURE DESIGN WILL BE MODIFIED FOR RIVER RELOCATION
New Sylvan (Under Construction)	NO	NOT APPLICABLE	RIVER NOT RELOCATED
Margaret Hunt Hill Bridge (Constructed)	NO	UNKNOWN IF CURRENT DESIGN IS MODIFIED FOR URBAN LAKE	UNKNOWN IF CURRENT DESIGN IS MODIFIED FOR RIVER RELOCATION

Bridge Name	*Part Of BVP Modification*	*Lake Affected By*	*Affected By Trinity River Relocation*
New IH-30 (Horseshoe Project under design) also known as Margaret McDermott	NO	UNKNOWN IF CURRENT DESIGN IS MODIFIED FOR URBAN LAKE	UNKNOWN IF CURRENT DESIGN IS MODIFIED FOR RIVER RELOCATION
New IH-35 (Horseshoe Project under design)	NO	UNKNOWN IF CURRENT DESIGN IS MODIFIED FOR NATURAL LAKE	UNKNOWN IF CURRENT DESIGN IS MODIFIED FOR RIVER RELOCATION

Micropiling, straddle bents, diaphragm walls, and underpinning design methods were considered alternatives for the bridge pier modifications. Diaphragm wall modifications were chosen as the preferred method to modify the existing bridge piers, due to its ease of construction and relatively low cost. This design methodology encases the surrounding soil before any excavation of lakes or relocation of the Trinity River is conducted. Typically a 3-foot thick reinforced concrete wall is constructed 5 feet into bedrock. The width of the diaphragm wall outside of the drilled cap is determined by the limits of load transfer in the soil beneath the pile cap and the inside of the diaphragm wall, minimum dimensions range from 4-7 ½ feet. A sample template from the report is shown on sheets C-504 and C-505. The modification plan is typical for all bridges in the bridge pier modification plan. The schematic design report and plans for the Natural, Urban, and West Dallas Lakes (September 2009) have addressed the Margaret McDermott Bridge (IH-30) piers. At the drilled shafts of Bents 6 and 7 that extend into the Central Island Berm, a proposed diaphragm wall of 30-inch thick reinforced concrete will extend, lake side, into bedrock. The diaphragm wall will be constructed in panels using bentonite slurry to keep the trench open. Details are included on the accompanying plan submittal to the lakes report. Another set of bridge piers for the Margaret McDermott Bridge, at bents 8 and 9, will penetrate through the clay lake lining. In order to protect these bridge piers from scour around the foundation, a 12-inch thick soil-cement layer will be placed on top of the 18 inch clay liner for protection. In order to control seepage around the drilled shafts and at the drilled concrete shaft cap, a geo-membrane, protruding twenty (20) feet beyond the concrete drilled shaft cap will be attached into the concrete cap with a stainless steel adhesive anchor. At the current time, there are no plans that discuss the impacts and analysis of the bridge piers for the Margaret Hunt Hill or the IH-35E Northbound and Southbound projects. IH-35 and IH-30 are part of the IH-30/IH-35 Horseshoe Project which is discussed in Section 3.2.5. Additionally, bridge construction plans are discussed as part of the local projects analysis in Section 3.2. Specifically, see Section 3.2.6 on the proposed and currently in construction Sylvan Avenue Bridge.

2.5.10 Proposed and Existing Feature Integration

The current stage of the BVP grading plan does not include tie-ins to existing grade. For instance, a contour of 410 feet above msl should tie back into an existing 410 elevation contour. The current grading plan does not, which could create an issue of drainage and resultant low spots. There are several instances across the BVP grading plan where proposed grade is above the surrounding existing grade. This is prevalent near the realigned Trinity River and West Dallas Lake. It has been noted that the intention of the Dallas Floodway and the BVP was to have drainage from surrounding areas flow into the closest feature, either lake or river. This is not achieved in many locations in the existing grading plan. Further iterations of design will include tie-ins to grade that ensure the entire Floodway is graded to drain as appropriate.

Creating the grading plan to allow for all features to grade to drain and flow into the closest hydraulic feature (as appropriate) is essential to the project. Potential issues include low spots which may result in emergent wetlands the City of Dallas is not prepared to maintain. The creation of the grading plan to include hardscape features, access roads and paths, will likely affect the entire width between levees. This should not have a large impact on the overall contours of the Dallas Floodway; however, there are certain areas where this is a concern. For example, the area between the West Levee and West Dallas Lake may require a significant amount of fill to grade the Floodway to drain. This could reduce the effective levee height as the proposed grade tie-in rises up the face of the levee, creating a new effective levee toe.

For feasibility, it is essential to ensure that enough earthen borrow material is available to create the various BVP, IDP, FRM, and local features, including the Trinity Parkway. Borrow locations and fill material is a critical piece of the project and construction phasing that is further addressed in Section 3.3. Additionally, the grading plan needs to be coordinated with the corresponding hydraulics model of the Dallas Floodway. It is important that these two items are consistent from a design standpoint. Drainage as well as conveyance issues need to be met to ensure the project is technically sound and functions as intended.

The BVP proposes that the levees will be raised uniformly 2 feet and the side slopes on the riverside of the levee would be flattened to 4H:1V. A levee raise will not be uniform across the entire length of both levees. Instead, only areas that are lower than a target water surface elevation will be raised. The 4H:1V side slope will be a constant based on the preferences of the City of Dallas. The future grading plan and design needs to include the levee base condition to ensure the plans are appropriately merged.

2.5.11 Balanced Vision Plan Conclusions

The BVP features are evaluated in the above sections with their individual concerns listed as part of the feature. The City of Dallas' BVP is technically sound for a feasibility level effort. All of the design issues can be remedied in future design. Further refinement of the design is not expected to significantly change the overall concept of the BVP. Changes to the design of the individual features will be localized and is not expected to prohibit the construction of any of the other Floodway features.

2.5.11.1 BVP Risks

There are six key issues that are current risks in the design of the BVP that need to be mitigated in future design. Both versions of the BVP design include a 35% grading plan. As it currently stands, the grading plan has some significant gaps in design which creates low spots in various areas of the Floodway and some inconsistencies in the integration of multiple features within the Dallas Floodway Levee System. This can be fixed in future design by properly grading to drain (as appropriate) the entire Floodway. Additionally, bridge pier modifications are necessary for the construction of the BVP's Lakes and River Relocation to ensure proper scour and erosion protection around the bridges. The current plan covers a majority of the affected bridges, but needs to be further expanded to include planned bridges in design stages. The three lakes of the BVP all have earthen berms, clay liners, and a lake drain system. The earthen berms, separating the lakes from the Trinity River, have not currently been evaluated to determine accordance with USACE design criteria. This includes the evaluation of the various pipes penetrating the berms. Both the berms and the lining system for the lake must be of suitable material. A detailed evaluation of the quantity and quality of the available material for construction has not been conducted. The earthen berms need to be evaluated for erosion due to storm events with water surface elevations that exceed their height. Lake drain systems may conflict with some utility relocations within the Floodway, specifically pressure sewers. The lake drain lines are proposed gravity flow drains that currently have some concerns as to the necessary pressure head differential between the top of lake and outfall structure to achieve flows for drainage. Finally, erosion control across the Floodway needs further evaluation in future design stages. River banks opposite discharge points need increased erosion protection to avoid blow outs, affects to other features within the Floodway including bridge piers, and to limit river migration. An erosion protection plan along the full length of the relocated Trinity River to include all predicted shear stresses and velocities at high volume and confluences of discharge needs to be developed in future design stages to ensure appropriate protection schemes are implemented.

2.6 Interior Drainage Plan

The IDP encompasses seven different pump stations that take surface runoff from the City of Dallas collected in the sumps on the landward side of the levees. The surface runoff is pumped over or through the levee into a network of outfall channels that drain into the Trinity River. The IDP involves the refurbishment of six existing pumping plants or additions to existing pump stations. The seventh pump station is located at an existing sump area, but no pump station is currently in place. The plan encompasses the seven pump stations, their respective pipes, sumps, access roads, and outfall structures and channels. In many cases, the outfall channels of the IDP are reactive features to the BVP. The relocation of the Trinity River and the creation of the three BVP Lakes necessitated the rerouting and construction of new outfall channels for the pump stations. The BVP includes a relocated Trinity River as well as three lakes and many other features in the Dallas Floodway Levee System. Section 2.5 of this appendix describes the BVP features.

The seven pump stations include three pump stations on the East Levee (Able, Baker, and Hampton), three on the West Levee (Charlie, Pavaho, and Delta), and one new pump station on the West Fork Levee (Trinity Portland). All of the pump stations are at various stages of design and construction. The seven pump stations and their interaction with the BVP and Section 408 features are shown on sheets CS100 through CS118. The reports and designs referenced in the evaluation of these features of the IDP were submitted to USACE and are included in the references of the appendix, Section 6.

2.6.1 Able Pump Station

Able Pump Station is located between Jefferson and Houston Street on the East Levee. The sump areas associated with Able Pump Station include nine (9) different ponds with a total drainage area of over three square miles. The drainage area is highly urbanized, and runoff is substantial. Current sump areas have hydraulic connectivity issues which create water routing issues during storm events. Currently there are two pump stations that service these sump areas, Small Able Pump Station and Large Able Pump Station. It was determined that the current state of the sump areas and pump stations are inadequate to handle the runoff from design storms.

The current design is at a 95% level and most recent designs were submitted in April 2014. The current design includes the construction of a new Able Pump Station in conjunction with the demolition of the two existing pump stations that service the Able Sumps. In addition to the pump station, several improvements to the hydraulic connectivity of the sumps are planned to allow for water to flow freely from one sump to the next and eventually to the pump station. The overall goal of the project is to improve the functionality of the nine pond areas and increase capacity of the Able Pump Station to account for urbanization and increased runoff in the drainage area.

The planned pump station is designed for a full capacity of 875,000 gpm with four pumps each rated at 219,000 gpm and 60 feet of total dynamic head to achieve this production. Each pump will have a discharge pipe of 108 inches in diameter. The pipes will pass over the levee crest and be welded steel pipe material. The initial phase of the discharge will outfall into the existing Trinity River alignment. Once the

BVP is constructed, the Trinity River will be rerouted closer to the West Levee and the outfall structure will have to be demolished and the pipe extended to reach the newly aligned Trinity River. The pipe extension will pass underneath the proposed Natural Lake and empty into the Trinity River.

The sump area work involves a combination of adding more culverts or constructing bridges to encourage hydraulic connectivity between the ponds. There are several adjacent projects to the Able Pump Station, including the IH-30 and IH-35E Horseshoe Project. The connection from Pond 2 to Pond 3 is part of the Horseshoe Project and the responsibility of the Texas Department of Transportation (TxDOT). The Able Pump Station and the Horseshoe Project require coordination during future design to ensure that proper hydraulic conductivity is achieved between the ponds. The Able Sump improved areas is included in the BVP because recreation amenities will be added into the project.

In the current state of design, there are a few minor conflicts that need to be remedied. This earthwork interfaces with a proposed access ramp to the Trinity Parkway and needs to be coordinated in order to ensure proper clearance is achieved. This is further discussed in Section 3.2.1. In addition, the grading needs to interface with the existing levee at a 4H:1V side slope and encompass the re-grading of the existing outfall structure that is to be demolished. The design is technically sound for feasibility design and can be addressed and accounted for in future design phases.

2.6.2 Baker Pump Station

The existing Baker Pump Station is comprised of two pump stations, Old Baker and New Baker, and is located on the landside of the East Levee between Hampton and Sylvan Bridges. New Baker Pump Station currently has a capacity of 400,000 gpm, and Old Baker has a capacity of 208,000 gpm. The two pump stations discharge into culverts that penetrate at the base of the East Levee and outfall into channels before eventual discharge into the Trinity River. A third gravity sluice outfall structure is just upstream from the two existing pump stations and consists of six 10’x10’ reinforced concrete box culverts. The pump stations are fed by Hampton-Oak Lawn sumps.

The plan is to construct a new pump station (Baker 3 Pump Station) that will replace Old Baker Pump Station. New Baker Pump Station is to remain in place and function as currently designed. The new pump station will replace the 208,000 gpm output from the Old Baker Pump Station and provide a total of 700,000 gpm of flow. This will bring the total flow to 1,100,000 gpm between the Baker 3 and New Baker Pump Station Sites. The Baker 3 Pump Station is proposed to utilize the current penetrations through the levee at the gravity sluices. Four 175,000 gpm pumps will each discharge into an 84-inch diameter and then into a 120-inch diameter steel pipe, before flowing into the existing 10’x10’ gravity sluices and the existing channel flowing into the Trinity River. A low flow 6,000 gpm pump will be included as part of the Baker 3 Pump Station design to assist with lowering the water level after the main pumps have been shut off and will discharge similarly. Minor sump work to include slope protection and increased hydraulic connectivity in the main sump area connected to the Baker Pump Stations will also be conducted. The slope work in the sump is minor and does not involve any cut from the existing levee template. The proposed sump work is to reinforce some areas of erosion in the sump and provide a more open pathway for drainage to the pump station.

The City of Dallas’ BVP involves the construction of several features within the main Dallas Floodway. These features include the realignment of the Trinity River which allows for the creation of other BVP features, including the three lakes. Subsequently, channels discharging into the Trinity River have been remodeled to incorporate the change in alignment. The current BVP designs, as shown on sheets CS105 and CS114, provide two newly aligned outfall channels for the proposed Baker 3 Pump Station and the New Baker Pump Station. These channels begin approximately 475 linear feet away from their respective existing outfall channels. In order to accommodate planned BVP features, discharge pipes for the Baker 3 and New Baker Pump Stations need to be extended to this revised outfall channel. Additionally, depending on construction order, the Old Baker Pump Station discharge structure would need to be extended, as well. The existing and new channels need to be evaluated to determine their adequacy for holding the possible maximum flows from the pump stations. Preliminary evaluation shows the revised discharge channels of the BVP are inadequate in width to handle a flared outfall structure. This can be remedied in future design in PED. The extension of the outfall structures will need to include the re-grading of any existing channel or outfall pond. These depressions will need to be backfilled to surrounding grade with suitable material in order to prevent ponding, seepage, or other negative effects on the levee and the various features within the Floodway.

Current designs for the discharge structures for Baker 3, Old and New Baker Pump Station are not fully developed to accommodate the Trinity River Relocation. It is technically sound for feasibility design and can be addressed and accounted for in PED.

2.6.3 Charlie Pump Station

The existing Charlie Pump Station is located adjacent to the West Levee and is southwest of the intersection of Jefferson and Zang Blvd. Jefferson and Zang merge to form Jefferson Blvd Viaduct that crosses the Dallas Floodway Levee System. The current 35% design proposes the construction of a new Charlie Pump Station and demolition of the existing pump station. The site of the new Charlie Pump Station is downstream from the existing pump station just east of Jefferson Blvd. The proposed capacity of the Charlie Pump Station is 225,000 gpm.

The current design calls for three 75,000 gpm pumps and a low flow pump of 6,000 gpm. Four pipes will travel up and over the existing levee template and discharge at a concrete headwall that will lead into an earthen channel. Building access and concrete pavement will be added to facilitate the buildings operations. The current up and over the levee profile by the discharge pipes requires sufficient cover over the pipes and the access road to be realigned to accommodate the vertical change in profile for the pipe cover. The proposed slope of the roadway is approximately 8H:1V or 12.5% and the slope on both levee faces is proposed at 3H:1V. Current demolition plans for the existing Charlie Pump Station involve utilizing the existing box culvert through the levee at the pump station for continued gravity drainage use. This would need to be designed to ensure that backflow is not induced.

At Charlie Pump Station, the Trinity River Relocation will move the river significantly towards the West Levee in order to accommodate the proposed Natural Lake footprint. Presently, the designs for Charlie Pump Station do not account for this shift and call for a shallow open channel to discharge into the existing location of the Trinity River. In addition, the current plans for the City of Dallas include a slope flattening to 4H:1V on all riverside slopes for operation and maintenance purposes. Current conditions are a little steeper than 4H:1V but flatter than 3H:1V. This is not consistent with the current slope designs of 3H:1V in the proposed grading model of the Charlie Pump Station. The slopes for Charlie Pump Station need to match the intent of the City of Dallas to flatten all levee side slopes to 4H:1V. It is also recommended that slopes tie back into the levee more gradually to create a smoother mowing surface for maintenance workers. Existing access roads on the crest of the levee are typically at a maximum slope of 10% or 10H:1V, while a recommended slope is at a 5% grade. A slope steeper than 12.5% is not recommended as it creates too steep a slope for access and flood fighting purposes.

Several slopes in the proposed earthwork plan are very steep and may be not constructible. Current designs show a raised berm that is required at the riverward toe of the levee to provide adequate cover for the discharge pipes. This creates low spots at the toe of the levee on either side of this berm where water can pool with no option for positive drainage. This could lead to the creation of additional wetlands, unintended maintenance issues, or minor seepage problems. The plan view design of the access road at the levee crest does not align with survey information of the existing levee crest access road. The channel for outfall within the Floodway is fairly shallow at only 3-4 feet. When intersecting with a deeper Trinity River Channel that may not be at full (top of bank) capacity, this will create erosion problems that need to be address through a deeper channel or proper erosion mitigation techniques. The depth of the channel may need to be evaluated in consideration of the amount of discharge. Many of the existing channels including the existing Charlie Pump Station have far deeper channels with different cross sections than the one proposed.

There are several design issues associated with the preliminary design of the new Charlie Pump Station. Prior to further submittals, slope issues, non-constructible slopes, drainage problems, and outfall structures and channels need to be corrected to accommodate proposed BVP work. Current designs for Charlie Pump Station are not fully developed to accommodate the Trinity River Relocation. It is technically sound for feasibility design and can be addressed and accounted for in PED.

2.6.4 Delta Pump Station

The Delta Pump Station is located on the West Levee just upstream from Hampton Road. It is on the protected side of the West Levee along a dirt access road. The current Delta Pump Station consists of one main pumping building with an intake and outfall structure passing through the levee. The current capacity of the Delta Pump Station is 40,000 gpm per pump.

The proposed project involves the renovation of the pump station and the improvement of the sump and outfall area to prevent further erosion and preserve the integrity of the levee. The pumps will be replaced with pumps of the same capacity and the existing two 4’x4’ box culverts will remain in place as the discharge structure. The current design includes the paving of portions of the existing gravel road with concrete and the installation of a retaining wall on the face of the levee above the pump station. It also calls for new concrete paving for maneuvering, a new building, transformer pad, and fencing around the entire pump station. Concrete slope protection is to be installed on both the intake structure near the sumps and around the outfall structure on the riverside of the levee.

The Delta Pump Station in its current design form is not compatible with the designs for the BVP Trinity River Relocation. The proposed outfall channel for the Delta Pump Station in the BVP is located approximately 400 feet from the existing outfall channel. This will require the discharge culverts to be extended about 400 feet with a new outfall structure and concrete slope protection to be put in place at the new outfall channel. The existing outfall channel would need to be backfilled with suitable material and ensure enough cover over the new discharge extension. The grading and outfall channel needs to be required for the new channel and to ensure that positive drainage on the surface and in the discharge pipe is achieved. Future design submittals need to address this issue. Current designs for Delta Pump Station are not fully developed to accommodate the Trinity River Relocation. It is technically sound for feasibility design and can be addressed and accounted for in PED.

2.6.5 Hampton Pump Station

Hampton Pump Station is located on the East Levee just upstream from the Hampton Road crossing the Dallas Floodway Levee System. The proposed Trinity Parkway, see Section 3.2.1, exits the interior of the Dallas Floodway just upstream of the pump station. The current submittal for the revised Hampton Pump Station is at the 35% level. The current Hampton Pump Station consists of the Old Hampton Pump Station and New Hampton Pump Station. The IDP proposal calls for the construction of Hampton 3 Pump

Station that will eventually replace Old Hampton Pump Station once operational. The New Hampton Pump Station will also receive some upgrades as part of the IDP. The current outfall structure has two outfall channels, one for each pump house, that merge together before entering the current location of the Trinity River. The current design extends and relocates the Hampton Pump Station outfall channels as needed for the Trinity River Relocation.

The current design calls for the construction of the Hampton 3 Pump Station that will add an additional 500,000 gpm of flow and take over the existing 200,000 gpm from Old Hampton Pump Station, bringing the total capacity to 700,000 gpm. This is to be achieved by having five 140,000 gpm pumps discharging into their own 84” steel pipe and one low flow pump at 10,000 gpm discharging into a 24” pipe. All pipes will traverse up the protected side of the levee and over the top of the levee before proceeding down the riverside slope of the levee at 4H:1V slope before exiting in a concrete outfall headwall and spillway at the base of the East Levee. The outfall structure will merge into the existing outfall channel from the Old Hampton Pump Station before merging with the channel for the New Hampton Pump Station. The riverward embankment covering the discharge pipes will be at a 4H:1V slope and will be protected from erosion by articulated concrete revetment mats. Because the pipes will be exposed going over the top of the levee, the access road on the crest of the levee will be realigned and re-graded to go up and over the pipes with a 16’ foot width. The plan view of the Hampton 3 Pump Station is shown in the CS100 sheets.

The existing outfall structure for the Old Hampton Pump Station does not align with the outfall channel design for the BVP. The proposed outfall channel for the Hampton 3 Pump Station denotes a wide channel with a bottom elevation of 396-395 feet above msl. This is approximately 6 feet above the bottom of the existing Old Hampton Pump Station channel and 10-11 feet above the proposed channel bottom for the proposed BVP Trinity River Relocation. This difference in elevation may cause turbulence and erosion at the intersection of the channels and will either require a smaller difference in bottom of channel elevation or the use of erosion protection mats.

Prior to BVP construction, an additional 500,000 gpm is projected to be flowing into the drainage channel intersecting with the Trinity River. In the current design, it is unclear whether the existing channel is able to accommodate this increase in flow in high storm events. There is also concern that the proposed channel draining into the realigned Trinity River has enough capacity to carry both operating pump stations.

Following full implementation of the Hampton 3 Pump Station, the Old Hampton Pump Station will be demolished. The demolition plans have not been made available at this stage of design. Depending on construction sequence, the existing outfall channel for the demolished pump station will have to be returned to surrounding grade with appropriate material. This will reduce ponding at the toe of the levee and around the outfall channels.

The main concern for the Hampton Pump Station is the capacity and erosion mitigation for the outfall channels. These issues can be coordinated with the BVP designers and changes can be made accordingly. It is technically sound for feasibility design and can be addressed and accounted for in PED.

2.6.6 Nobles Branch Sump

The latest report of the East Levee IDP recommends additional gated culverts in the Nobles Branch Sump. The suggestion is to construct three additional 60-inch gated culverts at the Grauwyler Gate at Empire Central Drive. A single existing 60” reinforced concrete pipe and headwall that spans underneath Empire Central Drive will be replaced. The design includes slight remodeling of the sump area on the north side of the roadway and concrete slope protection at the interface of the headwall and earthen sump walls. The location of the work is a significant distance away from the Dallas Floodway Levee System.

2.6.7 Pavaho Pump Station

The Pavaho Pump Station is located on the dry side of the West Levee just downstream from Sylvan Avenue. The IDP includes the removal (from service) of the existing 76,000 gpm pump and the installation of three 125,000 gpm capacity pumps. This increases the overall main capacity of the pump station from 76,000 gpm to 375,000 gpm. The pump station utilizes the existing box conduits from the original pump station as part of the proposed design. The sluice gate would be opened during low flow events to encourage gravity flow from the sump to the Trinity River and would close when the pump station is in service. This project has already been constructed and is operational.

There are no major issues with the design for the Pavaho Pump Station and can be considered technically sound. The proposed Trinity River Relocation will change the outfall channel alignment minimally for the Pavaho Pump Station. The increased flow potential through the discharge channel needs to be evaluated to ensure that proper velocities and flows are achieved. This needs to be evaluated as part of the BVP and needs to include the entire channel from the outfall structure of Pavaho Pump Station to the realigned Trinity River.

2.6.8 Pavaho Sump Improvements

In conjunction with the refurbishment of the existing Pavaho Pump station, there are planned improvements to the sumps feeding the pump station to increase the hydraulic connectivity of the system and overall functionality of the pump and sumps. It was recommended to provide reinforced box culverts under Sylvan Avenue and Canada Drive. These two roads separate sumps that drain to the Pavaho Pump Station with either restricted or insufficient flows. Under Sylvan Avenue, two 10’x6’ reinforced concrete box culverts are recommended. Canada Drive has a recommendation of one new 10’x8’ box culvert to be installed adjacent to an existing box culvert. These features have conceptual designs as part of their recommendation; however, no design submittals have been received for these features. Based on their location on the landside of the levees and within the sumps, it is important that the construction of these culverts not negatively affect the functionality of the levee or the sumps. It is technically sound for feasibility design and can be addressed and accounted for in PED.

2.6.9 Trinity Portland Pump Station

Trinity Portland Pumping Station would be a new pump station located on the West Fork Levee near Mexicana Drive. The pump station would be fed by the Trinity Portland basin. The proposed pump station is in the 35% design phase. Current plans call for two 125,000 gpm pumps to service this pump station. Each pump will discharge into a 78-inch steel pipe. The discharge pipes will flow up and over the levee crest and discharge into a concrete channel from an anchored, flared concrete headwall. According to designs the discharge pipes would cross the crest of the levee allowing for an elevation increase to 440 feet above msl. Concrete pavement will replace existing gravel access roads and will extend to Mexicana Drive for primary access. The proposed design would slightly modify the sump areas around the pump station to provide conveyance to the pump intake. These modifications would not affect the levee template itself. Access roads on the levee crest would be realigned accordingly to accommodate the increase in elevation due to the discharge pipes passing over the levee. The slopes covering the pipes accommodate the proposed 4H:1V slope flattening goal of the City of Dallas with added articulated concrete block protection occurring over the pipes on the riverside slope.

This is the only pump station that interacts with the proposed FRM plan (see Section 2.3 for information on the proposed FRM plan), by having discharge pipes going over the top of the levee. The proposed elevation increase in the current Trinity Portland Pump Station design plans includes a levee raise to 440 feet above msl. Current FRM plans in that area only specify the levee crest to be at an elevation of 438 feet above msl. Potential cost and quantity savings can be found by reducing the height of the levee that the discharge pipes have to clear.

The area in which the Trinity Portland Sump is fairly free from constraints in the form of bridges or other project features. One item that needs to be further evaluated is the outfall channel. Current design of the outfall channel depth is around 2.5 feet in areas immediately following the energy dissipaters, which may be overtopped during high flow events. It is recommended that the outfall channel be further evaluated to determine the depth of channel after velocity is decreased through the energy dissipaters, which will lead to higher water surface elevations. In addition, the outfall channel currently enters the West Fork of the Trinity River approximately three to four feet below top of bank of the existing river channel. During low stages of the river, this provides a large drop between river water surface elevation and the discharge from the pump station that could lead to channel erosion and an increase in turbulence.

The Trinity Portland Pump Station has minimal interaction with other Dallas Floodway Levee System features. There are minor discrepancies that can be addressed with minimal redesign in future stages of the project development. The channel design will be reevaluated and the levee raise assumption will be changed to reflect the current FRM plan in future design phases and this pump station is technically sound for feasibility design and can be addressed and accounted for in PED.

2.6.10 Trinity Portland and Eagle Ford Sump Improvements

The IDP recommends the construction of a gated conduit structure between Trinity Portland and Eagle Ford Sumps. The proposed gated conduit structure between Trinity-Portland and Eagle Ford sumps allows selective exchange of flow between these two sump areas. This item includes the construction of a new 6'x6' gated culvert with remote operated motor controller at the berm which currently divides Eagle Ford and Trinity-Portland sumps. A design submittal of these features will be developed in the future.

2.6.11 Outfall Structures

The BVP is planning several features in the Floodway including three lakes and a realigned Trinity River. The lakes and Trinity River realignment interact with all discharging structures in the main portion of the Dallas Floodway. Discharge pipes are required to be extended in some cases and discharge channels are realigned in most cases.

The proposed pump stations are increasing the amount of discharge entering the Floodway. However, the existing discharge channel is not fully designed to the extent of determining flow capacities and erosion protection. Increasing the discharge into these channels may require the expansion of the channel and/or additional scour protection throughout the channel. Many of the proposed pump station outfall structures are far shallower than their respective existing outfall channel. At the confluence of these outfall channels and the realigned Trinity River, there is a possibility of discharging several feet above the Trinity River’s water surface elevation. This creates turbulence and may lead to increases in erosion and expansion of the outfall channel that may interfere with other proposed features within the Floodway. Coordination in this issue is a must to ensure that both the IDP and BVP work cohesively and allow design flows to work together with regards to discharge and the Trinity River flows.

While the projects range from the 35% stage to construction, the outfall structures and their interaction with the BVP remains an integral issue. It is technically sound for feasibility design and can be addressed and accounted for in PED.

2.6.12 Sumps

The sump areas on the dry side of the levee system feed the various pump stations in the IDP. The sump areas are characterized by depressions on the dry side of the levee that are linear in fashion and extend along the toe of the levee. The sumps are primarily grasslands and range in depth and their tendency to hold water throughout the year. The sump areas have not been fully surveyed as many of them are under water a majority of the year. The Dallas Floodway Levee System has an extensive network of sump areas that are considered part of the Levee System. Therefore, work on the sumps is subject to review and regulation by USACE.

Several of the pump stations have minor slope work on the sump areas to construct their intake pipes or their pumping stations. Additionally, some pump stations plan to improve the overall hydraulic connectivity between sumps to improve drainage and enhance the functionality of the pump and sump system. The overall sump work is minimal and will not adversely affect the capacity of the sump areas or their ability to hold water, provided suitable material is used for fill. The minor work should not cut into the levee. The sumps are technically sound for feasibility design and can be addressed and accounted for in PED.

2.6.13 Interior Drainage Plan Conclusions

Individual design issues are described in their respective sections. Some features in the overall project need to be addressed as part of the further design of each pump station. The pump stations in the IDP have been submitted for review, previously; however, they were evaluated from a more isolated approach with existing conditions as the base condition. These evaluations fall short with regards to an overall review of their designs in relation to all other Dallas Floodway Levee System Projects. The following were identified as additional issues.

Future design needs to address the interface of the pump stations and the effort by the City of Dallas to flatten all slopes to 4H:1V. Either the slope needs to be flattened as part of the pump station’s design or the final slope over the pipes will need to be considered as the final side slope. Additionally, the flattening of certain slopes extends over the existing outfall structures that are being used as part of pump stations. These areas are shown on sheets CG100 through CG107. When these discharge pipes are extended, the resultant friction loss needs to be evaluated to ensure that pumping operations are not compromised.

The proposed pump stations increase discharge entering the Dallas Floodway. Increasing the discharge into existing channels may require the expansion of the channel and/or additional scour protection throughout the channel, which has not yet been evaluated. Many of the proposed pump station outfall structures are far shallower than their respective existing outfall channel. At the confluence of these outfall channels and the realigned Trinity River, there is a possibility of discharging several feet above the Trinity River’s water surface elevation. This creates turbulence and may lead to increases in erosion and expansion of the outfall channel that may interfere with other proposed features of the Dallas Floodway.

Other concerns include the issue of tying back into grade for fill covering discharge pipes extending down the face of the levee. The slope of these grade tie-ins should allow for ease of operations and maintenance as well as be compatible with the City’s 4H:1V side slope flattening plan. Proposed access roads on the crest of the levee, as they pass over pipes, should also be no steeper than 5% or 20H:1V to allow for proper flood fighting and maintenance operations. This increase in levee crest width and subsequently wider cross sections should predominantly impact the riverside of the levee. The goal of any access roads over pipes and subsequent levee cross section enlarging should be to extend from the existing protected side crest of levee, similar to levee raises shown as part of the FRM Plan, Sections 2.3 and 2.4. This would be to ensure minimal impacts on the real estate on the landward side of the levees and minimize impacts to sump areas.

While the projects range from the 35% stage to construction, the outfall structures and their interaction with the BVP remains an integral issue. The City of Dallas' IDP is technically sound for a feasibility level effort. All of the design issues can be remedied in future design. Further refinement of the design is not expected to significantly change the overall concept of the IDP. Changes to the design of the individual features will be localized and is not expected to prohibit the construction of any of the other Floodway features.

2.7 Project Construction Phasing

The Recommended Plan is a subset of the overall City of Dallas' BVP and IDP. It includes the pump station and sump improvements part of the East Levee IDP, the FRM Plan, 4H:1V side slope flattening, and a subset of the features described in the BVP. The remaining features of the City of Dallas' Plan are still recommended for construction as local features as the sole responsibility of the non-federal sponsor. They will be constructed by the City of Dallas through a Section 408 project.

2.7.1 General Phasing Plan

During the Comprehensive Analysis, construction phasing was determined an essential part of the design process. Construction phasing process has been developed for feasibility. The following phasing plan was developed for the entire BVP and IDP project. It is expected that the project would be constructed under a 10-year construction window. The entire project is expected to be built in seven phases. Table D-26 lists the features included in each phase.

Table D-26. Construction Phases

Construction Phases
Phase 1 – Levee Work and AT&SF Bridge Modification
Phase 2 – Interior Drainage Plan
Phase 3 – Trinity River Relocation (Top Reach)
Phase 4 – Trinity River Relocation (Middle Reach)
Phase 5 – Trinity River Relocation (Bottom Reach)
Phase 6 - Lakes
Phase 7 – Recreation and Ecosystem Amenities

The first phase consists of the AT&SF Bridge modifications, levee raises (NED Plan) and the side slope flattening, including the excavation of the borrow pit inside the Floodway. The AT&SF Bridge is on the far downstream end of the Dallas Floodway Levee System and is not affected by the construction of any other feature. This part of the FRM plan can be conducted independently of the rest of the project and at any time during the phased construction of the Federal Project.

Phase 2 includes the interior drainage plan features on the East and West Levee. It is expected that the outfall channel work will not be needed at the time of construction of the IDP features. The Pavaho, Baker, and Able pump stations are not part of this phase as they have or will already be constructed by the

City. The initiation and completion of this phase does not impact the design or construction of any other phase.

The third phase is the start of the River Relocation construction. The River Relocation would be split into three construction phases starting at the top (upstream) limits of the project, and proceeding to the middle and bottom reaches (Phase 4 and 5). Each reach could be split into sub-phases. Construction would consist of the river relocation and the necessary outfall channel work within the Floodway. It is assumed that the City will have completed all necessary utility relocations for construction of the River Relocation.

Phase 6 is construction of the Lakes and would be divided into two subphases. The final phase includes construction of the recreation and ecosystem amenities in the project.

2.7.2 Construction Phase 1 – Levee Work & AT&SF Bridge Modification

The levee raises not only affect other features within the Modified Dallas Floodway Project, such as the IDP and side slope flattening, they also impact the construction of other Section 408 features in the planning phases including bridges and the other BVP features. In conjunction with levee raise construction, it would be beneficial to incorporate the side slope flattening to 4H:1V side slopes. However, this is dependent upon available funding from the City of Dallas. The borrow source identified for both the levee side slope flattening and levee raise operations overlap as well as their impact areas on the levees. A general phasing of construction of the flatter 4H:1V side slopes at every levee raise locations would decrease costs for mobilization of construction, and also limit the number of times the levee will be impacted through scarification.

2.7.3 Construction Phase 2 – Interior Drainage Plan

After construction of the FRM levee raises, there are two features of the Modified Dallas Floodway Project that can be constructed relatively concurrent. The West and East Levee IDP features and the river relocation only intersect at discharge channels that can be managed through proper design. The majority of IDP work takes place on the protected side of the levee, while all river relocation is done on the interior of the levee system. In some cases, the IDP features may be constructed prior to the FRM levee raises due to availability of funds and design schedules. In this instance, proper coordination between USACE and the City of Dallas is necessary to ensure that the levee is at the correct height in the locations of the pump stations. Additionally, any slope work done as part of the pump station shall be consistent with the plan to flatten side slopes to 4H:1V.

2.7.4 Construction Phase 3, 4 and 5 – River Relocation

The river relocation plan is a difficult project to design, phase, and construct as it has a scope that impacts nearly all Floodway features. The current proposal calls for the construction of the new river channel in three phases. Each of these three phases would begin and end at intersections of the existing channel. The far downstream section of the river relocation will be heavily impacted due to the planned excavation of borrow sites and future lakes by the Trinity Parkway. Proper coordination is necessary in this section to ensure that the river is relocated properly while, at all times, maintaining channel integrity and not increasing the potential for erosion, scour, and sedimentation. The downstream and middle sections of the relocated river channel both impact the future creation of the proposed Urban and Natural Lakes. While these features are not part of the Modified Dallas Floodway Project, they are recommended as Section 408 local features. The Trinity River should be relocated in these areas prior to the City of Dallas' construction of the Urban and Natural Lake. Corinth would be constructed in the bottom River Relocation contract at the end of the contract. The upstream most section of the relocated river creates a more sinusoidal river channel and also creates the necessary space for the full extent of the West Dallas Lake.

In order to construct the upstream most section of the river channel in a technically sound fashion, the proposed cut-off wall must be in place along the East Levee. The construction order of these three segments will be determined based on constructability concerns and the construction schedules of other projects in the area.

Bridge pier modifications will be conducted as required by project feature (Trinity River Relocation or Lake). A bridge pier needing modification is requires immediately prior to construction of the Trinity River Relocation or Lake.

2.7.5 Construction Phase 6 – Lakes

The first subphase of the Lakes construction would include the modification of the borrow pit into the West Dallas Lake. The modification may include grading, planting of the fringe wetland, and associated elements. The second subphase would include the development of the Natural and Urban Lakes.

The final phase includes construction of the recreation and ecosystem amenities in the project. They would be divided up into subphases, consistent with the River Relocation project. The proposed order of the Phase 7 elements assumes the most efficient implementation for construction purposes.

2.7.6 Trinity Parkway Considerations

The associated cost estimate of the Federal Plan has some dependencies on the construction of other projects, primarily the Trinity Parkway. The Trinity Parkway is to be built on an earthen berm spanning 5.8 miles on the riverside toe of the East Levee. This earthen berm requires a significant amount of fill material that will be taken from within the Floodway. The current borrow sites identified for fill material are the three BVP Lakes and Oxbow Lake. The two downstream lakes, Urban and Natural Lake, are rough graded for borrow material in the current Trinity Parkway plan.

Additionally, the Trinity Parkway plans to include, levee raises and side slope flattening along the East Levee where the Trinity Parkway is to be built. These levee raises and side slope flattening projects will correspond to the project goals of FRM and will need to be built in accordance with the design by USACE. These features will be constructed using suitable levee material, whereas, the remaining embankment portion of the Trinity Parkway has much less stringent material considerations. The construction of the levee raises and side slope flattening by the Trinity Parkway would need to be coordinated with USACE to ensure proper project implementation.

3.0 COMPREHENSIVE ANALYSIS

The Comprehensive Analysis phase of the study took an overall look at the entire Dallas Floodway Levee System. During the Comprehensive Analysis, local features were reviewed against Corps engineer regulations and safety standards to ensure the projects would not have a significant adverse impact on the function of the MDFP. See Section 3.2 of the main report for additional details of the objectives of the Comprehensive Analysis. Upon completion of the Comprehensive Analysis the local interests were provided the results to use as an input into their Section 408 package. Technical analysis are contained in the individual local feature’s Section 408 packages and not included in this feasibility report. Some of these local features (Section 408 projects) are already constructed or in the later stages of design. Therefore, inconsistencies in design between interfacing projects may have to be settled in future design submittals. The goals, projects, risks, and overall project requirements are identified in this phase and discussed in further sections.

3.1 Goals of Comprehensive Analysis

The purpose of the Comprehensive Analysis is to determine potential conflicts in the integration of the multiple local features (Section 408 projects) and MDFP projects. The interaction is evaluated based on constructability, functionality, and risk. Conflicts will be resolved in future design phases and are identified in this stage of the study only for discussion purposes on the feasibility of the design. This includes the discussion of local features, an evaluation of construction phasing, an overview of potential operation and maintenance pertaining to MDFP projects, and the identification of various risks associated with the current evaluations of the projects.

3.2 Local Features: Section 408 Projects

Local features are projects submitted under Section 408 that are proposed additions or modifications to features within the Dallas Floodway. These are not considered part of the MDFP project; however, many of these projects have direct impact on the design of MDFP features. These features have submittals approved through USACE and several are already constructed or in future stages of design (beyond feasibility). The purpose of this discussion is to evaluate each local feature as it pertains to the overall vision and functionality of the Levee System. Individual features that have been submitted in the past have been evaluated on a case by case basis and not on an overall systems approach. Each feature must be evaluated on a system scale and must work with and without the construction of the MDFP features. This leads to a complicated analysis and may require additional design accommodations (in future phases of design) to be included in MDFP features or design restraints in the local features.

3.2.1 Trinity Parkway

The proposed Trinity Parkway feature impacts proposed BVP and the East Levee. As a result of this feature, two different BVPs are proposed. Two designs were developed for the BVP regarding the Trinity Parkway; one assuming the Trinity Parkway in the future condition, and one without the Trinity Parkway in the future condition. These two designs were the plans evaluated in the Environmental Impact Statement (EIS) completed for the BVP and IDP.

The “with” Trinity Parkway alternative of the BVP assumes the Trinity Parkway will be constructed as a local feature and will be a part of the Dallas Floodway Levee System located along the East Levee. The “without” Trinity Parkway alternative assumes the parkway is not constructed within the Floodway. The Trinity Parkway is considered implemented first in construction sequencing in relation to the BVP in the Comprehensive Analysis for the with- Trinity Parkway design in the Comprehensive Analysis. This assumption may not be reflective of the actual design and construction sequencing that will be determined in future stages of the design process. Current preliminary designs of the Trinity Parkway are at approximately a 35% conceptual submittal. The discussion below details the interaction of the Trinity Parkway and the BVP and the existing levee system.

3.2.1.1 The BVP with the Trinity Parkway in the Future Condition

The proposed Trinity Parkway extends along the face of the East Levee for approximately 5.3 miles, starting at the far downstream end of the Dallas Floodway Levee System at the AT&SF Bridge before exiting the Floodway just before the proposed Hampton Wetlands. The Trinity Parkway will be built through a combination of elevated earthen berms and bridge structures. The berms and bridges will support six lanes of traffic, three in each direction, but will originally be built with four lanes of traffic. Exit and entrance ramps and bridges will be built as needed to merge with existing roadway crossings of the Levee System. The earthen berm, built on the face of the East Levee, ranges in height from within a few feet of the top of the levee to only an elevation of a few feet above the existing toe of the levee. This fluctuates from upstream to downstream depending on the constraints of bridges and other features within the Dallas Floodway. The Trinity Parkway and its earthen berm are separated from the remainder of the Floodway by a flood separation wall, designed for the 100-year recurrence interval flood event. Supporting the Parkway and its operation and maintenance goals is a network of access roads that are on the interior of the levee system and on the levee crest.

Designs at this juncture are preliminary and consist of layout sketches, profile views, and cross sections at every 100-foot interval. Currently, the submittals do not include grading contours for the earthen berm, contours for the excavation of borrow pits located in the footprint of Urban and Natural Lake, designs for the required relocation of the river, design criteria for the flood separation wall, and there is limited information on the proposed mitigation efforts. There are several conflicts with the access road system and the access roads proposed by the BVP. The intent of the Trinity Parkway is to merge its access road network with the proposed BVP access roads. This is not shown in the current plans and will need further refinement in future design phases.

Realigned Trinity River

Construction of the Trinity Parkway prior to the BVP creates several major conflicts that the Trinity Parkway submittals at this juncture do not address fully. On the downstream end of the Dallas Floodway, between Corinth Street and IH-35, the current layout of the Trinity Parkway overlaps by approximately 100 feet with the existing Trinity River. This will require the relocation of the Trinity River with a sufficient buffer to accommodate the construction of the earthen berm supporting the Trinity Parkway. Current designs do not accurately depict or describe this essential feature. It is important that the Trinity River be realigned in such a way to maintain the existing integrity of the river channel while not creating any transition issue, erosion or scour, where the realigned channel interfaces with the existing channel. The current design of the Trinity Parkway does not show that this is a viable alternative and will work with the limited amount of realignment proposed. While the Trinity Parkway schematic design is at 35% stage it is expected that the design issue can be remedied in future design.

Excavation for the Trinity Parkway is also planned in the areas proposed by the BVP to be Oxbow Lake and the realigned Trinity River. This area is located between Corinth Street and IH-35. Current levels of design depict hatching in the areas where excavation is to occur. Further design is required to determine the viability of this excavation area. The proposed excavation is in the footprint of a segment of the Trinity River Realignment; however, the drainage intent in these areas is not shown. It is unclear with the given information on how this area interacts with the Trinity River. Backflow into these areas could create sedimentation that might make these areas wetlands, causing conflicts for future construction projects having to deal with increased wetlands and environmental issues. In addition, there is no delineated flow path that is distinguishable to this excavation channel. At this stage of design, there are concerns related to the constructability and effectiveness of the design but it is technically sound for feasibility design and can be addressed and accounted for in PED.

West Dallas Lake Excavation

The Comprehensive Analysis assumes the Trinity Parkway will be constructed prior the BVP. The Trinity Parkway plans to excavate portions of the BVP’s West Dallas Lake, Urban Lake and Natural Lake. Grading for excavation purposes is shown in the current design for West Dallas Lake. The West Dallas Lake will be excavated for borrow material and is graded to drain via outfall channels into the existing Trinity River. North Westmoreland Road separates the Lake and the plans do not reflect excavation around the bridge. The effective footprint of West Dallas Lake is divided into two separate excavation areas with an outfall channel for each portion of excavation. The portion upstream of North Westmoreland Road is graded into the existing Trinity River at an elevation of 387 feet above msl. The current bathymetry data shows the existing river channel bottom to be at an elevation of approximately 380 feet above msl. The second portion of excavation has an outfall channel with an outfall elevation of 381 feet above msl. This is approximately 10 feet above the existing river channel bottom. These are open channels draining directly into the Trinity River with an approximate channel length of 200 linear feet.

There are issues with the current excavation design at West Dallas Lake that need to be remedied in future design. Firstly, the proposed top of bank for the excavated West Dallas Lake does not tie back into the existing grade, and there are no plans for a containment berm. As proposed by the BVP, the berm separating the West Dallas Lake and Trinity River needs to have suitable fill material and scour protection to be able to withstand a 800-year recurrence interval storm event (the recurrence interval has been revised), see Section 2.5.1. Since the feasibility level design was developed, the SPF return interval has changed from approximately the 800-year to about 2,500 years (or 0.04% ACE). The referenced earthen berm is described in more detail in the Lakes Report and in Section 2.5.3.4. The proposed West Dallas Lake has a proposed clay liner that is 18-inches of compacted clay. This is to ensure proper containment of water. It is understood that the purpose of this excavation is not to maintain water but to ensure its proper drainage into the Trinity River. Both the earthen berm and clay liner help protect the Trinity River and West Levee from any failure that may occur during a storm event up to and including the required design flood stage. Other concerns include the use of an open channel draining into the Trinity River at such a low elevation. Backflow into the excavated area of West Dallas Lake from the Trinity River could cause sedimentation issues that may result in the loss of drainage from the excavated area. It is recommended that the drainage channel be evaluated to have a higher elevation at outfall with subsequent scour protection to limit backflow into the outfall channel. It may also be beneficial to use box culverts to achieve this drainage if it is determined that access is needed along the berm separating the Trinity River with the excavation areas.

There is some concern about the availability of suitable levee material. Presently, the areas identified as suitable borrow sources for side slope flattening material and the NED Plan levee raise are located within the footprint of West Dallas Lake. The current estimated amount of material needs from the West Dallas Lake is approximately 75% of the surface area of West Dallas Lake, however, only to a depth of ten feet. Coordination of these plans and the Trinity Parkway are required to ensure that proper material quantities and suitability is met for the various earthen features of the Trinity Parkway.

Urban Lake and Natural Lake Excavation

The current design for excavation in the proposed footprints of Urban and Natural Lake is limited. The current alignment of the Trinity River extends through the footprints of Urban Lake and Natural Lake as proposed by the BVP. The current design of the Trinity Parkway includes excavating portions of the Urban and Natural Lakes as borrow sources. Current designs show an outline of the area to be affected by these excavations; however, no grading contours are provided which causes concern. In several locations, there are large areas of excavations that border the river for large distances. This effectively creates a wider river channel. This could lead to potential sedimentation in the widened areas, from excavation, and scour in the smaller cross section of the untouched river.

Flood Separation Walls

Flood separation walls surround the earthen berm of the Trinity Parkway in order to protect the Trinity Parkway from storm events up to and including the 100-year flood recurrence interval. In areas where a bridge supports the Trinity Parkway, the flood separation wall design wraps around the berm and interfaces perpendicular to the levee face. Concerns arise as this could potentially create a penetration in the levee. In addition, future side slope flattening under areas where a bridge is being constructed to support the Trinity Parkway could create a large surface area of interface with the flood separation wall. The interaction between the flood separation wall and levee needs to be further addressed to ensure that no other seepage paths are created within the levee. See Figure D-37 (not to scale) for a schematic of this interface challenge.

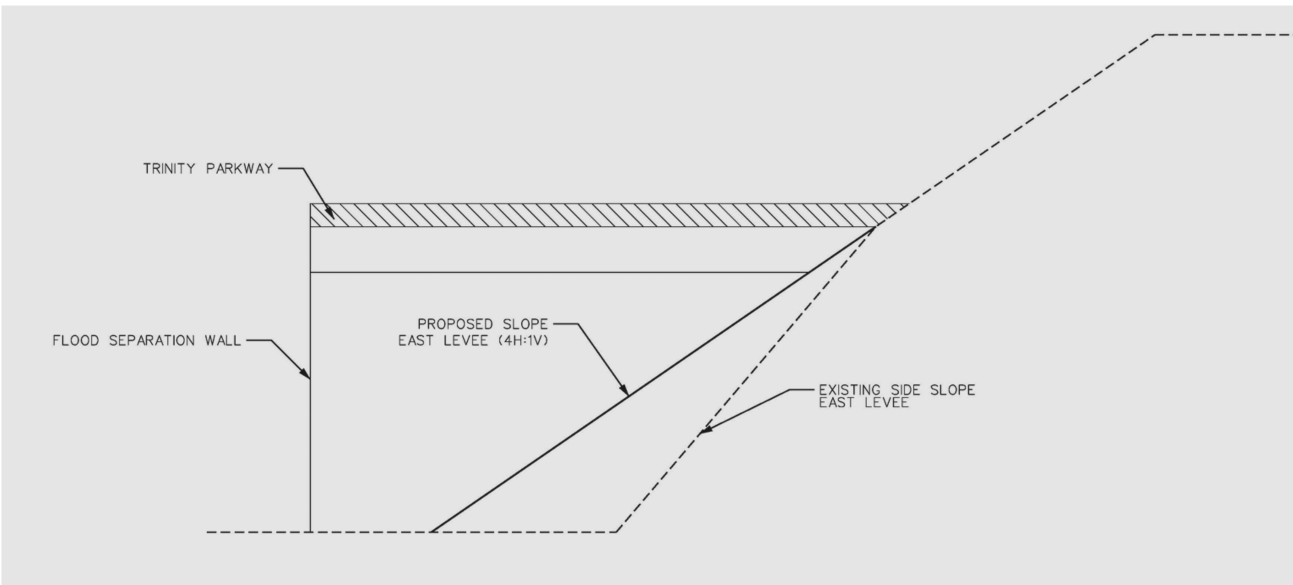


Figure D-37 Flood Separation Wall and East Levee Interface

In addition to this feature, the foundation of the flood separation wall has not been fully designed. This is critical to the functionality of this feature as well as the neighboring features. The design of this feature, when done properly, can be designed to support the loads intended and function as part of the Dallas Floodway Levee System correctly.

Hampton Wetlands

The Hampton Wetlands were a proposed hydraulic mitigation feature for the Trinity Parkway; however, the current plan is to not implement the feature.

Utilities

Several utilities are affected by the earthen berm for the Trinity Parkway. The partial extension of various storm sewer lines is assumed to be completed by the Trinity Parkway. The remaining extension of these features would be completed by the BVP. However, this is only accurate if the Trinity Parkway is constructed prior to the relocation of the Trinity River. If the Trinity Parkway is constructed after the completion of the BVP, the relocation and extension of the outfall structures would need to be coordinated with the BVP designers to ensure proper designs are coordinated.

A significant concern in the current design concept exists at the location of the Belleview Pressure Storm Sewer outfall structure. The pressure storm sewer discharges into the Trinity River through a very large horseshoe pipe with no outfall channel. The Belleview Pressure Storm Sewer is located between Corinth Street and IH-35, which is a congested area where the Trinity River needs to be realigned to accommodate the Parkway. The final Trinity River Relocation design needs to accommodate the Trinity Parkway and the extension of the Belleview Pressure Storm Sewer. An outfall channel of proper dimensions to handle the proposed flow of the pressure storm sewer is required. Scour protection and erosion protection measures might be needed at the confluence of the Belleview Storm Sewer and Trinity River.

Construction Methods

Presently, the construction methods for the Trinity Parkway berm are not defined. It is assumed that some cut into the existing levee would be needed to allow for a proper interface between the berm and levee. Notching into the levee would have to satisfy USACE design criteria. Suitable material would have to be used in these areas to maintain a proper levee template. The construction method needs to be further evaluated in the next design phase and is a critical item for determining the constructability of the Trinity Parkway earthen berm.

Conclusions

The current state of design poses potential issues regarding the compatibility of the Trinity Parkway and BVP design within the Floodway. The current timeline calls for the construction of the Parkway prior to any BVP work being done. The Trinity Parkway would have to interface with both the East Levee and the future construction of the BVP within the Floodway. The intent of the evaluation of the design at this stage of this study is to determine the technical soundness of the proposed updates to the East Levee and the BVP. The technical soundness of the East Levee and the BVP is predicated upon the proper design and construction of the Trinity Parkway. This will require a high level of coordination between the City of Dallas, USACE, and the Trinity Parkway design team.

Currently there are no grading plans provided by the Trinity Parkway. Future design development has to address USACE design concerns. The current design of the Trinity Parkway includes the realignment of a portion of the Trinity River. This section may have to be expanded to incorporate larger areas of realignment for the Trinity River. The Trinity Parkway may have to expand their scope of work in order to properly include earthen berms and clay lining material for borrow sites located in future BVP lake footprints. Future designs might also need to accommodate any new utility, drainage, or grading features. The current design of the Trinity Parkway has some design issues at the current state of development; however, it is believed to have the potential to be constructed if there is proper coordination between the BVP and Trinity Parkway design teams in future design phases, and proper design and construction methods are utilized. Future detailed design submittals for the BVP and Trinity Parkway will have to be reviewed and evaluated for compliance with USACE design criteria.

In the event the BVP is constructed before the Trinity Parkway, the full river realignment plan has the potential to allow for the construction of the Trinity Parkway. The full Trinity River realignment allows for the complete excavations in the lake borrow areas and has sufficient offsets from the proposed berm. The current design for the Trinity Parkway does not address the option for constructing the BVP before Parkway construction. Future detailed design submittals for this option, including the BVP and Trinity Parkway, will have to be reviewed and evaluated for compliance with USACE design criteria. The

Trinity Parkway will be reviewed under Section 408 and design issues at this level can be addressed and accounted for in PED.

3.2.1.2 The BVP without the Trinity Parkway in the Future Condition

There are minor differences in the actual BVP design in the without Trinity Parkway design. Because it is assumed that the Trinity Parkway is not in-place, certain BVP features would be different under this scenario. In addition, there would be additional cost for disposal of excess material off-site to build the BVP features, primarily the BVP Lakes. There would be no change to the NED (levee) component of the BVP or IDP improvements for this design. There is still some benching along the East Levee for soil disposal for the BVP Lakes. Evaluation results are generally the same from a civil and structural design perspective for the BVP and IDP for the design without the Trinity Parkway in the future condition, except design integration issues are reduced in this design.

3.2.2 Pavaho Wetlands

Due to 2004 violations of the Clean Water and the Resource Conservation and Recovery Act, construction of a Supplemental Environmental Project (SEP) was mandated through written Consent. The Consent Decree, issued in 2006, establishes the Pavaho Wetland as a feature in the general public interest, setting a 60-acre minimum project footprint. The Pavaho Wetlands consist of improvements to four wetland areas in the vicinity of Sylvan Avenue Bridge and Continental Avenue. They are located along the West Levee encompassing approximately 64 acres. The Western Wetland area is bounded to the east by Sylvan Avenue, bounded to the north by the relocated Trinity River, and bounded to the south by the West Levee. It encompasses approximately 24 acres. The Central Wetland area is bounded to the west by the Western Wetland area, to the north by the relocated Trinity River, and to the east by the Pavaho Pump Station discharge outfall channel, and bounded to the south by the West Levee. It encompasses approximately 14 acres. The Western Wetland Area is bounded to the west by the Pavaho Pump Station discharge outfall channel, to the north and east by the relocated Trinity River, and to the south by the West Levee, encompassing 17 acres. The Pre-treatment Wetland area, encompassing approximately 9 acres, is located to the south of the West Levee and West Wetland Area at the southeast intersection of Canada Drive and North Winnetka Avenue.

The proposed Pavaho Wetland Project includes shallow emergent marshes, deep marshes, and upland habitat surrounded by open water within the Trinity River Floodway and the existing Sump Pond B of the Pavaho Pump Station. The purposes of the Pavaho Wetland are to improve surface water quality through retention and pretreatment of storm flows and rainfall runoff, create wetland flora and fauna habitat, and serve as an aesthetically appealing amenity. Specific objectives include the capture and pretreatment of storm water runoff from urban areas, diversification of the topography within the wetland to quickly establish a diverse vegetative community, and create landscape components that increase pollutant removal. Additionally, the Wetlands should enhance habitat and promote a natural appearance that can be maintained during dry periods and provide habitats that attract greater range of wildlife and waterfowl. The designers were directed to maintain, at a minimum, a 200-foot buffer from the future toe of the West Levee. In order to avoid conflicts with the reconstruction of the Sylvan Bridge, there is an additional required 50-foot buffer zone on both sides of the bridge. The final buffer includes a 50-foot offset from the proposed top of bank for the relocated Trinity River, as described in the BVP.

Construction of the Western, Central, and Eastern Pavaho Wetlands focuses on the creation of wetland habitat and lessening the water quality impacts from storm runoff. The existing grading will be modified to trap and attenuate runoff and overbank flows by excavating depression areas, in conjunction with, the construction of interior berms and flow control structures designed to retain water and sustain wetland vegetation. Berm heights have minimized to about two or three feet above existing grade to avoid increasing ponding surface area during flood stages. The proposed grading would create varying water depths to develop habitat zones designed as low marsh (6 to 8 inch water depth), high marsh (0 to 6 inch water depth), deep marsh (3 to 5 feet of water depth), and upland habitat up to 2 feet above the highest water level. A small solar powered pump station will be installed in the Pavaho Pump station discharge channel to provide water to shallow pools in the Central and West Wetland areas. Two short boardwalks with observations decks will be installed to allow visitors to experience each wetland area. Within the boundaries of the new Pavaho Wetlands, existing jurisdictional wetland areas have been identified. The design has delineated these jurisdictional wetland areas in order to minimize disturbance in these areas during and after construction.

Provided that the design and construction of the Pavaho Wetlands adhere to the criteria put forth in their design documentation, no negative impacts should be anticipated on the remainder of the Floodway. It is important, however, that the surrounding contours from the BVP complement the intent of these Wetlands to ensure proper drainage and storm water catchment. These wetlands also need to be accurately included in the hydraulics and hydrology model with regards to the final vegetation and contours.

3.2.3 Dallas Wave (Standing Wave)

The Trinity River Standing Wave is located immediately downstream of the newly constructed Santa Fe Trestle Trail Bridge with supporting features further upstream and downstream. Construction of all features was completed in early 2011. The project consists of features within the existing Trinity River and supporting shore features abutting the Trinity River in Moore Park.

The in-stream features consist of a boat launch, and two separate structures each creating a high flow in-stream structure, low flow structure, and a bypass channels for boats that is adjacent to the Standing Wave structure on the East Levee side. The boat launch is approximately 200 feet upstream from the Standing Wave One in-channel structure. Standing Wave Structure One is immediately downstream of the Santa Fe Trestle Bridge and is approximately 83-feet wide for the high flow structure, 50 feet wide for the low flow structure, and approximately 54 feet in length along the river. The elevation difference is approximately six vertical feet from upstream to downstream. Standing Wave Structure Two is approximately 180 feet downstream from Standing Wave Structure One. The high and low flow structures for this standing wave are similar in length to Standing Wave Structure One, but are slightly shorter in length at only 46 feet along the river. The elevation drop from upstream to downstream at Standing Wave Structure Two is six vertical feet. The by-pass channels adjacent to both in-stream channels are approximately 21 feet wide and 61 feet in length. The elevation drop is less steep at the bypass channel with only a vertical difference of three feet. The by-pass channels not only allows for smoother boating, but is also designed for fish passage in the upstream direction. The in-stream features are constructed of gabions, reinforced with structural concrete beams and encapsulated by grouted limestone rocks. They are supported by concrete piers and epoxy coated steel tie back anchors. The design intent is to resist impact loads from floating debris for the 100-year recurrence interval storm event. To promote a more natural aesthetic look, large boulders are grouted and placed upstream and downstream of the reinforced concrete structures. These boulders are placed at an elevation lower than the in-stream structures to reduce the possibility of being hit and dislodged by floating debris.

The standing wave is designed to allow beginner and intermediate paddlers to utilize the normal flows within the Trinity River. This would be the case for a majority of the year. At higher flows, the Standing Wave features would be suitable for more experienced whitewater paddlers. The standing wave feature is designed to be used at a Trinity River flow rate of 500 to 4,000 cfs. Mean flows are expected at less than 1,000 cfs. The park had been closed due to safety issues, but reopened in 2014.

The adjacent shore features consist of trails that connect the Standing Wave to the Santa Fe Trestle Trail and include a new parking lot that provides trail access to an in-stream canoe launch. Trails will allow access along the West Levee side of the upstream and downstream in-channel features, tying into a center island. The shore component features have been modeled to be fully within the 100-year Trinity River floodplain.

3.2.4 Santa Fe Trestle Trail

The proposed Santa Fe Trestle Trail has been completed and is currently in use. The former area of the Santa Fe Trestle Bridge consisted of undeveloped land within floodplain and the historical AT&SF Railway crossing the Dallas Floodway approximately 1,500 feet downstream of Corinth Bridge. It serves as the separating feature between the Dallas Floodway Levee projects and the Dallas Floodway Extension projects. The DART Rail Red and Blue line runs parallel to and just upstream from the AT&SF Bridge.

The constructed Santa Fe Trestle Trail is a concrete hike and bike trail providing access to Moore Park located off East 8th Street, south of downtown Dallas. The trail meanders through the Dallas Floodway in a general northeast fashion, across the Trinity River via the historical AT&SF Trestle Bridge, before merging with parking areas and trails designed as part of the BVP. The Trail crosses the Trinity River with a new bridge deck, keeping the aesthetic and historic features of the existing AT&SF Bridge underneath the new Trail. The new bridge deck is not supported by the wooden trestle features of the existing bridge.

To improve the hydraulic performance of the Floodway and reduce the effect of debris catching on the existing AT&SF Bridge, the FRM Plan recommends the removal of portions of the AT&SF Bridge. This will not affect the wooden trestles incorporated as part of the Santa Fe Trestle Trail Project. Adjacent AT&SF Bridge structures not part of the Trail will be demolished. See Section 2.2.1.2 for more information on the AT&SF Bridge Removal. The FRM Plan will remove the remaining wooden piers of the AT&SF Bridge as well as the berm, supporting a portion of the old bridge, in the Floodway. The FRM Plan also recommends the removal of portions of the earthen berm extending from the West Levee that was part of the old AT&SF Bridge. However, this needs to be coordinated with the Santa Fe Trestle Trail project to ensure the demolition of this earthen berm does not affect the currently constructed project.

3.2.5 Horseshoe: IH-35E and IH-30

The Dallas Horseshoe Project reconstructs the existing IH-30 and IH-35E Bridges across the Dallas Floodway and improves access to downtown Dallas. The IH-30 Bridge will extend into the newly constructed IH-30 Canyon Area. The IH-35E Northbound will tie into the newly constructed expansion of the Lower Stemmons Freeway. The purpose of the project is to replace aging infrastructure, improve safety, and increase traffic capacity. The current plans are schematic in nature and were used in the solicitation of a design-build project, with the contractor selected in November of 2012. The IH-30 Bridge portion of the Horseshoe Project will receive supplemental City and private donations to make it the second signature bridge of the Dallas Floodway Levee System, known as the Margaret McDermott Bridge.

The IH-30 typical section consists of four separate bridges: the westbound frontage road, westbound main lanes, eastbound main lanes, and eastbound frontage roads. These four typical sections affect the Dallas Floodway East and West Levees, BVP features, and the Trinity Parkway. The typical section of westbound main lane’s bridge will included five 12-foot lanes with 10-foot shoulders on either side of the lanes, abutting a dual direction 14-foot wide high occupancy vehicle lane. On the outside of the westbound main lanes, the westbound frontage road will include two 12-foot lanes, a 9-foot outside shoulder, and a 4-foot inside shoulder. A portion of the westbound frontage road will support an 18-foot wide pedestrian/bike bridge. This will be additionally supported by cables tied to the bridge arch through a bearing connection interface. The eastbound main lanes will consist of five 12-foot lanes with 10-foot shoulders. On the outside of the eastbound main lanes, on a separate bridge cap, the eastbound frontage road will be built to contain two 12-foot lanes, a 9-foot outside shoulder, and a 4-foot inside shoulder. The Horseshoe Project will also provide access to the pedestrian and bike traffic trails located under the proposed frontage roads that were constructed as part of the BVP. These will be along both the East and West Levees.

The plans for the IH-30 Bridge portion of the Horseshoe Project show the proposed BVP features including the Trinity River relocation, the proposed Urban Lake, and the East and West Levee modifications. Current plans show the proposed IH-30 bridge piers penetrating Urban Lake's clay liner. The present BVP bridge pier modification schematics assume the IH-30 Horseshoe Project is built before the BVP features are constructed. Therefore, the BVP bridge pier modification project has measures to stabilize the IH-30 bridge piers for erosion and seepage. If the BVP features are constructed first, the design-build contractor will need to include erosion and seepage mitigation for the bridge piers as part of their design. Additionally, it does not appear that the updated Trinity Parkway plans have been integrated at the current stage of design. Further coordination will be required between the BVP designers, City of Dallas, TxDOT, USACE, and the Trinity Parkway in order to resolve potential conflicts with the Horseshoe design-build contractor during design and construction.

The IH-35E typical section consists of five separate bridge caps (from west to east): southbound collector drive (CD), southbound main lanes, main lane HOV, northbound main lane, and northbound CD. These five typical bridge caps affect the East and West Levees, BVP features, and the Trinity Parkway. Southbound CD typical section includes four 12-foot lanes with a 4-foot inside shoulder and an 8-foot outside shoulder. A six foot wide pedestrian and bike path is also included on this cap, separated from main traffic flow by a concrete traffic barrier. The southbound main lanes consist of four 12-foot lanes with 10-foot outside shoulders. The HOV lanes consist of two 12-foot lanes with a 4-foot inside and 10-foot outside shoulder. Northbound main lanes consist of three 12-foot lanes with 10-foot shoulders on either side. The northbound CD consists of four 12-foot lanes with 12 foot inside shoulders and an 8-foot outside shoulder. An additional six foot pedestrian and bike path is part of this bridge cap and is separated from the main traffic flow with a concrete traffic barrier.

The IH-35E portion of the Horseshoe Project currently includes plans that show the proposed BVP features including the Trinity River relocation, the proposed Natural Lake, East and West Levee modifications. However, current plans show no means to protect the proposed IH-35E bridge piers from either the Urban Lake or its overflow weir. Additionally, it does not appear that the updated Trinity Parkway plans have been integrated into the current IH-35E set of plans. Digital files were not available for the Horseshoe Project to enable further evaluation of this feature as it relates to the Trinity Parkway. Further coordination is needed in this respect to ensure that connecting ramps, clearance heights, and levee impacts. Coordination needs to occur between USACE, the City of Dallas, the BVP designers, TxDOT, and the design-build contractor for the Horseshoe Project is technically sound for feasibility design and can be addressed and accounted for in PED.

There are several temporary and interim modifications identified in the current Horseshoe Project design that may require addressing by the Horseshoe Project proponents. These include the construction of temporary earth berms to support construction equipment for drilled shafts on levee slopes, temporary earth crane pads for lifting bridge girders and related operations, temporary bridges for traffic during construction, and temporary access roads into the Dallas Floodway. At a minimum, the above issues need to be addressed to ensure the compatibility of the various projects proposed within the Dallas Floodway Levee System.

3.2.6 Sylvan Bridge

The City of Dallas and TxDOT have proposed improvements to Sylvan Avenue Bridge, a north-south arterial located west of downtown Dallas. The improvements will be for a distance of approximately one mile. The Sylvan Avenue Bridge improvements would replace the existing three concrete bridges with one bridge structure that would span the floodplain and East and West Levees of the Dallas Floodway Levee System. Most of Sylvan Avenue would expand from primarily two lanes to six lanes with 6 foot sidewalks. The new Sylvan Avenue bridge deck height is raised to accommodate the 277,000 cfs (SPF) flow water surface elevation. The proposed project would involve roadway improvements, an access ramp leading to the new Trammell Crow Park, the relocation of the existing boat ramp at Trammell Crow Park, and the realignment of an Oncor overhead electric transmission line.

The proposed project modification is within 50 feet of the existing levee toe. Construction would consist of three, five-column bents on concrete drilled shafts in both the East and West Levees to support the new Sylvan Avenue Bridge. It would also construct a concrete drilled shaft to support Oncor Tower T-114 on the protected side of the East Levee and remove the existing Sylvan Avenue Bridge supports in both the East and West Levees of the Dallas Floodway. Currently, construction has started for the Sylvan Bridge.

The Sylvan Avenue Bridge has a few potential conflicts with the BVP and the Trinity River Relocation. The construction design drawings for this project only show the Sylvan Avenue Bridge under existing conditions. The new Sylvan Avenue Bridge has drilled piers that are within the top of bank for the relocated Trinity River. Additionally, two of the drilled piers are penetrating an existing parking. The new Sylvan Avenue Bridge plans show the parking lot to be reconfigured with a new boat ramp off the edge of parking lot descending into the existing Trinity River. This boat ramp may need to be adjusted to fit the Trinity River relocation, specifically regarding grading contours. Drilled piers also penetrate the proposed BVP access road to Crow Lake. These features need to be remedied between the Sylvan Avenue Bridge project and the BVP. This can be completed during further design stages of the BVP, which may result in slight modifications to the relocation of the Trinity River and the bridge pier modification plan. This discussion is referenced in Section 2.5.2 and Section 2.5.9 regarding the river relocation and bridge pier modifications, respectively.

3.2.7 Jefferson Bridge

At this time, no design plans, preliminary schematics, or reports have been produced for this project. Under the 20% Bridge Pier Modification Project report, the existing Jefferson Bridge’s drilled piers will be modified to prevent erosion and seepage due to the relocation of the Trinity River or the proposed Natural Lake. The bridge piers will be continuously inundated with standing water or be subject to an increased frequency of flowing water in their proximity. This will cause seepage and erosion in these locations if not properly addressed. The Jefferson Bridge reconstruction will need to address similar problems depending on the alignment of its bridge piers. This will need to be evaluated as designs are developed.

3.2.8 Continental Bridge

The Continental Bridge Project involves keeping the existing bridge superstructure with redesign efforts to turn the vehicular bridge into a public recreation area. The future bridge structure will hold only pedestrian traffic. Recreation areas on the existing bridge superstructure will consist of a modified bridge surface, game areas, vegetation in landscape boxes, play areas with accompanying equipment, an event plaza, misting fountain, new lighting, and an irrigation system that will connect to the existing water lines at both ends of the bridge. Final designs for construction have not commenced. However, if bridge piers are not relocated or modified as part of this project, the BVP's bridge pier modification designs should accommodate any integration issues this project may have.

3.2.9 Dallas Water Utilities

Some Dallas Water Utilities will be relocated to be compatible with the modified Levee System. The current scope of work includes the reuse of a 60-inch sanitary sewer line for the purposes of effluent pumping from CWWTP to the proposed Natural Lake. This is discussed in more detail in Section 2.5.3.7. The project also includes the construction of four water mains crossing the Trinity River. A 36-inch pipe will be constructed near North Hampton Road/Inwood Drive. Near Corinth Street, the existing 24-inch water line will be upgraded to a 48-inch pipe. Near Mockingbird/Westmoreland Road, a 48-inch line will be placed, and a 24-inch line will be constructed at Houston Street. All lines will be installed using open-cut and/or auguring techniques.

All of the pipelines, aside from the 24-inch pipeline at Corinth Street, will be contained within the Floodway between the East and West Levee. They will connect to existing pipes between the levees and not create any new levee crossings. The design at Corinth Street currently has plans to extend the proposed 24-inch pipe underneath the East Levee before connecting to an existing pipeline near South Riverfront Road. Design issues can develop when passing underneath a levee. Proper design integration is required for the water lines and the proposed features of the BVP and Trinity Parkway. Any design issues identified at this stage of design can be remedied in future design phases.

3.3 IMPACTS OF CONSTRUCTION PHASING

Proper construction phasing needs to be addressed on an overall project scale to include MDFP and local features. There are few items that need to be constructed prior to the construction of other features. For example, the BVP Lakes cannot be constructed prior to the Trinity River Realignment. Some of the construction phasing issues will be reactive. For example, the construction of the Trinity Portland Pump Station prior to FRM levee raises and side slope flattening would necessitate coordination between the pump station designers and USACE. The pump station would need to ensure that their designs are compatible with the FRM features and follow their design strategies. Another construction phasing issue is the construction of one feature affecting construction plans for other features from an economic standpoint, i.e. there could be added costs due to constructing one feature before or after the other.

It is difficult to predict funding opportunities in advance, and creating schedules for the multitude of construction phasing possibilities. Therefore, it is recommended that a hierarchy of importance for various features be determined to assist in the construction phasing efforts. This process would identify critical features that cannot be added in after the construction of other projects. For instance, the Trinity River Relocation effort would be higher up in the construction phasing hierarchy than any other BVP feature due to its intent of allowing space for all other BVP features. Another example, the BVP lakes would not necessarily have to be in place before the construction of the FRM features.

As part of the construction phasing plan, determining which projects are allowed which borrow sources is critical. Presently the Trinity Parkway berm construction and the City's side slope flattening plans call for the use of the same sites for borrow material as the NED Plan. Precedence in these locations needs to be established to ensure that material is not double counted for use. As part of this, suitable material is sometimes a requirement for the earthen features, such as side slope flattening, and these areas of suitable material need to be coordinated so each feature receives the proper amount and quality of fill material. A construction phasing plan was developed for the entire project and is presented in Section 4.4 of this appendix.

3.4 Operation and Maintenance for the BVP and IDP

The intent of this section is not to create a plan for operations and maintenance; rather, the intent of this section is to identify key features of the project that need to be maintained to ensure the full functionality of the Floodway. The City of Dallas will have full responsibility for maintaining the Floodway and all its features.

Based upon the categories assigned to various BVP features, see Section 2.5.1, various features are designed to withstand various storm events. These categories help determine design criteria for various features, but can also be used to predict maintenance costs. Category 1 features are critical design features that require large amounts of money to fix if they fail. Category 4 features are deemed less critical and therefore are less costly to fix. These category metrics can be used to determine maintenance plans for all features within the Floodway. However, the associated flood recurrence intervals associated with these categories are for design purposes and do not reflect the recurrence of maintenance. All Floodway features will be inundated on average during the 10 to 25 year storm recurrence intervals.

Six critical items, pertaining to civil site design, have been identified as crucial operations and maintenance features. First, pump stations need to have proper maintenance and inspection to ensure proper discharge and flows through the outfall pipes. Secondly, outfall channels for pump stations and utilities need to be regularly inspected for signs of scour or major erosion that could impact the functionality of the surrounding Levee System features. Next, it is critical that access roads used for flood fighting be maintained to allow for the required vehicles to access necessary park features. This includes the maintenance of access roads during construction, especially around bridge-levee intersections where movement is especially limited. Additionally, flood events will occasionally impact the gradation and proper draining of the site. It is important that unintended low spots either through, settling or scour, be identified and fixed, especially when these low spots are located close to the levee or other critical features. The City of Dallas currently maintains the levees and fixes slides. With a flattening of the levee side slope, it is expected that this need will decrease; however, it is an important operation and maintenance function. Finally, the berms separating lakes and the Trinity River need to be periodically inspected for erosion or other flaws. These are critical elements that need to be fixed immediately as they directly impact the functionality of the Dallas Floodway Levee System.

Routine inspections of all elements in the Floodway including bridges and the earthen berm for the Trinity River are recommended. These features should be inspected on an annual basis before the rainy season and after every major flood event. Regular inspections of the levees and river are also recommended on an annual basis. The Trinity River should be inspected to ensure channel geometry is stable and erosion control measures are functioning. Inspections would be conducted of the entire reach of the river to include channel geometry surveys, visual inspections riprap, and other erosion control items. Inspections would also occur after every major flood event. Surveyed inspections of the levee will verify the level of protection for the project is achieved over the long term.

The City of Dallas currently performs mowing operations across the entire Dallas Floodway. These mowing operations will be modified after the construction of all features. Future mowing plans need to be in accordance with landscape preferences for grass length and need to be aware of new wetland features and other vegetation. Additionally, it is important from a hydraulic standpoint that vegetation features be regularly trimmed and maintained to ensure proper conveyance of water. Debris after a flood event will also be prevalent and will need to be removed to allow for proper water conveyance and hydraulic performance.

The BVP and IDP features have a largely developed operations and maintenance plan that is further discussed in the referenced reports. The FRM Plan and side slope flattening plans are not anticipated to significantly add additional O&M costs or efforts; the existing level of maintenance performed by the City on the levees would be satisfactory for the additions to the levees. A comprehensive operations and maintenance manual and plan will be created for the entire Floodway. This would include interim operation and maintenance plans for intermediate stages of construction.

3.5 Mechanical and Electrical Design Discussion

Mechanical and electrical engineering reviews of the BVP, IDP and local features were conducted. No concerns regarding the feasibility of these features were found and they can be considered technically sound from a feasibility review standpoint. Additional reviews would be required as future designs are developed.

3.6 Project Risks

The following risks were identified in the Comprehensive Analysis phase. These risks were either derived from specific projects or the overall integration of various features. Some risks pertain to the design and determination of the NED Plan, while others focus on potential issues that may arise during the future design and construction of BVP, IDP and local features. A full analysis of risks is provided in additional documentation as part of the risk register.

3.6.1 Overall Comprehensive Analysis Risks

Existing survey information used in the Comprehensive Analysis study is from 1991. More current survey information may be available, but was not used in the current stages of the study to remain consistent with the Hydraulics and Hydrology model. Risks include inaccurate survey information resulting in miscalculations in quantities. Additionally, smaller surveys may have been completed for individual projects, such as the pump stations. The accuracy of these surveys is unknown and could be the cause of some tie-in concerns. It is recommended that further designs for all projects use the same baseline survey that is more recent than 1991.

Design files were submitted not only with varying base survey information, but also in varying coordinate systems. The most prevalent discrepancy involved grid to surface coordinate system conversions. Having multiple projects use different coordinate systems creates a high risk to the integrity of the designs with regards to interfacing with other projects. It is recommended that all projects in the Dallas Floodway Levee System utilize State Plane Grid Coordinate system.

There is a significant amount of risk involved with making feasibility determinations based on projects designed by others. These designs have the potential to change during the design process. The current designs are evaluated as indicated in Section 6 of this appendix, and any major changes would need to be reevaluated from a comprehensive standpoint. It is possible that referenced files within the report are not the most current. This has caused problems in the evaluation process; however, it is expected that changes are going to remain within the general scope of the projects and design issues can be handled in future design phases.

These individual features were previously evaluated on an individual basis and not on an overall project scale. The above discussions focus on the overall integration of these projects. As this is not the case in some submittals, margin of error is expected when evaluating designs.

With respect to the plan set, the sheets showing bridges crossing the Dallas Floodway Levee System are approximations of the actual bridge footprints. These were derived from aerial imagery and a comprehensive bridge plan included with the Trinity Parkway.

3.6.2 Flood Risk Management Plan Risks

The major FRM risk involves the effect raising the levee has on the existing bridges crossing the Dallas Floodway Levee System. There are several bridges that have low chords below the projected 277,000 cubic feet per second flood's water surface elevation. The risk assessment (Appendix C) took the elevations of the bridge decks into account. No credible failure modes for the levee were identified based on debris loading and subsequent failure of a bridge structure. The failure mode for erosion of a bridge pier was deemed to be not significant and was not carried forward for risk analysis. A risk informed decision was made to accept the low risk of bridge failure based on the outcome of the Risk Assessment and develop the bridge seal plans in PED as appropriate

3.6.3 Balanced Vision Plan Risks

Present grading plans for the BVP are at a 35% submittal. In this submittal, grading intent is not well defined and slopes do not tie back into existing grade. This creates several low spots within the Floodway that are not graded to drain. Future designs are assumed to accommodate a grading to drain principle. It is expected that this process will require the extent of grading to reach from the East Levee to West Levee and potentially involve significant amounts of earthwork. This is not currently reflected in the hydraulic model of the Floodway and may impact the hydraulics of the Dallas Floodway Levee System.

Each of the BVP features is assigned a category for the purposes of design requirements. These categories are based on flood recurrence intervals that have been revised since the report has been written. Flood events are now being discussed in terms of flow rates rather than in previous iterations where recurrence intervals were the standard. It is recommended that flood recurrence intervals be redefined within these categories to reflect flow rates. This discrepancy could potentially lead to overdesign or the insufficient design of features, affecting project cost and functionality. These design categories and related recurrence intervals are for design purposes only and not for maintenance discussions. They are further discussed in Section 2.5.1.

There are several planned berms that separate the relocated Trinity River from the proposed lakes. These berms have been evaluated using criteria from the Texas Commission on Environmental Quality (TCEQ) and have not been evaluated based on USACE criteria. It is important that they be evaluated under both criteria with the most stringent requirements being applicable.

3.6.4 Quantities

Quantities were estimated for cost calculation purposes using a variety of different methods. These methods are explained in other sections of this appendix. Quantities estimation techniques inherently contain margins of error that could lead to inaccurate cost assumptions which is a project risk.

Various mathematical formula, aerial imagery, and cross sectional estimations were all used to develop project quantities. These quantities were transformed into project costs. Estimations from these techniques carry a margin of error which could, potentially, lead to inaccurate project costs. Further design of the features will refine the quantities using survey information and better modeling techniques.

The key risk involving quantities is the availability of material. There are a number of proposed projects within the Dallas Floodway Levee System that involve significant amounts of earthwork. Many projects claim to the same borrow sources which could affect project costs if not addressed properly. Further modeling of the whole Floodway to include earthwork quantities will address the issue more completely to ensure each stage of the project has the proper quantities of fill to be completed.

3.7 CONCLUSIONS

The Comprehensive Analysis took an overall look at all the various proposed features within the Floodway. This comprehensive approach combined local features with the MDFP plan to determine inconsistencies and fatal flaws in design that would prohibit the development and construction of the projects. The MDFP project consists of four major components. The BVP is a City of Dallas plan to develop the recreation and aesthetic features between the East and West Levee. The IDP identified weaknesses in the pump stations and sump areas that collected runoff from the urbanized areas of Dallas before discharging it into the Trinity River. The FRM Plan is a plan identified USACE to remediate the levees to satisfactorily contain a specific flood event. The final component of the MDFP plan is a preference by the City of Dallas to flatten all riverside levee side slopes to a 4H:1V slope. The integration of all these features is discussed in previous sections of the report. The major conflicts and conclusions are presented below, along with recommended future studies that may help reduce future project risks for subsequent phases.

3.7.1 Summary of Comprehensive Analysis

The current design stages for the projects within the study range from less than a 35% design submittal to completed projects. Because of the variances in design stage, it was difficult to evaluate each feature and how it relates to the remainder of the Floodway. Major concerns that would affect the technical soundness of the BVP when considering the other projects identified in the Floodway were identified but not project threatening and, therefore, could be included in further stages of design. Each feature was analyzed individually on how it fits into other features. It is important that summaries for all features be read to fully grasp concerns on a single project. In addition, much of the document assumes a certain construction phasing when discussing concerns.

Summaries for individual project features can be read at the end of each major section. The purpose of this summary is to highlight the major project concerns that need to be resolved to ensure technical soundness and constructability. The following are the major issues identified during Comprehensive Analysis, not a full overview of all issues. Major project issues include outdated designs, such as Charlie Pump Station, that require redesigns in future design phases to accommodate the BVP. Additionally, major issues are found with the lake drain lines and the current configuration of the Dallas Branch and Woodall Rodgers Pressure Storm Sewers. Incomplete grading plans are prevalent throughout a majority of the projects, which is to be expected because they are feasibility-level submittals of these projects. However, this could lead to imprecise quantities assessment, inaccurate assumptions regarding geometric space requirements, improper drainage calculations, and non-concurrence with the hydraulics and hydrology model. All of these risks have been accounted for in the Cost and Schedule Risk Analysis from a cost perspective as it is related to cost-shared features in the MDFP (described further in Section 4 of this appendix).

3.7.2 Final Considerations

Following the Comprehensive Analysis of all features within the Dallas Floodway System including local features and features part of the Modified Dallas Floodway Project (MDFP), conclusions were made about each individual feature. Technically sound conclusions are described at the end of each feature's individual section. Technically sound as it pertains to the MDFP and local features is described from an engineering, design, and construction, perspective is described in Section 2.1.1. There are many discrepancies that cause individual features to cause concern based on their current design and configuration. Individual recommendations are made to correct the concern in a risk register and in the respective sections in this report. The recommendations pertain solely to the feature it describes and it is assumed that all of them can be fixed in future design. For the feasibility phase the individual features can then be considered technically sound. As a whole, the Dallas Floodway Project, including the MDFP and local features, is technically sound, based on a design and construction perspective, provided that the issues described in this appendix are rectified appropriately in future design.

The feasibility-level analysis conducted for this study was completed on the entire system as a comprehensive system. This Comprehensive Analysis included all features of the BVP and IDP along with the other local projects identified in the future without-project condition. The purpose of this was to ensure that the Dallas Floodway would continue to function as a system. As with any Corps project, additional design and modeling will have to be completed for each feature as they are designed and proposed for construction to ensure that they do not have significant impacts during the project phasing. This may require interim hydraulic and geotechnical mitigation features during the construction phasing. Finally, if there are impacts that are significantly different from what is disclosed in the feasibility report (including this appendix) has substantial impacts to costs, or increased environmental damages then the appropriate course of action will be taken to include possible Limited Reevaluation Report, General Reevaluation Report, or supplemental environmental documents. See Section 5.2 of the main report for additional details of additional design and modeling required in future phases of project development.

4.0 MODIFIED DALLAS FLOODWAY PROJECT

After the comprehensive analysis, decisions were made to select a subset of the proposed plan to become the Modified Dallas Floodway Project (MDFP), based on their contributions to meet the Corps objectives of FRM and ecosystem restoration. The City of Dallas' BVP and IDP were evaluated as part of MDFP for technical soundness and environmental acceptability, as required in the construction authorization for the project. All BVP and IDP features were determined in the above sections to be technically sound for a feasibility level design, and can proceed to further design. The determination of technical soundness does not necessarily dictate the inclusion of these features into the MDFP.

4.1 Project Scope

The MDFP would be a federal cost share component of the larger project. The plan consists of the NED FRM Plan, Side Slope Flattening, the West Levee IDP except the Pavaho Pump Station, the East Levee IDP except the Able Pump station, Corinth Wetlands and the relocated Trinity River from the BVP. Additionally, the MDFP assumes the Trinity Parkway will be constructed as proposed along the riverside toe of the East Levee from the downstream edge of the Dallas Floodway project limits before exiting upstream just before the Hampton Pump Station with an approximate length of 5.8 miles. The Trinity

Parkway project will be completed as a Section 408 project within the Dallas Floodway Levee System as described in Section 3.2.1.

While the above mentioned features will be cost shared, it is assumed that the sponsor, City of Dallas, will continue with plans to construct the remainder of the BVP and the IDP as local features. These local projects will be the sole cost and responsibility of the City of Dallas, with approval from USACE under Section 408 authority. Reviews of the Section 408 projects will be done as required to ensure the environmental acceptability and technical soundness of each project, considering the effects on the MDFP and the City of Dallas' overall goals for the Dallas Floodway. The following sections discuss the specific inclusions and exclusions of the MDFP. Table D-27 displays the MDFP features as it relates to the overall BVP and IDP. This list is consistent with the Alternatives considered in the EIS for the overall BVP and IDP.

Table D-27. BVP and IDP and the Modified Dallas Floodway Project

Category	*Description*	*WRDA*[1]	*Alternative 2*	
			MDFP	*BVP/IDP*[2]
BVP Flood Risk Management				
Levees	Raise to 277,000 cfs Flood Height	✓	✓	
AT&SF	Removal of Wood Bridge Segment	✓	✓	
	Removal of Concrete Bridge Segment	✓	✓	
	Removal of Embankment Segments	✓	✓	
Levee Flattening	Flattening the Riverside Levee Side Slopes to 4H:1V[3]	✓	✓	
Cut-off Wall	Extend Cut-off Wall along the East Levee[4]	✓	✓	
Nonstructural	Emergency Action Plan Improvements	✓	✓	
	Install piezometers in the Floodway[4]	✓	✓	
BVP Ecosystem and Recreation				
Lakes	West Dallas Lake	✓		✓
	Urban Lake	✓		✓
	Natural Lake	✓		✓
River	Realignment and Modification	✓	✓	
Wetlands	Marshlands	✓		✓
	Corinth Wetlands	✓	✓	
Athletic Facilities	Potential Flex Fields	✓		✓
	Playgrounds	✓		✓
	River Access Points	✓		✓
General Features	Parking and Public Roads	✓		✓
	Lighting	✓		✓
	Vehicular Access	✓		✓
	Pedestrian Amenities	✓		✓
	Forested Ponds	✓		✓
	Restrooms	✓		✓
Interior Drainage Outfall Extensions	Extend Pump Station Outfalls	✓	✓	
	Extend Pressure Sewer Outfalls	✓	✓	
Able Sump Ponds	Recreation and Ecosystem Enhancements	✓		✓

Category	*Description*	*WRDA*[1]	*Alternative 2*	
			MDFP	*BVP/IDP*[2]
IDP Flood Risk Management				
East Levee	Demolish Old Hampton Pump Station	✓	✓	
	Construct New Hampton Pump Station	✓	✓	
	Nobles Branch Sump Improvements	✓	✓	
	Construct New Baker Pump Station	✓	✓[5]	
	Construct New Able Pump Station[6]	✓		
West Levee	Demolish Old Charlie Pump Station	✓	✓	
	Construct New Charlie Pump Station	✓	✓	
	Rehabilitate Existing Delta Pump Station	✓	✓	
	Construct New Trinity-Portland Pumping Plant	✓	✓	
	Construct New Pavaho Pump Station[6]	✓		
	Eagle Ford and Trinity-Portland Sump Improvements	✓		✓
	Pavaho and Delta Sump Improvements	✓		✓

Notes: [1] Includes Section 5141 of the WRDA 2007, as amended by WRRDA of 2014.
[2] Remaining non-Federal BVP elements to be completed by the City of Dallas under a future Section 408 submittal.
[3] Included in the MDFP, and entirely paid for by the City of Dallas as a betterment.
[4] Included in the MDFP as a risk mitigation feature of the River Relocation.
[5] The Baker Pump Station is part of the MDFP but was analyzed for NEPA compliance separately (Corps 2012).
[6] Able and Pavaho are not part of the MDFP and were processed under Section 408.

4.1.1 Flood Risk Management

4.1.1.1 NED Plan: 277,000 cfs Levee Raise and AT&SF Bridge Modification

The NED Plan is comprised of a levee raise to meet the 277,000 cfs water surface elevation and modifications to the AT&SF Bridge on the downstream end of the Dallas Floodway Levee System. The AT&SF Bridge modification will include the demolition and removal of 900 linear feet of wooden trestle ballast-deck bridge, demolition and removal of 100 linear feet of wooden trestle open deck bridge, and demolition and removal of 660 linear feet of concrete ballast-deck bridge. Additionally, approximately 53,000 CY of earthen berm supporting portions of the bridge will be removed and disposed of outside the levee system.

The levee raises will occur in any location where the effective levee height is less than that of the 277,000 cfs water surface elevation. The effective levee height of any levee was determined assuming that the existing access road is approximately eight inches thick based on borings within the crest of the levees. The effective levee height is assumed; therefore, to be 8 inches below the surveyed levee height at any point along the levees. Table D-28 depicts the levee stationing that requires levee raises.

Table D-28. Stationing of East and West Levee Reaches to be Raised

Reach Number	East Levee and Elm Fork		West Levee and West Fork	
	Begin Station	*End Station*	*Begin Station*	*End Station*
1	79+95	82+63	50+99	52+00
2	99+70	101+41	66+69	69+48
3	117+04	119+12	70+07	71+60
4	153+63	168+03	154+93	211+35
5	168+79	234+87	211+75	233+70
6	246+90	256+05	241+60	243+88
7	256+77	282+80	244+54	268+25
8	283+31	300+28	280+35	306+54
9	300+72	316+90	314+71	316+90
10	328+10	346+92	325+63	327+88
11	347+61	351+96	331+68	332+45
12	442+28	443+05	338+55	340+95
13	474+29	474+87	365+43	367+88
14	476+10	518+76	409+60	416+75
15	520+85	531+33	417+42	419+19
16	531+73	544+43	423+00	429+95
17	546+04	551+22	431+30	443+46
18	551+93	557+08	452+56	454+98
19	559+25	560+68	476+50	478+55
20	-	-	481+40	482+77
21	-	-	486+20	494+87
22	-	-	495+48	499+75
23	-	-	502+51	516+00
24	-	-	517+74	521+09
25	-	-	522+41	536+61
26	-	-	537+65	541+16
27	-	-	544+55	548+46
28	-	-	553+04	555+65
29	-	-	557+45	558+92
Total Length	**25,740 LF**		**23,529 LF**	

Levee raises will be constructed by first excavating the top eight inches of the levee and disposing the material. The levee will be scarified to a depth of 6 inches along flat surfaces. Scarification along the slopes for any levee work will need to be constructed by excavating and benching into the levee at a minimum of 10-foot wide steps. Levee raises will extend from the protected side crest at a 3H:1V slope to the required elevation. The levee crest will be a minimum of sixteen feet before tying into the riverside slope of the levee at a 3H:1V slope. A crushed limestone access road will be placed on top of the levee crest to a depth of 8" with a Geotextile liner between the levee and the road. Figures D-38 and D-39 show a typical levee raise template and the access road template, respectively.

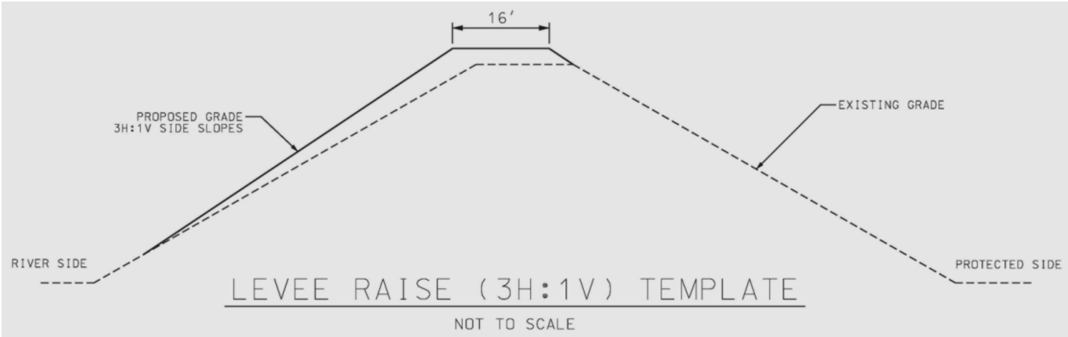


Figure D-38 3H:1V Levee Raise Template

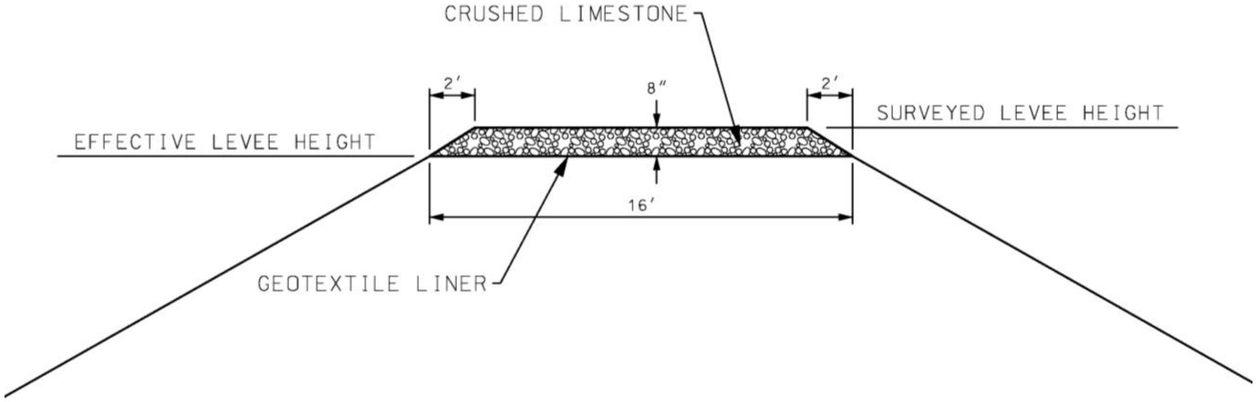


Figure D-39 New Crushed Limestone Access Road Template

The borrow source for the NED Plan is within the footprint of the proposed West Dallas Lake. An estimated 94,000 CY of material is needed for the construction of the NED Plan. This estimate takes into account compaction.

The NED Plan does not require utility relocation. There are three bridge-levee interfaces that require structural bridge sealing plans including Corinth, Union Pacific, and SH-356 on the East Levee. The Houston Street Bridge on the West Levee requires sandbagging at the 277,000 cfs flow.

4.1.1.2 Side Slope Flattening

The current side slopes of the levee system range in grade from approximately 2.8H:1V to 4H:1V. Based on the safety hazard of mowing steep side slopes and its inclusion in the BVP, the local sponsor wishes to pursue construction of 4H:1V side slopes on the entire length of the riverward side of the East and West Levees, including the forks, where the existing slopes are steeper than 4H:1V. Currently, the City of Dallas has implemented some sections of this plan along the downstream end of the Floodway. The extents of the existing efforts of side slope flattening are not defined; however, a survey prior to design and construction will delineate the full scope of the side slope flattening project. Quantities for the cost estimate of the side slope flattening were developed using a conservative assumption that the entire length of the levees would require flattening. Figure 40 displays the 4H:1V side slope template for the East and West Levee. The side slope flattening includes reconstruction of the access roads to match the new contours of the riverward side of the East and West Levee. The borrow source for the side slope flattening is within the footprint of the proposed West Dallas Lake. An estimated 1,400,000 CY of material is needed for the construction of the 4H:1V side slopes, including the NED Plan levee raise quantities.

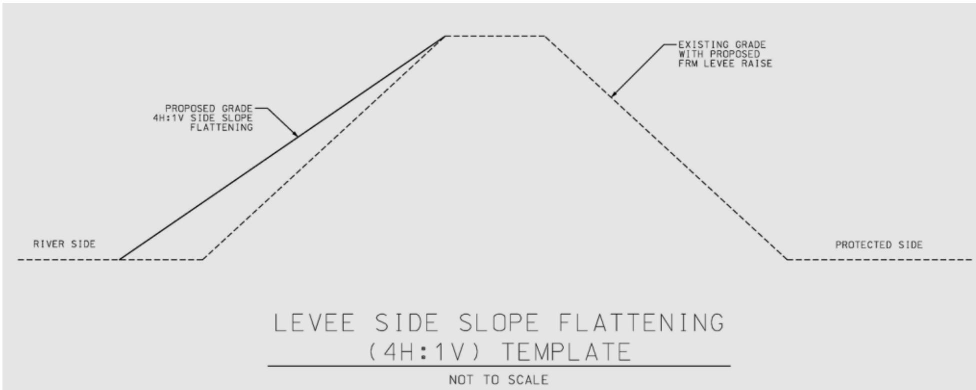


Figure D-40 4H:1V Typical Levee Side Slope Flattening Template

The outfall structures affected by flattening the side slopes include Old Coombs Creek, Coombs Creek, Turtle Creek, Nobles Branch Sump, and Eagle Ford Sump (Table D-29). The associated costs and quantities for the extension of the outfall structures for these features is solely related to the proposal to flatten all riverward levee side slopes to 4H:1V. The outfall structures affected by a BVP feature, is accounted for in the respective BVP feature cost. For example, the pressure sewer relocation work on the East Levee is primarily affected by the construction of the Urban or Natural Lake. The side slope flatting plan includes demolition of all existing revetment and riprap and replacement with new concrete underneath bridges using TxDOT standards. This is to create a uniform 4H:1V surface across the entire levee to improve operations and maintenance efforts.

Table D-29. Utility Relocations for Side Slope Flattening

Project Objective	*Utility Owner*	*Utilities*
Flood Risk Management	City Owned	Storm Pressure – Old Coombs Creek
	City Owned	Storm Pressure – Coombs Creek
	City Owned	Storm Pressure – Turtle Creek
	City Owned	Storm Gravity – Nobles Branch
	City Owned	Storm Gravity – Eagle Ford

This feature will be included in the Project – MDFP at 100% non-Federal cost, and has a first cost in October 2010 price levels of $39,639,000. The NED Plan levee raises impact approximately 40% of the linear length of the levees. To avoid disturbing the same sections of the levee multiple times and to reduce cost, it is recommended that the flattening of side slopes be constructed concurrent to the NED Plan construction.

Implementation of the 4H:1V side slopes are a betterment. Under the authority of PL 84-99 (Flood Control and Coastal Emergency Act), an eligible flood protection system can be rehabilitated if damaged by a flood event. The flood system would be restored to its pre-disaster status at no cost to the Federal system owner, and at 20% cost to the eligible non-Federal system owner. If the levees are damaged by a flood event, the city would be responsible for the cost to build back to a 4H:1V in excess of the 3H:1V.

4.1.1.3 East Levee Interior Drainage Plan

The East Levee IDP consists of the construction of new pump stations or improvements to existing pump stations and sump. This includes the construction of the new Able Pump Station, new Baker 3 Pump Station, and the new Hampton 3 Pump Station, and modifications to the Nobles Branch Sump at Empire Central Drive. The Baker 3 Pump Station is currently under construction, the new Hampton 3 Pump Station is at a feasibility level design, and Able Pump Station is beyond feasibility level design at approximately 65%.

Able Pump Station will be constructed between Houston Street and Jefferson Street at about station 99+00 on the East Levee with a planned capacity of 875,000 gpm. Baker 3 Pump Station is proposed to be constructed upstream of Sylvan Avenue at approximately station 241+00 on the East Levee. Baker 3 Pump Station will replace the Old Baker Pump Station and have a maximum capacity of 700,000 gpm. The new Hampton 3 Pump Station will be constructed upstream of Hampton Road at approximately station 315+00 along the East Levee. Hampton 3 Pump Station designs will replace Old Hampton Pump Station and have a maximum capacity of 700,000 gpm. The planned improvements of Nobles Branch Sump increase the connectivity of the sump through the construction of two new 60” reinforced concrete culverts and the replacement of one existing 60” concrete culvert under Empire Central Drive.

4.1.1.4 West Levee Interior Drainage Plan

The West Levee IDP consists of the construction of new pump stations or improvements to existing pump stations and sump areas. The current 35% design proposes the construction of a new Charlie Pump Station and demolition of the existing pump station. The site of the new Charlie Pump Station is downstream from the existing pump station just east of Jefferson Blvd. The proposed capacity of the Charlie Pump Station is 225,000 gpm. Demolition plans for the existing Charlie Pump Station involve utilizing the existing box culvert through the levee at the pump station for continued gravity drainage use. At Charlie Pump Station, the Trinity River Relocation will move the river significantly towards the West Levee in order to accommodate the proposed Natural Lake footprint. The slopes for Charlie Pump Station need to match the intent of the City of Dallas to flatten all levee side slopes to 4H:1V. It is also recommended that slopes tie back into the levee more gradually to create a smoother mowing surface for maintenance workers. Trinity Portland Pumping Station would be a new pump station located on the West Fork Levee near Mexicana Drive. The pump station would be fed by the Trinity Portland basin. The proposed pump station is in the 35% design phase. Current plans call for two 125,000 gpm pumps to service this pump station. The proposed design would slightly modify the sump areas around the pump station to provide conveyance to the pump intake. These modifications would not affect the levee template itself. Access roads on the levee crest would be realigned accordingly to accommodate the increase in elevation due to the discharge pipes passing over the levee. The slopes covering the pipes accommodate the proposed 4H:1V slope flattening goal of the City of Dallas with added articulated concrete block protection occurring over the pipes on the riverside slope.

The Delta Pump Station is located on the West Levee just upstream from Hampton Road. It is on the landward side of the West Levee along a dirt access road. The current Delta Pump Station consists of one main pumping building with an intake and outfall structure passing through the levee. The current capacity of the Delta Pump Station is 40,000 gpm. The proposed project involves the renovation of the pump station and the improvement of the sump and outfall area to prevent further erosion and preserve the integrity of the levee. The pumps will be replaced with pumps of the same capacity and the existing two 4’x4’ box culverts will remain in place as the discharge structure.

4.1.1.5 Emergency Action Plan Improvements

The city has an existing in-depth Emergency Action Plan that identifies elderly populations over 65, special needs households, and other structures that should to be targeted for evacuation during flood events. Floodplain inundation maps will be provided to the city to update their Emergency Action Plan to help them target the areas with these populations that are flooded the deepest so that they can be evacuated first.

4.1.2 Ecosystem Restoration

4.1.2.1 Trinity River Relocation

The Trinity River Relocation is proposed for ecosystem restoration in the Recommended Plan. The Corps will participate in vegetation plantings, edge treatments for the river, erosion protection, excavation of the new river channel, and backfill of the existing river channel. The remaining features of the River Relocation are proposed under the Section 408. The existing 7.2 miles of the Trinity River will be relocated between Corinth Street to the confluence of the Elm and West Forks to improve channel diversity and sinuosity. The meanders will add an additional 1.1 miles (6,000 linear feet) to the existing Trinity River in the Floodway. As part of the river relocation, an oxbow (Oxbow Lake) will be created upstream from Corinth Street. Oxbow Lake will have a length of approximately 2,400 linear feet. The Oxbow Lake will only be connected to the Trinity River at flows above 5,740 cfs. In order to minimize impacts to state listed threatened and endangered species, some parts of the existing channel will remain intact. The exact areas and extents will be determined during the detailed design.

The channel bottom width will remain at least 50 feet wide and will be widened in certain regions to improve transitions with elements of the floodplain park design. The geometry of the designed channel will also enable low-flow on the floodplain bench elevation at normal depth for flows of 500 cfs, floodplain bench slopes and landscape terrace sides slopes at 20:1 or flatter, for adequate drainage and transitions, and channel bank side slopes between floodplain benches and channel inverts or between floodplain benches and top of bank to be a maximum of 3:1 side slopes on the outside and 4H:1V on the insides of meander bends. The channel slopes will have bank treatments to prevent lateral migration and erosion. The channel profile design is intended to approximately preserve the existing average slope and rely on natural geomorphic processes to produce a diverse longitudinal profile over time. Constructed pools were also added to the cross sections and profiles to improve the initial ecological impact and the fish and bird habitat diversity.

After excavation of the new channel and backfill of the existing channel, the river relocation and oxbow lake are expected to have approximately 1.2 million CY of excess material. In order to mitigate the cost of the disposal of this material, the excess can be used for grading to drain the project features and neighboring features of the West Dallas Lake. The features neighboring West Dallas Lake are not a part of the Recommended Plan; however, providing suitable material for rough grading to meet future Floodway goals is recommended.

The relocation of the Trinity River requires relocation or extension of several utilities that either cross the Floodway or drain into the existing Trinity River. Table D-30 presents the required utility locations for the Trinity River Relocation. The discharges of the new Able Pump Station, Belleview Storm Sewer, Dallas Branch Storm Sewer, Turtle Creek and Woodall Rogers Storm Sewer need extensions from their current (or planned) outfalls to accommodate the relocated Trinity River. The initial extension would be provided by the Trinity Parkway. The Turtle Creek extension is bit required for the River Relocation. Two of the four Dallas Water Utilities will be relocated by the Trinity River Relocation at Houston Street and Hampton/Inwood Road.

Table D-30. Utility Relocations for River Relocation

Project Objective	*Utility Owner*	*Utilities*
Environmental Restoration	City Owned	Belleview Storm Sewer Outfall
	City Owned	Dallas Branch Storm Sewer Outfall
	City Owned	Woodall Rogers Sewer Outfall
	City Owned	Houston Street Viaduct Water Line
	City Owned	Hampton Road/Inwood Water Line
	City Owned	Removal of Misc. Pipelines
	City Owned	Able Pump Station Outfall
	Franchise (Atmos Energy)	Gas Main - 16" North of Houston Street
	Franchise (Atmos Energy)	Gas Main - 30" South of Sylvan Street
	Franchise (Oncor)	Underground Electric North of Commerce Street
	Franchise (Oncor)	Underground Electric South of Houston
	Franchise (Oncor)	Aerial 138kV Elec. Transm. North of Continental Street
	Franchise (AT&T)	Underground Telecomm. South of IH-30
	Franchise (Verizon)	Underground Fiber Optics South of Union Pacific
	Franchise (AT&T)	Underground Fiber Optics Between Sylvan and Continental Ave.
	Franchise (Magellan)	Jet Fuel Pipeline - 6" West of Westmoreland

Bridge pier modifications are required for Continental, Commerce Street, Houston Street, Jefferson Boulevard, and the existing IH-35E (southbound and northbound) because the relocated Trinity River will affect the existing bridge piers. The design methodology includes encasing the existing surrounding soil before any excavation of the River Relocation takes place.

Seepage pathways are shortened by the river relocation and the risk for heave (PFM 8) increases in the following locations: (1) West Levee, Station 3+00 to 29+00; (2) East Levee, Station 285+00 to 442+00; and (3) East Levee, Continental Avenue to Station 285+00. The city has constructed cut-off walls as part of their 100-year FEMA accreditation effort in these locations except the section on the East Levee from Continental Avenue to Station 285+00. The existing cut-off walls the city has constructed on the East Levee at Station 285+00 will be extended downstream to approximately Continental Avenue (approximately Station 170+00) to mitigate for the increase in risk due to the river relocation. With implementation of the additional cut-off wall, there is no increase in risk due to the river meanders. The city's cut-off wall and the extension of the cut-off wall from approximately Station 170+00 to Station 285+00 are part of the Recommended Plan as a seepage mitigation measure for the River Relocation. Piezometers will be installed along the East and West Levee for seepage monitoring purposes.

4.1.2.2 Corinth Wetlands

The Corinth Wetlands extend from Oxbow Lake, downstream between the relocated Trinity River and the West Levee. The intent of this feature is to expand the existing wetlands in that area. The Corps will participate in vegetation plantings and excavation of the new wetlands. All remaining features are provided by the City of Dallas under Section 408 including a boardwalk that borders the wetlands along the West Levee toe that is designed for viewing of the features of the Corinth Wetlands. There are multiple landscape and grading plans for this area that all have varying descriptions and details of the amount and type of work to be completed in this area. Some plans show large amounts of landscape work including riparian woodland plantings. The intent is for the area specified in the environmental analysis for Corinth Wetlands to be emergent wetlands; however, in future design some tree plantings could be incorporated into the design. Upon further design, the final vegetation plan needs to be accounted for within the hydraulics and hydrology model for the Floodway.

4.1.3 Borrow Sources

The BVP as proposed by the City of Dallas consists of three lakes, a relocated river, and several surficial and landscape features within the Dallas Floodway. These features are discussed in detail in Section 2.5. The scope of the BVP extends from the AT&SF Bridge, upstream to the confluence of the West and Elm Fork Rivers. As part of the recommended MDFP, a subset of the BVP features are part of the MDFP. The remaining BVP features are still recommended; however, they are to be included as local features to be completed solely by the City of Dallas as Section 408 projects.

The BVP has two alternatives that are dependent upon whether the Trinity Parkway is constructed or not, see Section 3.2.1. The alternative in the EIS assumed to be the "proposed action," assumes the construction of the Trinity Parkway along the riverside toe of the East Levee of the Dallas Floodway Levee System. As part of the analysis for the Federal Plan, a rough grading calculation for cut, fill, and balance was completed for the various overall features of the BVP with Trinity Parkway. This was completed in order to verify, on a rough order of magnitude, the costs assigned to the various project features. Additionally, it was used to determine the availability of material for the needs of all the various projects within the Dallas Floodway Levee System. Table D-31 displays rough estimates of cut and fill for each of the three lakes, the recreation fields adjacent to West Dallas Lake, and the relocation of the Trinity River.

Table D-31. BVP Rough Quantities

Quantities (CY)			
Item	*Cut*	*Fill*	*Balance*
Relocated Trinity River	5,779,290	4,730,048	**1,049,242**
Oxbow Lake	215,293	51,817	**163,476**
West Dallas Lake	3,502,620	296,590	**3,206,030**
Urban Lake	1,850,283	333,200	**1,517,083**
Natural Lake	667,818	221,982	**445,836**
Recreation Fields	244,168	1,137,964	**(893,796)**
Totals	**12,259,472**	**6,771,600**	**5,487,871**

These tables were created using grading models in MicroStation using GEOPAK. The volume analysis tool was used to generate the information in these tables. The model was based on the provided BVP information by the City of Dallas' contractor. These numbers contain no bulking factors and are in situ. The modeling included the backfill of the existing river within the relocated river quantities. Additionally, there is no grading to drain modeling, as recommended in the BVP section of the MDFP Plan analysis, Section 2.5. The numbers associated with each feature may vary because of additional grading around the feature to allow for positive drainage. Table D-31 indicates a net surplus of approximately 5.5 million CY of in situ material. These quantities may be different from previous iterations of estimation due to different assumptions and modeling techniques used.

In the final design of the features, specifically the BVP features, it is important that proper design and construction techniques are utilized. This is particularly in reference to grading to drain. The current preliminary design of the BVP and the quantities represented in Table D-31 do not reflect grading to drain. In some locations, this may be a significant amount of earthwork. This could cause discrepancies in the required material needs for each of the various project features. A more detailed earthwork plan for borrow and spoil material is necessary during design to incorporate all of the various features within the Dallas Floodway Levee System that require earthen material. This issue is a carryover from issues outlined in comprehensive analysis but also plays a role in the development of costs for the MDFP.

4.1.3.1 West Dallas Lake

West Dallas Lake has significant interest from several project features and the Trinity Parkway as it is a large, viable source of suitable material for levee construction. The borrow pits identified for the FRM levee raises, side slope flattening, and the Section 408 Trinity Parkway are within the footprint of the proposed West Dallas Lake. After the excavation of material by these three project features, the West Dallas Lake will have a majority of its footprint excavated.

According to a memo from Halff Associates dated May 3, 2011, regarding the Trinity Parkway earthwork quantities, the Trinity Parkway has estimated that 2.95 million CY of material will be excavated from West Dallas Lake for use as part of the Trinity Parkway earthen berm and levee improvements. All of this material is rated as suitable for levee use. The memo states that the remaining material to be removed from the area to create the BVP West Dallas Lake feature is approximately 610,000 CY.

The material required from a borrow standpoint for the levee raise and side slope flattening alternatives, will be taken from the West Dallas Lake footprint. It is estimated that, approximately 1,119,000 CY is required for the completion of these two features. Therefore, the Trinity Parkway, for the purposes of its earthen berm, needs to leave that amount of suitable material for the borrow material for the levees. These quantities are all in situ with no bulking factors associated with them.

The excess material excavated from the West Dallas Lake during the final construction of the Lake and its features can be used to ensure proper drainage in the surrounding features. Specifically, the area between West Dallas Lake and the West Levee can be filled in with this material to appropriately address drainage and ponding issues.

4.1.3.2 Trinity River Relocation

As shown in Table D-31, the Oxbow Lake and relocated Trinity River have a net an excess fill of approximately 1.2 million CY of material. In order to mitigate the cost of this material and its disposal, the material can be used for a couple purposes within the Floodway. Grading neighboring features of the West Dallas Lake and relocated Trinity River to drain can be accomplished using some of the material. However, a bulk of the material can be utilized in the rough grading of the recreation fields downstream of West Dallas Lake. While this feature is not a part of the cost-share plan, there are significant benefits for both the City of Dallas and USACE to utilize the recreation fields as an area to place spoil material, rough graded to meet future Floodway goals. While the feature will not be completed as part of the Federal Plan, rough grading the site as a disposal area for material is recommended. Project Phasing is discussed further in Section 4.4.

5.0 RECOMMENDED PLAN

The Recommended Federal Plan is the Modified Dallas Floodway Project Plan as described in Section 4.0. Although there are technical issues at this stage of design, the project is technically sound for feasibility phase and it is expected that design issues could be addressed in future design. Section 4013 of the Water Resources Reform and Development Act (WRRDA) of 2014 (P.L. 113-121), provides a technical correction to Section 5141(a)(2) of the WRDA 2007. Section 5141 is amended by inserting "and the Interior Levee Drainage Study Phase-II report, Dallas, Texas, dated January 2009," after "September 2006." The Recommended Plan now includes the IDP Phase II (Charlie, Delta and New Trinity Portland).

The BVP and IDP were examined to meet technically sound criteria. The Modified Dallas Floodway Project features were found to comply with technically sound criteria. The remaining BVP and IDP features and other local features of the Comprehensive Analysis not included in the Modified Dallas Floodway Project are subject to Section 408 criteria. During the Comprehensive Analysis, the proposals reviewed against engineer and safety standards.

5.1 FUTURE STUDIES

Based upon the Comprehensive Analysis of the Dallas Floodway Levee System and due to the large number of proposed projects, it is suggested that future studies be conducted as designs of the various features continue to progress. The studies would further the development and integration of all project features and give insight towards possible conflicts of design between projects. The recommended future studies include the creation of a grading model for the entire Levee System to include all earthwork projects, the further modeling and calculation of the outfall structures discharging into the Trinity River, and the development of a construction phasing plan to include borrow material claims. These three studies are recommended to ensure the overall functionality of the Dallas Floodway Levee System and its various features including the BVP, IDP, Slope Flattening Plan, FRM Plan, and the proposed Local Features.

The issues identified in the Comprehensive Analysis, from a civil site design perspective, were largely related to grading and contour issues. Unintentional low spots within the Floodway that are not graded to drain, inconsistencies in the merging of grades between features, and inconclusive evidence of proper interfaces between elements were prevalent throughout the analysis. While a majority of these issues are design related, there is the potential that proper grading could alter the shape of the Floodway to the extent that some features need to be modified or not feasible. This could potentially be seen in the design and grading of access roads along the face of the East and West Levee. The BVP also interfaces for several miles with the proposed Trinity Parkway earthen berm, which in turns interfaces with the East Levee at varying heights along its riverside levee face. Combining these features with plans to raise the levee and flatten the levee side slopes, as well as revising discharge structures associated with utilities and pump stations, creates a largely congested site where several projects interface on many different sides. These interface issues and the incomplete grading at this time provides a certain risk to the Floodway that has potentially major conflicts, yet has a relatively easy solution.

It is recommended that, as designs for the various features within the Dallas Floodway Levee System progress, a comprehensive grading plan be updated to ensure proper cohesion between features. Similar to the hydraulic modeling of the Trinity River, the grading model would be an overall representation of the entire Dallas Floodway. The suggestion is to show grading for major features and roads to give a general sense of earthwork and drainage paths. This grading plan would extend from levee to levee and include all features in between, including the Trinity River, BVP Lakes, pump stations, wetlands, and the Trinity Parkway earthen berm. This would allow for drainage on a full Floodway scale to be examined and any inconsistencies can be remedied on an overall project scale. This model would then be used to ensure accuracy with the hydraulic model. Currently, the hydraulic model reflects the current grading level; however, a substantial amount of grading and earthwork has yet to be included within the design and will need to be reflected in a revised hydraulic model. The hydraulic and grading model would work in harmony and allow for quick iterations of back and forth design to create a properly drained Floodway that satisfies all hydraulic criteria for improvements.

Another recommendation for future study is the analysis of all outfall channels for utilities, pump station discharges, and overflow weirs. The design of these features was inconsistent throughout all projects. Existing outfall channels are deeper and wider than proposed additional outfall channels for higher flows. This is the case for new outfall channels merging with BVP features, including the relocated Trinity River channel. In some cases, new outfall channels are proposed and merge with existing outfall channels that are, for the most part, not being reconstructed. These new outfall channels discharge substantial amounts of water and no analysis is done regarding the capacity of the existing channel. Improvements to the existing channel for new outfall structures need further evaluation. The suggestion is to take a comprehensive look at all discharge structures, their capacity, erosion protection, and depth. This is essential to ensure the proposed outfall channels do not erode and create complications for neighboring features and the final discharge into the Trinity River is adequately designed.

Based on the number of projects, a systematic approach is necessary for evaluation of a phasing and construction plan. The complexities of developing this plan involve the prediction of funds and availability of resources. It is impossible to recreate all possible iterations of phasing in construction that is present on all of these features. However, creating a hierarchical plan where critical features are identified would help in determining future courses of action when conflicts in construction arise. The phasing of projects is essential to mitigate costs and, in some cases, ensure technical soundness of individual features. A general framework for construction sequencing was developed for the feasibility phase and is described in Section 2.7. It is recommended that future phases of design consider refinement within the general construction sequencing plan. Recommended Plan Operations, Maintenance, Repair, Replacement, and Rehabilitation.

The information in this section was used to develop an estimated cost for replacement and repair of various features of the Recommended Plan. The full cost of all OMRR&R will be the responsibility of the non-Federal Sponsor.

Chapter 4 of the main report gives a full outline of all OMRR&R costs for each of the features included in the MDFP. This section includes the repair and replacement costs of features that are included in the Trinity River Relocation. It was estimated that a majority of the repair and replacement work, from a Civil Design perspective, would occur on the erosion protection and other surficial treatments of the Trinity River Relocation. It was further estimated that these features would be completely inundated between the 10- and 25-year storm recurrence intervals. For the purposes of estimation, the erosion protection and bank treatment features would need maintenance and possible replacement every twenty years. Assuming that the initial invested cost of the erosion protection features, bank treatments, and riprap would need to be reinvested every twenty years, a factor of 5% was applied to these features to represent an annualized cost. Replacement costs for trees and other vegetation surrounding the relocated Trinity River assumes a 5% factor for vegetation replacement costs.

These factors were used to approximate replacement and repair costs each year for these features. They are sufficient for a feasibility level design and costs for OMRR&R will be adjusted as the design of the features progresses. The costs that were factored using the above percentages originate from the cost estimate developed at the time of report writing. A comprehensive O&M plan will be created for the Floodway that will enumerate all the various features that will need inspection, repair, and replacement. OMRR&R costs for these features, outside the MDFP were not included in this report.

6.0 REFERENCES

The following reports, plan sets, and documentation were used in the development of this report. These were the documents available at the time of the report writing. Additional documentation may have been available, but it was not used in the development of this appendix.

6.1 PLANS AND DESIGN DRAWINGS

Table D-32 lists the plan sets and design drawings utilized in determining the technical soundness and constructability of the various features within the Dallas Floodway Levee System.

Table D-32. Plans and Design Drawings Utilized in Comprehensive Analysis

Paragraph Number	*Project*	*Description Of Plans*	*Dated*
2.5	BVP WITH PARKWAY	PARK-LANDSCAPE SCHEMATIC DESIGNS; INCLUDES PRELIMINARY GRADING AND OTHER FEATURES	Aug-2009
2.5	BVP WITHOUT PARKWAY	BALANCED VISION PLAN – NO PARKWAY ALTERNATIVE 35% DESIGN SUBMITTAL	Aug-2010
2.5.2	RIVER RELOCATION	DALLAS FLOODWAY PROJECT TRINITY RIVER DESIGN DALLAS, TX TRINITY RIVER RELOCATION SCHEMATIC DESIGN	Aug-2009
2.5.3	LAKES	DALLAS FLOODWAY PROJECT TRINITY RIVER DESIGN DALLAS, TX TRINITY LAKES SCHEMATIC DESIGN	Aug-2009
2.5.3.7	CWWTP PIPELINE	APPENDIX A OF PRELIMINARY DESIGN REPORT; CENTRAL WWTP EFFLUENT PUMP STATION AND 60-INCH ALTERNATE DISCHARGE LINE	Jan-2009
2.5.9	BRIDGE PIER MODIFICATION	DALLAS FLOODWAY PROJECT TRINITY RIVER DESIGN DALLAS, TX BRIDGE PIER MODIFICATIONS - 20% DESIGN	Jun-2009
2.6.1	ABLE PUMP STATION	ABLE PUMP STATION 35% DESIGNS	Feb-2013
2.6.2	BAKER PUMP STATION	BAKER PUMP STATION 95% DESIGNS	Jun-2011
2.6.3	CHARLIE PUMP STATION	CHARLIE PUMP STATION 35% DESIGN SUBMITTAL	May-2009
2.6.4	DELTA PUMP STATION	REHABILITATION OF THE DELTA PUMPING STATION 35% DESIGN SUBMITTAL	Nov-2009
2.6.5	HAMPTON 3 PUMP STATION	HAMPTON 3 PUMPING STATION 35% DESIGN SUBMITTAL	May-2009
2.6.6	NOBLES BRANCH SUMP	UBGRADES TO NOBLES BRANCH SUMP 35% SUBMITTAL	May-2009
2.6.7	PAVAHO PUMP STATION	PAVAHO STORM WATER PUMPING STATION FINAL SUBMITTAL	Mar-2010

Paragraph Number	*Project*	*Description Of Plans*	*Dated*
2.6.8	TRINITY PORTLAND PUMP STATION	NEW TRINITY-PORTLAND PUMPING STATION 35% DESIGN SUBMITTAL	May-2009
3.2.1	TRINITY PARKWAY	TRINITY PARKWAY 30% DESIGN; SECTIONS 1-5	Mar-2010
3.2.2	PAVAHO WETLANDS	PAVAHO STORMWATER WETLAND	Oct-2012
3.2.3	STANDING WAVE	(ATTACHMENT B PAGES 28 TO 38) STANDING WAVE AT MOORE PARK	May-2010
3.2.4	SANTA FE TRESTLE	PLANS OF PROPOSED HIKE AND BIKE TRAILS	Dec-2009
3.2.5	HORSESHOE: IH-35E AND IH-30	IH 30/IH35 RECONSTRUCTION DALLAS "HORSESHOE" RFP PRELIMINARY PLANS	Jun-2012
3.2.6	SYLVAN BRIDGE	TxDOT PLANS OF PROPOSED URBAN MINOR ARTERIAL IMPROVEMENT OF SYLVAN AVENUE	Mar-2011
3.2.8	CONTINENTAL BRIDGE	CONTINENTAL BRIDGE IMPROVEMENTS 100% DESIGN	Mar-2011
3.2.9	DWU WATER MAIN REPLACEMENTS	DALLAS WATER UTILITIES WATER MAIN REPLACENTS; FOUR DIFFERENT WATER MAINS CROSSING DALLAS FLOODWAY; 65% DESIGN SUBMITTAL	Sep-2010

6.2 Reports and Other Documentation

Table D-33 lists the reports used as references in the analysis of the Dallas Floodway Levee System and its proposed features as part of this Civil and Structural Appendix.

Table D-33. Reports and Other Documentation Referenced in Comprehensive Analysis

Paragraph Number	***Project***	***Description Of Plans***	***Dated***
2.5.2	RIVER RELOCATION	FINAL REPORT TRINITY RIVER CORRIDOR PROJECT FLUVIA GEOMORPHIC ASSESSMENT AND BASIS OF DESIGN FOR RIVER REALIGNMENT	Sep-2009
2.5.3	LAKES	NATURAL, URBAN, AND WEST DALLAS LAKES	Sep-2009
2.5.3.7	CWWTP PIPELINE	PRELIMINARY DESIGN REPORT: TRINITY LAKES PROJECT CENTRAL WWTP EFFLUENT PUMP STATION AND 60-INCH ALTERNATE DISCHARGE LINE IMPROVEMENTS	Jan-2009
2.5.8	UTILITIES AFFECTED BY BVP	UTILITY ADJUSTMENTS AND RELOCATIONS DESIGN REPORT TRINITY LAKES PROJECT (PRELIMINARY REPORT)	Sep-2008
2.5.9	BRIDGE PIER MODIFICATION	BRIDGE PIER MODIFICATIONS DESIGN CALCULATIONS	Oct-2009
2.6.1	ABLE PUMP STATION	DESIGN DEVELOPMENT REPORT FOR ABLE NO.3 STORM WATER PUMPING STATION	Feb-2013
2.6.2	BAKER PUMP STATION	SECTION 408 SUBMITTAL APPLICATION	Jun-2011
2.6.3	CHARLIE PUMP STATION	CHARLIE PUMP STATION DESIGN DOCUMENTATION REPORT	Nov-2009
2.6.4	DELTA PUMP STATION	DESIGN DOCUMENTATION REPORT FOR REHABILITATION OF THE DELTA PUMPING STATION	May-2009
2.6.5	HAMPTON 3 PUMP STATION	DESIGN DOCUMENTATION REPORT HAMPTON 3 PUMPING STATION	May-2009
2.6.6	NOBLES BRANCH SUMP	DESIGN DOCUMENTATION REPORT FOR UPGRADES TO NOBLES BRANCH SUMP/GRAUWYLER GATES PROJECT	May-2009
2.6.7	PAVAHO PUMP STATION	PAVAHO STORM WATER PUMP STATION DESIGN ANALYSIS (DRAFT)	May-2009
3.2.2	PAVAHO WETLANDS	CITY OF DALLAS SUPPLEMENTAL ENVIRONEMTAL PROJECT - PAVAHO WETLAND SECTION 408 PERMIT ENVIRONMENTAL ASSESSMENT	Dec-2012
2.6.8	TRINITY PORTLAND PUMP STATION	DESIGN DOCUMENTATION REPORT NEW TRINITY-PORTLAND PUMPING STATION	May-2009

Paragraph Number	***Project***	***Description Of Plans***	***Dated***
3.2.3	STANDING WAVE	RESUBMITTAL NATIONWIDE PERMIT 42 AND SECTION 10 PRE-CONSTRUCTION NOTIFICATION AND MITIGATION PLAN FOR STANDING WAVE-INSTREAM AND TERRESTIAL FEATURES AT THE TRINITY RIVER	May-2010
3.2.4	SANTA FE TRESTLE	CATEGORICAL EXCLUSION SANTA FE TRESTLE HIKE AND BIKE TRAIL CSJ: 0918-45-354	Jan-2010
3.2.5	HORSESHOE: IH-35E AND IH-30	IH 30 / IH 35E DALLAS HORSESHOE PROJECT SUMMARY REPORT INITIAL 408 SUBMITTAL PACKAGE	Jun-2012
3.2.6	SYLVAN BRIDGE	TxDOT PLANS OF PROPOSED URBAN MINOR ARTERIAL IMPROVEMENT OF SYLVAN AVENUE	Mar-2011
3.2.8	CONTINENTAL BRIDGE	SPECIAL PROVISIONS AND PROPOSAL FOR PAVAHO STORMWATER WETLAND SUPPLEMENTAL ENVIRONMENTAL PROJECT (SEP) - PBDECRE1	Dec-2012
4.1.3.1	TRINITY PARKWAY EARTHWORK QUANTITIES	ESTIMATION OF REQUIRED EARTHWORK BY HALFF ASSOCIATES FOR TRINITY PARKWAY EARTHEN BERM	May-2011

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TRINITY RIVER PROJECT, TX

DALLAS FLOODWAY LEVEES

US ARMY CORPS
OF ENGINEERS
Ft. Worth District

DALLAS FLOODWAY LEVEES FEASIBILITY STUDY

DALLAS, TEXAS

VOLUME 1 OF 1

NOT FOR CONSTRUCTION
DATED: AUGUST 06, 2013

This project was designed by the Fort Worth District of the U.S. Army Corps of Engineers. The initials or signatures and registration designations of individuals appear on these project documents within the scope of their employment as required by ER 1110-1-8152

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DF-LEVEE_STUDY-G-002.dgn	G-002	INDEX OF DRAWINGS
DF-LEVEE_STUDY-G-101.dgn	G-101	PROJECT LOCATION MAP
		CIVIL
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DF-LEVEE_STUDY-C-206.dgn	C-206	WEST LEVEE PROFILE I - STA 0+00 TO STA 150+00 (SHEET 1 OF 4)
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US Army Corps of Engineers
Fort Worth District

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

ENGINEERING/ CONSTRUCTION DIVISION DESIGN BRANCH

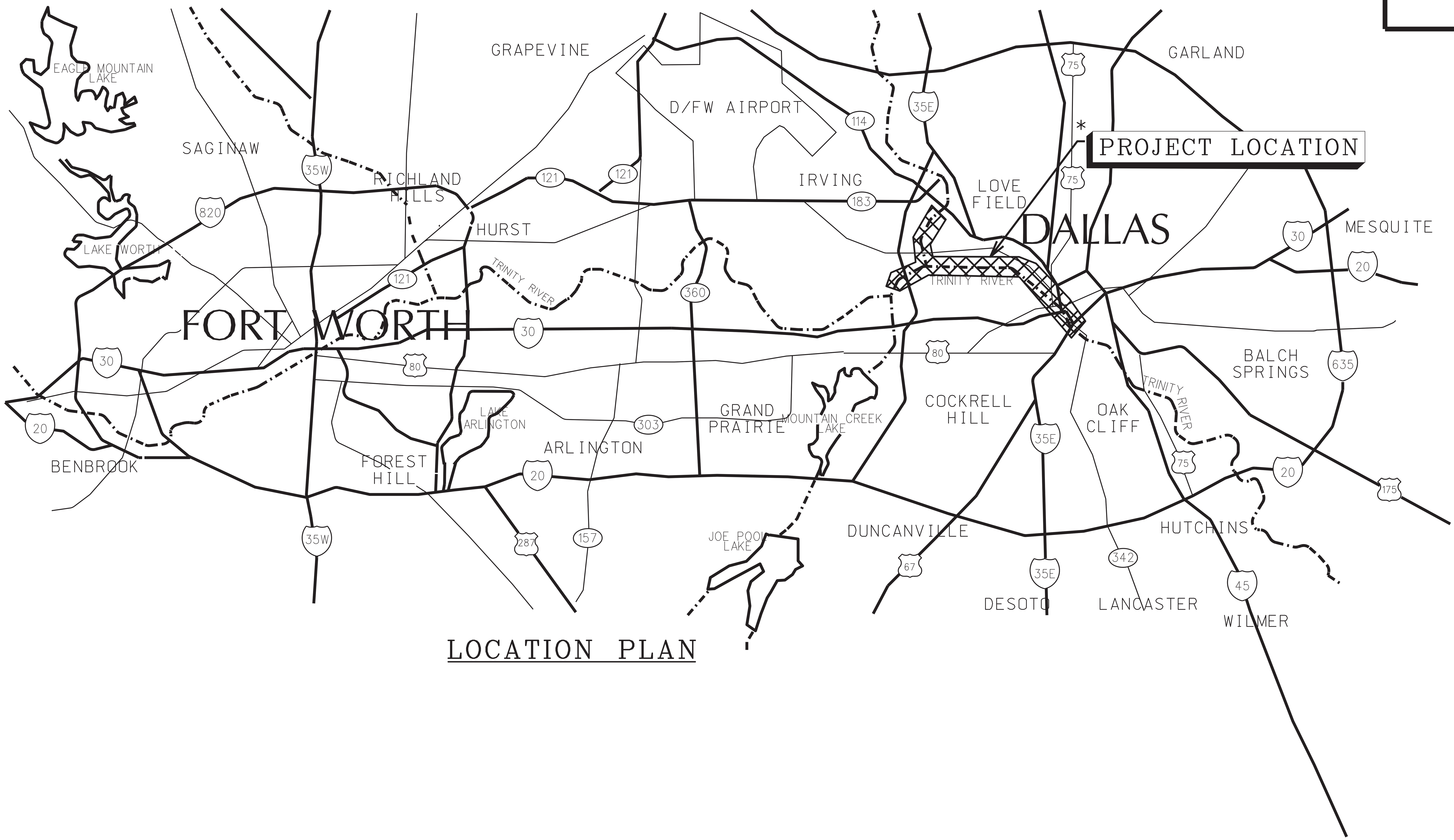
Designed by: C. CHINI
Dwn by: C. CHINI
Reviewed by: J. MCKENZIE, P.E.
Submitted by: DAVID E. BROWN, P.E. CHIEF, CIVIL SECTION
Date: 06 AUG 2013
Plot date: 7/25/2013

DALLAS FLOODWAY LEVEES FEASIBILITY STUDY DALLAS, TEXAS

INDEX OF DRAWINGS

Sheet reference number: G-002

DESIGN FILE: DF-LEVEE_STUDY-G-002.dgn



LOCATION PLAN

US Army Corps of Engineers
Fort Worth District

Designed by: C. CHINI	Dwn by: C. CHINI	Reviewed by: J. MCKENZIE, P.E.	Submitted by: DAVID G. BROWN, P.E. CHIEF, CIVIL SECTION	
Date: 06 AUG 2013	Sol No.	Contr No.	File name: Plot date: 7/25/2013 Plot scale:	Rev.

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

ENGINEERING/ CONSTRUCTION DIVISION DESIGN BRANCH

DALLAS FLOODWAY LEVEES FEASIBILITY STUDY DALLAS, TEXAS

PROJECT LOCATION MAP

Sheet reference number:

G-101

DESIGN FILE: DF-LEVEE_STUDY-G-101.dgn

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