APPENDIX F

HYDROLOGIC AND HYDRAULIC MODELING

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Hydrologic and Hydraulic Modeling for Alternative 3C

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APPENDIX F-1

HYDROLOGIC AND HYDRAULIC MODELING

CONTENTS

Note: FHWA recommends Build Alternative 3C; and accordingly, hydraulic data for Build Alternative 3C has been updated for this FEIS due to projects that have either been constructed or under construction since the publication of the SDEIS (February 2009).

For hydraulic modeling purposes, the following assumptions were made for Alternative 3C:

- Atchison, Topeka, and Santa Fe Bridge remains in place except for the portion of the bridge that would require removal if the proposed roadway alternative were constructed.
- Proposed work associated with Moore Park was not included in the model.
- Following projects are built or under construction: Standing Wave, Santa Fe Trestle Trail, and Sylvan Avenue.
- Horseshoe Bridges (IH-30 and IH-35E) are built.
- New Jefferson Bridge has not been constructed and is therefore not modeled.
- Cedar Crest Overlook has not been constructed and is therefore not modeled.
- Pavaho Wetlands have not been constructed and are therefore not modeled.

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TRINITY PARKWAY ALTERNATIVE 3C DESCRIPTION AND MODELING INPUT

The following presents a description of the Hydrology and Hydraulics (H&H) model input for Alternative 3C. In doing so, the discussion will first present the H&H model input for Alternative 3C as modeled in the SDEIS, followed by modeling updates completed as part of the FEIS for Alternative 3C, the FHWA-recommended alternative.

SDEIS Modeling

The program utilized for the evaluations as completed as part of the SDEIS was HEC-RAS 4.0 Beta. Each model was based on the existing conditions Corridor Development Certificate (CDC) model for the Trinity River, obtained from the U.S. Army Corps of Engineers (USACE) in May 2007. This model incorporates the Dallas Floodway Extension (DFE) Project, including the proposed Lamar (East) Levee from the end of the current Dallas Floodway to SH-310. The model also includes the Margaret Hunt Hill Bridge.

Alternative 3C: This alternative is a combined parkway alternative. This alternative avoids the need for levee-side retaining walls at depressed locations in the vicinity of downtown Dallas by shifting the roadway off the levee somewhat. The roadway crosses over the levee at the southern end of the floodway just north of the Burlington Northern Santa Fe (BNSF) Railroad and follows the East Levee until just north of Hampton/Inwood Road Bridge where it crosses back over the levee. Mannings roughness (n values) in the area of the roadway was set to 0.02. Proposed ramps and bridges associated with the parkway and park access were placed into the model using the lid option, with 'n' values in the vicinity of the proposed Trinity Parkway bridge structures adjusted to 0.07 to reflect the impacts of piers on flood flows under these structures. A portion of the abandoned AT&SF trestle was removed from the model where the proposed roadway cuts through the bridge. The AT&SF Bridge was also changed from a normal opening analysis to a multiple opening analysis since the area where the bridge will be removed will act more like an open channel (conveyance type of opening) than a bridge. Channel 'n' values were not altered from those in the existing conditions model. For the most part, overbank 'n' values remained consistent to those in the existing conditions model (0.055) except where proposed trees (0.075) would be planted to offset valley storage losses due to flood elevation reductions. The model also contains the proposed excavation associated with the future Balanced Vision Plan (BVP) lakes along with channelization from just upstream of Corinth to downstream of Jefferson. Bottom widths of the channelization range from 100 ft. to 150 ft. with 4:1 side slopes. Benches in some locations were also added. A swale in the area between Corinth and IH-35E (South R.L. Thornton Freeway) was also added. The model further reflects wetlands and reforestation between Hampton and Westmoreland. Wetlands were also included downstream of Hampton to near the Baker Pump Station Outfall. The Sylvan Avenue East Bridge was removed from the model due to the proposed roadway impacts. The new Hampton/Inwood Road Bridge was placed into the model based on plans.

<u>FEIS Modeling</u>

The program utilized for the evaluation as part of the FEIS was HEC-RAS 4.1.0. The evaluation was based on the Dallas Floodway Project - Risk Management Assessment base condition model for the Trinity River, obtained from the USACE in August 2012. This model incorporates the DFE Project including the proposed Lamar (East) Levee from the end of the current Dallas Floodway to SH-310. Notable projects in this model include: the Standing Wave Project, the Santa Fe Trestle Trail Project, and the Sylvan Avenue Bridge (currently under construction). For evaluation purposes, the existing conditions model obtained from the USACE was modified to include the Horseshoe Project (future bridges at IH-30 and IH-35E [South R.L. Thornton Freeway]), which was also obtained from USACE in February 2013.

Alternative 3C: Mannings roughness (n values) in the area of the roadway were set to 0.02. Proposed ramps and bridges associated with the parkway and park access were placed into the model using the lid option, with 'n' values in the vicinity of the proposed Trinity Parkway bridge structures adjusted to 0.07 to reflect the impacts of piers on flood flows under these structures. A portion of the abandoned AT&SF trestle was removed from the model where the proposed roadway cuts through the bridge. Channel 'n' values were not altered from those in the existing conditions model. For the most part, overbank 'n' values remained consistent to those in the existing conditions model (0.055). The model also contains the proposed excavation associated with the future BVP lakes along with channelization from just upstream of Corinth to downstream of IH-35E (South R.L. Thornton Freeway). Bottom widths of the channelization vary in width from cross section to cross section in order to match that of the proposed river channel in the BVP project. Side slopes vary as well. Several drainage swales in the area between Corinth and IH-35E (South R.L. Thornton Freeway) and between Hampton and Westmoreland were also added; several swale areas near and upstream of the Westmoreland Road bridge were removed from the model.

The hydraulic modeling results include estimates of the 100-year water surface elevations for each of the cross sections, and four representative cross sections illustrating modeling results are shown on page 13 of this appendix. Similarly, four representative cross sections showing the modeled water surface elevations for the SPF are shown on page 14 of this appendix. For additional information on the H&H modeling of Alternative 3C, please refer to **FEIS Section 4.14**.

100-Year Flood Hydraulic Analysis Comparison Table at Structures

Main Stem

Structure	Station	Existing Conditions [1]			Alternative 3C			Difference*
		WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)
Confluence Elm Fork/West Fork	148136	423.27	5.32	153051	422.75	5.54	154296.1	-0.52
Westmoreland	140690	421.56	6.38	145901.8	421.34	6.49	146357.8	-0.22
Hampton Rd	134826.5	420.32	5.52	140066.2	420.56	5.55	139294.5	0.24
Sylvan Avenue Bridge	128092.5	418.92	5.79	133204.3	418.93	6.25	132803.4	0.01
Sylvan - River Bridge	128010.5	418.88	5.42	133084.2	418.88	5.86	132694.8	0
Continental Ave.	122860	417.71	6.14	128428.2	417.57	5.44	128489.1	-0.14
Woodall Rodgers	122500	417.56	6.73	128174.8	417.42	5.8	128215	-0.14
U.P. R.R.	121623	417.32	6.45	127429	417.06	7.02	127440.1	-0.26
Commerce Street	120729	416.86	7.22	126781.1	416.91	5.49	126709.2	0.05
I.H. 30	118733	416.39	6.41	125437.5	416.52	6.1	125202.2	0.13
Houston Street	116214	415.41	6.53	123415.5	415.38	7.24	123195.5	-0.03
Jefferson Blvd	115734.5	415.24	6.82	123055.4	415.16	7.57	122895.4	-0.08
I.H. 35E S.	114517	415.04	6.27	122208.5	414.99	6.7	122151.6	-0.05
I.H. 35E N./Cadiz	114050	414.86	7.06	121891.7	414.88	7.07	121864.8	0.02
Corinth Street	109983	414.22	5.72	118376	414.3	6.19	118175.5	0.08
DART	108364	413.9	6.41	116670.4	413.93	6.79	116625.2	0.03
ATSF	108287	413.62	7.29	116595.4	413.57	7.8	116556.2	-0.05
MLK Jr. Blvd	105358	412.12	8.23	113590.3	412.11	8.07	113590	-0.01
BNSF	103493	411.5	5.9	111770.8	411.5	5.9	111770.7	0
S.H. 310/Cental	90498	407.44	6.18	101849.9	407.44	6.18	101849.8	0
U.P. R.R.	89537	406.88	4.25	100848	406.88	4.25	100848	0
Loop 12	75926	403.37	7.62	73732.61	403.37	7.62	73732.56	0

Elm Fork

Structure	Station	Existing Conditions [1]			Alternative 3C			Difference*
		WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)
Valley View Lane	67314	435.85	7.99	38187.81	435.83	8.02	37433.39	-0.02
I.H. 635/LBJ Freeway W. Bound	64450	434.29	5.54	37318.15	434.24	5.58	36566.96	-0.05
I.H. 635/LBJ Freeway E. Bound	64240	434.02	5.74	37250.62	433.97	5.78	36499.86	-0.05
Royal Lane	58572	432.97	6.76	33540.51	432.9	6.8	32802.71	-0.07
S.H. 348/Northwest Highway	48756	430.69	3.28	26951.42	430.55	3.36	26299.83	-0.14
California Crossing	43005.5	429.01	3.72	25247.91	428.88	3.78	24613.1	-0.13
Burlington Northern Railroad	37307	428.32	3.32	23478.24	428.16	3.36	22865.99	-0.16
Wildwood Drive	34191.5	427.54	3.16	22301.2	427.35	3.26	21705.31	-0.19
Loop 12	29378.5	426.78	3.63	18603.42	426.55	3.71	18075.17	-0.23
S.H. 482/ Story Lane	22501	425.52	3.02	14871.83	425.19	3.12	14449.74	-0.33
S.H. 183/John Carpenter Frwy	14478	424.75	4.18	8513.98	424.37	4.29	8251.01	-0.38
C.R.I.P. R. R.	6678	424	3.08	4339.38	423.56	3.19	4196.75	-0.44
S.H. 356 Blvd	4792.5	423.94	2.56	3442.18	423.48	2.64	3328.22	-0.46
Shady Grove Rd	3154	423.88	2.21	2429.62	423.42	2.28	2345	-0.46

West Fork

Structure	Station	Existing Conditions [1]			Alternative 3C			Difference*
		WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)
MacArthur Blvd	28795	436.1	4.77	19438.41	436.1	4.78	19136.86	0
Loop 12	9690	426.61	5.52	7139.59	426.4	5.63	6953.29	-0.21

Notes:
1. Alternative 3C (i.e., the FHWA-recommended alternative) existing conditions model based on the Dallas Floodway Project - Risk Management Assessment's base condition model for the Trinity River (obtained from USACE in August 2012).
* This column reflects the difference in water surface elevation between Alternative (to left) and existing conditions.
** Cumulative volume in the reach of the river between the confluence of the Elm Fork and West Fork and the structure listed.

Standard Project Flood Hydraulic Analysis Comparison Table at Structures

Main Stem

Structure	Station	Existing Conditions [1]			Alternative 3C			Difference*
		WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)
Confluence Elm Fork/West Fork	148136	435.4	6.17	257356.4	434.79	6.34	257481.2	-0.61
Westmoreland	140690	433.99	7.09	244237	433.51	7.23	243645.7	-0.48
Hampton Rd	134826.5	432.89	6.32	233687.7	432.63	6.76	232022.3	-0.26
Sylvan Avenue Bridge	128092.5	431.49	7.23	221771.7	430.87	7.85	220932.2	-0.62
Sylvan - River Bridge	128010.5	431.41	6.88	221564.8	430.77	7.53	220745.4	-0.64
Continental Ave.	122860	430.03	8.26	213727.1	429.18	7.53	213755.2	-0.85
Woodall Rodgers	122500	429.87	8.83	213303.5	429	7.96	213308	-0.87
U.P. R.R.	121623	429.59	8.33	212057.4	428.68	8.28	212022.5	-0.91
Commerce Street	120729	429.02	9.34	210958.7	428.37	7.76	210838.2	-0.65
I.H. 30	118733	428.46	8.53	208702.6	427.88	8.35	208421.7	-0.58
Houston Street	116214	427.22	9.09	205313	426.81	8.43	204963.8	-0.41
Jefferson Blvd	115734.5	426.86	9.45	204720.9	426.48	9.22	204393.2	-0.38
I.H. 35E SB	114517	426.55	8.99	203346.1	426.11	9.27	203088.2	-0.44
I.H. 35E HOV & NB	114050	426.33	9.78	202833.4	425.95	9.71	202601.3	-0.38
Corinth Street	109983	425.45	8	197170.1	425.09	8.04	196903.1	-0.36
DART	108364	425	9.1	194376.6	424.55	9.35	194308.4	-0.45
ATSF	108287	424.62	10.31	194248.3	424.06	10.34	194189.1	-0.56
MLK Jr. Blvd	105358	422.6	9.94	189239.5	422.55	9.81	189238.1	-0.05
BNSF	103493	421.56	7.94	186257.4	421.56	7.94	186257.4	0
S.H. 310/Cental	90498	417.09	7.54	168448.7	417.09	7.54	168448.7	0
U.P. R.R.	89537	416.18	5.38	166777.8	416.18	5.38	166777.8	0
Loop 12	75926	412.07	10.73	119179	412.07	10.73	119179	0

Elm Fork

Structure	Station	Existing Conditions [1]			Alternative 3C			Difference*
		WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)
I.H. 35E Access Road S. Bound	110194	453.27	9.93	123358.91	453.26	9.95	121465.89	-0.01
Sandy Lake Road	93254.5	449.48	5.68	109379.48	449.41	5.76	107568.14	-0.07
Southern Pacific Railroad	87531	448.45	6.01	100786.73	448.36	6.05	99041.94	-0.09
Belt Line	87383	447.52	9.24	100737.91	447.43	9.3	98993.36	-0.09
Valley View Lane	67314	443.83	7.73	83858.97	443.68	7.82	82229.69	-0.15
I.H. 635/LBJ Freeway W. Bound	64450	442.05	5.51	82250.21	441.87	5.58	80636.95	-0.18
I.H. 635/LBJ Freeway E. Bound	64240	441.89	5.57	82113.84	441.71	5.65	80502.2	-0.18
Royal Lane	58572	441.21	6.17	74047.73	440.99	6.36	72562.89	-0.22
S.H. 348/Northwest Highway	48756	440.52	2.98	57115.45	440.25	3.06	55907.91	-0.27
California CrossingRoad	43005.5	439.74	3.79	53005.72	439.41	3.88	51873.64	-0.33
Burlington Northern Railroad	37307	439.3	4.06	48870.52	438.94	4.2	47824.6	-0.36
Wildwood Drive	34191.5	438.75	2.21	45690.98	438.35	2.29	44720.19	-0.4
Loop 12	29378.5	438.45	4.17	37639.62	438.03	4.33	36846.11	-0.42
S.H. 482/ Story Lane	22501	437.9	3.61	28028.57	437.44	3.73	27454.85	-0.46
S.H. 183/John Carpenter Frwy	14478	437.04	5.37	15978.75	436.54	5.49	15628.76	-0.5
C.R.I.P. R. R.	6678	436.09	5.39	8026.31	435.53	5.53	7847.88	-0.56
S.H. 356 Blvd	4792.5	436.04	2.63	6353.14	435.47	2.69	6211.61	-0.57
Shady Grove Rd	3154	435.99	2.29	4543.85	435.42	2.34	4439.07	-0.57

West Fork

Structure	Station	Existing Conditions [1]			Alternative 3C			Difference*
		WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)	Channel Velocity (ft/sec)	Cumulative Volume** (Acre-ft)	WSEL (ft)
Roy Orr Blvd./N.W. 19th Street	61198	459.29	15.56	101038.67	459.29	15.56	99987.98	0
Belt Line Road	44291.5	448.67	7.22	75015.08	448.65	7.24	73986.64	-0.02
MacArthur Blvd	28795	444.12	7.92	40593.97	443.91	8.05	39886.92	-0.21
Loop 12	9690	438.15	6.16	14451.21	437.74	6.3	14138.88	-0.41

Notes:
1. Alternative 3C (i.e., the FHWA-recommended alternative) existing conditions model based on the Dallas Floodway Project - Risk Management Assessment's base condition model for the Trinity River (obtained from USACE in August 2012).
* This column reflects the difference in water surface elevation between Alternative (to left) and existing conditions.
** Cumulative volume in the reach of the river between the confluence of the Elm Fork and West Fork and the structure listed.

METHODOLOGY USED FOR DETERMINING IMPACTS TO VALLEY STORAGE

The following paragraphs describe the steps used to calculate potential impacts to valley storage by Alternative 3C. The results of hydraulic modeling for this alternative are summarized in the tables on the following two pages for the 100-year flood and the standard project flood (SPF).

1. The ROD hydraulic criteria require that valley storage changes be expressed in terms of percentage, but does not outline a specific methodology for computing valley storage loss. The valley storage comparison methods used in this analysis are based on discussions with and guidance from Fort Worth District Corps of Engineers Hydrology and Hydraulics personnel. In order to express the valley storage gain or loss as a percent, a pre-project or on-site amount of storage must be computed, typically over a defined project footprint. The interpretation of on-site (pre-project) valley storage for this alternative differs somewhat from the typical project in that all of the floodplain on both sides of the river channel from the project's most upstream limits to the downstream limits has been included as part of the project footprint. This includes areas in the floodway where alteration due to the Trinity Parkway does not occur. For the typical project, the on-site valley storage is interpreted as the actual pre-project valley storage that exists directly above the permit applicant's proposed development or all contiguous land areas in which the applicant has controlling interest. This strict interpretation allows adjacent undeveloped lands (usually other landowners) the same opportunity for development with the same allowance for valley storage loss. This project is unique in that there is a single controlling entity within the project reach of the river floodplain and all future proposed floodplain modifications will be intertwined with the proposed project. Since it will be extremely difficult to hydraulically separate this proposed project from future proposed projects within this project reach for comparison to the ROD criteria in the traditional way, future projects proposed for construction within the same on-site valley storage area will be evaluated in terms of both the individual impacts of the project as well as the cumulative impacts (i.e., in combination with other planned projects) for comparison to the ROD criteria and will use the same existing conditions hydraulic model as a baseline comparison.

2. Tables of valley storage volume (acre-feet) were developed from the results of the HEC-RAS hydraulic model for existing conditions and for Alternative 3C. This model processes the primary input of hydrologic flow, cross sectional geometry, and ground

cover characteristics to estimate the velocity and water surface elevation at specified cross sections (generally 200 feet apart) for the river channel. The combination of cross section area and water surface elevation allows the calculation of valley storage at peak flood stages. While the HEC-RAS model provided data on valley storage for each cross section, the attached tables report the cumulative valley storage over entire river segments.

3. In the attached Table A for each flood event, the volume shown for the Main Stem of the Trinity River represents the total cumulative volume in acre-feet for the entire river between the confluence of the Elm/West Forks and the beginning of the model (a point approximately 1.4 miles downstream of Dowdy Ferry Road). The second line in this table shows the amount of valley storage from the upstream face of the Burlington Northern Santa Fe Railroad Bridge and the same beginning point downstream noted above.

4. The “Project Area Volume” for existing conditions and Alternative 3C was calculated in Table A from the difference between the two locations specified. The “Volume Change Compared to Existing” reflects the difference between the Project Area Volume for Alternative 3C and the valley storage volume determined for existing conditions. Losses in valley storage are preceded by a minus sign.

5. For each of the Trinity River’s branches (Table B for Elm Fork and Table C for West Fork), the “Cumulative Volume” represents the total valley storage volume in each branch between the confluence of the branches with the Main Stem and a point upstream where the predicted impacts to water surface elevations returned to zero for more than one cross section; the “Station” (noted in terms of feet upstream from the confluence) at which zero impacts was reached is noted in each of the tables. For each of Tables B and C, the amount of valley storage at the confluence is zero, as that is the point from which valley storage upstream was computed for the 100-year and SPF flood events.

6. Similar to the procedure for the Main Stem, for the lower halves of Tables B and C the “Elm Fork Volume” and “West Fork Volume” were calculated from the difference between the two locations specified. “Volume Change Compared to Existing” was determined based on the difference (gain or loss) in volume between Alternative 3C and model results for existing conditions.

7. In Table D for each flood event modeled, the term “Within Project Study Area” refers to that area of the project between the Burlington Northern Santa Fe Railroad Bridge and the Main Stem’s confluence with the Elm Fork and West Fork. Therefore, the “Difference in Project Volume” for Alternative 3C in Table D is taken from the “Volume Change Compared to Existing” for the Main Stem in Table A.

8. The “Total Including Upstream Reaches” in Table D refers to the project area (between the Burlington Northern Santa Fe Railroad Bridge and the Main Stem’s confluence with the Elm/West Forks) plus the area of expected impacts upstream in both the Elm Fork and West Fork. The “Difference in Project Volume” for Alternative 3C is determined by adding all the “Volume Change Compared to Existing” values in Tables A, B, and C; this yields a cumulative predicted impact to valley storage of Alternative 3C for the combined river reaches (i.e., Main Stem, Elm Fork, and West Fork).

9. The “Percent Change in Project Volume” was determined by dividing the “Difference in Project Volume” by the “Existing Project Area Volume” to calculate a percentage of change within the project area or in the combined project area plus the upstream reaches.

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Valley Storage Calculations Table -- 100-Year Flood Event

Table A. Main Stem Trinity River

Location	Existing Volume (acre-ft) [6]	Alt. 3C Volume (acre-ft)
Confluence of Elm Fork/West Fork (XS 148136)[1]	153051.0	154296.1
U/S Face of BNSF RR Bridge (XS 103533)	111770.8	111770.7
Project Area Volume	41280.2	42525.4
Volume Change Compared to Existing		1245.2

Table B. Elm Fork

Location	Station	Existing Cum.Volume (acre-ft) [6]	Alt. 3C Cum.Volume (acre-ft)
Point where water surface elevations returned to 0 for more than one cross section[2]	84959	46568.9	45791.9
Confluence of Elm Fork/West Fork	0[3]	0	0
Elm Fork Volume		46568.9	45791.9
Volume Change Compared to Existing			-777

Table C. West Fork

Location	Station	Existing Cum.Volume (acre-ft) [6]	Alt. 3C Cum.Volume (acre-ft)
Point where water surface elevations returned to 0 for more than one cross section[2]	28479	19387.7	19086.2
Confluence of Elm Fork/West Fork	0[3]	0	0
West Fork Volume		19387.7	19086.2
Volume Change Compared to Existing			-301.5

Table D. Percent Gain/Loss Calculations Based on Project Volume

	Existing Project Area Volume (acre-ft)	Difference in Project Volume (acre-ft)[4]	Percent Change in Project Volume[5] (acre-ft)
	Alt. 3C		
Within Project Study Area	41280.2	1245.2	3.0%
Total Including Upstream Reaches	41280.2	166.7	0.4%

Notes:

1. XS = cross section.
2. The point where water surface elevations returned to zero for more than one cross section on both the Elm Fork and West Fork dictated the point where valley storage computations were ended for Alternative 3C.
3. The hydraulic model was built using the confluence as starting point for stationing up each of the branches (Elm Fork and West Fork), therefore, Main Stem XS 148136 equals Station 0 for each branch.
4. Gain or loss in volume (acre-ft) in the Trinity Parkway Build Alternative 3C compared to the existing project area volume.
5. Percent Change in Project Volume is equal to the Difference in Project Volume divided by the Existing Project Area Volume multiplied by 100.
6. Alternative 3C (i.e., the FHWA-recommended alternative) existing conditions model based on the Dallas Floodway Project - Risk Management Assessment's base condition model for the Trinity River (obtained from USACE in August 2012).

Valley Storage Calculations Table -- Standard Project Flood (SPF)

Table A. Main Stem Trinity River

Location	Existing Volume (acre-ft) [6]	Alt. 3C Volume (acre-ft)
Confluence of Elm Fork/West Fork (XS 148136) [1]	257356.4	257481.2
U/S Face of BNSF RR Bridge (XS 103533)	186257.4	186257.4
Project Area Volume	71099.0	71223.8
Volume Change Compared to Existing		124.8

Table B. Elm Fork

Location	Station	Existing Cum.Volume (acre-ft) [6]	Alt. 3C Cum.Volume (acre-ft)
Point where water surface elevations returned to 0 for more than one cross section[2]	112617	124454.8	122558.7
Confluence of Elm Fork/West Fork	0[3]	0	0
Elm Fork Volume		124454.8	122558.7
Volume Change Compared to Existing			-1896.08

Table C. West Fork

Location	Station	Existing Cum.Volume (acre-ft) [6]	Alt. 3C Cum.Volume (acre-ft)
Point where water surface elevations returned to 0 for more than one cross section[2]	53730	94054.4	93005.0
Confluence of Elm Fork/West Fork	0[3]	0	0
West Fork Volume		94054.4	93005.0
Volume Change Compared to Existing			-1049.4

Table D. Percent Gain/Loss Calculations Based on Project Volume

	Existing Project Area Volume (acre-ft)	Difference in Project Volume (acre-ft)[4]	Percent Change in Project Volume[5] (acre-ft)
	Alt. 3C		
Within Project Study Area	71099.0	124.8	0.2%
Total Including Upstream Reaches	71099.0	-2820.7	-4.0%

Notes:

1. XS = cross section.

2. The point where water surface elevations returned to zero for more than one cross section on both the Elm Fork and West Fork dictated the point where valley storage computations were ended for Alternative 3C.

3. The hydraulic model was built using the confluence as starting point for stationing up each of the branches (Elm Fork and West Fork), therefore, Main Stem XS 148136 equals Station 0 for each branch.

4. Gain or loss in volume (acre-feet) in the Trinity Parkway Build Alternative 3C compared to the existing project area volume.

5. Percent Change in Project Volume is equal to the Difference in Project Volume divided by the Existing Project Area Volume multiplied by 100.

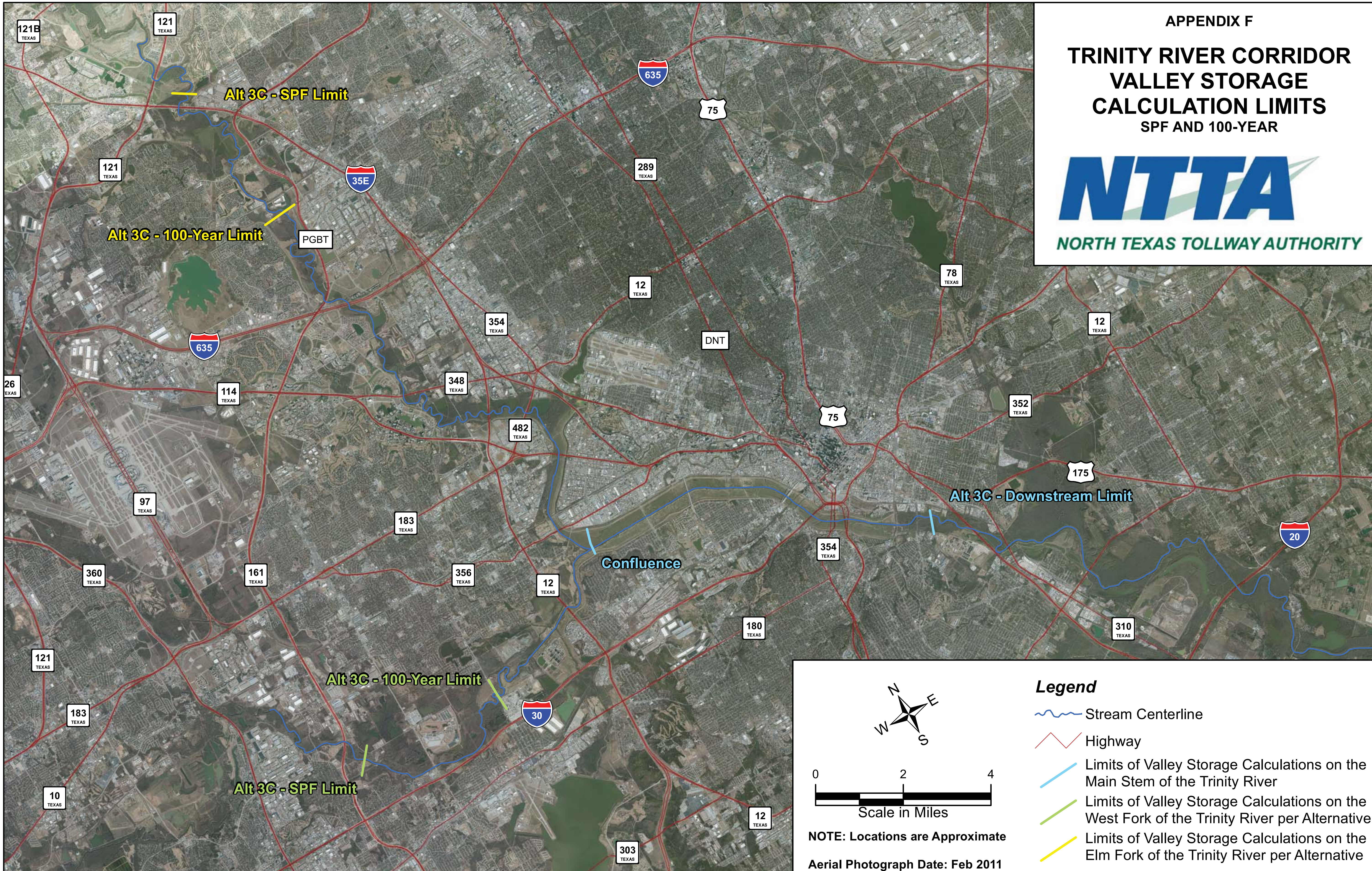
6. Alternative 3C (i.e., the FHWA-recommended preferred alternative) existing conditions model based on the Dallas Floodway Project - Risk Management Assessment's base condition model for the Trinity River (obtained from USACE in August 2012).

APPENDIX F

TRINITY RIVER CORRIDOR VALLEY STORAGE CALCULATION LIMITS

SPF AND 100-YEAR

NTTA
NORTH TEXAS TOLLWAY AUTHORITY



NOTE: Locations are Approximate

Aerial Photograph Date: Feb 2011

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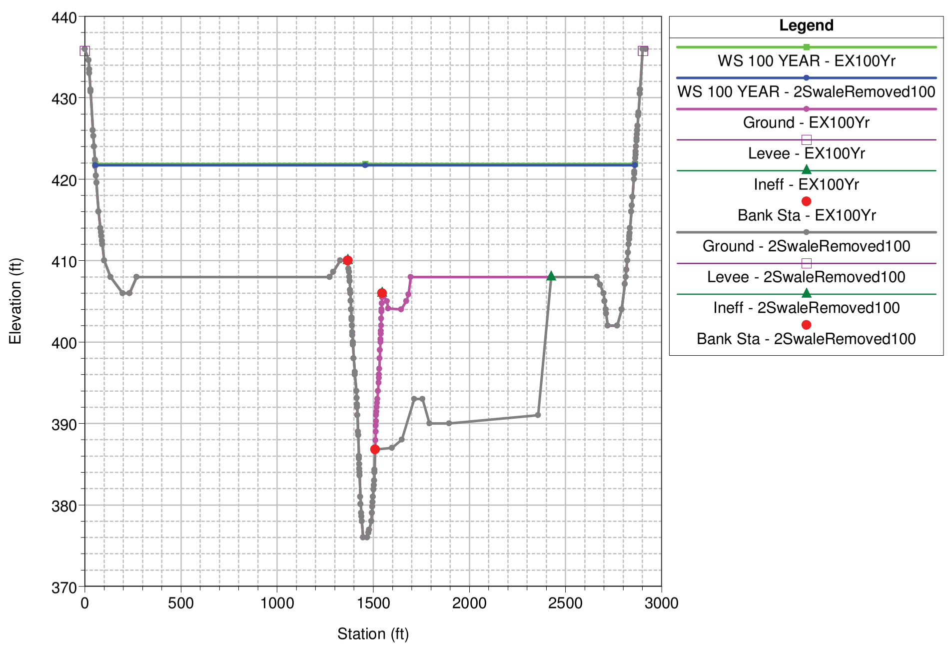
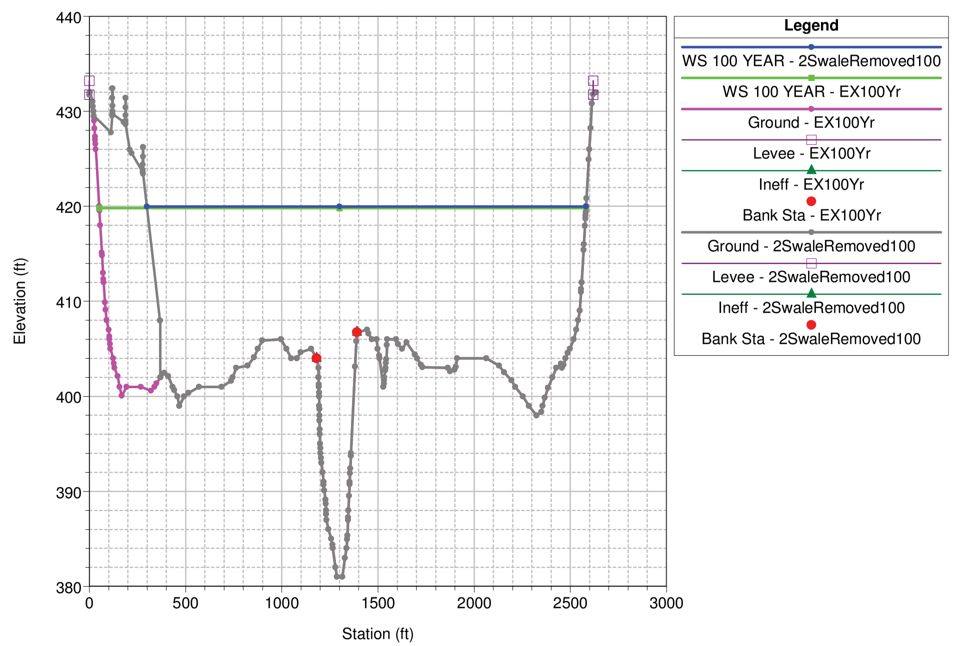
Alternative 3C

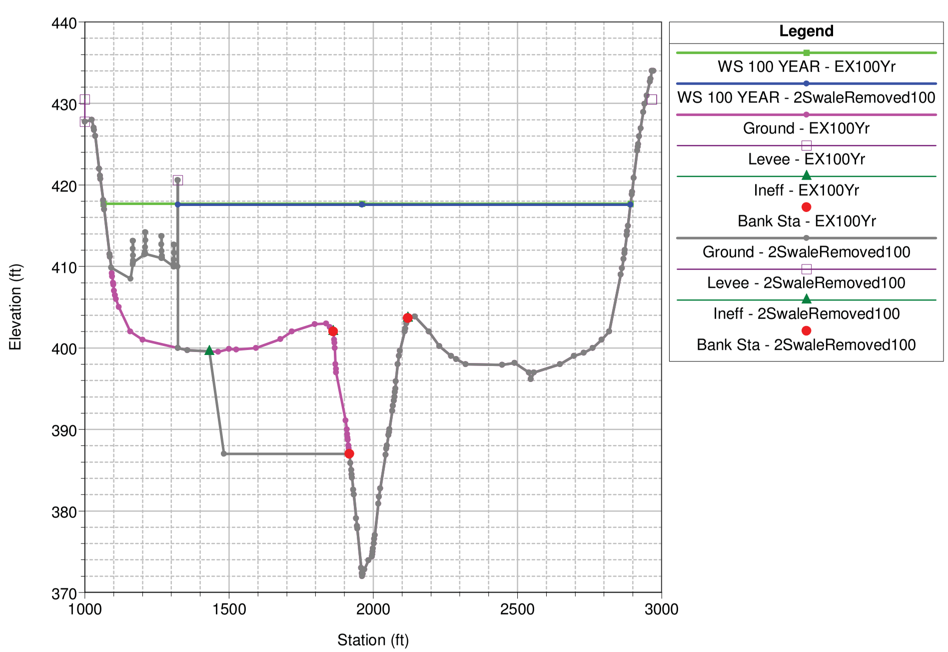
Upper Trinity CDC georeferenced   Plan: 1) 2SwaleRemoved100 2) EX100Yr
RS = 142004.



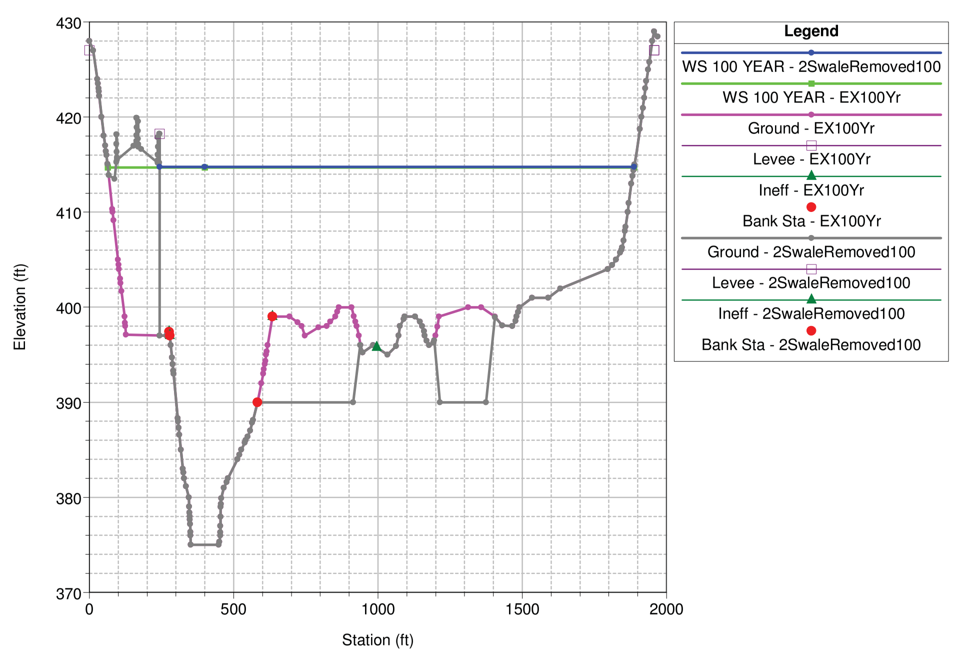
Upper Trinity CDC georeferenced   Plan: 1) 2SwaleRemoved100 2) EX100Yr
RS = 132417.



Upper Trinity CDC georeferenced   Plan: 1) 2SwaleRemoved100 2) EX100Yr
RS = 122886.

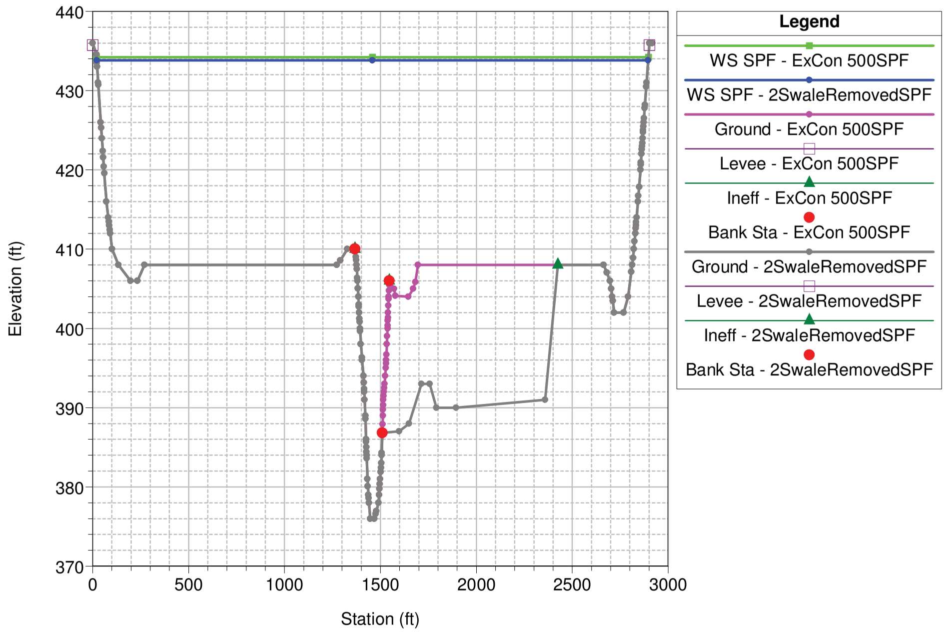


Upper Trinity CDC georeferenced   Plan: 1) 2SwaleRemoved100 2) EX100Yr
RS = 113405.

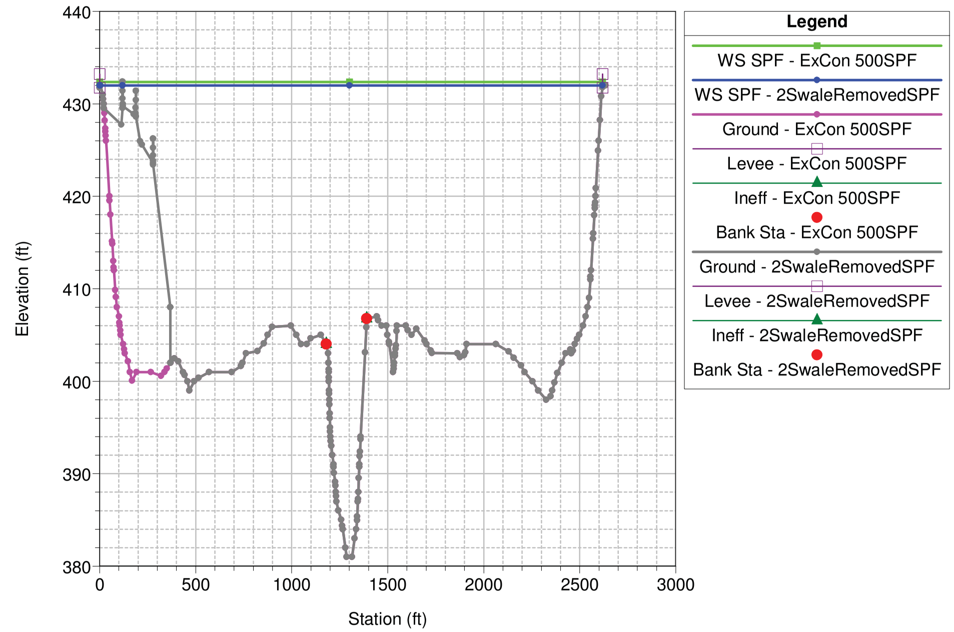


Alternative 3C

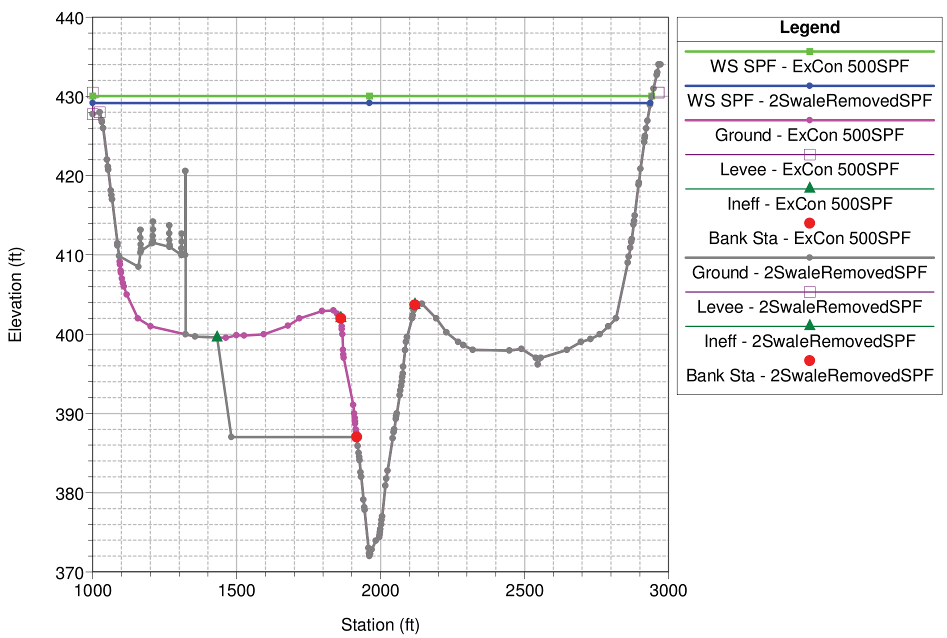
Upper Trinity CDC georeferenced Plan: 1) 2SwaleRemovedSPF 2) ExCon 500SPF
RS = 142004.



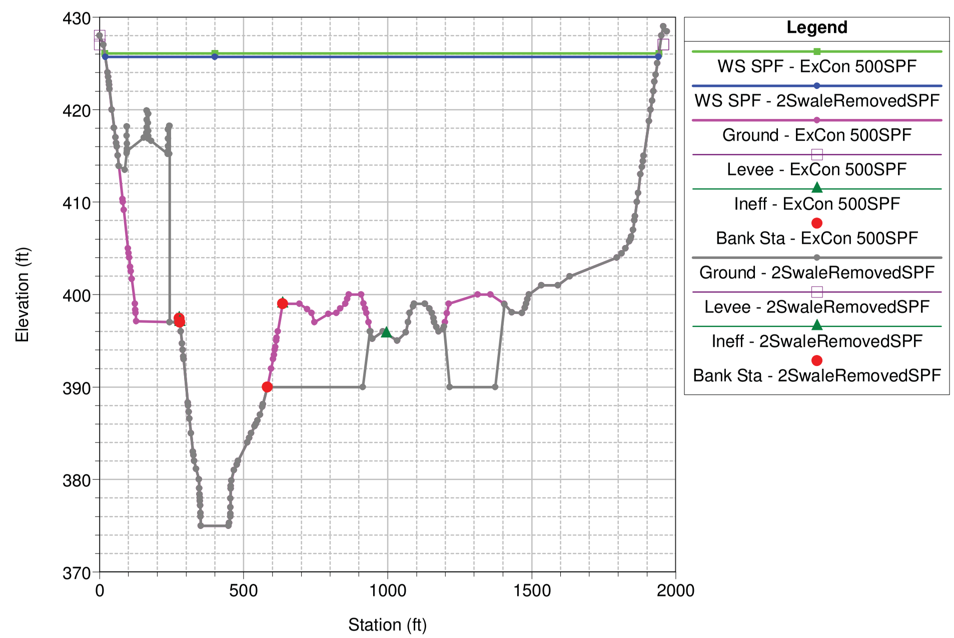
Upper Trinity CDC georeferenced Plan: 1) 2SwaleRemovedSPF 2) ExCon 500SPF
RS = 132417.



Upper Trinity CDC georeferenced Plan: 1) 2SwaleRemovedSPF 2) ExCon 500SPF
RS = 122886.



Upper Trinity CDC georeferenced Plan: 1) 2SwaleRemovedSPF 2) ExCon 500SPF
RS = 113405.



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MEETING MINUTES

To: All Attendees

From: Matt Craig, Halff Associates, Inc.

Subject: Trinity Parkway:
Hydraulics Work Group Coordination Meeting

Meeting Date: May 30, 2007

Location: Teleconference

Minutes Date: June 5, 2007

AVO No. 17826 / WO29

Attendees:

USACE – David Wilson
Dallas – Greg Ajemian
LGG – Doug Guinn
LGG – Richard Carson
LGG - Phillip
Halff – Matt Craig
Halff – Walter Skipwith
Halff – Russell Erskine
Halff – Todd Milburn

Item	Description

This meeting was held to coordinate hydraulic modeling efforts for the proposed Trinity Parkway, City of Dallas Lakes and USACE's flood fighting capabilities.

Topics for discussion:
1. Previous HECRAS model
2. New model runs for Trinity Parkway Alternatives 3C and 4B
3. Revisions needed for the River Relocation and latest Lake Design
4. Coordination between Modelers
5. Schedule
6. Next Meeting time

1. **Previous Models**

The last hydraulic models for the Trinity Parkway were run on July 2006. USACE noted that the CDC model has since been updated for BNSF Railroad bridge, 1990's channel excavation and levee embankment additions using new cross sections from updated survey work. The Model was also updated to HECRAS Version 4.0. USACE did not expect to do any more updates or tweaks to the CDC model. David Wilson will provide a copy of the latest CDC model to Halff and LopezGarcia Group (LGG).

2. **New Model Development**

Halff is completing the geometric layouts for the new Trinity Parkway Alternative 3C for NTTA, and will be ready to develop HECRAS cross sections in about a week. LGG is working with CH2M Hill on the proposed lake layout and river realignment geometry for the City of Dallas. Halff will also be developing the geometry for the new Parkway Alternative 4B.

USACE asked if the levee crossings of the Parkway had been settled with the Geotech Work Group. Halff noted that the geometry of the Parkway had been settled with the Geotech Group using diaphragm walls at the crossings. However, the Hampton Rd area crossing has yet to be finalized, and the size and depth of the West Dallas Lake (west overbank between Hampton

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and Westmoreland Rd) may vary based on the needs to balance the earthwork borrow requirements. Halff will send the layout of the Parkway Alternative 3C plan to USACE.

Halff will be generating the new HECRAS cross sections for the Parkway, and asked LGG for a TIN file (3D CADD file) of the proposed lakes and river relocation. This TIN file would be used with the roadway TIN file to cut new sections to import into HECRAS.

3. **Model Versions**

The group discussed which scenarios should be modeled. Work will start with the latest USACE CDC model. Halff will then model the "Excavation Plan" which represents the dry excavation of the lakes and the dry part of the river relocation from DART bridge to Sylvan Ave. Dallas asked that the full excavation of the river be included in this model, since they would like to fully excavate the channel first. USACE stated this may be acceptable if there was not a big time difference between the river excavation and the lake excavations for the Parkway. Team members will investigate if this can be done together.

USACE is studying the levee raises without the Parkway and lake excavations to show its impacts as a stand alone project, although borrow sites would be in general location with the proposed lakes. They will then do a model with the Parkway and lake excavations. USACE will also model the ATSF railroad bridge removal as part of the Federal project and not as a stand alone project. Halff noted that the hydraulic model for the ATSF Trestle Trail was modeled with neutral impacts, only taking out a short 20' to 40' section of the ATSF bridge by the truss section. USACE work would account for the full ATSF bridge removal.

4. **Coordination of Model Production**

LGG will develop the TIN file for the lakes and river relocations, and provide to Halff. Halff will cut the full HECRAS sections which include the road, lakes and river. Dallas noted that they are studying the river cross section for low flows in the channel. Dallas is meeting with the interior drainage consultant next week (~June 5) to determine the channel cross section, and will provide results to LGG for their work.

5. **Schedule**

LGG expected development of the lakes and river TIN file generation to take about two weeks. Halff asked for results by June 8 since the Parkway has a deadline for completion of the internal SDEIS draft by July 31, and needs about 10 weeks to complete the hydraulic modeling. LGG is working with CH2M Hill on the channel location refinement to meet the USACE need for the river (and other excavations) to be at least 200' from the toe of the proposed levees. Lake design team will be meeting with Dallas early next week to resolve lake/river location issues.

The Hydraulics Work Group plans to hold a second teleconference meeting at 11 a.m. on June 6, 2007.

This concludes the Meeting Minutes. Our goal is to provide a complete and accurate summary of the proceedings of the subject meeting in these minutes. If you feel that any of the items listed above are not correct, or that any information is missing or incomplete, please contact Halff Associates so that the matter can be resolved, and a correction issued if necessary. These minutes will be assumed to be correct and accepted if we do not hear from you within ten (10) calendar days from your receipt.

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MEETING MINUTES

To: All Attendees

From: Matt Craig, Halff Associates, Inc.

Subject: Trinity Parkway: Hydraulics Work Group Coordination Meeting

Meeting Date: June 6, 2007

Location: Teleconference

Minutes Date: June 18, 2007

AVO No. 17826 / WO29

Attendees:

USACE – Darlene Prochaska
NTTA – Chris Anderson
Dallas – Greg Ajemian
LGG – Bernie Hietbrink
Halff – Matt Craig
Halff – Dick Westsmith
Halff – Russell Erskine
Halff – Todd Milburn
Halff – Joe Novoa

Item	Description

This meeting was held to continue coordination on hydraulic modeling efforts for the proposed Trinity Parkway, City of Dallas Lakes and USACE's flood fighting capabilities.

Topics for discussion followed the minutes of the May 30, 2007 Hydraulics Group Meeting:
1. Previous HECRAS model
2. New model runs for Trinity Parkway Alternatives 3C and 4B
3. Revisions needed for the River Relocation and latest Lake Design
4. Coordination between Modelers
5. Schedule
6. Next Meeting time

1. **Previous Models**

Halff received a copy of the latest CDC model from the USACE.

2. **New Model Development**

Halff is completing the geometric layouts for the new Trinity Parkway Alternative 3C for NTTA. LGG submitted revised lake layout and river realignment geometry to CH2M Hill on June 5. CH2M Hill will use that information to develop a TIN file (3D CADD file) of the proposed lakes and river relocation, and submit to Halff early in the week of June 11. Halff will use the TIN file with the roadway TIN file to cut new sections to import into HECRAS. Halff will generate the new HECRAS cross sections for the Parkway and have initial results of HECRAS within about three weeks from receipt of the lake/river TIN file. Initial results will be shared with the hydraulics work group.

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3. **Model Versions**

The group discussed which scenarios should be modeled. The team confirmed that work will start with the latest CDC model as provided by USACE. Halff will then model the "Excavation Plan" which represents the dry excavation of the lakes and the dry part of the river relocation from DART bridge to Sylvan Ave. The Trinity Parkway Supplemental DEIS (SEIS) will only publish the results of the "Excavation Plan" with the Trinity Parkway "Build" alternatives following the river alignment (3A, 3B, 3C, 4A, 4B and maybe 5). The Final EIS (FEIS) would report the final results of the modeling needed for the final alternative selected for the Parkway. NTTA noted that the modeling by the Parkway team will only cover that needed for its permitting. Dallas asked that the full excavation of the river be included in the "Excavation Plan" model, since they would like to fully excavate the channel first. A separate meeting will be conducted for the team members to discuss the construction sequencing and permitting requirements.

The City is also working with their interior drainage consultant on the low flow volumes and channel cross section of the Trinity River. The total flow of 20,000 cfs comprises the 13,000 cfs target releases in the channel, plus 7,000 cfs from the floodway outfalls discharging a 100 year/ 24 hour rainfall. Dallas will be meeting with their consultant to decide on channel cross section to carry this flow. The team agreed that if the Excavation Plan lowers the water surface of this low flow (approx. 2 year storm), then it would not be considered a negative impact.

USACE is studying the levee raises without the Parkway and lake excavations to show its impacts as a stand alone project, although borrow sites would be in the general location of the proposed lakes. Results of their efforts are expected in August.

4. **Coordination of Model Production**

Discussed in previous section.

5. **Schedule**

The general schedule for hydraulic modeling is as follows:
- One week for river/lake geometry by LGG/CH2M to Halff
- Then two weeks after that for HECRAS model development for Alt. 3C
- Results of Trinity Pky Alt. 3C – July 31 (to be included in SDEIS internal draft due July 31)
- Results of Trinity Pky Alternative 4B – August
- Results of USACE Levee Raise – August 15

6. **Next Meeting**

The Hydraulics Work Group plans to hold a third teleconference meeting at 1:30 p.m. on June 20, 2007.

This concludes the Meeting Minutes. Our goal is to provide a complete and accurate summary of the proceedings of the subject meeting in these minutes. If you feel that any of the items listed above are not correct, or that any information is missing or incomplete, please contact Halff Associates so that the matter can be resolved, and a correction issued if necessary. These minutes will be assumed to be correct and accepted if we do not hear from you within ten (10) calendar days from your receipt.

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MEETING MINUTES

To:	All Attendees
From:	Matt Craig, Halff Associates, Inc.
Subject:	Trinity Parkway: Hydraulics Work Group Coordination Meeting
Meeting Date:	June 20, 2007
Location:	Teleconference
Minutes Date:	July 9, 2007
AVO No.	17826 / WO29

Attendees:

USACE – David Wilson
USACE – Gene Rice
USACE – Darlene Prochaska
NTTA – Chris Anderson
Dallas – Greg Ajemian
LGG – Bernie Hietbrink
LGG – Richard Carson
Halff – Matt Craig
Halff – Russell Erskine
Halff – Todd Milburn

Item	Description
	This meeting was held to continue coordination on hydraulic modeling efforts for the proposed Trinity Parkway, City of Dallas Lakes and USACE's flood fighting capabilities.

Topics for discussion followed the minutes of the June 20, 2007 Hydraulics Group Meeting:
1. Previous HECRAS model
2. New model runs for Trinity Parkway Alternatives 3C and 4B
3. Revisions needed for the River Relocation and latest Lake Design
4. Coordination between Modelers
5. Schedule
6. Next Meeting time

1. **Previous Meeting Minutes**

No comments on the June 6, 2007 meeting minutes.

2. **New Model Development**

Halff is refining the geometric layouts for the new Trinity Parkway Alternative 3C for NTTA. CH2M Hill provided a TIN file (3D CADD file) of the proposed lakes and river relocation during the week of June 11. Halff needs to edit the TIN file for the excavation work of the roadway ("Excavation Only" plan). They will then add in the roadway TIN file to cut new sections to import into HECRAS. Halff will generate the new HECRAS cross sections for the Parkway and have initial results of HECRAS within about three weeks from receipt of the lake/river TIN file. Initial results will be shared with the hydraulics work group.

3. **Model Versions**

The group discussed which scenarios should be modeled. The team confirmed that work will

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start with the latest CDC model as provided by USACE. Halff will then model the "Excavation Plan" which represents the dry excavation of the lakes and the dry part of the river relocation from DART bridge to Sylvan Ave. The Trinity Parkway Supplemental DEIS (SEIS) will only publish the results of the "Excavation Plan" with the Trinity Parkway "Build" alternatives following the river alignment (3A, 3B, 3C, 4A, 4B and maybe 5). The Final EIS (FEIS) would report the final results of the modeling needed for the final alternative selected for the Parkway. NTTA noted that the projects need to maintain independent utility as a stand-alone project. USACE will schedule a meeting during the week of July 4 with Presley Hatcher and others at the Corps to discuss the permitting issues. Models to be run include:

1) Alt. 3C Excavation Only Plan - Halff - model creation due early July, results by July 31
2) Alt. 4B Excavation Only Plan - Halff – results in August
3) Alt. 3A/3B Excavation Only Plan - Halff - results in August
4) Alt. 4A Excavation Only Plan - Halff - results in August
5) Levee Raise Only – USACE- results in August, plan formulation in Sept.
6) Ultimate Plan, with road, lakes, levee raise and channel meander - Dallas

All runs will include the 100 year and SPF flows.

The City is also working with CH2M Hill on low flows and sediment loading that may change the channel cross section.

NTTA asked that the USACE and team come to consensus on basic policy issues that go into the model, such as permitting excavation within the floodway. USACE noted that their HQ office would need to make the final decision. NTTA asked about the CDC criteria in the 1988 ROD. USACE noted that each project will be evaluated based on its individual impacts.

4. **Schedule**

The general schedule for hydraulic modeling is as follows:
- Two weeks after that for HECRAS model development for Alt. 3C
- Results of Trinity Pky Alt. 3C – July 31 (to be included in SDEIS internal draft due July 31)
- Results of Trinity Pky Alternative 4B – August
- Results of USACE Levee Raise – September

5. **Next Meeting**

The Hydraulics Work Group plans to hold a fourth teleconference meeting at 1:30 p.m. on July 9, 2007.

This concludes the Meeting Minutes. Our goal is to provide a complete and accurate summary of the proceedings of the subject meeting in these minutes. If you feel that any of the items listed above are not correct, or that any information is missing or incomplete, please contact Halff Associates so that the matter can be resolved, and a correction issued if necessary. These minutes will be assumed to be correct and accepted if we do not hear from you within ten (10) calendar days from your receipt.

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MEETING MINUTES

To: All Attendees

From: Matt Craig, Halff Associates, Inc.

Subject: Trinity Parkway: Hydraulics Work Group Coordination Meeting

Meeting Date: July 9, 2007

Location: Teleconference

Minutes Date: July 9, 2007

AVO No. 17826 / WO29

Attendees:

USACE – David Wilson
USACE – Gene Rice
NTTA – Chris Anderson
LGG – Bernie Hietbrink
LGG – Richard Carson
Halff – Matt Craig
Halff – Russell Erskine
Halff – Todd Milburn
Halff – Walter Skipwith
FHWA – Ruth Rentch (by phone)
FHWA – Joe Krolak (by phone)

Item	Description

This meeting was held to continue coordination on hydraulic modeling efforts for the proposed Trinity Parkway, City of Dallas Lakes and USACE's flood fighting capabilities.

1. **Previous Meeting Minutes**

No comments on the June 20, 2007 meeting minutes.

2. **New Model Development**

Halff is refining the new HECRAS cross sections for the Parkway Alt. 3C and will have initial results of HECRAS within about two to three weeks. Initial results will be shared with the hydraulics work group. Halff noted that the embankment against the Trinity Parkway floodwall may need to be removed for hydraulic conveyance. LGG will coordinate with the Lake Design team on this potential. Halff also noted that as a result of the interagency meeting on July 3 regarding permitting and processing, the Alt. 3C model ("Excavation Only Plan") will not include the Trinity River channel relocation. The channel relocation will be part of the City of Dallas Lakes design work, hydraulic modeling and permitting.

The USACE is continuing its model development for the levee raise as a stand-alone condition. USACE will provide the status of their modeling at the next meeting. USACE asked that the other modelers be sure to use the latest CDC model with the recent changes. Halff stated they were using the CDC model recently provided by USACE as the baseline condition. NTTA asked that the USACE and team come to consensus on basic policy issues that go into the model, such as permitting excavation within the floodway.

HALFF

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3. **Model Versions** (not part of this meeting, but included for future reference)

The work will start with the latest CDC model as provided by USACE. Halff will then model the "Excavation Plan" which represents the dry excavation of the lakes. The Trinity Parkway Supplemental DEIS (SEIS) will only publish the results of the "Excavation Plan" with the Trinity Parkway "Build" alternatives following the river alignment (3A, 3B, 3C, 4A, 4B and maybe 5). The Final EIS (FEIS) would report the final results of the modeling needed for the final alternative selected for the Parkway. Consensus of the team was that each project needs to maintain independent utility (i.e. to work as stand-alone projects.) Models to be run include:

1) Alt. 3C Excavation Only Plan - Halff
2) Alt. 4B Excavation Only Plan - Halff
3) Alt. 3A/3B Excavation Only Plan - Halff
4) Alt. 4A Excavation Only Plan - Halff
5) Levee Raise Only – USACE
6) Ultimate Plan, with road, lakes, levee raise and channel meander - Dallas

All runs will include the 100 year and SPF flows.

The City is also working with CH2M Hill on low flows and sediment loading that may change the channel cross section.

4. **Next Meeting**

The Hydraulics Work Group planned to hold a fifth teleconference meeting before the July 26, 2007 Lake Design monthly meeting. **[Meeting was postponed until September 18]**

This concludes the Meeting Minutes. Our goal is to provide a complete and accurate summary of the proceedings of the subject meeting in these minutes. If you feel that any of the items listed above are not correct, or that any information is missing or incomplete, please contact Halff Associates so that the matter can be resolved, and a correction issued if necessary. These minutes will be assumed to be correct and accepted if we do not hear from you within ten (10) calendar days from your receipt.

Appendix F-2

Additional Discussion of Hydrologic/Hydraulic Attributes of Alternative 3C

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APPENDIX F-2

Additional Technical Discussion of Hydrologic/Hydraulic Attributes of Alternative 3C

TABLE OF CONTENTS

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APPENDIX F-2
ADDITIONAL DISCUSSION OF HYDROLOGIC/HYDRAULIC ATTRIBUTES OF ALTERNATIVE 3C

This appendix includes further discussion of hydrologic/hydraulic attributes of Alternative 3C, including inundation sequence and repair costs for a flood in excess of the 100-year design event (September 2011 and revised April 2013).

F-1 INTRODUCTION

This appendix is intended to provide information gathered from the February 2009 Supplemental Draft Environmental Impact Statement (SDEIS), the Limited Scope Supplemental (LSS) to the SDEIS, revisions made to Alternative 3C for the FEIS, and other sources on the hydrologic and hydraulic attributes of Trinity Parkway Alternative 3C, including inundation effects and repair costs in the event the roadway were subject to a flood in excess of the 100-year design event. The larger floods to be considered include the "standard project flood" (SPF) and until recently was considered to be approximately an 800-year event in the Dallas Floodway. However, due to the recent evaluation performed by the U.S. Army Corps of Engineers (USACE) as part of a Base Condition Risk Assessment for the Dallas Floodway, the SPF now approximates a 2,500 year event and is being used by the USACE to set levee top elevations.

The attributes of the Trinity Parkway are described in the **FEIS Chapter 2**, and the consequences of a Dallas Floodway event in excess of a 100-year event are discussed in **FEIS Section 2.7** and **FEIS Appendix H-3** (Draft Emergency Action Plan). Alternative 3C would have approximately 6.2 miles or approximately 70% of the total length located on a raised embankment riverside of the levees within the Dallas Floodway. Within the Floodway, the road surface would typically be set above the 100-year water surface elevation. As described in the **FEIS Section 2.3.2.4**, in segments where the road is depressed below the 100-year level, flood separation walls and pump stations would be added to maintain 100-year flood protection. **SDEIS Section 2.8** provides additional details on the flood separation walls, including a conceptual design for a pump station (see **FEIS Plate 2-7**).

The 100-year flood protection standard is commensurate with the designs of other roadways on the North Texas Tollway Authority (NTTA) system, and meets or exceeds the Federal Highway Administration (FHWA) design standards. Alternative 3C is designed to meet the published standards for major highways. Additionally, Alternative 3C within the Dallas Floodway, with its large embankment and established vegetation, would be resilient enough to withstand major damages from such (unlikely) flooding. As shown in the draft Emergency Action Plan (see **FEIS Appendix H-3**), the roadway is intended to be shut down in an orderly way prior to impending flooding. Further, expected "damages" would mostly comprise clean-up costs (i.e., clearing of silt and accumulated debris). Major road failures are not anticipated, even if the design flood level is exceeded.

Notwithstanding the above statement, the cost of flood damages and road closure for an event exceeding the 100-year event is disclosed in **FEIS Chapter 6**. This analysis accounts for the cost of clean-up and restoration, plus the loss of tolls during an anticipated down time, which assumes no substantial physical damage to the road; only accumulation of silt and debris. This topic is further discussed in **Section F-2** below, along with the possibility of increased damages and downtime in the event the road pavement is physically damaged by localized, unforeseen flow concentrations.

The following sections are intended to provide more information on the topic of greater than 100-year flood inundation of the Trinity Parkway in the Dallas Floodway for public consideration.

F-2 DURATION OF SPF INUNDATION

In **FEIS Chapter 6**, the out-of-service time for an SPF inundating Alternative 3C is estimated as five days, comprising pre-event closure, inundation, pump out of flooded low points, and cleanup. To further document this finding, the following data has been compiled for the Commerce Street Gauge (located approximately midpoint of the Trinity Parkway Project) using the hydrographs for the SPF (~2,500-year) and the 100-year flood on the Trinity River in Dallas:

Commerce Gauge Datum = 368.02 feet (NGVD29)
Top of Bank = 402.00 feet (Hydrologic Engineering Center (HEC) River Analysis System (RAS) model) (Gauge Level ~40 feet)
Approximate Discharge to reach top of bank = 16,400 cubic feet per second (cfs) (i.e. "Flood Stage")
100-year Discharge = 119,800 cfs
SPF Discharge = 277,000 cfs

The following durations are taken from the USACE SPF hydrograph (HEC-1) for the Trinity River:

- 22 hours (approximately) between out of banks to 100-year discharge;
- 13 hours (approximately) between 100-year peak and SPF peak;

- 17 hours (approximately) between SPF peak and falling back to 100-year; and
- 92+ hours (approximately) between 100-year discharge and falling back to top of banks (note HEC-1 model execution stops before flow returns to within banks of the Trinity River).

Therefore, if Alternative 3C was subject to an SPF event:

(i) The timing is such that overtopping of the road would not be a "flash" flood event but would have approximately 22 hours warning time from flood stage to the time of 100-year inundation. This period would be closely observed by NTTA and city staff in accordance with the draft Emergency Action Plan (see **FEIS Appendix H-3**) and an orderly shutdown of the road would be implemented at the appropriate time.

(ii) Based on the **FEIS Chapter 6** analysis, it is expected that "damages" in the event of road inundation would mostly comprise clean-up costs of clearing of silt and accumulated debris. Large scale road failures are not anticipated if the design flood level is exceeded. Loss of life is not anticipated because the road would be barricaded, and police would be on-site.

(iii) The duration of inundation of the road would be approximately 30 hours for an SPF event. Unless there was unexpected structural damage, the inundation and cleanup is estimated in **FEIS Chapter 6** as lasting five days before return to service. The **FEIS Chapter 6** analysis estimates a total cost of restoration of Alternative 3C as $4.4 million comprised of $3.2 million in cleanup and landscape repairs, and $1.2 million of lost tolls during five days of downtime. The cleanup cost is detailed in this section, and was provided by NTTA operations and maintenance staff. This estimate results in an annualized cost of restoration and downtime of $44,000 (considering the 100+ year probability).

(iv) The inflow and outflow of water as a flood event rises and falls is a concern in the design of any road that may be inundated. Flow concentrations may cause high velocities in some areas, which, if not planned for, could result in localized failures and needed repairs. This issue would need to be addressed carefully in design of a Dallas Floodway Alternative to anticipate and appropriately address any potential problem areas through armoring or other means. For instance, as addressed in **FEIS Section 2.7.2**, the flood separation walls at depressed segments along Alternative 3C *"would be designed to allow a managed inflow of water, suitably protected from erosion and other hazards of the inflow."* To address "unforeseen damages," the sponsors have agreed to consider a contingency amount ($2.0 million) to cover additional repairs, such as pavement failures, due to unforeseen damages by an SPF. The sponsors have also agreed to add an additional ten days of downtime beyond the originally-assumed five days (resulting in an additional $2.4 million of lost tolls) to affect repairs. These assumptions would increase the total downtime and restoration costs for Alternative 3C to $8.8 million, compared to $4.4 million in bullet (iii) above, giving an annualized cost of $88,000. Assuming the relatively short period of closure (15 full days total assuming pavement damage), and accounting for the very low probability (100+ year event), closures due to high floods do not appear to rise to the level of threatening the practicability of Alternative 3C. **FEIS Chapter 6** covers the topic of 100+ year flood inundation.

Should Alternative 3C be selected in the anticipated ROD, the draft Emergency Action Plan (see **FEIS Appendix H-3**) would need to be reviewed and approved by the City of Dallas, NTTA, TxDOT, the FHWA, and USACE prior to final approval of construction by the USACE.

F-3 FLOW VELOCITIES AND POSSIBLE SCOUR DURING AN SPF EVENT

FEIS Chapter 6 provides a general statement about the velocities over a Dallas Floodway Build Alternative in the event of an SPF. To supplement the FEIS information and answer any question as to whether the smoother roughness values of the paved lanes adjacent to the riverside toe of the levee may increase local velocities that could contribute to toe scouring and failure of the levees, velocities have been tabulated based on the available HEC-RAS modeling for the SPF over the 6.2 miles that Alternative 3C is located in the Dallas Floodway. Velocities have been averaged by section in three zones: (i) Levee face (exposed face of improved levee above the road embankments), (ii) Roadside swale area (the grassed drainage area generally between the levee toe at the embankment and the edge of road shoulder), and (iii) Paved area (the outer Trinity Parkway lanes and shoulder). A data table is included at the end of this appendix (see **Table F-1**). A summary follows:

Alternative 3C (Combined Parkway Further Modified)

- In the levee face area, velocities generally range from 0.2 to 4.0 feet per second (fps) in the segment from the Atchison Topeka & Santa Fe (AT&SF) Railroad Bridge (downstream end of Trinity Parkway) to Continental Avenue (the only exceedance is a 6.3 fps reported velocity under the Houston Street Bridge). Upstream of Continental Avenue to the Trinity Parkway exit point from the Dallas Floodway, the velocities fall into the 0 to 2.7 fps range.

- In the roadside swale area, velocities generally range from 0.6 to 7.8 fps from the AT&SF Railroad Bridge to Continental Avenue (with the 2-3.5 fps range most frequent). Upstream of Continental Avenue, the velocities fall into the 0.5 to 3.9 fps range (the model reports 10.2 fps under the AT&SF Railroad Bridge).
- Within the paved area, velocities generally range from 0.7 to 11.3 fps, with some velocity spikes under bridges (13.7 fps under AT&SF Railroad Bridge, 9.9 fps under Corinth Street, and 13.0 fps at the Union Pacific (UP) Railroad Bridge).

Velocities less than 6.0 fps are generally considered acceptable for withstanding erosion, assuming established grass and short term inundations. The velocities reported are therefore not considered to be erosive over the grassed roadside swale areas nor on the faces of the levees above the road embankment level. There may be a need for further design analysis and possibly local armoring in some of the higher velocity bridge underpasses discussed previously in this appendix. These should be addressed (in cooperation with the USACE) in future design if Alternative 3C is selected in the anticipated ROD.

F-4 EARTHWORKS BALANCE AND FLOODWAY CONVEYANCE EFFECTS

Alternative 3C is proposed to be constructed using borrow material from within the Dallas Floodway, creating an earthworks balance. The resulting road embankments, floodway excavations, and related features have been modeled in detail to assure no loss of conveyance (see **FEIS Section 4.14,** along with modeling output data in **FEIS Appendix F**). As evidenced by the administrative record and **FEIS Appendix F**, the modeling work has been extensively coordinated with the USACE to date, and would be expected to be coordinated further if Alternative 3C is selected in the anticipated ROD. Likewise, should Alternative 3C be selected in the anticipated ROD, all construction plans for work within the Dallas Floodway would be subject to a USACE Section 408 approval process.

Alternative 3C within the Dallas Floodway is intended to comply with the USACE 1988 ROD Criteria for the Trinity River in Dallas, and the subsequent/related Trinity River Corridor Development Certificate (CDC) process managed by the North Central Texas Council of Governments (NCTCOG). Based on the hydraulic work to date, the modeling shows that the Trinity Parkway would not reduce conveyance, jeopardize existing features, or increase risks to levees. **LSS Chapter 3** and **FEIS Section 2.7** are intended to demonstrate compatibility of the Trinity Parkway with the USACE Levee Remediation Plan for the Dallas Floodway.

The subject of fill material for the roadway embankments and borrow sites in the Dallas Floodway is covered in **FEIS Section 2.7**. **FEIS Appendix H-2** also includes further technical information and discussion on the topic. The assumed borrow sites are primarily excavations consistent with lakes proposed by the City of Dallas in its Balanced Vision Plan (BVP) for the Dallas Floodway (see **FEIS Section 1.6.1.2**). The subject of fill settlement is a construction issue, and is assumed included in the cost estimates and scheduling for the Trinity Parkway. For instance, the Alternative 3C schedule allows 18 months for establishment of embankments. This would allow some pre-settlement of the fills, and implementation of other settlement control measures which might be included in the detailed design. The issue of settlement of fill embankments was recognized in preliminary geotechnical investigations for the Trinity Parkway project done in 2008. Measures for mitigation of the settlement were identified in this work. The cost estimates for Alternative 3C include construction of wick drains and a drainage layer to address potential settlement of embankments.

F-5 BRIDGE PIER PENETRATIONS

This section provides an updated discussion on the subject of bridge pier penetrations at locations where Alternative 3C would overpass the levees, focusing on whether these piers drilled into the levees might cause discontinuities and stresses, or possibly local pier scour holes in the levees. Other reinforcement measures considered in addition to or in lieu of concrete diaphragm walls (see **FEIS Section 2.7.1**) are also discussed below.

Trinity Parkway bridge foundations are proposed to be established using reinforced concrete drill shafts. In favorable ground conditions, drill shafts are poured against the native soil; in less favorable conditions (e.g. high water table and sandy soil) these may have steel casings into which the reinforced concrete is placed. To date, the focus of USACE interest regarding pier construction in the areas of the levees has been not so much on concerns about temporarily "stressing" the levee, but on the interface between the clay levee soil and the concrete pier. There has been concern that desiccation cracking may occur along this surface, possibly leading to a flow path for seepage down the vertical face of the shaft.

There are multiple existing bridge crossings along the Dallas Floodway, all of which involve pier penetrations through the levee down to the underlying shale formation (approximately 50 feet to 100 feet deep below the base of levee). These foundations have been subject to considerable interest from the USACE in recent years, notably in the December 2007 *Periodic Inspection Report No. 9, Dallas Floodway, Trinity River, Dallas County, Texas* (see **FEIS Sections 1.6.4** and

2.7.1), which found multiple "unacceptable" ratings in the Dallas Levees, including 18 existing bridges listed with pier encroachments.

Due to the number of pier penetrations in close proximity and parallel to the land side toe of the levee(s), Alternative 3C would include a diaphragm wall along the East Levee as a seepage control measure at the proposed Continental Avenue and Margaret Hunt Hill Bridge connections. Diaphragm walls are considered a worst case solution to the pier penetration issue. The walls would be expected to cut off seepage down to bedrock in the affected areas and would be designed to withstand floodwater loads in the unlikely event large parts of the levee were washed away. These walls are more expensive than the filter collar method discussed above and cost on the order of $1 million for each 100 feet length of wall. Another possible solution considered during coordination with the USACE was implementing bridges that could free-span over the entire levee plus 50 foot clearance either side (see **FEIS Appendix H-2, Memorandum 3.1**). The free span idea is considered impractical because of spans in excess of 500 feet.

Regarding future design development for Alternative 3C within the Dallas Floodway, as stated in **FEIS Section 2.7.1.1,** there is a possibility a different solution to the pier penetration/seepage concerns may be developed as the USACE further studies the condition (at existing or other proposed bridges) and develops possible solutions within the framework of its Levee Remediation Plan for the Dallas Floodway. The USACE has approved pier penetrations at the Margaret Hunt Hill Bridge levee crossings and at the proposed Sylvan Avenue Bridge (currently under construction). For these projects, bridge columns located immediately landside of the levees included sand and concrete filter collars as redundant treatments to mitigate potential under-seepage along the interface between the concrete drilled shaft and adjacent clay soils. These levee crossings have also been reinforced with landside berms and French drains at the landside toe. If these kinds of solutions are applied at the Trinity Parkway levee crossings, it is expected costs would be reduced from the costs for the diaphragm walls. The proposed Trinity Parkway may affect filter collars at existing bridges because the proposed tollroad embankments would raise the ground elevations around individual piers. This can be resolved through appropriate design measures; the city-proposed collars could be left in place, they could be demolished and rebuilt closer to the new ground surface, or they could be extended with additional collar material up to the new ground surface. Such measures would be made at the time of design development, in the event Alternative 3C is selected in the anticipated ROD, and would be subject to design review, permitting and construction oversight by the USACE. Therefore, the proposed Trinity Parkway would be compatible with filter collars.

Regarding bridge scour, the information previously presented in **FEIS Appendix Section F-3** provides additional details regarding flow velocities. The flow conditions (even under the SPF) are not considered to be erosive at the bridge pier locations within the levee face or roadside swale areas. In the event a localized transition or condition might cause a bridge scour concern, these areas can be armored. For instance, the proposed Sylvan Avenue Bridge includes concrete paving on the levee slopes as a mitigation measure to prevent scour.

TABLE F-1. RIVER FLOW VELOCITIES FOR TRINITY PARKWAY ALTERNATIVE 3C UNDER THE SPF EVENT VELOCITIES AVERAGED OVER THE LEVEE FACE, ROADSIDE SWALE AND PAVED AREA

Location	River Station	Levee Face	Roadside Swale	Paved Area
	108128	5.28	3.98	5.27
	108158	3.29	3.87	4.40
	108240	2.93	3.99	5.23
	108250	2.71	3.80	5.23
	108270	2.56	3.99	5.07
	108276	4.13	4.04	6.74 [1]
AT&SF Bridge	108287	5.30 [u]	10.22 [1u]	13.72 [1u]
	108298	3.97	4.32	5.92
	108348	2.49	2.89	4.21
Dallas Area Rapid Transit (DART) Bridge	108364	2.02 [u]	1.65 [u]	3.94 [u]
	108380	2.46	2.73	5.20
	108457	1.81	2.86	4.31
	108514	1.78	1.88	3.86
	108530	1.86	1.98	4.68
	108552	1.84	2.05	4.57
	108688	0.85	1.22	3.29
	108698	0.95	1.25	3.33
	108866	0.22	0.69	2.53
	108871	0.17	0.58	3.70
	109035	0.63	1.00	3.12
	109246	0.94	1.19	2.61
	109458	1.50	1.55	4.35
	109670	2.32	2.51	6.08 [1]
	109882	2.28	2.36	6.70 [1]
	109957	2.67	2.78	7.43 [1]
Corinth Street	109983	3.36 [u]	3.83 [u]	9.90 [1u]
	110009	2.39	2.49	7.07 [1]
	110086	2.60	2.42	6.90 [1]
	110214	2.59	6.00 [1]	5.10
	110342	2.10	2.21	4.26
	110470	1.81	1.84	3.19
	110626	1.84	2.01	2.76
	110783	1.66	1.81	2.17
	110929	1.47	1.60	2.33
	111076	0.00 [2]	0.00 [2]	0.00 [2]
	111223	0.00 [2]	0.00 [2]	0.00 [2]
	111400	0.00 [2]	0.00 [2]	0.00 [2]
	111577	Road not flooded		
	111754	0.00 [2]	0.00 [2]	0.00 [2]
	111940	N/A	N/A	N/A
	112127	N/A	N/A	N/A
	112314	N/A	N/A	N/A
	112473	0.60	0.60	1.02
	112633	1.20	1.45	2.36
	112783	1.48	1.52	2.05
	112883	1.54	1.54	2.29
	112933	1.43	1.61	3.87
	113089	1.51	1.77	4.25
	113247	1.75	1.86	4.53
	113405	1.73	1.93	4.80
	113563	1.71	2.10	4.25
	113726	1.95	2.14	3.95

Location	River Station	Levee Face	Roadside Swale	Paved Area
Corinth Street – Cont.	113890	2.22	1.97	5.97
	113902	2.25	2.40	5.99
IH-35E HOV & Northbound (NB)	114050	2.06 [u]	2.71 [u]	3.98 [u]
	114219	2.41	2.67	3.92
	114371	2.31	2.57	3.77
IH-35E Southbound (SB)	114517	2.48 [u]	1.16 [u]	6.58 [1u]
	114663	1.86	2.26	6.10 [1]
	114773	2.04	2.35	6.24 [1]
	114905	1.52	2.05	6.24 [1]
	115038	3.06	3.49	6.26 [1]
	115236	2.34	2.77	4.11
	115434	2.37	2.94	6.32 [1]
	115633	2.97	3.22	6.20 [1]
	115705	2.98	3.31	7.39 [1]
Jefferson Boulevard	115734.5	2.94 [u]	2.01 [u]	7.74 [1u]
	115764	2.66	3.35	7.00 [1]
	115937	2.66	3.85	8.78 [1]
	116111	2.69	5.41	9.11 [1]
	116185	2.78	3.41	6.82 [1]
Houston Street	116214	6.26 [1u]	2.45 [u]	4.59 [u]
	116243	2.93	2.77	8.92 [1]
	116314	2.93	3.29	8.98 [1]
	116464	2.64	2.93	8.26 [1]
	116615	2.96	3.17	8.59 [1]
	116766	3.30	3.79	7.34 [1]
	116942	3.52	5.42	11.28 [1]
	117118	3.64	6.76 [1]	11.22 [1]
	117294	3.74	3.91	11.24 [1]
	117403	3.45	3.87	8.71 [1]
	117572	3.52	3.51	9.74 [1]
	117672	2.88	3.59	7.55 [1]
	117801	3.13	3.50	6.09 [1]
	117920	3.26	3.49	6.04 [1]
	118000	3.21	3.93	8.78 [1]
	118075	3.05	3.43	8.01 [1]
	118283	2.96	3.35	5.37
	118381	2.94	4.84	8.21 [1]
	118500	2.93	5.96	8.07 [1]
IH-30	118733	2.67 [u]	3.13 [u]	5.02 [1u]
	118966	2.49	2.92	4.69
	119150	2.23	2.72	6.92 [1]
	119334	2.08	2.48	4.63
	119518	2.21	2.47	6.74 [1]
	119686	2.21	2.49	4.63
	119855	2.35	3.10	4.83
	120023	2.40	2.95	3.94
	120192	2.49	3.04	3.77
	120337	2.56	3.58	7.52 [1]
	120483	2.69	3.02	7.84 [1]
	120629	2.70	3.00	6.94 [1]
	120693	1.88	2.89	6.22 [1]
Commerce Street	120729	4.20 [u]	7.83 [1u]	7.00 [1u]
	120765	2.40	2.81	4.48
	120831	2.08	2.72	4.60
	121002	1.91	2.46	4.71
	121174	2.01	3.80	6.82 [1]
	121345	2.56	3.73	7.35 [1]

Location	River Station	Levee Face	Roadside Swale	Paved Area
Commerce Street – Cont.	121517	2.44	3.26	8.38 [1]
	121607	2.95	4.12	9.67 [1]
Union Pacific Railroad (UPRR) Bridge	121623	4.01 [u]	6.06 [1u]	13.02 [1u]
	121639	3.44	5.15	9.68 [1]
	121723	3.61	5.00	9.67 [1]
	121884	2.79	3.21	8.42 [1]
	122045	2.49	4.62	7.37 [1]
	122206	2.37	3.28	6.96 [1]
	122390	2.53	2.79	6.32 [1]
	122438	2.59	2.82	5.83
Woodall Rodgers	122500	2.69 [u]	2.01 [u]	5.08 [u]
	122562	2.54	2.84	6.43 [1]
	122760	2.35	2.78	7.01 [1]
	122834	2.33	2.82	5.18
Continental Avenue	122860	3.99 [u]	6.69 [1u]	7.63 [1u]
	122886	2.31	3.87	7.29 [1]
	122961	2.54	2.64	7.26 [1]
	123161	2.65	2.71	7.11 [1]
	123341	2.42	2.66	5.58
	123441	2.22	2.49	3.83
	123511	1.89	2.33	3.72
	123661	1.04	1.74	4.26
	123861	0.93	1.56	2.91
	124052	0.47	1.21	2.75
	124243	0.00 [2]	0.00 [2]	2.32
	124434	0.00 [2]	0.00 [2]	3.47
	124626	0.00 [2]	0.00 [2]	3.03
	124841	0.00 [2]	0.00 [2]	2.77
	125056	0.00 [2]	0.00 [2]	3.21
	125272	N/A	N/A	N/A
	125487	N/A	N/A	N/A
	125703	0.00 [2]	0.00 [2]	0.67
	125884	0.74	0.71	0.72
	126065	0.78	0.88	0.90
	126246	0.72	0.82	1.00
	126428	0.76	0.76	0.80
	126609	0.64	0.75	1.12
	126791	0.55	1.18	2.17
	126973	0.67	1.28	2.78
	127155	0.52	1.19	2.53
	127352	0.61	1.11	2.28
	127549	0.55	1.11	1.66
	127746	0.38	0.46	1.81
	127779	0.41	0.48	1.91
	127994	0.89	1.10	2.39
Sylvan Avenue	128010.5	1.00 [u]	1.35 [u]	2.99 [u]
	128027	0.83	1.12	2.47
	128092.5	1.13 [u]	1.62 [u]	3.20 [u]
	128158	1.07	1.52	3.03
	128290	0.68	1.26	2.46
	128323	1.22	1.57	2.98
	128538	0.00 [2]	0.00 [2]	2.79
	128727	0.00 [2]	0.00 [2]	1.82
	128916	0.00 [2]	0.00 [2]	0.00 [2]
	129105	0.00 [2]	0.00 [2]	0.00 [2]
	129284	N/A	N/A	N/A
	129463	N/A	N/A	N/A

Location	River Station	Levee Face	Roadside Swale	Paved Area
Sylvan Avenue – Cont.	129642	N/A	N/A	N/A
	129822	N/A	N/A	N/A
	129999	N/A	N/A	N/A
	130176	N/A	N/A	N/A
	130354	1.10	0.78	2.57
	130531	0.59	2.09	3.22
	130709	0.92	1.59	2.26
	130926	0.61	1.72	3.52
	131144	0.56	1.69	3.04
	131361	0.65	1.46	3.03
	131579	0.34	1.73	3.24
	131788	1.41	1.59	2.28
	131998	1.35	1.58	3.10
	132207	0.48	1.20	2.68
	132417	0.40	0.95	1.29
	132627	0.35	0.84	1.49
	132849	0.38	1.06	2.47
	133071	0.98	1.43	2.74

Notes:
[1] denotes velocity ≥ 6 feet/second.
[2] denotes ineffective area in model.
[u] denotes upstream face of structure.