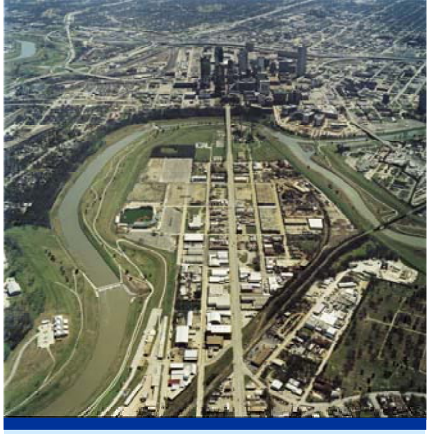
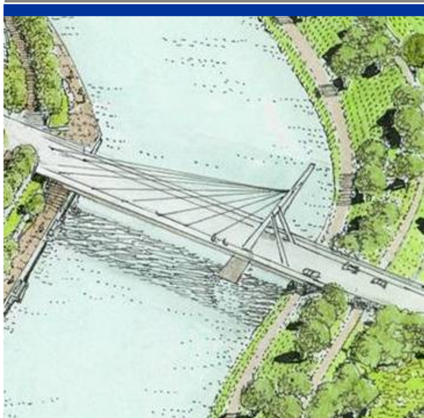


Fort Worth Central City Preliminary Design

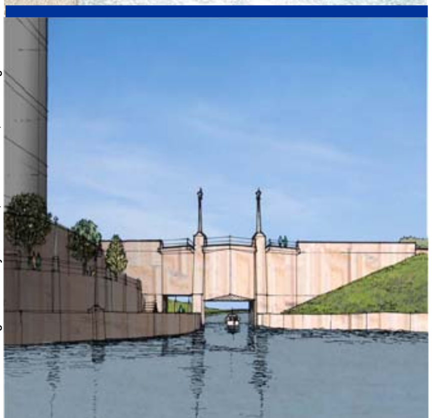
Hydrology and Hydraulics



Draft Environmental Impact Statement

Appendix A

May 2005



Images courtesy of CDM, Gideon Toal, and Bing Thom Architects

CDM

Fort Worth Central City Preliminary Design

Hydrology and Hydraulics

Draft Environmental
Impact Statement

Appendix A

May 2005

This document is released for the purpose of interim review under the authority of Eric D. Loucks, Texas PE License 94545 on 13-May-2005. It is not to be used for construction, bidding, permitting or other purposes.

Contents

Section 4 Operations and Maintenance

Section 5 Summary and Conclusions

Section 6 References

Attachments

Digital Data Submitted on CD

Figures

Tables

Section 1
Introduction

1.1 Project Description

The Fort Worth Central City (FWCC) Project consists of a bypass channel, levee system and associated improvements to divert flood flows around a segment of the existing Trinity River adjacent to downtown Fort Worth. The proposed bypass channel is approximately 8,400 feet long and approximately 300 feet wide between the top of levees. The bypass channel would be approximately 30 feet below existing grade. Design level of protection of the project is SPF plus four feet. The essential components of the project are shown in Figures 1-1 through 1-3.

Water levels in the bypass channel would be controlled by a dam with crest gates. The dam is proposed on the West Fork of the Trinity River just east of the Samuels Avenue bridge and would be designed to maintain normal water level of approximately 525 feet above sea level in the bypass channel and interior area. Flood isolation gates would be incorporated into the levee system to protect the interior area, otherwise known as Trinity Uptown. The gates are located upstream at the confluence of the bypass channel and the Clear Fork (Clear Fork Gate), at the midpoint of the bypass channel and the West Fork confluence (Trinity Point Gate), and downstream at the confluence of the bypass channel and the West Fork (TRWD Gate).

Construction of the bypass channel, dam and isolation gates would create an approximately two-mile segment of the existing West Fork Trinity River as a controlled, quiescent watercourse. A water feature or urban lake, approximately 2900 feet long, is proposed for the interior area (Trinity Uptown). The water feature would extend from the bypass channel southeast to the existing West Fork and Clear Fork confluence of the Trinity River.

Six bridges are proposed for the project, including four vehicular bridges and two pedestrian bridges. Vehicular bridges are proposed over the bypass channel at North Main Street, over the bypass channel and Fort Worth and Western Railroad (FW&W Railroad) at Henderson Street and White Settlement Road, and on the White Settlement Road extension over the urban lake. Two pedestrian bridges are also proposed, across the bypass channel downstream of Henderson Street, and across the West Fork, approximately 500 feet upstream of the existing FW&W Railroad Bridge.

The project also includes proposed modifications to University Drive, which would effectively raise the roadway approximately 10 feet from existing grade and out of the 100 year floodplain. The proposed modifications begin north of the existing bridge over the West Fork extending to Jacksboro Highway (State Highway 199).

Without mitigation, the project would result in a loss of floodplain or valley storage due to the fact that the bypass channel is shorter and contains less volume than the existing river channel. To mitigate for this potential loss of storage, valley storage mitigation sites are included in the preliminary design. A wide range of valley storage mitigation alternatives were considered. Valley storage mitigation sites would be provided in three areas, along the West Fork of the Trinity River upstream of the project area, in the vicinity of the Samuels Avenue Dam, and slightly downstream of the dam in proximity to Riverside Park. Construction of the bypass channel and associated valley storage sites would not increase downstream water surface elevations or downstream flows.

1.2 Purpose and Scope

This appendix to the Draft Environmental Impact Statement summarizes the existing hydrologic, hydraulic, and associated regulatory conditions within the project area (Section 1). This document also outlines the development of the hydrologic and hydraulic models and associated hydrologic and hydraulic analyses for the FWCC Project (Sections 2 and 3). Operational and maintenance consideration are detailed in Section 4. Summary and conclusions are presented in Section 5 and references in Section 6.

These analyses were completed by CDM on behalf of the Tarrant Regional Water District (TRWD) in collaboration with the U.S. Army Corps of Engineers (USACE), and the City of Fort Worth The objective of the analyses is to demonstrate a viable configuration of the Project that maintains flood protection with regard to the relevant design criteria (discussed in Section 1.3), while being consistent with other project objectives, including environmental enhancement, recreation, and urban revitalization The hydraulic analyses include modeling a bypass channel to divert flood flows from the West Fork and Clear Fork of the Trinity River near downtown Fort Worth, and include four structures to control water flow (one dam and three isolation gates).

1.3 Regulatory Considerations

In the mid-1980's, USACE prepared a regional programmatic Environmental Impact Statement (EIS) to establish a floodplain development permitting strategy for the Upper Trinity River and its tributaries. USACE issued a Record of Decision in April 1988 specifying criteria the USACE would use to evaluate Section 404 permit applications in the Upper Trinity River Corridor. As a result, the cities and counties in the Upper Trinity River Corridor formed the Trinity River Steering Committee, facilitated by the North Central Texas Council of Governments. The Steering Committee developed and is responsible for implementing the Corridor Development Certificate (CDC) process to meet the 1988 Record of Decision.

The CDC program and accompanying CDC Manual affirm local government authority for local floodplain management while establishing a set of common permit criteria and procedures for development within the Upper Trinity River Corridor. The Trinity River Steering Committee, consisting of local elected official from jurisdictions in the Upper Trinity River Corridor, approved the first edition of the CDC manual May 23, 1991. Within the next two years, the participating communities (Arlington, Carrollton, Coppell, Dallas, Farmers Branch, Fort Worth, Grand Prairie, Irving, Lewisville) officially amended their floodplain ordinances to adopt the CDC common permitting criteria and process. In the CDC process, the CDC model (a HEC-RAS model developed and maintained by USACE) is considered the baseline design model for proposed development projects in the Upper Trinity River Corridor.

1.4 Existing Conditions

The Upper Trinity River has been considerably urbanized over the past century as a part of the Dallas /Fort Worth (DFW) metropolitan area, otherwise known as the Metroplex. In 2000, the population of the ten county Metroplex was just over five million and covered a land area of over 7,200 square miles (NCTCOG 2003). The 2030 projected population for the region indicates an increase of an additional four million people.

The waterways of the Upper Trinity River basin are currently and will continue to be heavily influenced by urban hydrology. Waterways are further influenced by discharges from surrounding man-made reservoirs. The combined effects of urban development and flood control activities within the basin have permanently altered the natural-state hydroperiod and hydraulic regime.

The Central City study area shown on Figure 1-1, encompasses the confluence of the Clear Fork and West Fork of the Trinity River within the developed metropolitan area of Fort Worth. Several flood control projects dating back to the 1920's were constructed within the study area and the area is currently an active Federal floodway operated and maintained by the Tarrant Regional Water District. Water supply and flood control reservoirs exist upstream on both the Clear Fork (Benbrook Lake) and the West Fork (Lake Worth and Eagle Mountain Lake).

The study area is part of the Upper Trinity River system, which is covered by two major floodplain management policies, the 1988 Record-of-Decision associated with the USACE's Upper Trinity River Feasibility Study and the resulting CDC Program. The CDC hydrologic and hydraulic models, as the foundation to the CDC Program, are used for analysis of proposed floodplain development projects within the Upper Trinity River Corridor.

The baseline condition hydraulic model used for this study is the current CDC model which was developed and is maintained by the USACE. The CDC model was originally developed using the backwater program HEC-2 Water Surface Profiles. The model was subsequently converted to HEC-RAS River Analysis System version 3.0, but has most recently been used in version 3.1.2. The West Fork Trinity River CDC model limits are the confluence of the West Fork and the Elm Fork in Dallas County on the downstream side and the confluence to Lake Worth Dam on the upstream side, a distance of 58.08 miles.

The original CDC West Fork hydraulic models were developed by extensive use of digitized 2-foot contour interval topography. The topographic data was developed from February/March 1991 aerial photography. The majority of the cross-section data were supplied by the surveying contractor and generated from the topographic data, with cross sections locations developed by the USACE. Additional cross sections were developed from the topographic files and included in the models as necessary. Other information used in the development of the CDC models originated from bridge plans, bridge surveys, field reconnaissance, and levee surveys. Channel data originated from 1975 field surveys. Aerial photographs and field reconnaissance were used to determine roughness coefficients.

The Federal Emergency Management Agency (FEMA) maintains maps of local floodplains as a part of its administration of the National Flood Insurance Program. For the Central City Project area, Figure 1-4 illustrates the existing 100-yr and 500-yr floodplains as defined by FEMA.

1.5 Relevant Design Criteria

Several hydrologic and hydraulic criteria are applicable to proposed projects within the Upper Trinity River floodplain and include criteria associated with USACE regulations and the regional CDC Program.

In consultation with the USACE, it was determined that if the hydrologic and hydraulic analysis of the Central City Project met the standard criteria set forth by the regional CDC guidelines, then all regulatory criteria would be met. The specifics of the CDC criteria are:

- No increase in 100-year and SPF water surface elevations outside the project limits;
- No increase in 100-year flood or effective increases in SPF water surface elevations within the project limits unless appropriate flood protection is provided;
- No decrease in valley storage for 100-year flows; and
- No more than five percent decrease in valley storage for SPF flows.

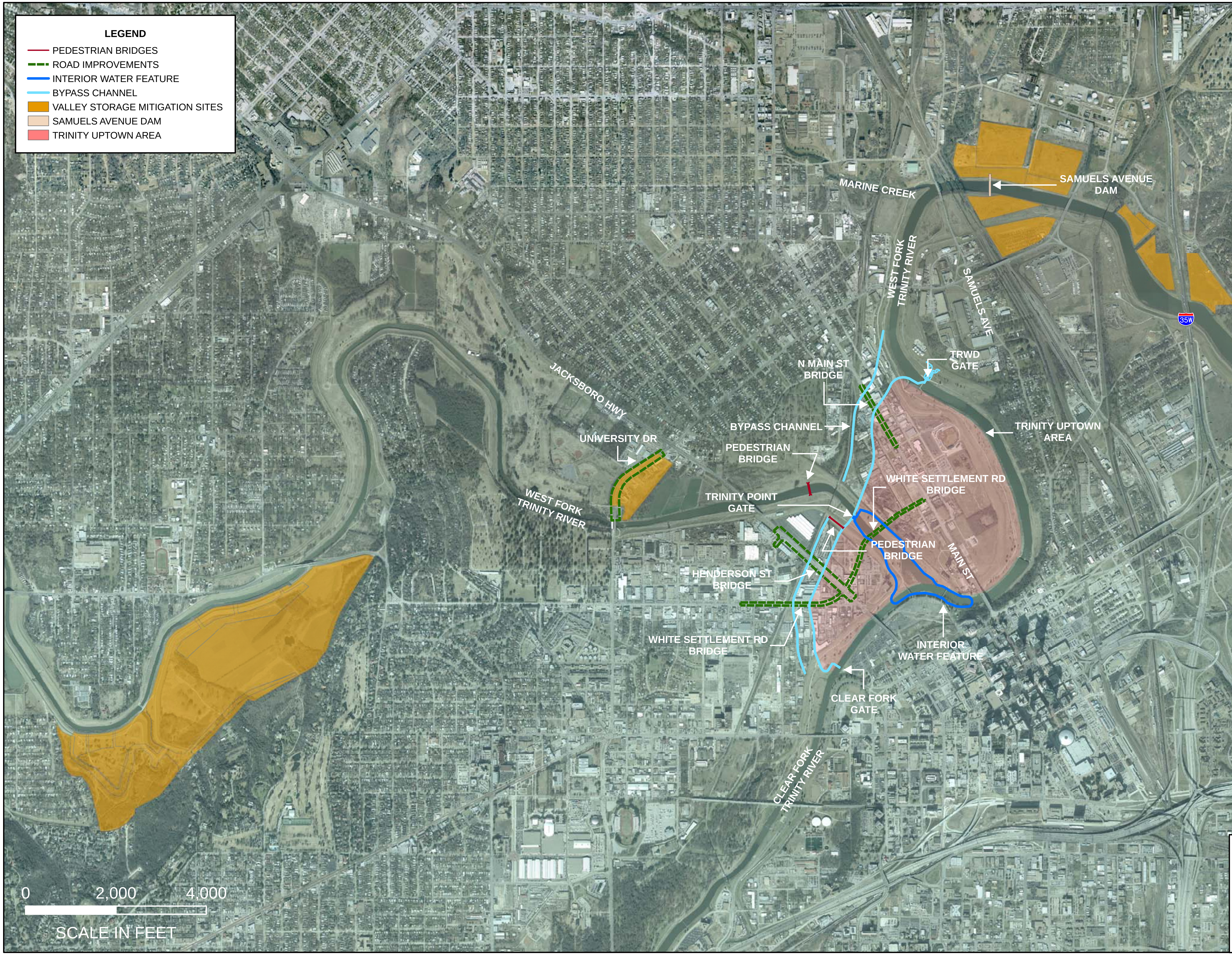
In addition to the CDC criteria, the design will be subject to the following hydraulic performance requirements:

- No increase in the SPF water surface elevation as this is the Record of Decision Criteria for the Upper Trinity planning area and base USACE criteria for construction within a Federal flood control project;
- Discharges will not be increased downstream of the project limits;
- Increases in the base flood elevation (BFE) will be mitigated with appropriate flood protection measures;

- Velocities will not be increased above erosive levels outside the project limits;

- Manageable flow velocities will be maintained throughout the range of return periods such that infrastructure, earthen structures, habitats, and the like will not be damaged; and

- Levee freeboard above the SPF water surface elevation will be provided consistent with the existing level of protection. USACE preference is for "SPF plus four feet," which will be provided for all new levees.

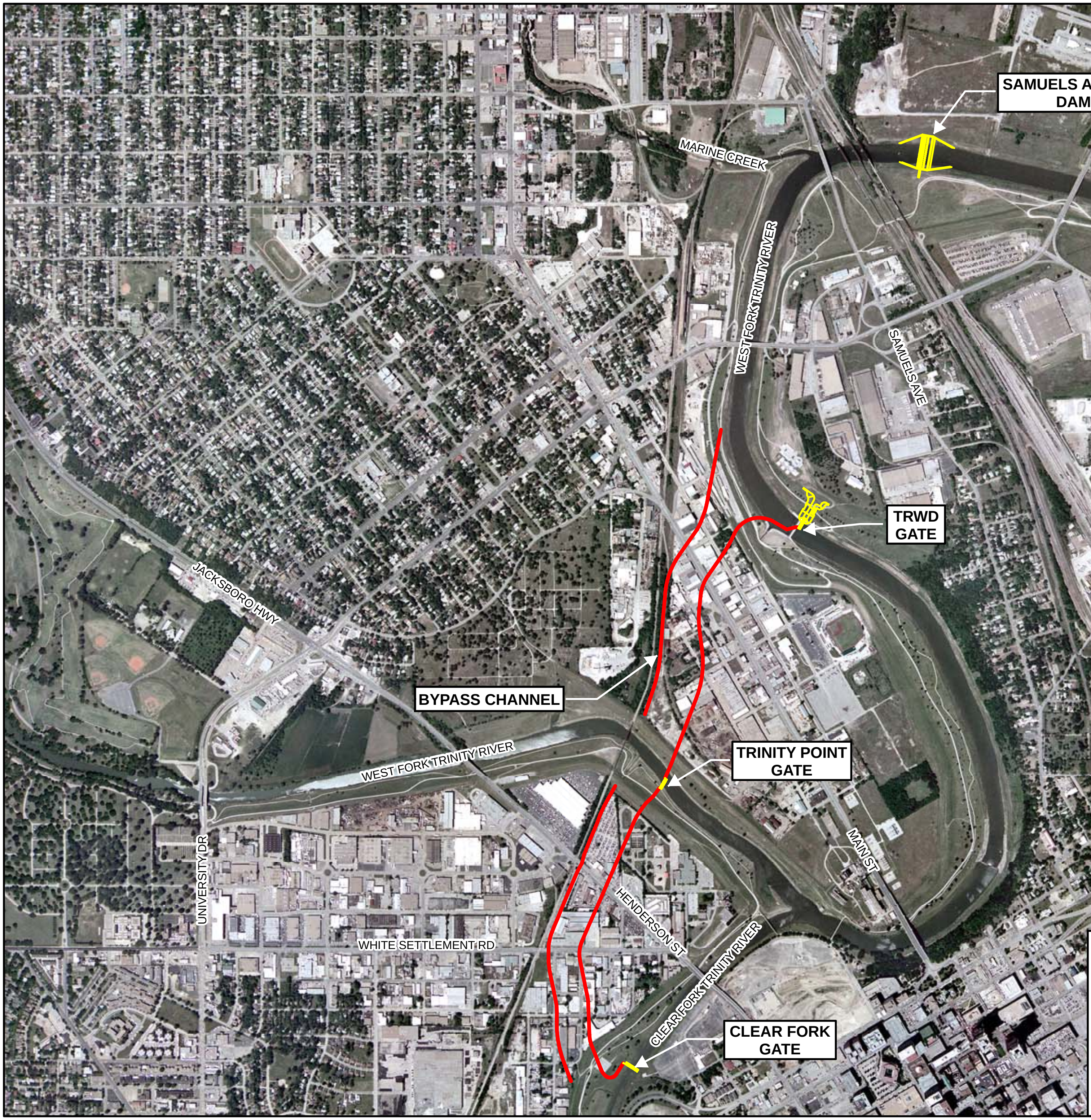


FORT WORTH CENTRAL CITY
APPENDIX A - HYDROLOGY AND HYDRAULICS

FIGURE 1-1
PROJECT LOCATION

CDM

DATE: MAY 2005 | SHEET 1 OF 1



FORT WORTH CENTRAL CITY

APPENDIX A - HYDROLOGY AND HYDRAULICS

TARRANT REGIONAL WATER DISTRICT

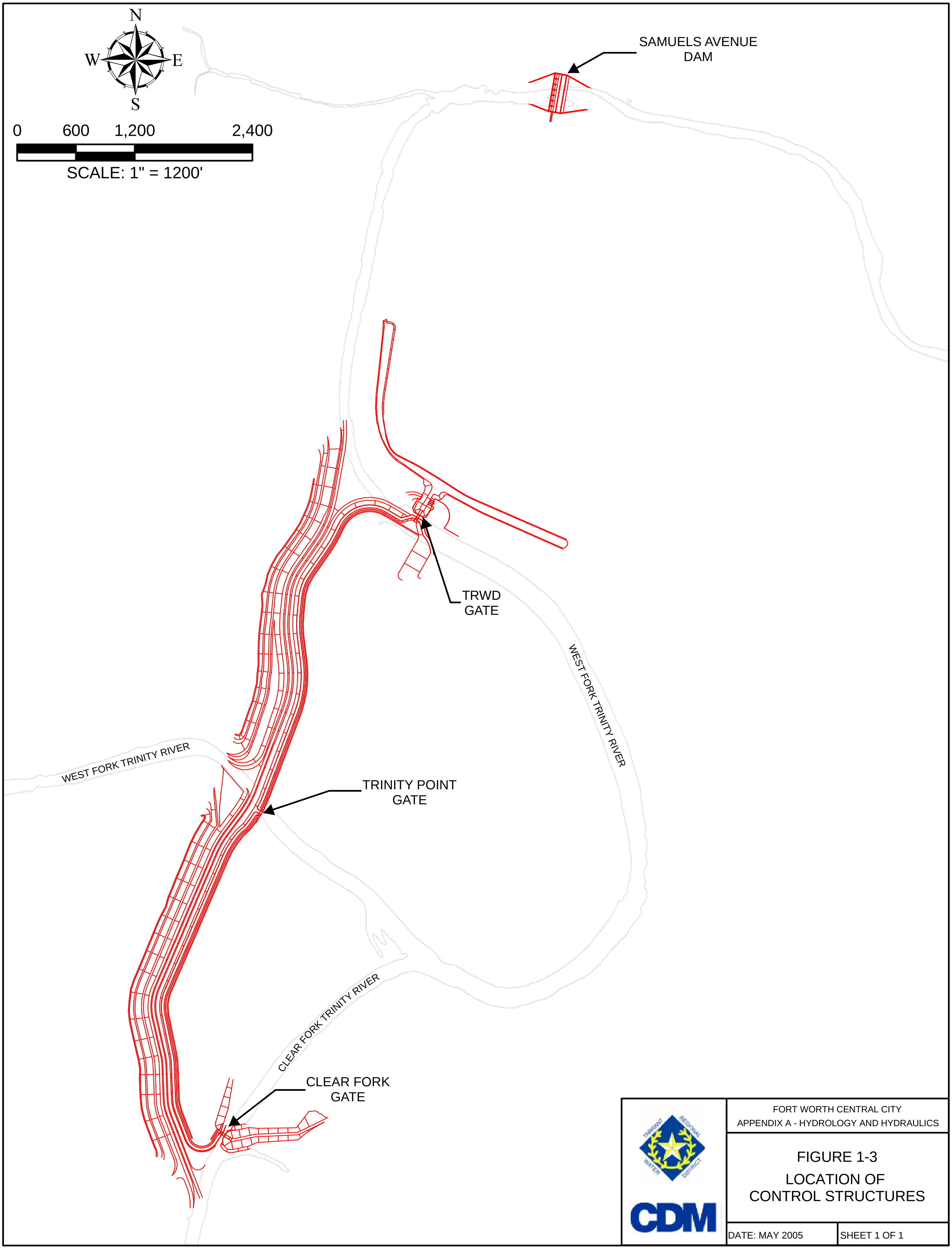
CDM

FIGURE 1-2

LOCATION OF BYPASS CHANNEL AND ASSOCIATED STRUCTURES

DATE: MAY 2005

SHEET 1 OF 1

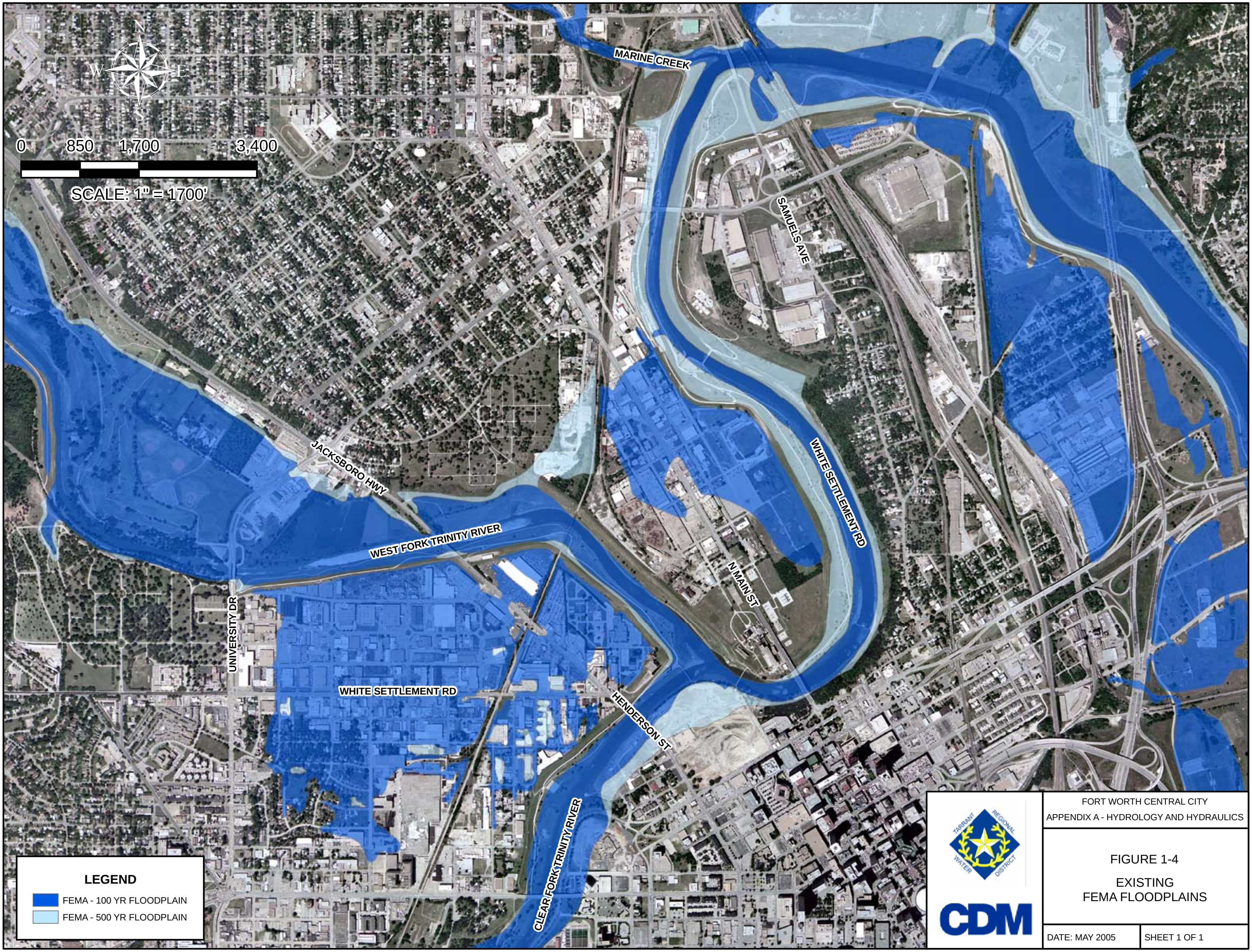


FORT WORTH CENTRAL CITY
APPENDIX A - HYDROLOGY AND HYDRAULICS

FIGURE 1-3
LOCATION OF CONTROL STRUCTURES

DATE: MAY 2005

SHEET 1 OF 1


N
W
E
S
0
850
1,700
3,400
SCALE: 1" = 1700'
MARINE CREEK
SAMUELS AVE
JACKSBORO HWY
WHITE SETTLEMENT RD
WEST FORK TRINITY RIVER
N MAIN ST
UNIVERSITY DR
WHITE SETTLEMENT RD
HENDERSON ST
CLEAR FORK TRINITY RIVER
LEGEND
FEMA - 100 YR FLOODPLAIN
FEMA - 500 YR FLOODPLAIN
TARRANT REGIONAL WATER DISTRICT
CDM
FORT WORTH CENTRAL CITY
APPENDIX A - HYDROLOGY AND HYDRAULICS
FIGURE 1-4
EXISTING
FEMA FLOODPLAINS
DATE: MAY 2005
SHEET 1 OF 1

Section 2 Hydrologic Analysis

2.1 Baseline Model

The starting point for the hydrologic analysis of the Central City Project was a HEC-1 model of the Upper Trinity River system provided by the USACE. The model was developed for the regional CDC process and is maintained by the USACE Fort Worth District. In order for this model to serve as a baseline model for this assessment, modifications to the model were required after consultation with USACE.

For the analyses associated with the Central City Project, the baseline HEC-1 model was developed from the CDC HEC-1 model to provide the best available representation of Year 2050 flows in the existing configuration of the floodway. This required updating of the routing reach storage and outflow data in the project area so that the modeled storage for each reach conformed to the most current channel geometry in the Upper Trinity HEC-RAS model. CDM and USACE prepared the updated hydrologic model during July and August of 2004. Nine HEC-1 routing reaches were modified during this process. These reaches are listed in Table 2-1.

The updated model produces the baseline condition flows listed in Table 2-2. The updated baseline HEC-1 model flow outputs were then assigned to locations in the HEC-RAS model indicated in Table 2-2. This includes all flow values except the Standard Project Flood (SPF) flow values for the Clear Fork, which are shown in Table 2-3 and were provided by USACE staff based on spills from Benbrook Lake and a separate evaluation, previously established, SPF pool elevation. At the direction of the USACE, these flows for the Clear Fork were used throughout the analysis for SPF conditions.

2.1.1 Addressing Uncertainty in Sizing of the Project

Per the design criteria described in Section 1.5, the project must provide protection for all flood flows up to and including the SPF. In areas where levees are used for protection, USACE requirements per the 1988 Record of Decision are that four feet of freeboard must be provided.

USACE also employed coincident events and critical pool elevations to develop the SPF flows for the baseline model. This included defining a one-half PMP storm center over each tributary watershed and assuming full pools in key reservoirs. The defined condition has been developed addressing potential uncertainty in the sizing of elements as the design flows are well above the 0.2 percent chance of exceedence flows.

The consensus with USACE is that these two approaches adequately address uncertainty in project sizing.

2.2 Proposed Conditions Flows

Although a proposed conditions hydrologic model was developed, the baseline flows were used in evaluating the project. This was done in consensus with USACE and was found to be a conservative assumption. It is also consistent with previous applications of the CDC process. For reference purposes, proposed conditions flows are included in the discharge results provided in Section 2.2.2.

2.2.1 Discharge Frequency Relationships

Baseline conditions discharges were computed as discussed in Section 2.1. A proposed conditions model was developed by modifying the routing reaches that would be changed by the proposed project. These modifications include storage losses in reaches LWORCF, FWHWF and FWOMAR. Mitigation storage was incorporated into LWORCF and MARSYC. Some of these reaches were redefined for proposed conditions. Notably, FWHWF was cut off at station 3590 and includes the upper bypass. LWORCF is cut off at 257426 and FWOMAR is cut off at its upstream end at 245866, but would include the lower bypass.

The baseline and proposed conditions HEC-1 models were run for a range of storm frequencies. Discharge results are provided in Table 2-4. Comparison of baseline and proposed flows show decreases in flows from upstream of the confluence through the bypass to Marine Creek. The system experiences slight increases in flow in some locations downstream of Marine Creek although there is no overall increase in 100-year or SPF flow downstream of the project. As previously indicated, these flow decreases were not used to evaluate the project.

2.2.2 Project Induced Changes Obligating Mitigation

The primary activity that would affect the nature of flood flows in the project area is the re-routing of flood flow through the proposed bypass channel rather than the existing reaches of the Clear and West Forks of the river. As the bypass channel shortens an existing meander in the river, there would be a net loss of reach storage. The reduced storage values were determined by conducting a multiple profile analysis on a proposed conditions HEC-RAS model that included a likely bypass channel configuration and ancillary structures. The bypass channel results directly in storage losses in the following HEC-1 reaches: LWORCF (Lower), FWHWF, and FWOMAR.

These reaches are most affected by the fact that the bypass channel reduces the length of conveyance channel in the system. Since valley storage is calculated based on a water surface elevation, losses in valley storage were also caused by lowered water surface elevations resulting from the proposed project. Observed reductions in water surface elevations in the proposed configuration of the bypass channel occur because the bypass channel: 1) presents less resistance to flow than the current channel; and 2) has a greater slope than the current channel. The greater slope occurs because the routing of the river through the bypass channel would now result in the same grade change over a much shorter distance. This combines to reduce valley storage through a "draw down" effect on water surface elevations in the both the Clear Fork and West Fork upstream of their confluence with the proposed bypass channel.

The construction of the proposed bypass channel is estimated to cause a net loss of approximately 2,850 acre feet of valley storage under SPF conditions. An additional estimated 2,400 acre feet of valley storage would be lost due to drawdown under SPF conditions, if no action is taken to reduce drawdown. In the proposed project, the aggregate lost valley storage (5,250 acre feet) would be mitigated using in-line and off-line storage and an additional structure to reduce water surface draw down.

An analysis was performed to determine the expected effect on flows by incorporating the proposed changes into the HEC-1 model. The proposed valley storage in each reach was determined using HEC-RAS, except for the off-line storage at Riverbend, which was calculated using Microstation. The HEC-1 model was run with mitigation storage in place to determine the expected 100-year and SPF flows under proposed conditions. These flows are included in Table 2-2. Although the proposed conditions flows accurately depict projected flows, they are not used to evaluate CDC compliance.

2.2.3 SPF Flooding

There are areas within the Upper Trinity River Basin that are currently subject to flooding under SPF flow conditions. The project would reduce SPF flooding within the project area due to resulting lower water levels on the West Fork upstream of the proposed confluence and increased levee protection levels associated with the bypass channel. The project would not exacerbate SPF flooding at any location outside the project area.

2.2.4 Stage-Discharge Relationships

The hydraulic model employs a stage-discharge relationship that is defined at the model limit at cross-section 206218. This stage-discharge relationship was provided by USACE. No additional stage-discharge relationships were developed for this analysis.

2.2.5 Flow Duration

Figures 2-1 and 2-2 show computed hydrographs upstream and downstream of the project area for existing and proposed conditions. The hydrographs illustrate several important points: the effect of the mitigation storage on the shape of the hydrograph and the reduction of the second flood peak and the change in controlling peak flows upstream and downstream of Marine Creek. In upstream areas and through the bypass, the second peak has higher peak flow. The maximum flow shifts to the first peak downstream of Marine Creek. In either case, there are no changes in the duration of flooding.

2.2.6 Reservoir Yields/Discharges

The upstream project analysis limits are Benbrook Lake on the Clear Fork and Lake Worth on the West Fork. The storage-discharge behaviors of these two reservoirs were incorporated into the HEC-1 models by the USACE.

2.3 Residual and Induced Flooding

An additional benefit of the project is that some portion of the existing floodplain would be eliminated or reduced in extent. The project would reduce residual flooding in some locations because of lower water levels, lesser peak flows, and increased levee level protection. Residual flooding would not be increased at any location within the project area. There is also no induced flooding associated with this project during either construction or post-construction project conditions. Any water elevation increases would occur in protected areas within the limits of the project. Anticipated changes to the FEMA 100-yr and 500-yr floodplains as a result of the project are shown in Figure 2-3.

As shown, overbank flooding would be eliminated within the interior drainage basin. This would be accomplished through levee construction along with the interior drainage pump station. Drainage improvements and levee construction would also eliminate flooding in the Northwest basin as shown on Figure 2-3.

The project is expected to reduce the 100-yr water surface profile by up to 4 feet on the West Fork between the bypass channel and University Drive. This reduction in water level could reduce the extent of the overbank flooding north of the West Fork and in the 14W/15W drainage basin. The extent of the floodplain reduction in these areas would be determined in analyses to be conducted during 2005 in association with the development of a Conditional Letter of Map Revision (CLOMR) for the project. A LOMR is part of the formal process to have the FEMA floodplain maps revised once the project is constructed.

Table 2-1
HEC-1 Reaches in the Central City Area

Reach ID	HEC-RAS River Reach	HEC-RAS Station Upstream	HEC-RAS Station Downstream
LWORCF	WF4	306246	269743
LWORCF	WF4	269743	254346
MRYFWH	CF	41045	11918
FWHWF	CF	11918	477
FWOMAR	WF3	254346	242451
MARSYC	WF3	242451	219536
SYCBFL	WF3	219536	206314

Table 2-2
Flow Results for Baseline and Proposed Conditions

Location		*100-yr Flow (cfs)*		*SPF Flow (cfs)*	
		Baseline	**Proposed**	**Baseline**	**Proposed**
Clear Fork[1]	CFBMRY	27600	27600	54400	54400
	FWHT2	32300	32300	63100	63100
	CFAWF	32100	32200	62100	62300
West Fork 4	FLWT2	35400	35400	56400	56400
	WFACF	35400	33000	59800	56400
West Fork 3	FWOT2	48400	46900	119000	115200
	WFAMAR	48100	47000	118900	115100
	WFBMAR	50300	50100	122400	121200
	WFASYC	51000	51000	127300	127800
	WFBSYC	73000	73600	156400	156900
	WFABFL	63400	63200	147800	146600

[1] The Clear Fork flows computed in HEC-1 are not used directly in HEC-RAS. They are listed here for information only.

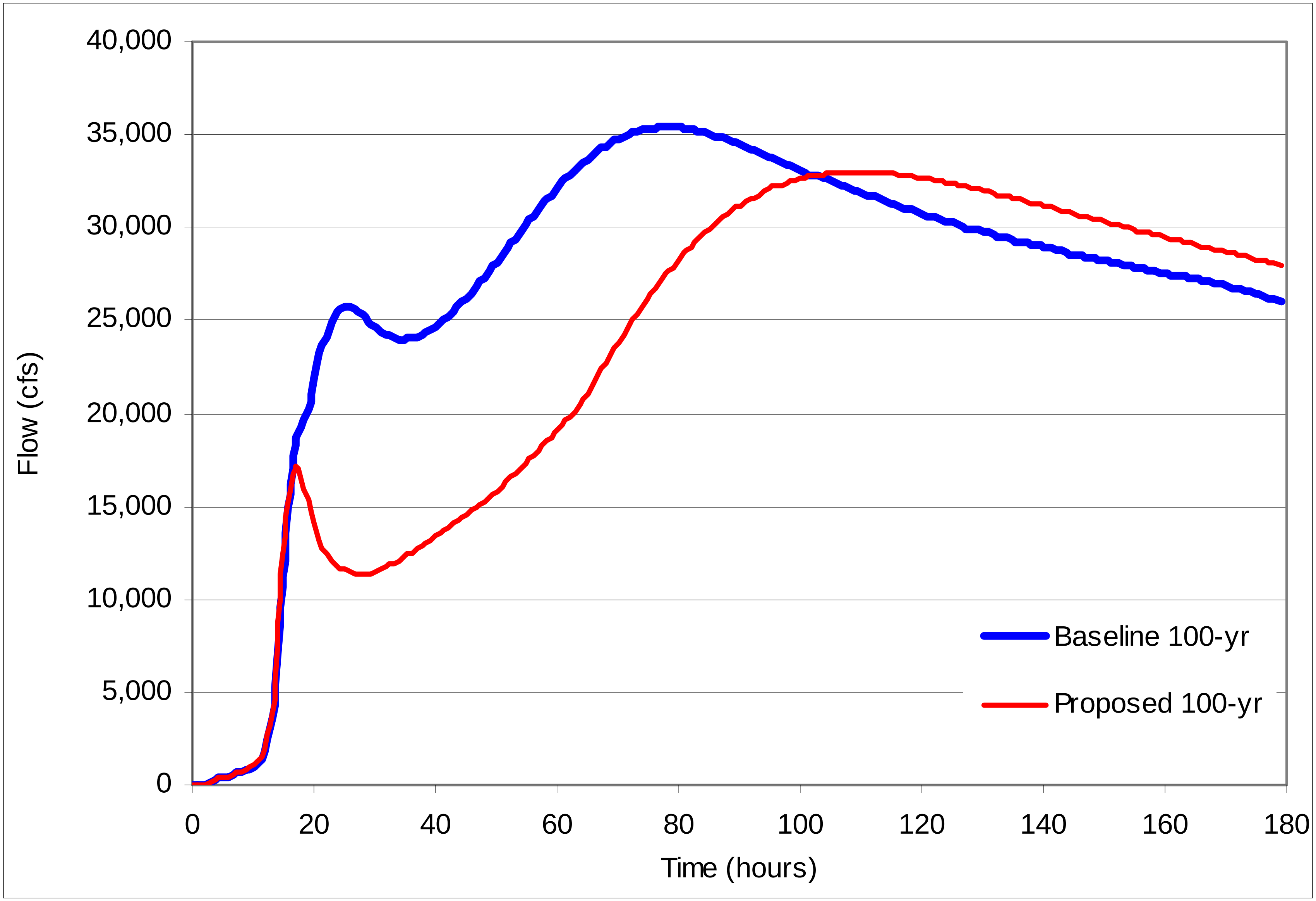
Table 2-3
Clear Fork Baseline SPF Flows

Location	Flow
CFBMRY	71800 cfs
FWHT2	81300 cfs
CFAWF	77800 cfs

Table 2-4
Frequency Discharges for Baseline and Proposed Conditions

Location		Baseline Flow (cfs)			
		2-yr	5-yr	10-yr	25-yr
Clear Fork	CFBMRY	5000	10600	14800	19000
	FWHT2	6800	12200	17100	22200
	CFAWF	7200	13000	17700	22700
West Fork 4	FLWT2	13600	18900	22200	26500
	WFACF	13600	18900	22200	26500
West Fork 3	FWOT2	13600	18900	24400	32300
	WFAMAR	13600	18900	24100	32500
	WFBMAR	13700	19500	26100	33700
	WFASYC	13700	19500	26200	34200
	WFBSYC	21200	34200	42200	51800
	WFABFL	15900	24700	31900	40700

Location		Proposed Flow (cfs)			
		2-yr	5-yr	10-yr	25-yr
Clear Fork	CFBMRY	5000	10600	14800	19000
	FWHT2	6800	12200	17100	22300
	CFAWF	7000	13000	17700	22800
West Fork 4	FLWT2	13600	18900	22200	26500
	WFACF	12700	16400	20000	24400
West Fork 3	FWOT2	12700	17100	24500	31800
	WFAMAR	12700	17100	24400	32000
	WFBMAR	12700	20500	27300	34500
	WFASYC	12700	19600	26800	34900
	WFBSYC	21500	34300	42300	51900
	WFABFL	16200	25000	32300	40900



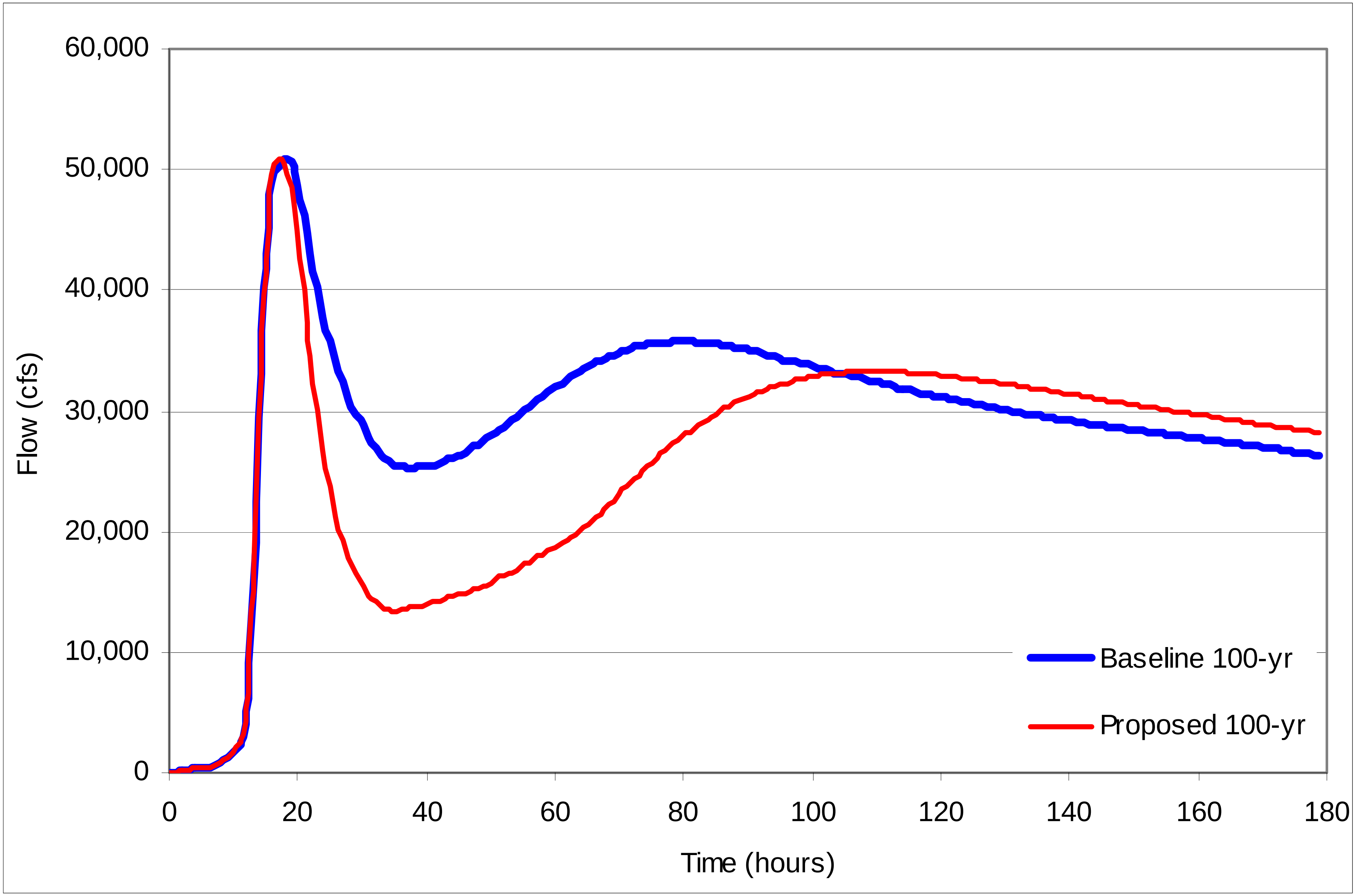
CDM

FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 2-1
BASELINE AND PROPOSED 100-YR FLOOD HYDROGRAPHS ON THE WEST FORK ABOVE THE CLEAR FORK

DATE: MAY 2005

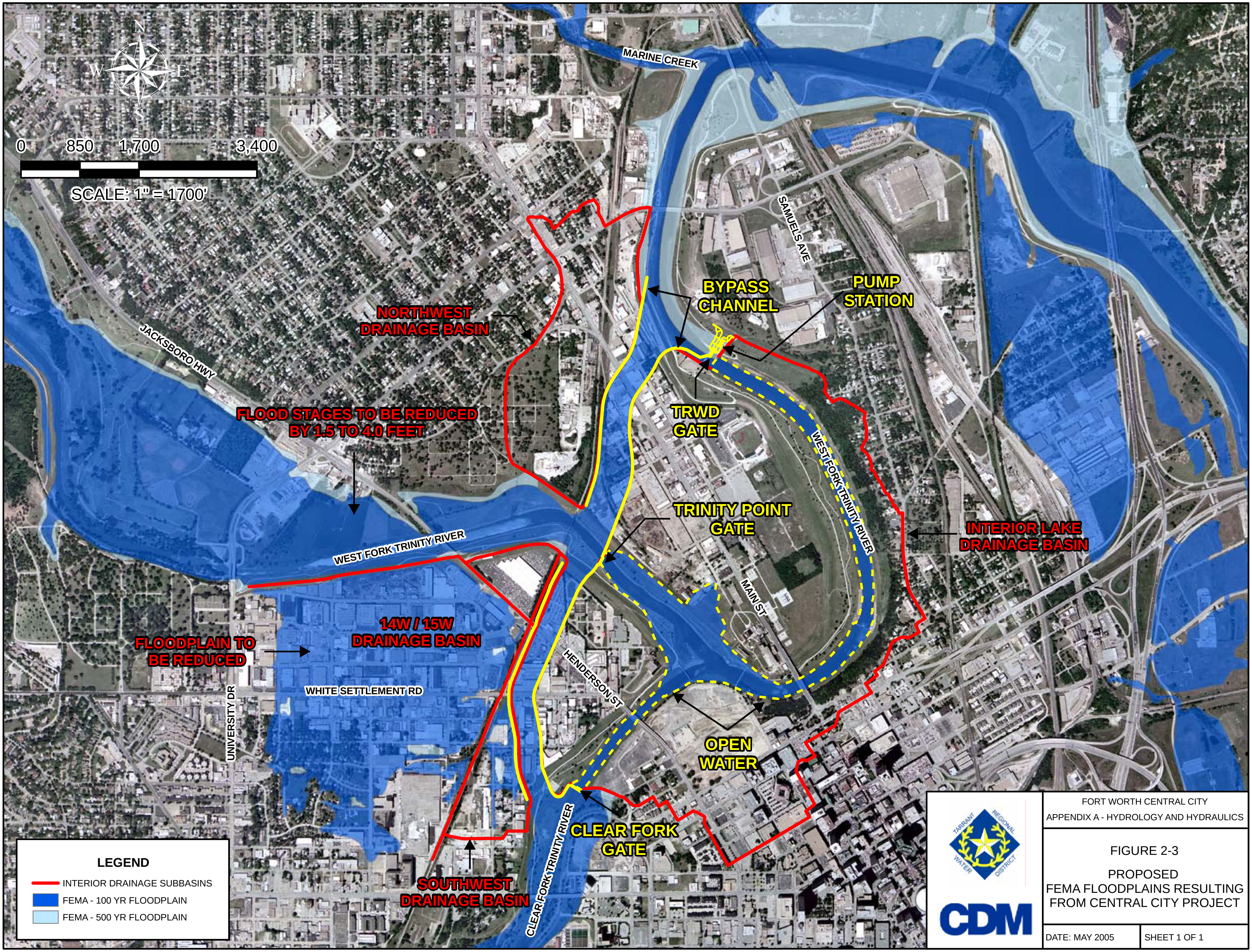
SHEET 1 OF 1



FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 2-2
BASELINE AND PROPOSED 100-YR FLOOD HYDROGRAPHS ON THE WEST FORK ABOVE SYCAMORE CREEK

DATE: MAY 2005	SHEET 1 OF 1



FORT WORTH CENTRAL CITY

APPENDIX A - HYDROLOGY AND HYDRAULICS

FIGURE 2-3

PROPOSED FEMA FLOODPLAINS RESULTING FROM CENTRAL CITY PROJECT

DATE: MAY 2005 | SHEET 1 OF 1

Section 3
Hydraulic Analysis

3.1 Approach

The hydraulic evaluation of the proposed bypass channel alignment for the Fort Worth Central City (FWCC) Project was performed using the U.S. Army Corps of Engineers (USACE) HEC-RAS version 3.1.2. HEC-RAS is a hydraulic step-backwater software program which calculates water surface elevations and computes resulting river reach storage (usually referred to as valley storage) and flow velocities. In order to demonstrate compliance with the CDC criteria described in Section 1, the steady-flow capabilities of HEC-RAS were employed. Flow inputs were obtained from the HEC-1 hydrologic analysis described in Section 2.

Unsteady flow analyses will be needed to facilitate design of the operable features of the project including the control gates and dam. The unsteady flow analyses of the project will be conducted prior to final design.

3.2 Hydraulic Assessments

3.2.1 Baseline Condition

CDM obtained an updated regional hydraulic model of the Upper Trinity River system from the USACE Fort Worth District. The model, referred to as the Corridor Development Certificate or CDC model, is maintained by the USACE as a part of their ongoing work with other entities in the region. A subset of the larger Upper Trinity CDC model sufficient to evaluate the project was provided to CDM by the USACE. This subset of the Upper Trinity CDC model, referred to as the Central City model, is the baseline hydraulic model for this analysis. The modeled area extends from Benbrook Lake on the Clear Fork and Lake Worth on the West Fork downstream past the confluence to East First Street on the West Fork.

3.2.2 Proposed Condition

The major hydraulic elements of the proposed project were incorporated into the baseline model to create the proposed conditions model. This included the addition of the proposed bypass channel, three isolation gates, Samuels Avenue Dam and the proposed valley storage mitigation sites. In addition, three roadway bridges and two pedestrian bridges were incorporated into the proposed conditions model.

3.2.2.1 Structural Sizing Needed to Meet Design Capacities

The proposed improvements were incorporated into the proposed conditions model as described below. Each improvement was adjusted until the size and configuration of each element was adequate to fulfill the project design criteria outlined in Section 1.

3.2.2.2 Bypass Channel

The bypass channel extends from the Clear Fork downstream of West Seventh Street to the West Fork, intersecting the West Fork approximately 2,600 feet upstream of the existing confluence with the Clear Fork. The bypass channel continues to the northeast and rejoins the West Fork 8,500 feet downstream of the existing confluence with the Clear Fork. The overall length of the bypass channel is approximately 8,400 feet. The proposed Bypass Channel Plan is provided in Figures 3-1, 3-2 and 3-3. These figures show model cross-section locations.

The bypass channel has upper and lower segments. The upper segment carries flow diverted from the Clear Fork and the lower bypass carries flow from both the Clear and West Forks. Manning 'n' values were determined based on channel and floodplain 'n' values assigned to nearby areas of the West Fork in the baseline model. These values are n = 0.035 in the channel and n = 0.055 in the overbank areas. The pedestrian walkway element of cross-section was assigned an 'n' value of 0.025. The bottom profile of the bypass channel was set to match invert elevations at each intersection with an existing stream. To reduce excavation quantities and potential tractive forces, a grade control structure is located at Station 9+80. A profile of the proposed bypass channel is shown in Figure 3-4.

3.2.2.3 Isolation Gates

The project would include three isolation gates designed to protect the interior area east of the bypass channel from water entry during flood events. The gates were not explicitly represented in this steady flow model, as it was not necessary for these analyses. The steady flow model represents a "snap shot" during the peak of a flood event and, therefore, the gates are assumed to already be in the closed position and the interior area is sealed off. As the operation of the system is modeled in detail, an unsteady, dynamic model of the project will be developed to simulate the movement of the isolation gates during storm events.

3.2.2.4 Samuels Avenue Dam

Water levels with in the project area would be controlled by a dam with adjustable gates located approximately 1,200 feet downstream of Samuels Avenue. The crest is at 524.3 feet, and the dam is designed to maintain normal water levels in the project area from 524.3 feet to 525.0 feet. The dam is an overflow type with gates designed to open downward lowering the crest to allow major flood events to pass. The maximum gate opening is 17.5 feet deep; thus, the crest elevation is of the fully opened dam is 507 feet. In the proposed conditions model, the dam was modeled assuming the gates were in the fully open position for both the 100-year and the SPF flood events. During the detailed design phase, operation of the gates will be modeled dynamically using an unsteady flow model.

3.2.2.5 Bridges

Five bridges were added to the model. Three roadways would cross the bypass: White Settlement Road, Main Street and Henderson Road. These bridges would be built with bridge decks above the levee crest. Therefore only the proposed piers would interact with the modeled flow. Two pedestrian bridges are also proposed. The pedestrian bridges would be designed to pass the 100-year flow through the opening while the SPF would pass over the deck. One bridge would be located at Station 44+26 on the upper bypass. A cross-section view of this bridge is provided in Figure 3-5. The second pedestrian bridge would be located at Station 2579+95 on the West Fork. A cross-section view is shown in Figure 3-6 and a plan showing the location of this bridge is in Figure 3-7.

3.2.2.6 Mitigation Storage

The project would mitigate valley storage that is displaced or lost due to construction of the bypass channel. With no corrective action, as much as 5,250 acre feet of valley storage could be lost. The project would replace this storage in several ways. Figure 3-8 is a general overview, while Figure 3-9 is a more detailed overview, of these mitigation sites, which include:

- Off-line valley storage mitigation site upstream on the West Fork in the Riverbend area;
- Approximately six in-line, overbank sites around and downstream of Samuels Avenue; and
- Drawdown mitigation by raising University Drive.

The Riverbend off-line valley storage mitigate site is located adjacent to the West Fork approximately 4 miles upstream of the existing confluence of the Clear and West Forks, between Stations 2768+53 and 2834+00 in the HEC-RAS model. A plan of the proposed Riverbend site is shown in Figures 3-10 to 3-13. The Riverbend valley storage mitigation site would be constructed by cutting "notches" in the existing levee and allowing flow to occupy the low-lying area behind the levee. The inverts of the notches are set below the 2-year flood but well above the normal water level of the channel. Depending on the final configuration of the site, a back levee may be constructed to prevent flooding of any private property. Calculations provided in Attachment A indicate that this site would provide 1,594 acre feet of storage in the 100-year flood and 3,246 acre feet in the SPF.

Downstream of Samuels Avenue, six storage areas would be developed by excavating overbank areas between Station 2417+08 and 2355+22. Preliminary plans for these sites are provided in Figures 3-14 to 3-17. These sites were incorporated into the model cross-sections because portions of the facilities can both convey and store flow.

The SPF storage volume they provide was calculated in HEC-RAS and is approximately 607 acre feet.

More than 2,000 acre feet of valley storage could be lost along the West Fork due to the drawdown effect of the bypass channel. To recover a portion of this storage, the project would raise University Drive at Station 2625+48 on the West Fork. This proposed modification would return 100-year and SPF water levels upstream of University Drive to near the levels of baseline conditions.

The proposed site layout for raising University Drive is provided in Figures 3-18, 19 and 20. Figure 3-21 shows how ineffective flow areas were defined in the HEC-RAS model to reflect the changes in flow pattern caused by raising University Drive.

3.2.2.7 Hydraulic Roughness Coeffecients

Manning roughness coefficient ('n') values were selected for the bypass channel and for proposed in-line storage areas in consensus with USACE. The construction and morphology of the bypass channel should mimic the existing channel to the extent possible. As a result, the selected Manning roughness coefficient values are similar to those employed in the baseline model of the West and Clear Forks. Throughout the project area, the baseline model from USACE uses the following values.

- All main channels, n=0.035
- Clear Fork overbank areas, n=0.060
- West Fork overbank areas, n=0.055

As a result, the bypass channel generally was assigned n=0.035 in the main channel and n=0.055 in the overbank areas. Exceptions to these values are the areas proposed to be hard surface. These fall into two classifications:

- Smooth paved surfaces with few appurtenances or attached features were assigned an n value of 0.015 ; and
- Paved surfaces with attached features and/or architectural elements were assigned an n value of 0.025.

The proposed in-line storage areas that were incorporated into the model are also mostly assigned to n=0.035 in the channel and n=0.055 in the overbanks. However, a few overbank storage areas that are proposed to be highly maintained lawns and completely free of trees or obstructions have been assigned n=0.035.

3.2.2.8 Criteria for Facility and Utility Relocations

Utility relocation criteria and requirements are discussed in Appendix C – Civil/Structural.

3.2.2.9 Interior Drainage

The project will require appropriate interior drainage storage and conveyance facilities to prevent flooding in interior areas. The analysis and design of these facilities are described in Attachment B.

3.3 Results of Analyses and Compliance with CDC Criteria

3.3.1 Valley Storage

Computed valley storage for baseline and proposed conditions for both the 100-year and SPF events is summarized in Table 3-1. All valley storage volumes were obtained from the HEC-RAS model except for the Riverbend site. As the Riverbend site operates as off-line storage, it was not directly included in the model such that valley storage amounts could be computed in HEC-RAS. Volume calculations for Riverbend were performed using CAD and are described in Attachment A. As indicated in Table 3-1, the valley storage in the 100-year flood is mitigated well over 100%. The net loss of valley storage in SPF is less than 40 acre feet. Project limits are defined as the area between the start of the bypass channel and Samuels Avenue Dam, so this loss is less than one half of one percent – effectively zero for regulatory considerations.

The local sponsor established a goal of mitigating 100 percent of the project's valley storage reductions, which is beyond the requirements of the CDC process. In addition, the valley storage calculations do not account for the substantial additional storage that is provided in the interior area. The capacity of this interior area is approximately 270 acre feet during a 100-yr event at which time there is an estimated 100 acre feet of valley storage. The storage volume of this interior area will be included in final calculations.

3.3.2 Water Surface Elevations

Steady-flow baseline and proposed conditions water surface elevations for both 100 year and SPF events are shown in Table 3-2. The project decreases or maintains baseline water levels at all locations with just a few minor exceptions. Water levels increase for the SPF at seven cross-sections, and at five cross-section for 100-year event. The maximum water level increases are 0.07 feet (less than 1-inch) in the 100-year flood and 0. 12 feet (1.5 inches) in the SPF.

There are slight increases in the immediate project area upstream and downstream of Samuels Avenue Dam and within the proposed storage mitigation sites between Samuels Avenue Dam and I-35. Increased in water levels occur because of expansions and contractions of flow introduced by the widening of overbank areas in the valley storage mitigation sites. The increases are confined to areas that would be purchased and maintained by TRWD, thus would have no impact on private property if the increases actually occur. As new levees are constructed in the immediate project area, additional levee protection can easily be provided to compensate.

3.3.3 Head Loss

Construction of the bypass channel effectively shortens the West Fork by approximately 7,000 feet. This results in a reduction in head loss that must be partly restored in order to prevent significant additional loss of valley storage. Head loss would be returned to the system through modification or addition of structures. These include raising University Drive upstream on the West Fork, restrictive bypass channel sections, building Samuels Avenue Dam and two pedestrian bridges.

3.3.4 Average Channel Velocities

The agreed-upon CDC criteria for the proposed project include important provisions regarding channel velocities. Table 3-3 shows average channel velocity at selected locations for both baseline and proposed conditions. The table shows that velocity increases are generally less than 1 foot per second. Modeling analyses to date indicate exceptions to these increases may exist at the entrance to the bypass channel and at University Drive. Further analyses, using a physical model or additional modeling, would be undertaken prior to final design to evaluate appropriate armoring that may be necessary to prevent erosion or scour. Table 3-4 list velocities in the bypass channel. Designing the bypass to handle these flow velocities has been determined to be feasible with common engineering practices.

3.3.5 Existing and Post-Project Sedimentation

A sediment transport analysis of the proposed project is necessary to support several aspects of the project including:,

- Prediction of significant erosion and/or depositional impacts to existing infrastructure or ecosystems;
- Input to design considerations for improvements associated with the project;
- Definition of operation and maintenance needs of the floodway after project implementation; and
- Support of the environmental impact assessment associated with the project.

The objectives of the sediment transport analysis include the assessment of the sediment transport characteristics of the proposed system during years with significant flows and development of recommendations regarding subsequent analyses, data collection, project design considerations and project operation and maintenance based on sediment transport assessments. Figures 3-22 and 3-23 show results of this analysis. A more detailed description of the sediment transport analyses and the results are included in Attachment C. The analyses indicates that the construction of Samuels Avenue Dam is required to maintain the channel without severe sediment aggradation or degradation after construction of the bypass channel.

3.3.6 Energy Dissipation/Erosion Control Features

Energy dissipation features are included in the design of Samuels Avenue Dam in order to protect the dam's structure during releases. Refer to the Civil/Structural Appendix (Appendix C) of this Draft Environmental Impact Statement for more information on Samuels Avenue Dam. Additional energy dissipation downstream of the dam is not anticipated, but would be confirmed during final design. As Tables 3-3 and 3-4 and the sedimentation analysis indicate, there appear to be no need for erosion control other than standard practices typically associated with structures such as bridges (e.g., aprons, pier protection, etc.).

However, additional investigations relative to erosion and deposition would be undertaken and the project's design would be adjusted accordingly should additional protections be warranted.

3.3.7 Control of Water and Project Sequence

Sequencing of the bypass channel construction and other elements will be critical to protect the environment and maintain comparable flood protection levels. Care will be taken in planning the construction activities to minimize any potential negative impacts on the river. Separate erosion and water control plans would be prepared for various construction contracts and elements of the project. The plans would include requirements and guidelines for contractor staging and equipment maintenance areas.

Mass excavation and grading would be planned and sequenced to minimize in-channel and bank excavation. Where in-channel or swale excavation is required, the excavation would be scheduled from downstream to upstream and major equipment and supplies removed from the floodway each day. Dewatering discharges from excavations would not be allowed to discharge directly to the river or storm sewer. Discharges would be directed to sedimentation basins outside of the existing floodway, prior to discharge to the river.

Buffer zones and barriers would be provided in excavation and fill areas to minimize erosion and siltation to water courses and/or the storm sewer system. Seeding of new levees would be completed as soon as possible to produce rapid establishment and maturity of cover. Temporary biodegradable erosion control blankets would be used in selected areas to help minimize erosion and facilitate the growth of vegetative cover.

Consideration was given, during the development of the sequence of work, to minimizing construction impacts to waterways. A preliminary sequence of construction has been established based on assumptions that environmental assessments, land acquisition, permitting, and funding activities would not adversely impact the schedule. Key issues and objectives considered and factored into the development of this preliminary sequence include:

- Minimizing the duration of construction activities within or directly connected to the River channel;
- Maintaining a comparable level of flood protection during construction;
- Phasing of improvements to have valley storage mitigation areas on-line at the appropriate time; and
- Maximizing construction opportunities under dry conditions.

For discussion purposes, the construction sequence can be described in eight basic segments. Actual contract packages, construction contract size, and specific timing would be developed in more detail as the project detailed design progresses. The overall sequencing requirements and constraints are shown by the following construction segment overview:

- ***Construction Segment No. 1: Roadway Bridges:*** Construct temporary roadway bypasses at Henderson, Main St., and White Settlement. Construct bridge piers, bridges, and roadway approaches at all three locations. Complete roadway improvements and tie-in to new bridges. This would allow for the construction of the bridges and roadways "in the dry" without the need for temporary bridgeworks.
- ***Construction Segment No. 2: Interior Bypass Channel:*** Construct the interior portions of the upper and lower bypass channels without breaching the existing levees to the river. Complete excavation, utility relocations, new levee construction, and interior retaining walls. This would allow for a major portion of the channel to be constructed "in the dry" condition, except for potential groundwater.
- ***Construction Segment No. 3: Riverbend Mitigation:*** Complete the Riverbend mitigation site grading, ecosystem restoration and levee modifications. This would provide additional valley storage to compensate for the drawdown when the bypass channel is initially opened.
- ***Construction Segment No. 4: Bypass Channel Tie-ins:*** Construct the remaining reaches of the upper and lower bypass channel excavation, levee, and retaining walls. Breach levees and tie-in new bypass channel beginning from lower to upper channel connections. This would minimize the amount of construction within the existing channel and reduce the amount of coffer dam construction.

- ***Construction Segment No. 5: Construct University Drive Mitigation:*** Reconstruction of University Dr. to raise it out of the 100 year flood elevation and to provide for valley storage mitigation would closely follow the completion of the bypass channel. This component is required to partially restore the 100-year and SPF flood elevations from the drawdown effect of the bypass channel on the West Fork. Construction would be deferred until the bypass channel is complete so there would not be an increase in flood elevations during construction.

- ***Construction Segment No. 6: Construct Isolation Gates:*** After the completion of the bypass channel and "upstream" valley storage mitigation the existing West Fork interior channel can be taken out of service for major flow events. This would allow for the construction of the isolation gates for the interior area. Coffer dam construction is envisioned to segregate the construction area and provide protected working conditions from river flows. This segment would include the construction of all three isolation gates, tie-ins to the bypass channel retaining walls, levees, and the stormwater pump station at the TRWD gate.

- ***Construction Segment No. 7 Samuels Avenue Dam:*** Construction of the Samuels Avenue Dam would also include the remaining downstream valley storage mitigation sites. Construction of these improvements would be concurrent with the construction of the isolation gates thus providing the remaining valley storage when the interior area is completely isolated.

- ***Construction Segment No. 8 Interior Water Feature and Connector:*** Completion of the isolation gates and valley storage sites would enable the re-routing of flows from the interior area to the new bypass channel. This would allow for the construction of the interior water feature and the completion of the White Settlement Connector.

Table 3-1: Valley Storage Calculations for Proposed and Baseline Conditions

Reach	Reach limits D/S Station	Reach limits U/S Station	100-yr Baseline (ac ft)	100-yr Proposed (ac ft)	100-yr Gain or Loss (ac ft)	SPF Baseline (ac ft)	SPF Proposed (ac ft)	SPF Gain or Loss (ac ft)
East First to Riverside Drive	206218	222998	9721.3	9721.3	0.0	17838.0	17838.0	0.0
Riverside Drive to Highway 121	222998	231100	2877.5	2877.5	-0.1	5343.6	5343.6	0.0
Highway 121 to U/S Samuels Dam	231100	241255	2982.3	3733.1	750.8	5393.6	6262.6	869.0
U/S Samuels Dam to Bypass Outlet	241255	245866	823.7	850.2	26.5	1834.8	1891.9	57.1
Bypass Rejoin to Confluence	245866	254346	1377.9	Interior	-1377.9	2871.4	Interior	-2871.4
Current Confluence to New Confluence	254346	257026	402.2	Interior	-402.2	876.6	Interior	-876.6
New Confluence to FWRR	257026	257557	78.2	52.6	-25.6	165.7	150.6	-15.2
FWRR to University Drive	257557	262497	942.6	794.4	-148.2	2413.4	1827.8	-585.6
Univeristy Drive to Above Riverbend	262497	283400	4707.5	4633.6	-73.9	9541.4	8898.6	-642.8
Riverbend/Rivercrest mitigation area			Not there	1718.0	1718.0	Not there	3246.0	3246.0
Upper West Fork above Riverbend	283400	306246	3435.2	3434.2	-1.0	6460.0	6386.7	-73.3
Clear Fork below Bypass	0	3465	442.8	Interior	-442.8	1238.6	Interior	-1238.6
Clear Fork above start of Bypass	3465	65616	5957.4	5854.6	-102.8	22590.0	22549.0	-41.0
Lower Bypass	0	3656	Not there	539.8	539.8	Not there	1001.6	1001.6
Upper Bypass	3656	8421	Not there	504.0	504.0	Not there	1132.2	1132.2
Total			33748.6	34713.1	964.5	76567.1	76528.6	-38.5

Baseline = Fort Worth Central City Model
Proposed = Proposed Project

Table 3-2: Water Surface Elevations - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Water Surface Elevation (ft)			Reach	River Station	Water Surface Elevation (ft)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
cf	3590	539.40	537.95	-1.45	cf	3590	552.10	551.85	-0.25
cf	3803	539.42	538.02	-1.40	cf	3803	552.11	551.92	-0.19
cf	4057	539.67	538.39	-1.28	cf	4057	552.24	552.17	-0.07
cf	4267	539.56	538.24	-1.32	cf	4267	552.20	552.14	-0.06
cf	4371	539.58	538.25	-1.33	cf	4371	552.28	552.21	-0.07
cf	4372	539.58	538.25	-1.33	cf	4372	552.28	552.21	-0.07
cf	4402				cf	4402			
cf	4433	539.70	538.42	-1.28	cf	4433	552.41	552.34	-0.07
cf	4535	539.81	538.58	-1.23	cf	4535	552.42	552.35	-0.07
cf	5170	540.16	539.10	-1.06	cf	5170	552.34	552.27	-0.07
cf	5990	541.25	540.41	-0.84	cf	5990	553.59	553.53	-0.06
cf	6101	541.13	540.24	-0.89	cf	6101	553.60	553.54	-0.06
cf	6102	541.13	540.25	-0.88	cf	6102	553.60	553.54	-0.06
cf	6130				cf	6130			
cf	6158	541.19	540.32	-0.87	cf	6158	553.63	553.57	-0.06
cf	6258	541.58	540.82	-0.76	cf	6258	553.76	553.70	-0.06
cf	6656	541.65	540.93	-0.72	cf	6656	553.70	553.64	-0.06
cf	6707	541.53	540.79	-0.74	cf	6707	553.68	553.62	-0.06
cf	6757	541.64	540.94	-0.70	cf	6757	553.70	553.64	-0.06
cf	7400	541.92	541.31	-0.61	cf	7400	553.80	553.74	-0.06
cf	8073	542.68	542.15	-0.53	cf	8073	554.25	554.19	-0.06
cf	8178	542.72	542.20	-0.52	cf	8178	554.06	554.01	-0.05
cf	8179	542.72	542.20	-0.52	cf	8179	554.07	554.01	-0.06
cf	8189				cf	8189			
cf	8200	542.92	542.43	-0.49	cf	8200	554.32	554.26	-0.06
cf	8243	542.52	541.97	-0.55	cf	8243	554.67	554.62	-0.05
cf	8293	543.51	543.09	-0.42	cf	8293	554.62	554.56	-0.06
cf	9045	544.57	544.22	-0.35	cf	9045	554.99	554.94	-0.05
cf	9515	544.92	544.59	-0.33	cf	9515	555.19	555.15	-0.04
cf	9566	544.60	544.25	-0.35	cf	9566	555.17	555.12	-0.05
cf	9614	545.18	544.87	-0.31	cf	9614	555.29	555.25	-0.04
cf	10175	545.45	545.15	-0.30	cf	10175	555.50	555.46	-0.04
cf	10906	545.78	545.50	-0.28	cf	10906	555.74	555.70	-0.04
cf	10956	545.22	544.90	-0.32	cf	10956	555.55	555.50	-0.05
cf	11006	546.16	545.90	-0.26	cf	11006	555.83	555.79	-0.04
cf	11918	546.55	546.32	-0.23	cf	11918	555.87	555.83	-0.04
cf	12019	546.70	546.47	-0.23	cf	12019	556.21	556.18	-0.03
cf	12020	546.70	546.47	-0.23	cf	12020	556.22	556.18	-0.04
cf	12075				cf	12075			
cf	12130	546.89	546.67	-0.22	cf	12130	556.54	556.51	-0.03
cf	12131	546.89	546.67	-0.22	cf	12131	556.37	556.34	-0.03
cf	12261	546.90	546.68	-0.22	cf	12261	556.42	556.39	-0.03
cf	12262	546.90	546.68	-0.22	cf	12262	556.42	556.39	-0.03
cf	12287				cf	12287			
cf	12313	547.17	546.96	-0.21	cf	12313	556.94	556.91	-0.03
cf	12411	547.29	547.08	-0.21	cf	12411	557.18	557.16	-0.02
cf	12541	547.40	547.20	-0.20	cf	12541	557.47	557.44	-0.03
cf	12565	547.71	547.52	-0.19	cf	12565	557.83	557.81	-0.02
cf	12616				cf	12616			
cf	12626	551.96	551.94	-0.02	cf	12626	558.72	558.71	-0.01
cf	12665	551.95	551.93	-0.02	cf	12665	558.60	558.59	-0.01
cf	12688	551.94	551.92	-0.02	cf	12688	558.53	558.52	-0.01
cf	12704		0.00		cf	12704		0.00	
cf	12719	552.13	552.11	-0.02	cf	12719	558.94	558.93	-0.01
cf	12765	552.09	552.08	-0.01	cf	12765	558.99	558.98	-0.01
cf	12766	552.09	552.08	-0.01	cf	12766	559.12	559.10	-0.02
cf	12826				cf	12826			
cf	12886	552.32	552.30	-0.02	cf	12886	559.47	559.46	-0.01
cf	12887	552.32	552.30	-0.02	cf	12887	559.47	559.46	-0.01
cf	12988	552.36	552.35	-0.01	cf	12988	560.60	560.58	-0.02
cf	13376	552.64	552.63	-0.01	cf	13376	560.98	560.97	-0.01
cf	13381	552.65	552.63	-0.02	cf	13381	560.99	560.98	-0.01
cf	13386				cf	13386			
cf	13396	552.70	552.69	-0.01	cf	13396	561.17	561.16	-0.01
cf	14297	553.71	553.70	-0.01	cf	14297	561.72	561.72	0.00
cf	14949	554.13	554.12	-0.01	cf	14949	562.17	562.16	-0.01
cf	15442	554.52	554.51	-0.01	cf	15442	562.92	562.92	0.00
cf	15613	554.64	554.63	-0.01	cf	15613	562.76	562.76	0.00

Table 3-2: Water Surface Elevations - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Water Surface Elevation (ft)			Reach	River Station	Water Surface Elevation (ft)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
cf	15948	555.22	555.21	-0.01	cf	15948	563.67	563.66	-0.01
cf	16054	555.27	555.26	-0.01	cf	16054	563.61	563.60	-0.01
cf	16078				cf	16078			
cf	16100	555.33	555.32	-0.01	cf	16100	563.81	563.81	0.00
cf	16120	555.26	555.25	-0.01	cf	16120	563.69	563.69	0.00
cf	16140		0.00		cf	16140		0.00	
cf	16161	555.33	555.32	-0.01	cf	16161	563.92	563.92	0.00
cf	16268	555.36	555.35	-0.01	cf	16268	564.23	564.23	0.00
cf	16547	555.36	555.35	-0.01	cf	16547	564.10	564.09	-0.01
cf	16746	555.58	555.57	-0.01	cf	16746	564.61	564.61	0.00
cf	17057	555.65	555.64	-0.01	cf	17057	564.57	564.56	-0.01
cf	17161	556.08	556.07	-0.01	cf	17161	564.59	564.58	-0.01
cf	17162	556.08	556.07	-0.01	cf	17162	564.59	564.59	0.00
cf	17184				cf	17184			
cf	17206	556.21	556.20	-0.01	cf	17206	565.15	565.15	0.00
cf	17302	556.28	556.27	-0.01	cf	17302	565.41	565.41	0.00
cf	17746	556.85	556.84	-0.01	cf	17746	565.72	565.72	0.00
cf	18275	557.13	557.13	0.00	cf	18275	565.87	565.87	0.00
cf	18867	557.67	557.67	0.00	cf	18867	566.07	566.07	0.00
cf	19645	558.53	558.53	0.00	cf	19645	567.22	567.22	0.00
cf	20351	559.29	559.29	0.00	cf	20351	568.32	568.32	0.00
cf	21239	560.31	560.31	0.00	cf	21239	570.01	570.01	0.00
cf	21279	560.02	560.02	0.00	cf	21279	569.67	569.66	-0.01
cf	21329	560.49	560.49	0.00	cf	21329	570.14	570.14	0.00
cf	21844	561.11	561.11	0.00	cf	21844	570.85	570.84	-0.01
cf	22604	562.20	562.20	0.00	cf	22604	572.11	572.11	0.00
cf	23535	563.58	563.58	0.00	cf	23535	573.72	573.72	0.00
cf	24198	564.72	564.72	0.00	cf	24198	575.02	575.02	0.00
cf	24297	565.43	565.43	0.00	cf	24297	576.12	576.12	0.00
cf	24298	565.43	565.43	0.00	cf	24298	576.13	576.13	0.00
cf	24326				cf	24326			
cf	24355	565.58	565.58	0.00	cf	24355	576.31	576.31	0.00
cf	24456	565.45	565.45	0.00	cf	24456	576.00	576.00	0.00
cf	25321	566.88	566.88	0.00	cf	25321	577.29	577.29	0.00
cf	25371	566.93	566.93	0.00	cf	25371	577.51	577.51	0.00
cf	25421	567.17	567.17	0.00	cf	25421	577.86	577.86	0.00
cf	26300	567.99	567.99	0.00	cf	26300	578.79	578.79	0.00
cf	27364	569.33	569.33	0.00	cf	27364	579.95	579.95	0.00
cf	28689	571.65	571.65	0.00	cf	28689	582.40	582.40	0.00
cf	29435	572.83	572.83	0.00	cf	29435	585.13	585.13	0.00
cf	29485	572.70	572.70	0.00	cf	29485	585.20	585.20	0.00
cf	29535	573.30	573.30	0.00	cf	29535	585.59	585.59	0.00
cf	29613	573.35	573.35	0.00	cf	29613	585.10	585.10	0.00
cf	29638	571.67	571.67	0.00	cf	29638	584.38	584.38	0.00
cf	29663	574.71	574.71	0.00	cf	29663	586.56	586.56	0.00
cf	30174	576.01	576.01	0.00	cf	30174	587.25	587.25	0.00
cf	30913	577.14	577.14	0.00	cf	30913	587.83	587.83	0.00
cf	31770	578.47	578.47	0.00	cf	31770	589.02	589.02	0.00
cf	32371	579.68	579.68	0.00	cf	32371	590.11	590.11	0.00
cf	32940	580.42	580.42	0.00	cf	32940	590.11	590.11	0.00
cf	33577	581.58	581.58	0.00	cf	33577	591.32	591.32	0.00
cf	34116	582.55	582.55	0.00	cf	34116	592.43	592.43	0.00
cf	34699	584.08	584.08	0.00	cf	34699	594.61	594.61	0.00
cf	34814	583.37	583.37	0.00	cf	34814	593.47	593.47	0.00
cf	34830				cf	34830			
cf	34846	584.32	584.32	0.00	cf	34846	594.81	594.81	0.00
cf	34878	584.56	584.56	0.00	cf	34878	595.15	595.15	0.00
cf	34897				cf	34897			
cf	34915	585.15	585.15	0.00	cf	34915	595.77	595.77	0.00
cf	34957	586.30	586.30	0.00	cf	34957	597.89	597.89	0.00
cf	35016	585.91	585.91	0.00	cf	35016	598.03	598.03	0.00
cf	35076	586.56	586.56	0.00	cf	35076	598.27	598.27	0.00
cf	35519	587.40	587.40	0.00	cf	35519	598.56	598.56	0.00
cf	35969	587.87	587.87	0.00	cf	35969	598.78	598.78	0.00
cf	36466	588.65	588.65	0.00	cf	36466	599.07	599.07	0.00
cf	37449	590.00	590.00	0.00	cf	37449	600.04	600.04	0.00
cf	38091	590.61	590.61	0.00	cf	38091	600.28	600.28	0.00
cf	38738	591.15	591.15	0.00	cf	38738	600.67	600.67	0.00

Table 3-2: Water Surface Elevations - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Water Surface Elevation (ft)			Reach	River Station	Water Surface Elevation (ft)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
cf	39023	592.16	592.16	0.00	cf	39023	601.88	601.88	0.00
cf	39056	593.81	593.81	0.00	cf	39056	600.69	600.69	0.00
cf	39068	594.87	594.87	0.00	cf	39068	601.76	601.76	0.00
cf	39101	597.35	597.35	0.00	cf	39101	607.10	607.10	0.00
cf	39380	597.59	597.59	0.00	cf	39380	606.93	606.93	0.00
cf	39879	598.00	598.00	0.00	cf	39879	607.73	607.73	0.00
cf	39977	597.98	597.98	0.00	cf	39977	607.46	607.46	0.00
cf	40021				cf	40021			
cf	40064	598.12	598.12	0.00	cf	40064	607.64	607.64	0.00
cf	40178	597.99	597.99	0.00	cf	40178	607.63	607.63	0.00
cf	41045	600.82	600.82	0.00	cf	41045	611.05	611.05	0.00
cf	43324	609.67	609.67	0.00	cf	43324	615.14	615.14	0.00
cf	44342	610.87	610.87	0.00	cf	44342	616.16	616.16	0.00
cf	45015	611.41	611.41	0.00	cf	45015	618.34	618.34	0.00
cf	45544	612.12	612.12	0.00	cf	45544	620.22	620.22	0.00
cf	46175	612.67	612.67	0.00	cf	46175	621.30	621.30	0.00
cf	46489	612.67	612.67	0.00	cf	46489	621.08	621.08	0.00
cf	46490	612.67	612.67	0.00	cf	46490	621.09	621.09	0.00
cf	46550				cf	46550			
cf	46610	612.86	612.86	0.00	cf	46610	622.77	622.77	0.00
cf	46611	612.86	612.86	0.00	cf	46611	622.77	622.77	0.00
cf	46736	612.98	612.98	0.00	cf	46736	624.37	624.37	0.00
cf	49420	615.79	615.79	0.00	cf	49420	627.62	627.62	0.00
cf	50598	617.49	617.49	0.00	cf	50598	628.32	628.32	0.00
cf	51599	618.70	618.70	0.00	cf	51599	628.88	628.88	0.00
cf	52140	619.18	619.18	0.00	cf	52140	629.09	629.09	0.00
cf	52192	619.18	619.18	0.00	cf	52192	629.13	629.13	0.00
cf	52242	619.27	619.27	0.00	cf	52242	629.15	629.15	0.00
cf	53352	620.36	620.36	0.00	cf	53352	629.79	629.79	0.00
cf	53901	621.18	621.18	0.00	cf	53901	630.46	630.46	0.00
cf	54806	622.40	622.40	0.00	cf	54806	631.30	631.30	0.00
cf	57021	624.63	624.63	0.00	cf	57021	632.64	632.64	0.00
cf	58850	626.97	626.97	0.00	cf	58850	634.00	634.00	0.00
cf	60451	630.15	630.15	0.00	cf	60451	635.56	635.56	0.00
cf	61472	631.00	631.00	0.00	cf	61472	636.28	636.28	0.00
cf	62405	631.00	631.00	0.00	cf	62405	636.28	636.28	0.00
cf	62953	631.00	631.00	0.00	cf	62953	636.28	636.28	0.00
cf	64380	631.00	631.00	0.00	cf	64380	636.28	636.28	0.00
cf	65344	631.00	631.00	0.00	cf	65344	636.28	636.28	0.00
cf	65616	631.00	631.00	0.00	cf	65616	636.28	636.28	0.00
wf3	206218	511.83	511.83	0.00	wf3	206218	519.72	519.72	0.00
wf3	206314	511.87	511.87	0.00	wf3	206314	519.80	519.80	0.00
wf3	206327				wf3	206327			
wf3	206340	512.16	512.16	0.00	wf3	206340	519.93	519.93	0.00
wf3	206439	512.12	512.12	0.00	wf3	206439	519.90	519.90	0.00
wf3	208797	512.92	512.92	0.00	wf3	208797	520.38	520.38	0.00
wf3	209288	513.08	513.08	0.00	wf3	209288	520.57	520.57	0.00
wf3	209960	513.30	513.30	0.00	wf3	209960	520.82	520.82	0.00
wf3	210574	513.91	513.91	0.00	wf3	210574	521.16	521.16	0.00
wf3	211133	514.30	514.30	0.00	wf3	211133	521.50	521.50	0.00
wf3	212018	514.97	514.97	0.00	wf3	212018	521.98	521.98	0.00
wf3	213435	516.09	516.09	0.00	wf3	213435	523.04	523.04	0.00
wf3	214788	517.08	517.08	0.00	wf3	214788	523.98	523.98	0.00
wf3	214946	517.21	517.21	0.00	wf3	214946	524.16	524.16	0.00
wf3	215762	517.65	517.65	0.00	wf3	215762	524.66	524.66	0.00
wf3	217369	518.59	518.59	0.00	wf3	217369	525.45	525.45	0.00
wf3	217981	518.60	518.60	0.00	wf3	217981	525.40	525.40	0.00
wf3	217982	518.53	518.53	0.00	wf3	217982	525.37	525.37	0.00
wf3	217999	518.54	518.54	0.00	wf3	217999	525.38	525.38	0.00
wf3	218000	518.74	518.74	0.00	wf3	218000	525.47	525.47	0.00
wf3	218384	518.75	518.75	0.00	wf3	218384	525.38	525.38	0.00
wf3	218496	518.73	518.73	0.00	wf3	218496	525.34	525.34	0.00
wf3	218528				wf3	218528			
wf3	218560	519.04	519.04	0.00	wf3	218560	526.66	526.66	0.00
wf3	218677	519.39	519.39	0.00	wf3	218677	527.08	527.08	0.00
wf3	219536	519.51	519.51	0.00	wf3	219536	527.28	527.28	0.00
wf3	220594	519.70	519.70	0.00	wf3	220594	527.48	527.48	0.00
wf3	221044	519.72	519.72	0.00	wf3	221044	527.52	527.52	0.00

Table 3-2: Water Surface Elevations - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Water Surface Elevation (ft)			Reach	River Station	Water Surface Elevation (ft)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
wf3	221650	519.73	519.73	0.00	wf3	221650	527.53	527.53	0.00
wf3	222503	519.77	519.77	0.00	wf3	222503	527.49	527.49	0.00
wf3	222789	519.76	519.76	0.00	wf3	222789	527.50	527.50	0.00
wf3	222896	519.43	519.43	0.00	wf3	222896	526.75	526.75	0.00
wf3	222897	519.43	519.43	0.00	wf3	222897	526.75	526.75	0.00
wf3	222947				wf3	222947			
wf3	222998	520.07	520.07	0.00	wf3	222998	527.78	527.78	0.00
wf3	223089	520.23	520.23	0.00	wf3	223089	528.16	528.16	0.00
wf3	223377	520.35	520.35	0.00	wf3	223377	528.48	528.48	0.00
wf3	223820	520.75	520.75	0.00	wf3	223820	529.21	529.21	0.00
wf3	224594	520.86	520.86	0.00	wf3	224594	529.32	529.32	0.00
wf3	225271	520.94	520.94	0.00	wf3	225271	529.43	529.43	0.00
wf3	225658	520.94	520.94	0.00	wf3	225658	529.40	529.40	0.00
wf3	225923	520.95	520.95	0.00	wf3	225923	529.44	529.44	0.00
wf3	226962	521.04	521.04	0.00	wf3	226962	529.58	529.58	0.00
wf3	227288	521.07	521.07	0.00	wf3	227288	529.61	529.61	0.00
wf3	227980	521.07	521.07	0.00	wf3	227980	529.63	529.63	0.00
wf3	228084	520.99	520.99	0.00	wf3	228084	529.28	529.28	0.00
wf3	228085	520.99	520.99	0.00	wf3	228085	529.28	529.28	0.00
wf3	228095				wf3	228095			
wf3	228105	521.04	521.04	0.00	wf3	228105	529.50	529.50	0.00
wf3	228106	521.04	521.04	0.00	wf3	228106	529.50	529.50	0.00
wf3	228208	521.15	521.15	0.00	wf3	228208	529.88	529.88	0.00
wf3	228755	521.22	521.22	0.00	wf3	228755	530.03	530.03	0.00
wf3	229360	521.37	521.37	0.00	wf3	229360	530.24	530.24	0.00
wf3	229394	521.38	521.38	0.00	wf3	229394	530.22	530.22	0.00
wf3	229412	521.04	521.04	0.00	wf3	229412	529.55	529.55	0.00
wf3	229428	521.05	521.05	0.00	wf3	229428	529.57	529.57	0.00
wf3	229429	521.61	521.61	0.00	wf3	229429	530.70	530.70	0.00
wf3	229462	521.63	521.63	0.00	wf3	229462	530.70	530.70	0.00
wf3	229463	521.63	521.63	0.00	wf3	229463	530.70	530.70	0.00
wf3	229494				wf3	229494			
wf3	229526	521.67	521.67	0.00	wf3	229526	530.89	530.89	0.00
wf3	229527	521.67	521.67	0.00	wf3	229527	530.89	530.89	0.00
wf3	229630	521.69	521.69	0.00	wf3	229630	530.97	530.97	0.00
wf3	230254	521.84	521.84	0.00	wf3	230254	531.39	531.39	0.00
wf3	230852	521.98	521.98	0.00	wf3	230852	531.80	531.80	0.00
wf3	230949	521.99	521.99	0.00	wf3	230949	531.82	531.82	0.00
wf3	230950	521.99	521.99	0.00	wf3	230950	531.82	531.82	0.00
wf3	231025				wf3	231025			
wf3	231100	522.04	522.04	0.00	wf3	231100	531.99	531.99	0.00
wf3	231101	522.04	522.04	0.00	wf3	231101	531.99	531.99	0.00
wf3	231188	522.07	522.07	0.00	wf3	231188	532.03	532.03	0.00
wf3	231242	522.00	522.00	0.00	wf3	231242	531.88	531.88	0.00
wf3	231291	521.96	521.96	0.00	wf3	231291	531.79	531.79	0.00
wf3	231292	521.96	521.96	0.00	wf3	231292	531.79	531.79	0.00
wf3	231316				wf3	231316			
wf3	231340	522.05	522.05	0.00	wf3	231340	531.99	531.99	0.00
wf3	231341	522.05	522.05	0.00	wf3	231341	531.99	531.99	0.00
wf3	231452	522.26	522.26	0.00	wf3	231452	532.48	532.48	0.00
wf3	232217	522.22	522.22	0.00	wf3	232217	532.40	532.40	0.00
wf3	233091	522.50	522.50	0.00	wf3	233091	533.04	533.04	0.00
wf3	233994	522.61	522.61	0.00	wf3	233994	533.29	533.29	0.00
wf3	234857	522.66	522.66	0.00	wf3	234857	533.42	533.38	-0.04
wf3	235192	522.71	522.71	0.00	wf3	235192	533.54	533.49	-0.05
wf3	235296	522.67	522.67	0.00	wf3	235296	533.43	533.41	-0.02
wf3	235297	522.67	522.67	0.00	wf3	235297	533.43	533.42	-0.01
wf3	235354				wf3	235354			
wf3	235412	522.71	522.71	0.00	wf3	235412	533.49	533.48	-0.01
wf3	235413	522.71	522.71	0.00	wf3	235413	533.49	533.48	-0.01
wf3	235522	522.69	522.69	0.00	wf3	235522	533.48	533.53	0.05
wf3	236729	522.91	522.94	0.03	wf3	236729	533.92	533.99	0.07
wf3	237615	522.88	522.91	0.03	wf3	237615	533.85	533.90	0.05
wf3	238288	522.92	522.86	-0.06	wf3	238288	533.98	534.00	0.02
wf3	238390	523.08	523.01	-0.07	wf3	238390	534.16	534.11	-0.05
wf3	238391	523.08	523.01	-0.07	wf3	238391	534.16	534.11	-0.05
wf3	238401				wf3	238401			
wf3	238411	523.11	523.03	-0.08	wf3	238411	534.20	534.16	-0.04

Table 3-2: Water Surface Elevations - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Water Surface Elevation (ft)			Reach	River Station	Water Surface Elevation (ft)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
wf3	238412	523.11	523.03	-0.08	wf3	238412	534.20	534.16	-0.04
wf3	238508	522.99	522.90	-0.09	wf3	238508	534.07	534.08	0.01
wf3	238751	523.00	522.90	-0.10	wf3	238751	533.97	533.97	0.00
wf3	239095	523.20	523.10	-0.10	wf3	239095	533.97	533.86	-0.11
wf3	239197	523.27	523.16	-0.11	wf3	239197	534.09	533.96	-0.13
wf3	239198	523.27	523.16	-0.11	wf3	239198	534.09	533.96	-0.13
wf3	239229				wf3	239229			
wf3	239261	523.33	523.22	-0.11	wf3	239261	534.19	534.05	-0.14
wf3	239262	523.33	523.22	-0.11	wf3	239262	534.19	534.05	-0.14
wf3	239369	523.35	523.42	0.07	wf3	239369	534.35	534.36	0.01
wf3	239744	523.49	523.48	-0.01	wf3	239744	534.71	534.63	-0.08
wf3	240517	523.68	523.74	0.06	wf3	240517	535.12	535.24	0.12
wf3	241255	523.81	523.83	0.02	wf3	241255	535.34	535.34	0.00
wf3	241708	523.90	523.89	-0.01	wf3	241708	535.36	535.33	-0.03
wf3	241811	523.77	523.69	-0.08	wf3	241811	535.15	534.87	-0.28
wf3	241812	523.77	523.69	-0.08	wf3	241812	535.15	534.87	-0.28
wf3	241825				wf3	241825			
wf3	241838	523.95	523.87	-0.08	wf3	241838	535.83	535.55	-0.28
wf3	241839	523.95	523.87	-0.08	wf3	241839	535.84	535.56	-0.28
wf3	241926	523.95	523.87	-0.08	wf3	241926	535.80	535.52	-0.28
wf3	241927	523.95	523.87	-0.08	wf3	241927	535.80	535.52	-0.28
wf3	241937				wf3	241937			
wf3	241947	524.01	523.93	-0.08	wf3	241947	536.16	535.85	-0.31
wf3	241948	524.01	523.93	-0.08	wf3	241948	536.17	535.86	-0.31
wf3	242099	524.30	524.22	-0.08	wf3	242099	536.55	536.25	-0.30
wf3	242100	524.30	524.22	-0.08	wf3	242100	536.55	536.25	-0.30
wf3	242110				wf3	242110			
wf3	242120	524.36	524.29	-0.07	wf3	242120	536.73	536.43	-0.30
wf3	242121	524.36	524.29	-0.07	wf3	242121	536.73	536.43	-0.30
wf3	242222	524.36	524.28	-0.08	wf3	242222	536.83	536.53	-0.30
wf3	242259	524.32	524.24	-0.08	wf3	242259	536.76	536.46	-0.30
wf3	242318	524.40	524.32	-0.08	wf3	242318	536.55	536.25	-0.30
wf3	242340				wf3	242340			
wf3	242363	524.67	524.60	-0.07	wf3	242363	536.86	536.59	-0.27
wf3	242451	524.71	524.64	-0.07	wf3	242451	537.56	537.30	-0.26
wf3	242813	524.99	524.92	-0.07	wf3	242813	537.87	537.62	-0.25
wf3	243471	525.06	524.99	-0.07	wf3	243471	537.71	537.46	-0.25
wf3	243785	525.26	525.19	-0.07	wf3	243785	537.72	537.47	-0.25
wf3	244635	525.56	525.49	-0.07	wf3	244635	538.05	537.82	-0.23
wf3	244735	525.64	525.58	-0.06	wf3	244735	538.17	537.94	-0.23
wf3	244736	525.64	525.58	-0.06	wf3	244736	538.17	537.94	-0.23
wf3	244766				wf3	244766			
wf3	244797	525.77	525.70	-0.07	wf3	244797	538.37	538.14	-0.23
wf3	244798	525.77	525.70	-0.07	wf3	244798	538.37	538.15	-0.22
wf3	244898	525.86	525.79	-0.07	wf3	244898	538.45	538.23	-0.22
wf4	257426	538.01	528.26	-9.75	wf4	257426	551.20	545.70	-5.50
wf4	257535	538.06	533.40	-4.66	wf4	257535	551.20	545.71	-5.49
wf4	257536	538.06	533.41	-4.65	wf4	257536	551.20	545.71	-5.49
wf4	257546				wf4	257546			
wf4	257557	538.21	534.24	-3.97	wf4	257557	551.39	545.87	-5.52
wf4	257654	538.33	535.72	-2.61	wf4	257654	551.42	546.45	-4.97
wf4	258103	539.02	535.96	-3.06	wf4	258103	551.74	546.59	-5.15
wf4	258678	539.00	535.92	-3.08	wf4	258678	551.74	546.56	-5.18
wf4	259003	538.98	535.92	-3.06	wf4	259003	551.71	546.55	-5.16
wf4	259337	538.97	535.96	-3.01	wf4	259337	551.61	546.42	-5.19
wf4	259463	538.57	535.36	-3.21	wf4	259463	551.29	546.09	-5.20
wf4	259501				wf4	259501			
wf4	259538	538.93	536.31	-2.62	wf4	259538	551.49	546.43	-5.06
wf4	259657	539.69	537.88	-1.81	wf4	259657	551.77	547.18	-4.59
wf4	260385	540.62	539.05	-1.57	wf4	260385	552.69	548.52	-4.17
wf4	261002	540.70	539.20	-1.50	wf4	261002	552.77	548.71	-4.06
wf4	262394	540.55	539.65	-0.90	wf4	262394	552.90	548.76	-4.14
wf4	262497	540.64	539.74	-0.90	wf4	262497	552.89	549.24	-3.65
wf4	262548				wf4	262548			
wf4	262599	541.38	540.17	-1.21	wf4	262599	553.04	551.21	-1.83
wf4	262705	542.07	541.48	-0.59	wf4	262705	553.01	551.47	-1.54
wf4	263531	542.78	542.19	-0.59	wf4	263531	553.23	551.93	-1.30
wf4	264804	542.87	542.64	-0.23	wf4	264804	553.26	552.00	-1.26

Table 3-2: Water Surface Elevations - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Water Surface Elevation (ft)			Reach	River Station	Water Surface Elevation (ft)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
wf4	266213	542.95	542.88	-0.07	wf4	266213	553.28	552.02	-1.26
wf4	267221	542.97	542.89	-0.08	wf4	267221	553.24	551.97	-1.27
wf4	268190	543.46	543.39	-0.07	wf4	268190	553.42	552.21	-1.21
wf4	269070	543.75	543.68	-0.07	wf4	269070	553.63	552.44	-1.19
wf4	269743	544.01	543.95	-0.06	wf4	269743	553.73	552.57	-1.16
wf4	270249	544.07	544.01	-0.06	wf4	270249	553.74	552.58	-1.16
wf4	270730	544.49	544.44	-0.05	wf4	270730	553.90	552.77	-1.13
wf4	271402	544.49	544.44	-0.05	wf4	271402	553.83	552.70	-1.13
wf4	271794	544.71	544.66	-0.05	wf4	271794	553.93	552.82	-1.11
wf4	272377	544.89	544.84	-0.05	wf4	272377	554.07	552.98	-1.09
wf4	273102	544.67	544.62	-0.05	wf4	273102	554.00	552.89	-1.11
wf4	273902	545.43	545.39	-0.04	wf4	273902	554.32	553.28	-1.04
wf4	274754	546.23	546.19	-0.04	wf4	274754	554.75	553.79	-0.96
wf4	275461	546.20	546.17	-0.03	wf4	275461	554.52	553.55	-0.97
wf4	275969	546.90	546.87	-0.03	wf4	275969	555.05	554.18	-0.87
wf4	276325	547.08	547.05	-0.03	wf4	276325	555.19	554.34	-0.85
wf4	276562	547.38	547.36	-0.02	wf4	276562	555.62	554.82	-0.80
wf4	276627				wf4	276627			
wf4	276692	547.74	547.71	-0.03	wf4	276692	555.91	555.12	-0.79
wf4	276853	547.80	547.77	-0.03	wf4	276853	555.92	555.13	-0.79
wf4	277391	548.43	548.41	-0.02	wf4	277391	556.57	555.84	-0.73
wf4	278130	548.81	548.79	-0.02	wf4	278130	556.90	556.23	-0.67
wf4	279002	549.20	549.18	-0.02	wf4	279002	557.30	556.65	-0.65
wf4	280042	549.68	549.66	-0.02	wf4	280042	557.56	556.95	-0.61
wf4	281199	550.28	550.27	-0.01	wf4	281199	558.08	557.53	-0.55
wf4	281771	551.02	551.01	-0.01	wf4	281771	558.97	558.47	-0.50
wf4	281820	551.05	551.04	-0.01	wf4	281820	559.11	558.61	-0.50
wf4	281821	551.20	551.18	-0.02	wf4	281821	559.15	558.66	-0.49
wf4	281831	551.21	551.19	-0.02	wf4	281831	559.26	558.77	-0.49
wf4	281832	551.27	551.26	-0.01	wf4	281832	559.24	558.75	-0.49
wf4	281871	551.28	551.27	-0.01	wf4	281871	559.25	558.76	-0.49
wf4	282801	551.17	551.15	-0.02	wf4	282801	559.03	558.54	-0.49
wf4	283400	551.68	551.67	-0.01	wf4	283400	559.51	559.05	-0.46
wf4	283853	551.97	551.95	-0.02	wf4	283853	559.82	559.38	-0.44
wf4	284944	552.84	552.83	-0.01	wf4	284944	560.65	560.26	-0.39
wf4	285970	553.46	553.45	-0.01	wf4	285970	561.23	560.87	-0.36
wf4	286710	553.81	553.80	-0.01	wf4	286710	561.53	561.19	-0.34
wf4	286808	553.91	553.90	-0.01	wf4	286808	561.50	561.17	-0.33
wf4	286844				wf4	286844			
wf4	286880	554.08	554.07	-0.01	wf4	286880	561.73	561.40	-0.33
wf4	286976	554.17	554.16	-0.01	wf4	286976	562.05	561.72	-0.33
wf4	287615	554.54	554.53	-0.01	wf4	287615	562.51	562.20	-0.31
wf4	288475	555.19	555.18	-0.01	wf4	288475	562.95	562.66	-0.29
wf4	289136	555.55	555.54	-0.01	wf4	289136	563.39	563.12	-0.27
wf4	289236	555.40	555.40	0.00	wf4	289236	563.03	562.75	-0.28
wf4	289275				wf4	289275			
wf4	289313	555.58	555.57	-0.01	wf4	289313	563.25	562.98	-0.27
wf4	289379	555.77	555.76	-0.01	wf4	289379	563.67	563.40	-0.27
wf4	289428	555.79	555.79	0.00	wf4	289428	563.70	563.43	-0.27
wf4	289429	555.81	555.80	-0.01	wf4	289429	563.84	563.58	-0.26
wf4	289441	555.82	555.81	-0.01	wf4	289441	563.85	563.59	-0.26
wf4	289442	555.81	555.81	0.00	wf4	289442	563.81	563.55	-0.26
wf4	289479	555.84	555.83	-0.01	wf4	289479	563.83	563.57	-0.26
wf4	290271	556.32	556.32	0.00	wf4	290271	564.35	564.11	-0.24
wf4	291282	556.98	556.98	0.00	wf4	291282	565.36	565.14	-0.22
wf4	291834	557.27	557.27	0.00	wf4	291834	565.15	564.93	-0.22
wf4	292711	557.81	557.80	-0.01	wf4	292711	565.64	565.43	-0.21
wf4	293499	558.51	558.51	0.00	wf4	293499	566.42	566.23	-0.19
wf4	293600	558.35	558.34	-0.01	wf4	293600	566.10	565.90	-0.20
wf4	293621				wf4	293621			
wf4	293642	558.46	558.46	0.00	wf4	293642	566.18	565.98	-0.20
wf4	293744	558.89	558.88	-0.01	wf4	293744	566.91	566.73	-0.18
wf4	294211	559.14	559.13	-0.01	wf4	294211	566.92	566.75	-0.17
wf4	295195	559.56	559.55	-0.01	wf4	295195	567.16	566.99	-0.17
wf4	296125	560.18	560.17	-0.01	wf4	296125	567.76	567.61	-0.15
wf4	296992	560.68	560.68	0.00	wf4	296992	568.03	567.89	-0.14
wf4	297107	560.87	560.87	0.00	wf4	297107	568.06	567.91	-0.15
wf4	297127				wf4	297127			

Table 3-2: Water Surface Elevations - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Water Surface Elevation (ft)			Reach	River Station	Water Surface Elevation (ft)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
wf4	297146	560.96	560.95	-0.01	wf4	297146	568.16	568.02	-0.14
wf4	297265	561.01	561.00	-0.01	wf4	297265	568.37	568.24	-0.13
wf4	297822	561.42	561.42	0.00	wf4	297822	569.07	568.94	-0.13
wf4	298198	561.60	561.59	-0.01	wf4	298198	569.19	569.05	-0.14
wf4	298248	561.63	561.63	0.00	wf4	298248	569.20	569.07	-0.13
wf4	298249	561.22	561.22	0.00	wf4	298249	569.18	569.04	-0.14
wf4	298259	561.24	561.24	0.00	wf4	298259	569.18	569.05	-0.13
wf4	298260	561.39	561.38	-0.01	wf4	298260	569.17	569.03	-0.14
wf4	298300	561.56	561.56	0.00	wf4	298300	569.38	569.25	-0.13
wf4	298645	562.50	562.50	0.00	wf4	298645	569.60	569.48	-0.12
wf4	299489	563.66	563.66	0.00	wf4	299489	570.18	570.08	-0.10
wf4	299539	563.72	563.72	0.00	wf4	299539	570.21	570.11	-0.10
wf4	299540	563.71	563.71	0.00	wf4	299540	570.22	570.12	-0.10
wf4	299545	563.72	563.72	0.00	wf4	299545	570.23	570.12	-0.11
wf4	299546	563.81	563.81	0.00	wf4	299546	570.23	570.13	-0.10
wf4	299590	563.86	563.86	0.00	wf4	299590	570.26	570.16	-0.10
wf4	300278	564.59	564.59	0.00	wf4	300278	570.60	570.51	-0.09
wf4	301177	565.90	565.90	0.00	wf4	301177	571.26	571.19	-0.07
wf4	302041	566.60	566.60	0.00	wf4	302041	571.79	571.72	-0.07
wf4	303421	567.57	567.57	0.00	wf4	303421	572.41	572.36	-0.05
wf4	304157	568.03	568.03	0.00	wf4	304157	572.77	572.73	-0.04
wf4	304207	568.06	568.06	0.00	wf4	304207	572.81	572.76	-0.05
wf4	304208	567.93	567.93	0.00	wf4	304208	572.73	572.68	-0.05
wf4	304213	567.94	567.94	0.00	wf4	304213	572.74	572.69	-0.05
wf4	304214	567.79	567.79	0.00	wf4	304214	572.56	572.51	-0.05
wf4	304259	567.85	567.85	0.00	wf4	304259	572.63	572.58	-0.05
wf4	305256	568.92	568.92	0.00	wf4	305256	573.78	573.74	-0.04
wf4	306246	569.28	569.28	0.00	wf4	306246	574.24	574.21	-0.03

Table 3-3: Channel Velocities - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Velocity (ft/s)			Reach	River Station	Velocity (ft/s)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
cf	3590	6.47	7.42	0.95	cf	3590	7.10	7.87	0.77
cf	3803	7.14	8.01	0.87	cf	3803	7.80	8.28	0.48
cf	4057	6.42	7.08	0.66	cf	4057	7.36	7.34	-0.02
cf	4267	7.60	8.49	0.89	cf	4267	8.00	7.98	-0.02
cf	4371	7.94	8.91	0.97	cf	4371	7.81	7.84	0.03
cf	4372	7.94	8.91	0.97	cf	4372	7.81	7.84	0.03
cf	4402				cf	4402			
cf	4433	7.86	8.79	0.93	cf	4433	7.76	7.79	0.03
cf	4535	7.69	8.54	0.85	cf	4535	7.86	7.89	0.03
cf	5170	8.27	8.89	0.62	cf	5170	9.87	9.90	0.03
cf	5990	5.90	6.33	0.43	cf	5990	5.77	5.79	0.02
cf	6101	7.56	8.24	0.68	cf	6101	6.52	6.54	0.02
cf	6102	7.56	8.24	0.68	cf	6102	6.52	6.54	0.02
cf	6130				cf	6130			
cf	6158	7.51	8.18	0.67	cf	6158	6.50	6.53	0.03
cf	6258	5.21	5.60	0.39	cf	6258	4.78	4.80	0.02
cf	6656	6.07	6.48	0.41	cf	6656	6.02	6.04	0.02
cf	6707	7.17	7.69	0.52	cf	6707	6.50	6.53	0.03
cf	6757	6.83	7.25	0.42	cf	6757	6.42	6.45	0.03
cf	7400	8.85	9.21	0.36	cf	7400	7.83	7.86	0.03
cf	8073	8.96	9.25	0.29	cf	8073	7.24	7.27	0.03
cf	8178	9.37	9.68	0.31	cf	8178	8.92	8.95	0.03
cf	8179	9.37	9.68	0.31	cf	8179	8.92	8.95	0.03
cf	8189				cf	8189			
cf	8200	9.25	9.54	0.29	cf	8200	8.78	8.81	0.03
cf	8243	11.36	11.86	0.50	cf	8243	7.58	7.62	0.04
cf	8293	8.70	8.93	0.23	cf	8293	7.94	8.00	0.06
cf	9045	6.85	6.98	0.13	cf	9045	7.60	7.62	0.02
cf	9515	6.31	6.41	0.10	cf	9515	7.46	7.48	0.02
cf	9566	8.49	8.70	0.21	cf	9566	8.14	8.17	0.03
cf	9614	6.36	6.47	0.11	cf	9614	7.36	7.38	0.02
cf	10175	6.30	6.40	0.10	cf	10175	7.60	7.63	0.03
cf	10906	6.34	6.43	0.09	cf	10906	8.22	8.25	0.03
cf	10956	9.80	10.05	0.25	cf	10956	9.93	9.97	0.04
cf	11006	6.61	6.70	0.09	cf	11006	8.66	8.69	0.03
cf	11918	7.83	7.94	0.11	cf	11918	11.63	11.65	0.02
cf	12019	7.57	7.67	0.10	cf	12019	11.08	11.11	0.03
cf	12020	7.57	7.67	0.10	cf	12020	11.08	11.10	0.02
cf	12075				cf	12075			
cf	12130	7.48	7.58	0.10	cf	12130	10.89	10.90	0.01
cf	12131	7.48	7.58	0.10	cf	12131	11.41	11.43	0.02
cf	12261	8.04	8.16	0.12	cf	12261	11.89	11.91	0.02
cf	12262	8.04	8.16	0.12	cf	12262	11.89	11.91	0.02
cf	12287				cf	12287			
cf	12313	7.91	8.02	0.11	cf	12313	11.56	11.57	0.01
cf	12411	7.77	7.87	0.10	cf	12411	11.19	11.21	0.02
cf	12541	7.77	7.87	0.10	cf	12541	10.86	10.87	0.01
cf	12565	6.56	6.63	0.07	cf	12565	9.80	9.81	0.01
cf	12616				cf	12616			
cf	12626	6.93	6.93	0.00	cf	12626	11.20	11.21	0.01
cf	12665	7.13	7.14	0.01	cf	12665	11.77	11.78	0.01
cf	12688	7.33	7.34	0.01	cf	12688	12.23	12.24	0.01
cf	12704				cf	12704			
cf	12719	7.23	7.24	0.01	cf	12719	11.97	11.97	0.00
cf	12765	7.68	7.69	0.01	cf	12765	12.12	12.13	0.01
cf	12766	7.68	7.69	0.01	cf	12766	11.87	11.88	0.01
cf	12826				cf	12826			
cf	12886	7.56	7.57	0.01	cf	12886	11.61	11.62	0.01
cf	12887	7.56	7.57	0.01	cf	12887	11.61	11.62	0.01
cf	12988	7.76	7.76	0.00	cf	12988	9.12	9.13	0.01
cf	13376	8.17	8.18	0.01	cf	13376	8.74	8.74	0.00
cf	13381	8.17	8.18	0.01	cf	13381	8.73	8.74	0.01
cf	13386				cf	13386			
cf	13396	8.14	8.15	0.01	cf	13396	8.59	8.60	0.01

Table 3-3: Channel Velocities - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Velocity (ft/s)			Reach	River Station	Velocity (ft/s)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
cf	14297	7.14	7.14	0.00	cf	14297	9.02	9.03	0.01
cf	14949	7.41	7.42	0.01	cf	14949	9.39	9.40	0.01
cf	15442	7.32	7.32	0.00	cf	15442	8.34	8.34	0.00
cf	15613	7.36	7.36	0.00	cf	15613	10.00	10.00	0.00
cf	15948	5.72	5.73	0.01	cf	15948	7.40	7.41	0.01
cf	16054	5.73	5.73	0.00	cf	16054	8.27	8.28	0.01
cf	16078				cf	16078			
cf	16100	5.71	5.71	0.00	cf	16100	8.13	8.13	0.00
cf	16120	6.28	6.28	0.00	cf	16120	8.96	8.97	0.01
cf	16140				cf	16140			
cf	16161	6.25	6.25	0.00	cf	16161	8.79	8.79	0.00
cf	16268	6.45	6.46	0.01	cf	16268	7.92	7.93	0.01
cf	16547	7.79	7.79	0.00	cf	16547	9.88	9.88	0.00
cf	16746	7.62	7.62	0.00	cf	16746	8.54	8.55	0.01
cf	17057	8.98	8.99	0.01	cf	17057	10.41	10.41	0.00
cf	17161	7.87	7.87	0.00	cf	17161	10.37	10.37	0.00
cf	17162	7.87	7.87	0.00	cf	17162	10.37	10.37	0.00
cf	17184				cf	17184			
cf	17206	7.80	7.81	0.01	cf	17206	9.84	9.85	0.01
cf	17302	7.92	7.92	0.00	cf	17302	9.39	9.39	0.00
cf	17746	7.09	7.09	0.00	cf	17746	9.16	9.16	0.00
cf	18275	8.09	8.09	0.00	cf	18275	10.72	10.72	0.00
cf	18867	8.42	8.42	0.00	cf	18867	12.70	12.70	0.00
cf	19645	8.34	8.34	0.00	cf	19645	12.81	12.81	0.00
cf	20351	8.56	8.56	0.00	cf	20351	12.83	12.84	0.01
cf	21239	8.46	8.46	0.00	cf	21239	12.09	12.10	0.01
cf	21279	10.18	10.19	0.01	cf	21279	13.50	13.50	0.00
cf	21329	8.99	8.99	0.00	cf	21329	12.62	12.62	0.00
cf	21844	9.43	9.43	0.00	cf	21844	13.39	13.39	0.00
cf	22604	9.56	9.56	0.00	cf	22604	13.54	13.54	0.00
cf	23535	10.00	10.01	0.01	cf	23535	13.76	13.76	0.00
cf	24198	10.22	10.22	0.00	cf	24198	13.57	13.57	0.00
cf	24297	8.41	8.41	0.00	cf	24297	11.45	11.45	0.00
cf	24298	8.41	8.41	0.00	cf	24298	11.45	11.45	0.00
cf	24326				cf	24326			
cf	24355	8.33	8.33	0.00	cf	24355	11.34	11.34	0.00
cf	24456	9.65	9.65	0.00	cf	24456	12.87	12.87	0.00
cf	25321	8.86	8.86	0.00	cf	25321	12.62	12.62	0.00
cf	25371	8.92	8.92	0.00	cf	25371	12.26	12.26	0.00
cf	25421	8.29	8.29	0.00	cf	25421	11.59	11.59	0.00
cf	26300	9.08	9.08	0.00	cf	26300	12.17	12.17	0.00
cf	27364	10.20	10.20	0.00	cf	27364	13.59	13.59	0.00
cf	28689	9.98	9.98	0.00	cf	28689	13.50	13.50	0.00
cf	29435	10.65	10.65	0.00	cf	29435	10.63	10.63	0.00
cf	29485	11.67	11.67	0.00	cf	29485	10.82	10.82	0.00
cf	29535	10.39	10.39	0.00	cf	29535	10.00	10.00	0.00
cf	29613	10.87	10.88	0.01	cf	29613	12.31	12.31	0.00
cf	29638	16.93	16.93	0.00	cf	29638	14.95	14.95	0.00
cf	29663	10.68	10.68	0.00	cf	29663	10.50	10.50	0.00
cf	30174	9.62	9.62	0.00	cf	30174	10.80	10.80	0.00
cf	30913	9.62	9.62	0.00	cf	30913	11.97	11.97	0.00
cf	31770	10.13	10.13	0.00	cf	31770	12.08	12.08	0.00
cf	32371	9.39	9.39	0.00	cf	32371	11.23	11.23	0.00
cf	32940	10.20	10.20	0.00	cf	32940	13.95	13.95	0.00
cf	33577	10.29	10.29	0.00	cf	33577	14.30	14.30	0.00
cf	34116	10.67	10.67	0.00	cf	34116	14.52	14.52	0.00
cf	34699	9.31	9.31	0.00	cf	34699	12.15	12.15	0.00
cf	34814	13.33	13.33	0.00	cf	34814	16.58	16.58	0.00
cf	34830				cf	34830			
cf	34846	12.24	12.24	0.00	cf	34846	15.23	15.23	0.00
cf	34878	11.91	11.91	0.00	cf	34878	14.85	14.85	0.00
cf	34897				cf	34897			
cf	34915	11.34	11.34	0.00	cf	34915	14.21	14.21	0.00
cf	34957	8.09	8.09	0.00	cf	34957	8.88	8.88	0.00

Table 3-3: Channel Velocities - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Velocity (ft/s)			Reach	River Station	Velocity (ft/s)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
cf	35016	10.47	10.47	0.00	cf	35016	8.97	8.97	0.00
cf	35076	8.84	8.84	0.00	cf	35076	8.17	8.17	0.00
cf	35519	8.02	8.02	0.00	cf	35519	8.16	8.16	0.00
cf	35969	8.59	8.59	0.00	cf	35969	8.76	8.76	0.00
cf	36466	8.12	8.12	0.00	cf	36466	9.61	9.61	0.00
cf	37449	7.33	7.33	0.00	cf	37449	9.42	9.42	0.00
cf	38091	8.11	8.11	0.00	cf	38091	11.54	11.54	0.00
cf	38738	10.73	10.73	0.00	cf	38738	14.54	14.54	0.00
cf	39023	9.44	9.44	0.00	cf	39023	13.34	13.34	0.00
cf	39056	15.60	15.60	0.00	cf	39056	20.41	20.41	0.00
cf	39068	13.66	13.66	0.00	cf	39068	18.82	18.82	0.00
cf	39101	6.62	6.62	0.00	cf	39101	7.67	7.67	0.00
cf	39380	6.25	6.25	0.00	cf	39380	9.11	9.11	0.00
cf	39879	5.64	5.64	0.00	cf	39879	6.98	6.98	0.00
cf	39977	6.35	6.35	0.00	cf	39977	9.16	9.16	0.00
cf	40021				cf	40021			
cf	40064	6.29	6.29	0.00	cf	40064	9.07	9.07	0.00
cf	40178	8.03	8.03	0.00	cf	40178	10.00	10.00	0.00
cf	41045	11.88	11.88	0.00	cf	41045	9.85	9.85	0.00
cf	43324	5.58	5.58	0.00	cf	43324	6.40	6.40	0.00
cf	44342	4.50	4.50	0.00	cf	44342	11.08	11.08	0.00
cf	45015	5.67	5.67	0.00	cf	45015	11.64	11.64	0.00
cf	45544	4.78	4.78	0.00	cf	45544	9.34	9.34	0.00
cf	46175	3.30	3.30	0.00	cf	46175	10.30	10.30	0.00
cf	46489	5.03	5.03	0.00	cf	46489	15.26	15.26	0.00
cf	46490	5.03	5.03	0.00	cf	46490	15.26	15.26	0.00
cf	46550				cf	46550			
cf	46610	4.98	4.98	0.00	cf	46610	13.65	13.65	0.00
cf	46611	4.97	4.97	0.00	cf	46611	13.64	13.64	0.00
cf	46736	4.81	4.81	0.00	cf	46736	9.78	9.78	0.00
cf	49420	5.89	5.89	0.00	cf	49420	4.58	4.58	0.00
cf	50598	6.08	6.08	0.00	cf	50598	5.95	5.95	0.00
cf	51599	4.35	4.35	0.00	cf	51599	4.39	4.39	0.00
cf	52140	3.36	3.36	0.00	cf	52140	4.51	4.51	0.00
cf	52192	4.01	4.01	0.00	cf	52192	4.55	4.55	0.00
cf	52242	3.70	3.70	0.00	cf	52242	4.52	4.52	0.00
cf	53352	5.77	5.77	0.00	cf	53352	7.15	7.15	0.00
cf	53901	5.50	5.50	0.00	cf	53901	6.68	6.68	0.00
cf	54806	4.32	4.32	0.00	cf	54806	5.50	5.50	0.00
cf	57021	4.38	4.38	0.00	cf	57021	5.56	5.56	0.00
cf	58850	6.91	6.91	0.00	cf	58850	7.33	7.33	0.00
cf	60451	5.57	5.57	0.00	cf	60451	5.67	5.67	0.00
cf	61472	0.00	0.00	0.00	cf	61472	0.00	0.00	0.00
cf	62405	0.00	0.00	0.00	cf	62405	0.00	0.00	0.00
cf	62953	0.00	0.00	0.00	cf	62953	0.00	0.00	0.00
cf	64380	0.00	0.00	0.00	cf	64380	0.00	0.00	0.00
cf	65344	0.00	0.00	0.00	cf	65344	0.00	0.00	0.00
cf	65616	0.00	0.00	0.00	cf	65616	0.00	0.00	0.00
wf3	206218	6.46	6.46	0.00	wf3	206218	6.70	6.70	0.00
wf3	206314	6.93	6.93	0.00	wf3	206314	6.22	6.22	0.00
wf3	206327				wf3	206327			
wf3	206340	5.04	5.04	0.00	wf3	206340	4.24	4.24	0.00
wf3	206439	6.68	6.68	0.00	wf3	206439	6.65	6.65	0.00
wf3	208797	4.74	4.74	0.00	wf3	208797	5.65	5.65	0.00
wf3	209288	5.04	5.04	0.00	wf3	209288	5.61	5.61	0.00
wf3	209960	7.17	7.17	0.00	wf3	209960	6.86	6.86	0.00
wf3	210574	6.23	6.23	0.00	wf3	210574	6.93	6.93	0.00
wf3	211133	7.59	7.59	0.00	wf3	211133	8.28	8.28	0.00
wf3	212018	6.74	6.74	0.00	wf3	212018	7.93	7.93	0.00
wf3	213435	7.21	7.21	0.00	wf3	213435	8.44	8.44	0.00
wf3	214788	5.32	5.32	0.00	wf3	214788	6.51	6.51	0.00
wf3	214946	5.17	5.17	0.00	wf3	214946	5.90	5.90	0.00
wf3	215762	7.82	7.82	0.00	wf3	215762	8.81	8.81	0.00
wf3	217369	4.71	4.71	0.00	wf3	217369	6.48	6.48	0.00

Table 3-3: Channel Velocities - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Velocity (ft/s)			Reach	River Station	Velocity (ft/s)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
wf3	217981	5.53	5.53	0.00	wf3	217981	8.07	8.07	0.00
wf3	217982	6.85	6.85	0.00	wf3	217982	8.99	8.99	0.00
wf3	217999	6.85	6.85	0.00	wf3	217999	8.98	8.98	0.00
wf3	218000	5.49	5.49	0.00	wf3	218000	8.04	8.04	0.00
wf3	218384	6.12	6.12	0.00	wf3	218384	9.59	9.59	0.00
wf3	218496	6.51	6.51	0.00	wf3	218496	10.17	10.17	0.00
wf3	218528				wf3	218528			
wf3	218560	5.89	5.89	0.00	wf3	218560	7.61	7.61	0.00
wf3	218677	4.21	4.21	0.00	wf3	218677	5.71	5.71	0.00
wf3	219536	3.95	3.95	0.00	wf3	219536	4.84	4.84	0.00
wf3	220594	2.41	2.41	0.00	wf3	220594	3.45	3.45	0.00
wf3	221044	2.40	2.40	0.00	wf3	221044	3.24	3.24	0.00
wf3	221650	3.15	3.15	0.00	wf3	221650	4.34	4.34	0.00
wf3	222503	2.96	2.96	0.00	wf3	222503	5.16	5.16	0.00
wf3	222789	3.42	3.42	0.00	wf3	222789	5.66	5.66	0.00
wf3	222896	6.86	6.86	0.00	wf3	222896	11.11	11.11	0.00
wf3	222897	6.86	6.86	0.00	wf3	222897	11.11	11.11	0.00
wf3	222947				wf3	222947			
wf3	222998	6.59	6.59	0.00	wf3	222998	10.54	10.54	0.00
wf3	223089	5.84	5.84	0.00	wf3	223089	9.20	9.20	0.00
wf3	223377	5.79	5.79	0.00	wf3	223377	8.72	8.72	0.00
wf3	223820	3.58	3.58	0.00	wf3	223820	5.31	5.31	0.00
wf3	224594	3.17	3.17	0.00	wf3	224594	5.18	5.18	0.00
wf3	225271	2.98	2.98	0.00	wf3	225271	5.09	5.09	0.00
wf3	225658	3.26	3.26	0.00	wf3	225658	5.70	5.70	0.00
wf3	225923	3.35	3.35	0.00	wf3	225923	5.73	5.73	0.00
wf3	226962	3.59	3.59	0.00	wf3	226962	6.18	6.18	0.00
wf3	227288	3.61	3.61	0.00	wf3	227288	6.47	6.47	0.00
wf3	227980	4.64	4.64	0.00	wf3	227980	7.76	7.76	0.00
wf3	228084	5.49	5.49	0.00	wf3	228084	9.89	9.89	0.00
wf3	228085	5.49	5.49	0.00	wf3	228085	9.89	9.89	0.00
wf3	228095				wf3	228095			
wf3	228105	5.48	5.48	0.00	wf3	228105	9.81	9.81	0.00
wf3	228106	5.48	5.48	0.00	wf3	228106	9.81	9.81	0.00
wf3	228208	5.08	5.08	0.00	wf3	228208	8.91	8.91	0.00
wf3	228755	5.30	5.30	0.00	wf3	228755	9.13	9.13	0.00
wf3	229360	5.01	5.01	0.00	wf3	229360	9.05	9.05	0.00
wf3	229394	4.98	4.98	0.00	wf3	229394	9.16	9.16	0.00
wf3	229412	7.57	7.57	0.00	wf3	229412	12.34	12.34	0.00
wf3	229428	7.57	7.57	0.00	wf3	229428	12.33	12.33	0.00
wf3	229429	4.86	4.86	0.00	wf3	229429	8.93	8.93	0.00
wf3	229462	4.79	4.79	0.00	wf3	229462	8.90	8.90	0.00
wf3	229463	4.79	4.79	0.00	wf3	229463	8.90	8.90	0.00
wf3	229494				wf3	229494			
wf3	229526	4.78	4.78	0.00	wf3	229526	8.85	8.85	0.00
wf3	229527	4.78	4.78	0.00	wf3	229527	8.85	8.85	0.00
wf3	229630	4.78	4.78	0.00	wf3	229630	8.76	8.76	0.00
wf3	230254	4.30	4.30	0.00	wf3	230254	7.84	7.84	0.00
wf3	230852	3.82	3.82	0.00	wf3	230852	6.87	6.87	0.00
wf3	230949	3.79	3.79	0.00	wf3	230949	6.85	6.85	0.00
wf3	230950	3.79	3.79	0.00	wf3	230950	6.85	6.85	0.00
wf3	231025				wf3	231025			
wf3	231100	3.79	3.79	0.00	wf3	231100	6.82	6.82	0.00
wf3	231101	3.79	3.79	0.00	wf3	231101	6.82	6.82	0.00
wf3	231188	3.61	3.61	0.00	wf3	231188	6.60	6.60	0.00
wf3	231242	4.47	4.47	0.00	wf3	231242	7.72	7.72	0.00
wf3	231291	4.91	4.91	0.00	wf3	231291	8.49	8.49	0.00
wf3	231292	4.91	4.91	0.00	wf3	231292	8.49	8.49	0.00
wf3	231316				wf3	231316			
wf3	231340	4.89	4.89	0.00	wf3	231340	8.43	8.43	0.00
wf3	231341	4.89	4.89	0.00	wf3	231341	8.43	8.43	0.00
wf3	231452	3.53	3.53	0.00	wf3	231452	6.31	6.31	0.00
wf3	232217	4.86	4.86	0.00	wf3	232217	8.22	8.22	0.00
wf3	233091	3.58	3.58	0.00	wf3	233091	6.19	6.19	0.00

Table 3-3: Channel Velocities - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Velocity (ft/s)			Reach	River Station	Velocity (ft/s)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
wf3	233994	3.21	3.21	0.00	wf3	233994	5.56	5.56	0.00
wf3	234857	3.34	3.36	0.02	wf3	234857	5.51	5.76	0.25
wf3	235192	3.12	3.12	0.00	wf3	235192	5.16	5.37	0.21
wf3	235296	3.75	3.75	0.00	wf3	235296	6.22	6.23	0.01
wf3	235297	3.75	3.75	0.00	wf3	235297	6.22	6.23	0.01
wf3	235354				wf3	235354			
wf3	235412	3.74	3.74	0.00	wf3	235412	6.21	6.21	0.00
wf3	235413	3.74	3.74	0.00	wf3	235413	6.21	6.21	0.00
wf3	235522	4.04	4.04	0.00	wf3	235522	6.50	6.20	-0.30
wf3	236729	3.18	2.45	-0.73	wf3	236729	5.08	4.17	-0.91
wf3	237615	4.59	3.97	-0.62	wf3	237615	7.02	6.41	-0.61
wf3	238288	5.53	5.34	-0.19	wf3	238288	7.78	6.82	-0.96
wf3	238390	4.72	4.54	-0.18	wf3	238390	6.83	6.10	-0.73
wf3	238391	4.72	4.54	-0.18	wf3	238391	6.83	6.10	-0.73
wf3	238401				wf3	238401			
wf3	238411	4.72	4.53	-0.19	wf3	238411	6.82	6.08	-0.74
wf3	238412	4.72	4.53	-0.19	wf3	238412	6.82	6.08	-0.74
wf3	238508	5.88	5.78	-0.10	wf3	238508	8.08	7.17	-0.91
wf3	238751	6.20	6.22	0.02	wf3	238751	8.97	8.24	-0.73
wf3	239095	5.67	5.69	0.02	wf3	239095	9.22	9.05	-0.17
wf3	239197	5.47	5.49	0.02	wf3	239197	8.98	8.82	-0.16
wf3	239198	5.47	5.49	0.02	wf3	239198	8.98	8.82	-0.16
wf3	239229				wf3	239229			
wf3	239261	5.45	5.48	0.03	wf3	239261	8.95	8.79	-0.16
wf3	239262	5.45	5.48	0.03	wf3	239262	8.95	8.79	-0.16
wf3	239369	5.46	4.44	-1.02	wf3	239369	8.66	7.70	-0.96
wf3	239744	5.14	4.62	-0.52	wf3	239744	7.85	7.38	-0.47
wf3	240517	5.03	3.62	-1.41	wf3	240517	7.25	5.45	-1.80
wf3	241255	5.32	4.75	-0.57	wf3	241255	7.19	5.36	-1.83
wf3	241708	5.52	5.10	-0.42	wf3	241708	7.89	6.65	-1.24
wf3	241811	6.61	6.64	0.03	wf3	241811	9.19	9.30	0.11
wf3	241812	6.61	6.64	0.03	wf3	241812	9.20	9.31	0.11
wf3	241825				wf3	241825			
wf3	241838	6.55	6.58	0.03	wf3	241838	8.95	9.05	0.10
wf3	241839	6.55	6.58	0.03	wf3	241839	8.94	9.04	0.10
wf3	241926	6.92	6.95	0.03	wf3	241926	9.49	9.60	0.11
wf3	241927	6.93	6.95	0.02	wf3	241927	9.50	9.61	0.11
wf3	241937	0.00	0.00	0.00	wf3	241937	0.00	0.00	0.00
wf3	241947	6.91	6.93	0.02	wf3	241947	9.36	9.48	0.12
wf3	241948	6.90	6.93	0.03	wf3	241948	9.34	9.46	0.12
wf3	242099	5.98	6.00	0.02	wf3	242099	8.41	8.52	0.11
wf3	242100	5.98	6.00	0.02	wf3	242100	8.41	8.52	0.11
wf3	242110				wf3	242110			
wf3	242120	5.96	5.98	0.02	wf3	242120	8.35	8.45	0.10
wf3	242121	5.96	5.98	0.02	wf3	242121	8.35	8.45	0.10
wf3	242222	6.35	6.37	0.02	wf3	242222	8.35	8.46	0.11
wf3	242259	6.87	6.89	0.02	wf3	242259	8.95	9.07	0.12
wf3	242318	6.66	6.68	0.02	wf3	242318	10.20	10.32	0.12
wf3	242340				wf3	242340			
wf3	242363	6.58	6.60	0.02	wf3	242363	10.08	10.19	0.11
wf3	242451	6.56	6.58	0.02	wf3	242451	8.39	8.49	0.10
wf3	242813	5.75	5.77	0.02	wf3	242813	7.35	7.44	0.09
wf3	243471	6.94	6.96	0.02	wf3	243471	9.47	9.57	0.10
wf3	243785	6.67	6.69	0.02	wf3	243785	10.06	10.15	0.09
wf3	244635	7.12	7.14	0.02	wf3	244635	10.63	10.70	0.07
wf3	244735	6.98	7.01	0.03	wf3	244735	10.47	10.55	0.08
wf3	244736	6.98	7.01	0.03	wf3	244736	10.47	10.55	0.08
wf3	244766				wf3	244766			
wf3	244797	6.94	6.97	0.03	wf3	244797	10.40	10.47	0.07
wf3	244798	6.94	6.97	0.03	wf3	244798	10.40	10.47	0.07
wf3	244898	6.76	6.78	0.02	wf3	244898	10.29	10.36	0.07
wf4	257426	8.52	20.46	11.94	wf4	257426	6.70	8.75	2.05
wf4	257535	7.96	11.45	3.49	wf4	257535	6.40	8.33	1.93
wf4	257536	7.96	11.45	3.49	wf4	257536	6.40	8.33	1.93

Table 3-3: Channel Velocities - Proposed and Baseline Conditions

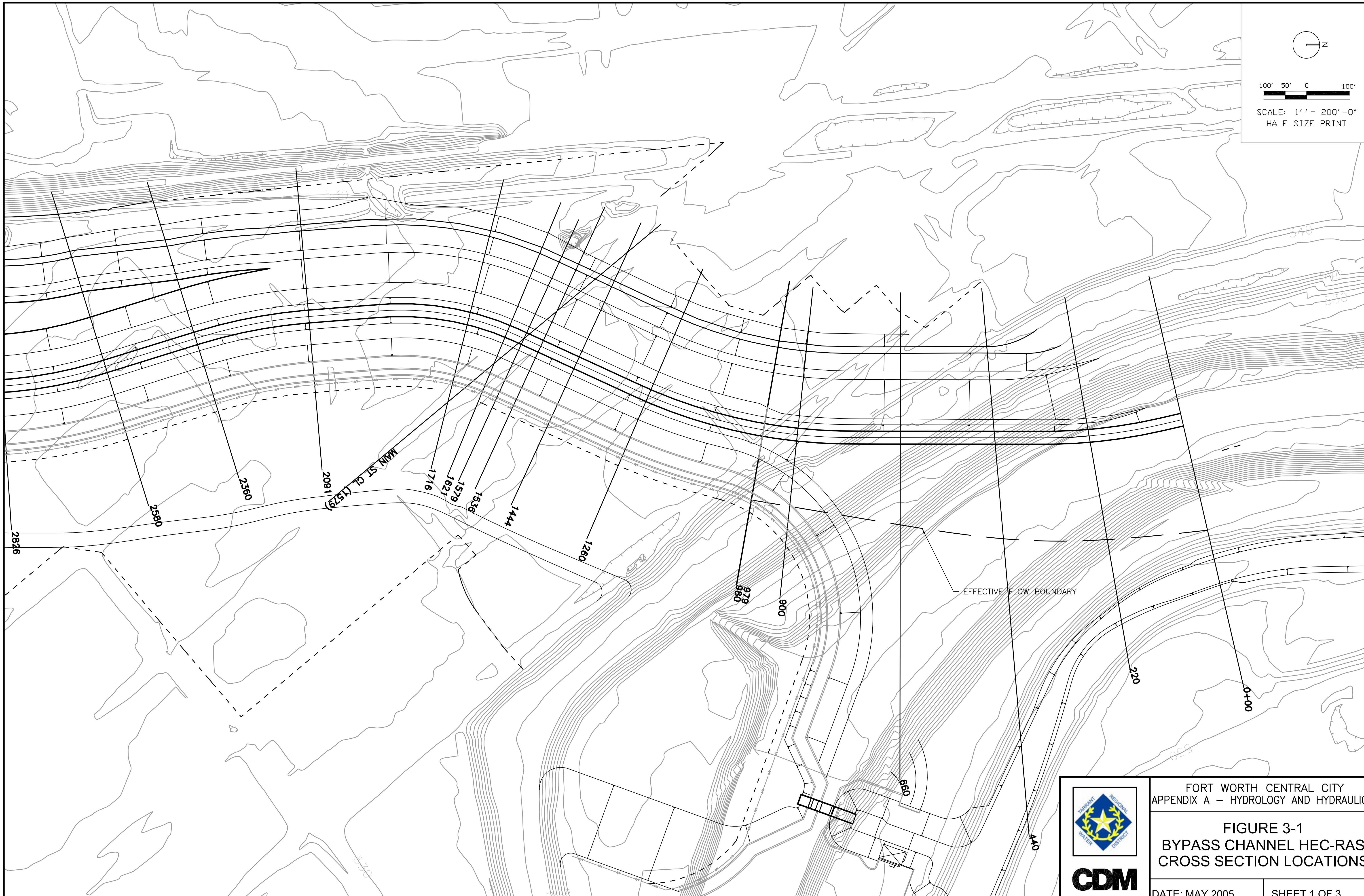
100-yr					SPF				
Reach	River Station	Velocity (ft/s)			Reach	River Station	Velocity (ft/s)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
wf4	257546				wf4	257546			
wf4	257557	7.87	10.71	2.84	wf4	257557	6.35	8.26	1.91
wf4	257654	7.50	5.59	-1.91	wf4	257654	6.19	5.07	-1.12
wf4	258103	4.48	5.49	1.01	wf4	258103	4.11	5.08	0.97
wf4	258678	5.98	7.49	1.51	wf4	258678	5.07	6.61	1.54
wf4	259003	6.84	8.54	1.70	wf4	259003	5.84	7.36	1.52
wf4	259337	8.36	10.34	1.98	wf4	259337	7.46	9.33	1.87
wf4	259463	10.68	13.22	2.54	wf4	259463	9.57	11.98	2.41
wf4	259501				wf4	259501			
wf4	259538	10.44	12.38	1.94	wf4	259538	9.50	11.79	2.29
wf4	259657	8.10	8.95	0.85	wf4	259657	8.25	9.75	1.50
wf4	260385	4.89	6.13	1.24	wf4	260385	4.19	6.09	1.90
wf4	261002	5.62	7.14	1.52	wf4	261002	4.16	6.11	1.95
wf4	262394	10.10	10.77	0.67	wf4	262394	4.81	10.22	5.41
wf4	262497	10.17	10.92	0.75	wf4	262497	5.14	9.20	4.06
wf4	262548				wf4	262548			
wf4	262599	9.24	10.68	1.44	wf4	262599	4.36	7.44	3.08
wf4	262705	6.71	7.29	0.58	wf4	262705	4.81	5.99	1.18
wf4	263531	3.33	6.02	2.69	wf4	263531	2.37	2.99	0.62
wf4	264804	3.34	4.56	1.22	wf4	264804	2.32	2.52	0.20
wf4	266213	4.65	4.67	0.02	wf4	266213	3.24	3.52	0.28
wf4	267221	7.12	7.16	0.04	wf4	267221	5.80	6.27	0.47
wf4	268190	6.17	6.20	0.03	wf4	268190	5.44	5.76	0.32
wf4	269070	6.18	6.23	0.05	wf4	269070	4.76	5.16	0.40
wf4	269743	5.59	5.63	0.04	wf4	269743	4.37	4.70	0.33
wf4	270249	6.83	6.87	0.04	wf4	270249	5.52	5.92	0.40
wf4	270730	5.12	5.15	0.03	wf4	270730	4.68	4.95	0.27
wf4	271402	6.94	6.97	0.03	wf4	271402	6.82	7.20	0.38
wf4	271794	5.83	5.85	0.02	wf4	271794	6.19	6.49	0.30
wf4	272377	6.11	6.13	0.02	wf4	272377	6.40	6.71	0.31
wf4	273102	9.30	9.33	0.03	wf4	273102	8.51	9.05	0.54
wf4	273902	8.62	8.64	0.02	wf4	273902	8.50	8.98	0.48
wf4	274754	7.08	7.10	0.02	wf4	274754	7.59	7.94	0.35
wf4	275461	9.42	9.44	0.02	wf4	275461	10.50	10.98	0.48
wf4	275969	8.37	8.38	0.01	wf4	275969	9.72	10.08	0.36
wf4	276325	8.69	8.70	0.01	wf4	276325	10.12	10.49	0.37
wf4	276562	8.21	8.22	0.01	wf4	276562	9.21	9.55	0.34
wf4	276627				wf4	276627			
wf4	276692	8.05	8.07	0.02	wf4	276692	9.09	9.42	0.33
wf4	276853	8.27	8.28	0.01	wf4	276853	9.47	9.82	0.35
wf4	277391	6.89	6.89	0.00	wf4	277391	7.99	8.28	0.29
wf4	278130	6.66	6.66	0.00	wf4	278130	7.65	7.88	0.23
wf4	279002	6.83	6.84	0.01	wf4	279002	7.59	7.86	0.27
wf4	280042	7.26	7.27	0.01	wf4	280042	8.58	8.79	0.21
wf4	281199	7.95	7.95	0.00	wf4	281199	9.34	9.57	0.23
wf4	281771	6.01	6.02	0.01	wf4	281771	7.01	7.16	0.15
wf4	281820	5.98	5.98	0.00	wf4	281820	6.63	6.78	0.15
wf4	281821	5.19	5.20	0.01	wf4	281821	6.22	6.34	0.12
wf4	281831	5.17	5.17	0.00	wf4	281831	5.85	5.97	0.12
wf4	281832	5.21	5.22	0.01	wf4	281832	6.36	6.47	0.11
wf4	281871	5.21	5.22	0.01	wf4	281871	6.36	6.47	0.11
wf4	282801	8.24	8.24	0.00	wf4	282801	9.62	9.83	0.21
wf4	283400	7.94	7.94	0.00	wf4	283400	9.42	9.60	0.18
wf4	283853	8.18	8.19	0.01	wf4	283853	9.52	9.70	0.18
wf4	284944	7.65	7.65	0.00	wf4	284944	9.08	9.22	0.14
wf4	285970	7.47	7.47	0.00	wf4	285970	8.91	9.04	0.13
wf4	286710	7.99	7.99	0.00	wf4	286710	9.52	9.66	0.14
wf4	286808	7.82	7.82	0.00	wf4	286808	9.78	9.90	0.12
wf4	286844				wf4	286844			
wf4	286880	7.76	7.76	0.00	wf4	286880	9.71	9.82	0.11
wf4	286976	7.67	7.67	0.00	wf4	286976	9.02	9.15	0.13
wf4	287615	7.76	7.76	0.00	wf4	287615	8.75	8.89	0.14
wf4	288475	7.10	7.10	0.00	wf4	288475	8.55	8.65	0.10
wf4	289136	7.13	7.13	0.00	wf4	289136	8.23	8.32	0.09

Table 3-3: Channel Velocities - Proposed and Baseline Conditions

100-yr					SPF				
Reach	River Station	Velocity (ft/s)			Reach	River Station	Velocity (ft/s)		
		Baseline	Proposed	Proposed - baseline			Baseline	Proposed	Proposed - baseline
wf4	289236	8.38	8.38	0.00	wf4	289236	10.37	10.47	0.10
wf4	289275				wf4	289275			
wf4	289313	8.31	8.32	0.01	wf4	289313	10.29	10.39	0.10
wf4	289379	7.96	7.96	0.00	wf4	289379	9.56	9.66	0.10
wf4	289428	7.95	7.95	0.00	wf4	289428	9.55	9.65	0.10
wf4	289429	7.75	7.76	0.01	wf4	289429	8.80	8.90	0.10
wf4	289441	7.75	7.75	0.00	wf4	289441	8.80	8.90	0.10
wf4	289442	7.75	7.76	0.01	wf4	289442	9.01	9.11	0.10
wf4	289479	7.74	7.75	0.01	wf4	289479	9.00	9.10	0.10
wf4	290271	7.86	7.86	0.00	wf4	290271	8.68	8.76	0.08
wf4	291282	7.67	7.68	0.01	wf4	291282	6.68	6.79	0.11
wf4	291834	7.78	7.79	0.01	wf4	291834	8.62	8.70	0.08
wf4	292711	8.01	8.01	0.00	wf4	292711	8.62	8.71	0.09
wf4	293499	7.20	7.20	0.00	wf4	293499	7.21	7.29	0.08
wf4	293600	8.41	8.41	0.00	wf4	293600	9.07	9.17	0.10
wf4	293621				wf4	293621			
wf4	293642	8.36	8.36	0.00	wf4	293642	9.03	9.13	0.10
wf4	293744	7.04	7.05	0.01	wf4	293744	6.64	6.71	0.07
wf4	294211	6.94	6.94	0.00	wf4	294211	7.29	7.35	0.06
wf4	295195	7.74	7.74	0.00	wf4	295195	8.40	8.46	0.06
wf4	296125	7.48	7.49	0.01	wf4	296125	7.79	7.85	0.06
wf4	296992	7.33	7.33	0.00	wf4	296992	8.16	8.21	0.05
wf4	297107	6.76	6.76	0.00	wf4	297107	8.11	8.15	0.04
wf4	297127				wf4	297126			
wf4	297146	6.73	6.73	0.00	wf4	297146	8.08	8.12	0.04
wf4	297265	6.85	6.85	0.00	wf4	297265	7.66	7.71	0.05
wf4	297822	6.75	6.75	0.00	wf4	297822	6.25	6.31	0.06
wf4	298198	7.09	7.09	0.00	wf4	298198	6.47	6.52	0.05
wf4	298248	7.07	7.07	0.00	wf4	298248	6.46	6.52	0.06
wf4	298249	9.56	9.56	0.00	wf4	298249	7.10	7.19	0.09
wf4	298259	9.54	9.54	0.00	wf4	298259	7.10	7.18	0.08
wf4	298260	9.00	9.01	0.01	wf4	298260	7.16	7.25	0.09
wf4	298300	8.70	8.71	0.01	wf4	298300	6.23	6.31	0.08
wf4	298645	7.32	7.32	0.00	wf4	298645	6.21	6.29	0.08
wf4	299489	6.37	6.37	0.00	wf4	299489	5.19	5.25	0.06
wf4	299539	6.34	6.34	0.00	wf4	299539	5.17	5.23	0.06
wf4	299540	6.41	6.41	0.00	wf4	299540	5.04	5.10	0.06
wf4	299545	6.41	6.41	0.00	wf4	299545	5.04	5.10	0.06
wf4	299546	5.93	5.93	0.00	wf4	299546	4.88	4.94	0.06
wf4	299590	5.90	5.90	0.00	wf4	299590	4.87	4.92	0.05
wf4	300278	7.11	7.12	0.01	wf4	300278	5.95	6.01	0.06
wf4	301177	6.29	6.30	0.01	wf4	301177	6.07	6.12	0.05
wf4	302041	6.36	6.36	0.00	wf4	302041	6.04	6.08	0.04
wf4	303421	5.58	5.58	0.00	wf4	303421	6.05	6.08	0.03
wf4	304157	5.08	5.08	0.00	wf4	304157	6.15	6.17	0.02
wf4	304207	5.07	5.07	0.00	wf4	304207	6.14	6.16	0.02
wf4	304208	6.53	6.53	0.00	wf4	304208	7.41	7.44	0.03
wf4	304213	6.53	6.53	0.00	wf4	304213	7.40	7.43	0.03
wf4	304214	7.36	7.36	0.00	wf4	304214	8.48	8.51	0.03
wf4	304259	7.34	7.34	0.00	wf4	304259	8.43	8.47	0.04
wf4	305256	3.29	3.29	0.00	wf4	305256	4.19	4.19	0.00
wf4	306246	3.65	3.65	0.00	wf4	306246	4.22	4.23	0.01

Table 3-4: Bypass Channel Velocities

River Station	100-yr velocity (ft/s)	SPF velocity (ft/s)
0	6.33	9.38
220	6.25	10.01
440	5.60	9.01
660	6.32	9.85
900	7.96	11.71
980	11.71	15.91
1260	12.47	16.91
1444	12.28	16.67
1536	12.19	16.56
1579	**North Main Street**	
1621	12.12	16.40
1716	12.04	16.31
2091	11.77	15.97
2360	11.53	15.14
2580	11.11	13.50
2826	10.86	12.95
2926	10.82	12.93
3026	10.77	12.90
3136	10.72	12.87
3426	10.53	12.77
3556	8.99	11.58
3656	6.54	9.52
4096	8.06	10.29
4391	9.32	11.73
4426	**Pedestrian bridge**	
4506	9.27	11.25
4616	9.25	11.25
4726	9.23	11.24
5051	9.17	11.22
5266	9.14	11.22
5396	9.12	11.21
5421	9.11	11.21
5476	**North Henderson Road**	
5531	9.09	11.15
5804	9.35	11.45
6004	9.62	11.75
6196	9.57	11.73
6224	9.56	11.73
6311	9.54	11.72
6353	**White Settlement Road**	
6395	9.50	11.65
6511	9.50	11.67
6569	9.63	11.80
6724	9.98	12.18
6906	10.38	12.62
6979	10.34	12.61
7001	10.33	12.61
7199	10.23	12.56
7354	10.16	12.54
7517	10.09	12.50
7669	10.03	12.48
7829	9.93	12.41
8010	6.88	9.31
8202	6.08	7.95
8307	5.30	6.42
8421	7.03	7.44

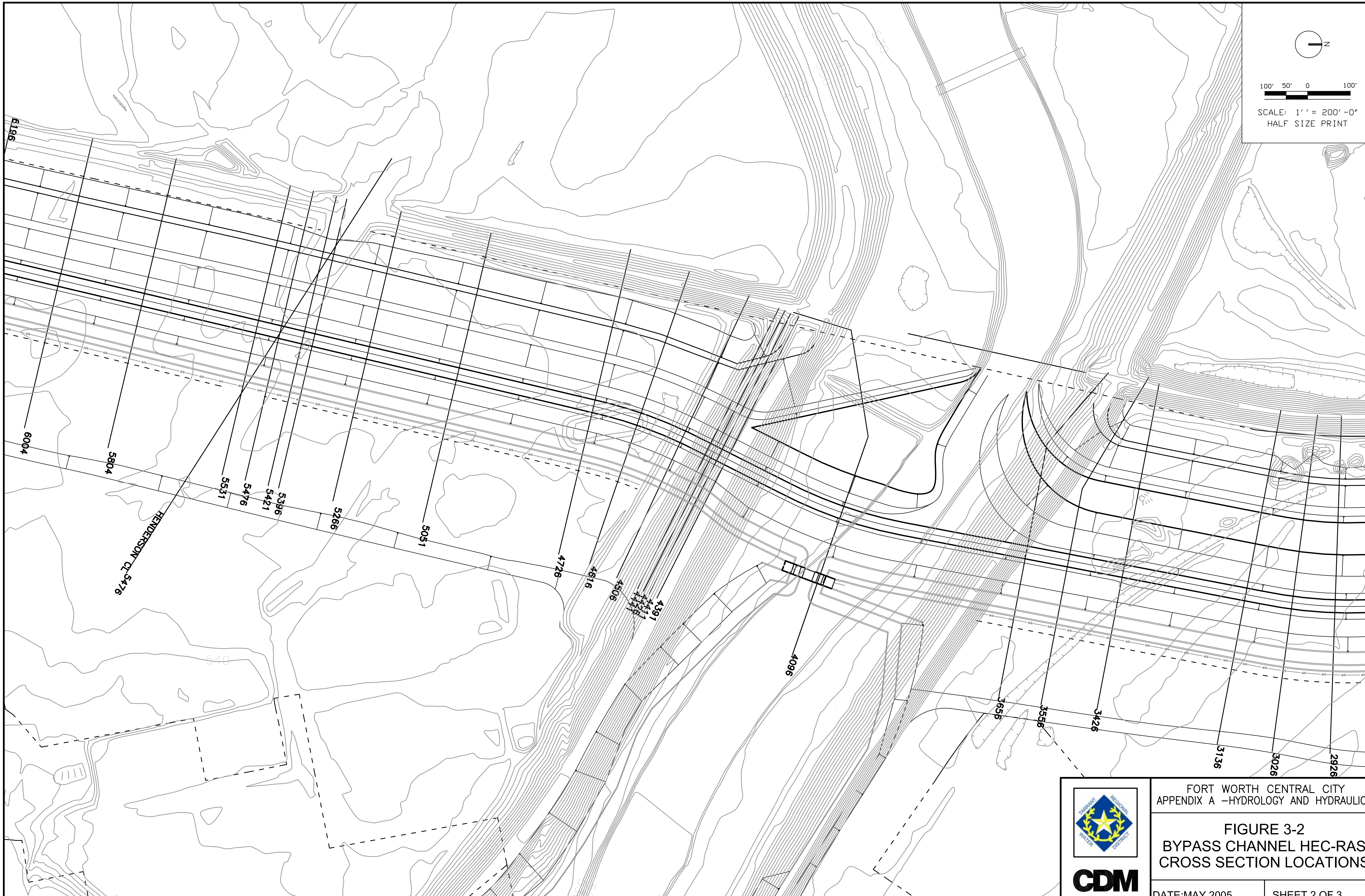


FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-1
BYPASS CHANNEL HEC-RAS CROSS SECTION LOCATIONS

DATE: MAY 2005

SHEET 1 OF 3



TARRANT REGIONAL WATER DISTRICT

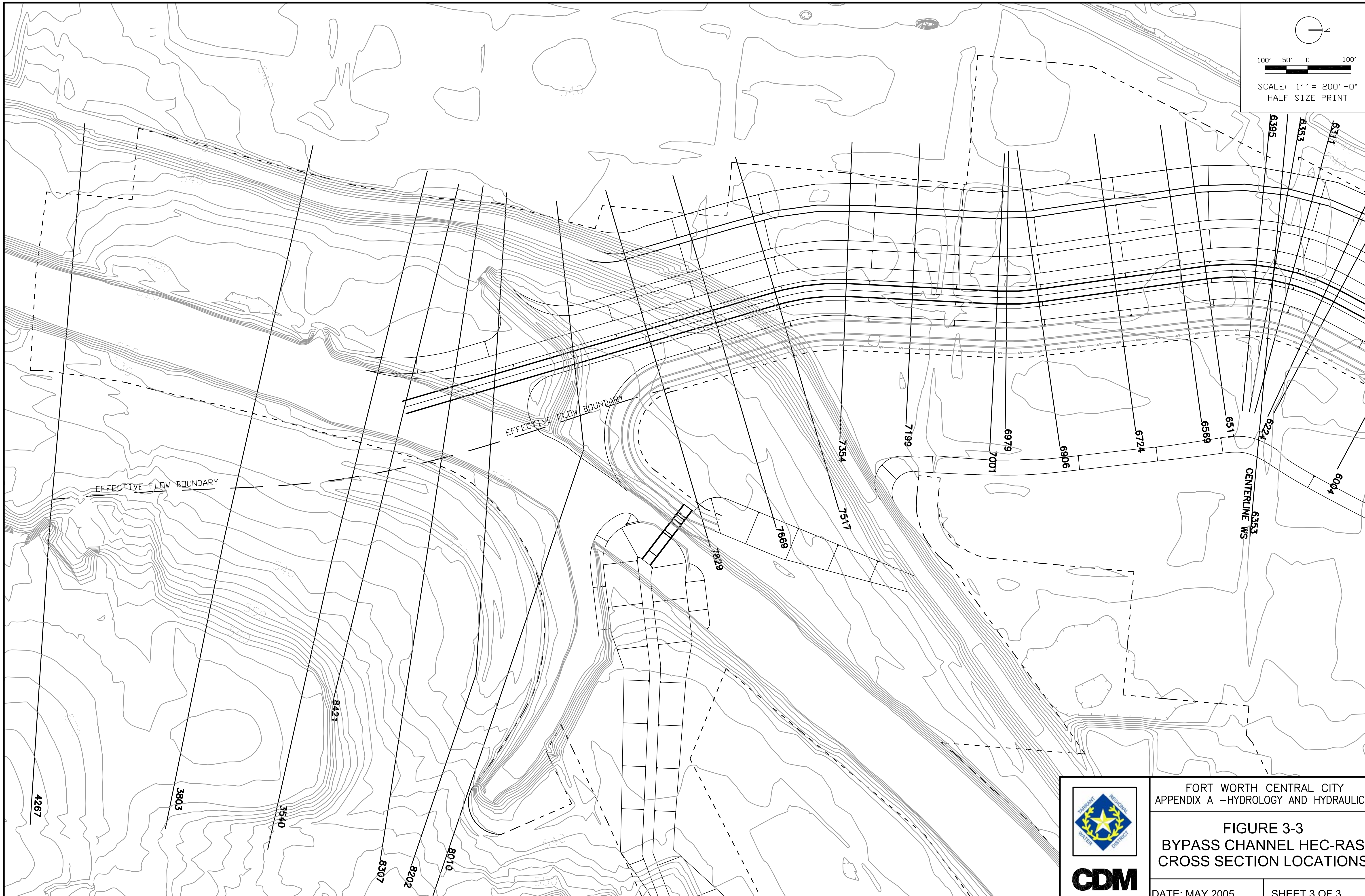
CDM

FORT WORTH CENTRAL CITY
APPENDIX A –HYDROLOGY AND HYDRAULICS

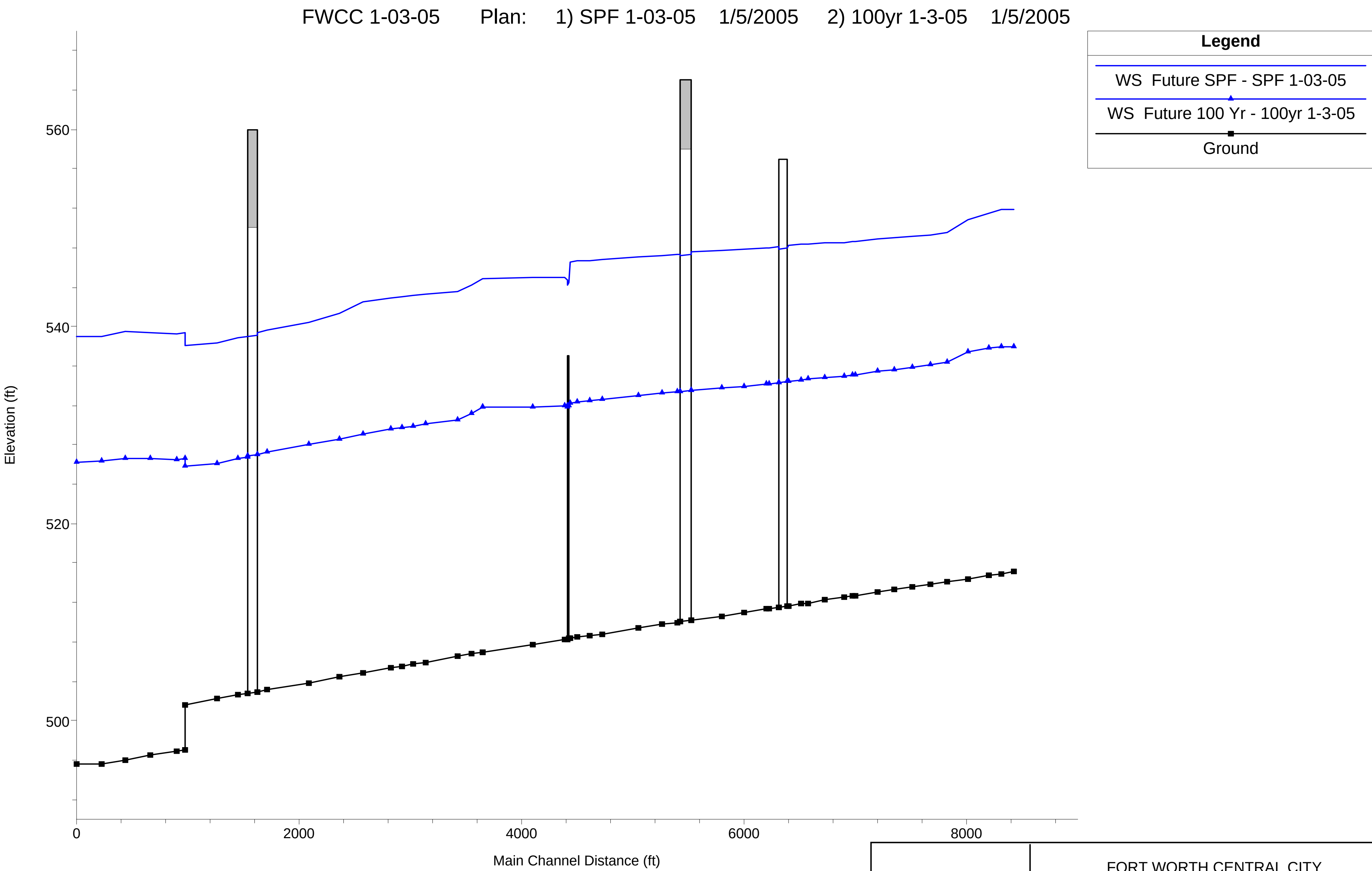
FIGURE 3-2
BYPASS CHANNEL HEC-RAS
CROSS SECTION LOCATIONS

DATE:MAY 2005

SHEET 2 OF 3



EFFECTIVE FLOW BOUNDARY
EFFECTIVE FLOW BOUNDARY
4267
3803
3540
8421
8307
8202
8010
7829
7669
7517
7354
7199
7001
6979
6906
6724
6569
6511
6224
6004
CENTERLINE WS
6353
6395
6353
6311
N
100' 50' 0 100'
SCALE: 1'' = 200'-0"
HALF SIZE PRINT
TARRANT REGIONAL WATER DISTRICT
CDM
FORT WORTH CENTRAL CITY
APPENDIX A –HYDROLOGY AND HYDRAULICS
FIGURE 3-3
BYPASS CHANNEL HEC-RAS
CROSS SECTION LOCATIONS
DATE: MAY 2005
SHEET 3 OF 3

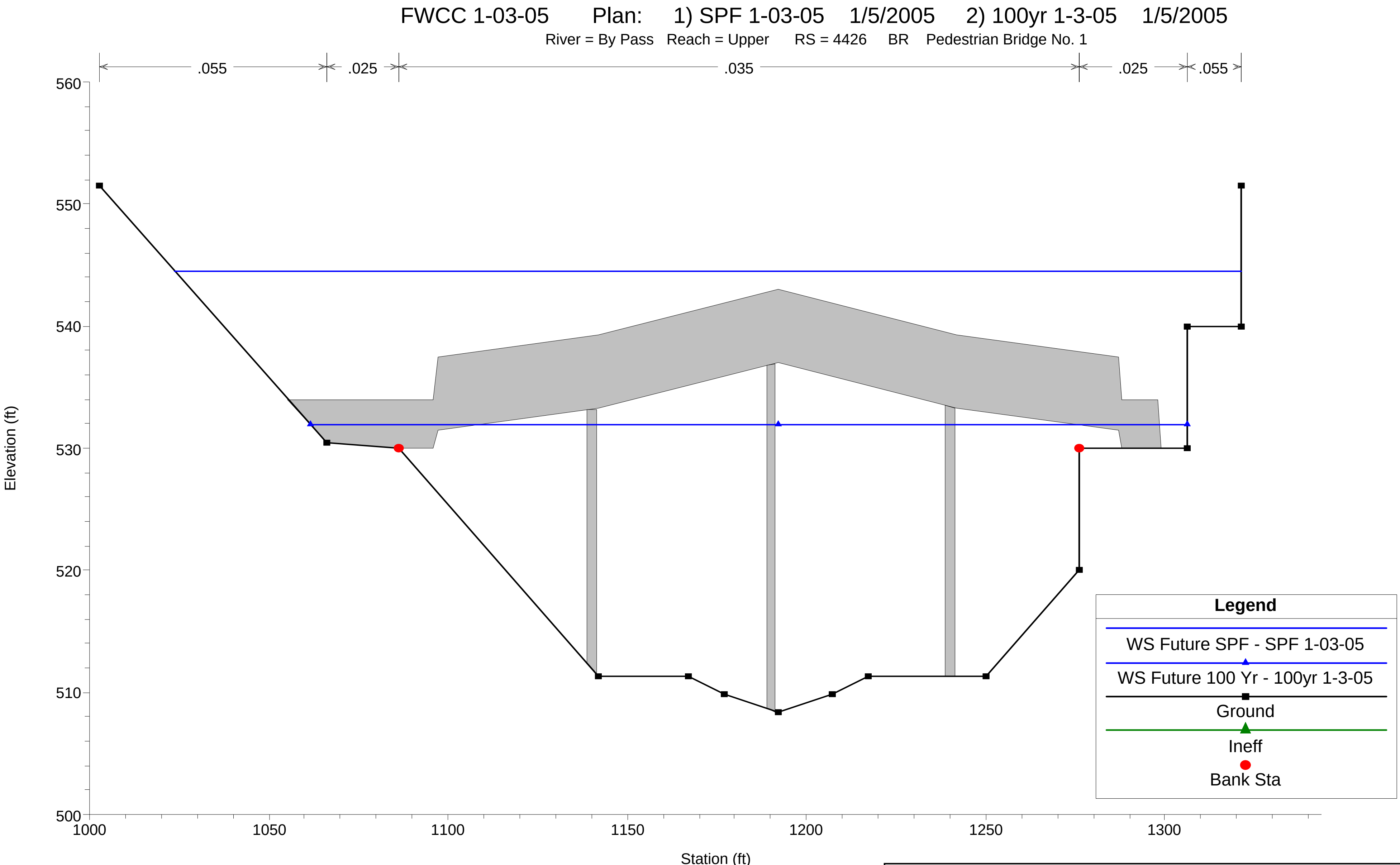


FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-4
BYPASS CHANNEL PROFILE WITH SPF AND 100-YEAR WATER SURFACE PROFILES

DATE: MAY 2005

SHEET 1 OF 1

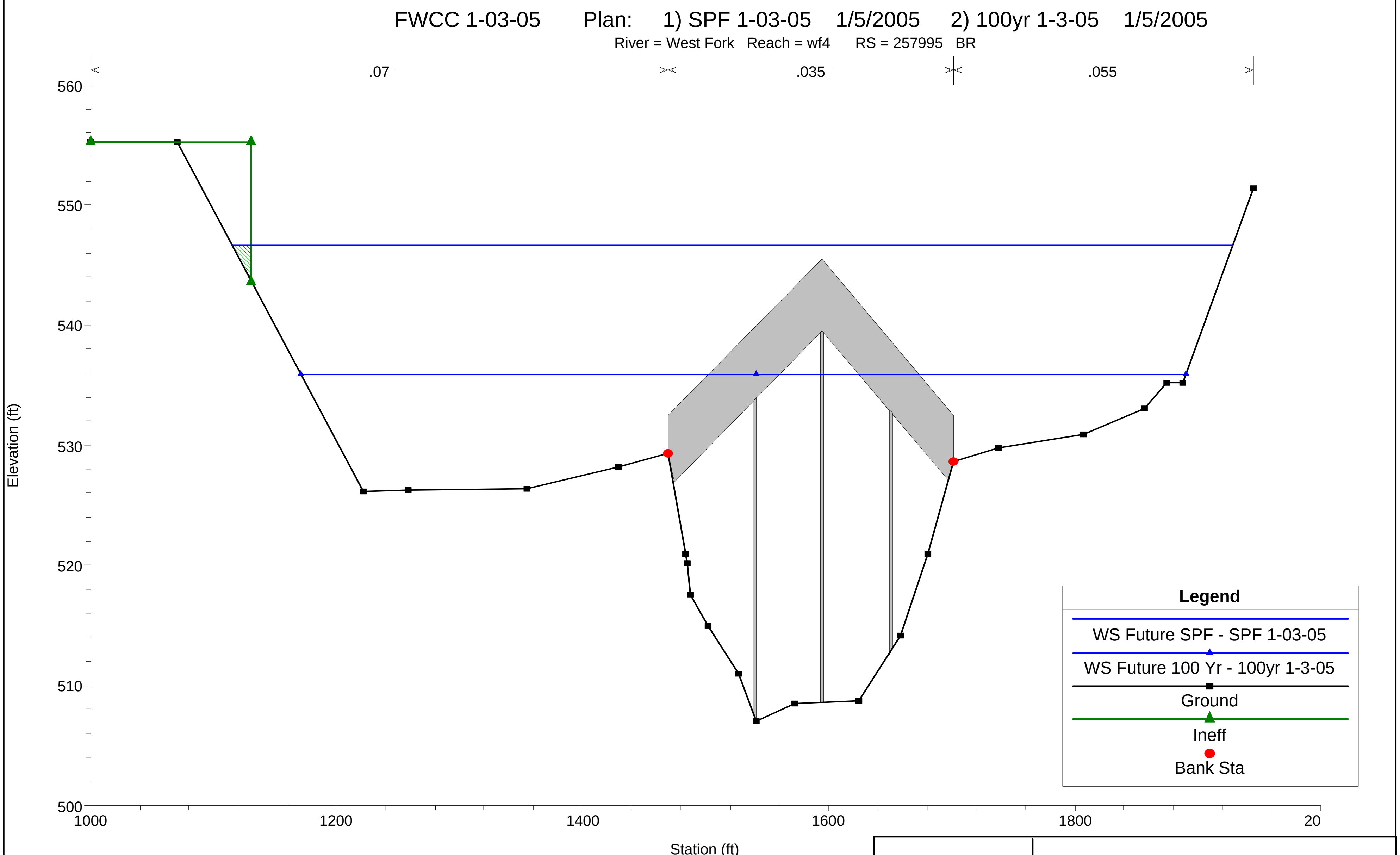


FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

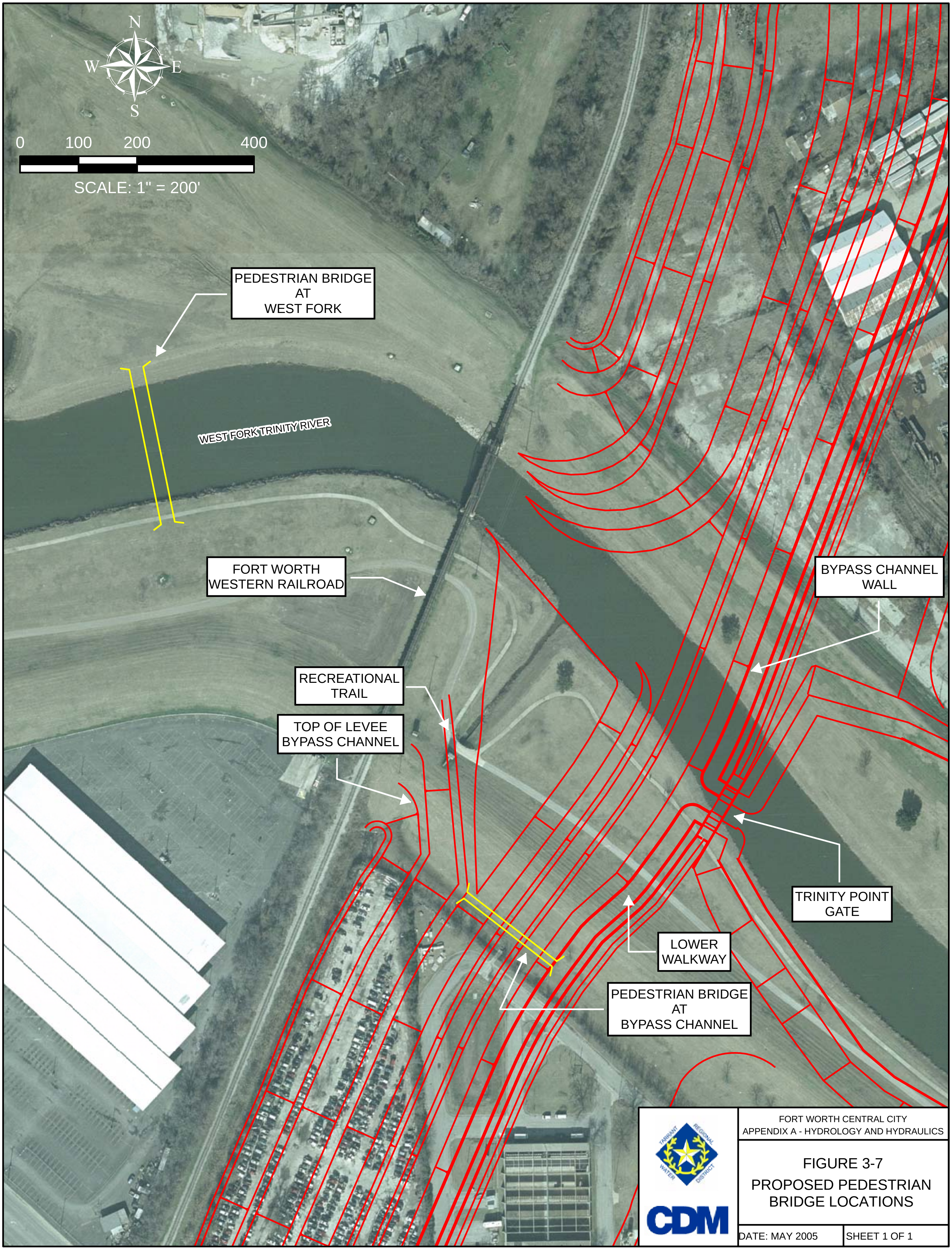
FIGURE 3-5
UPPER BYPASS CHANNEL PEDESTRIAN BRIDGE CROSS-SECTION

DATE: MAY 2005

SHEET 1 OF 1



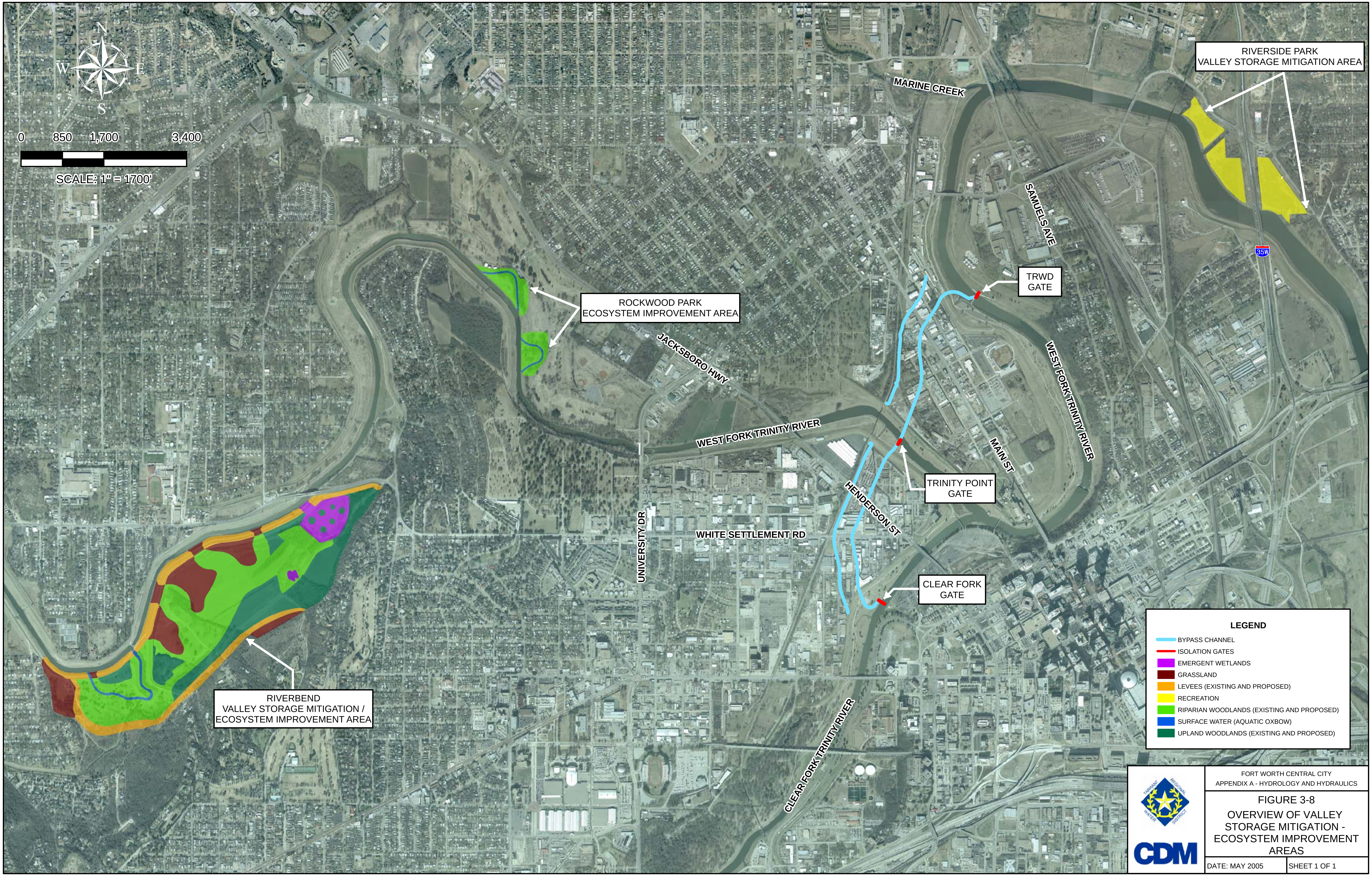
FORT WORTH CENTRAL CITY APPENDIX A – HYDROLOGY AND HYDRAULICS	
FIGURE 3-6 WEST FORK 4 PEDESTRIAN BRIDGE CROSS-SECTION	
DATE: MAY 2005	SHEET 1 OF 1

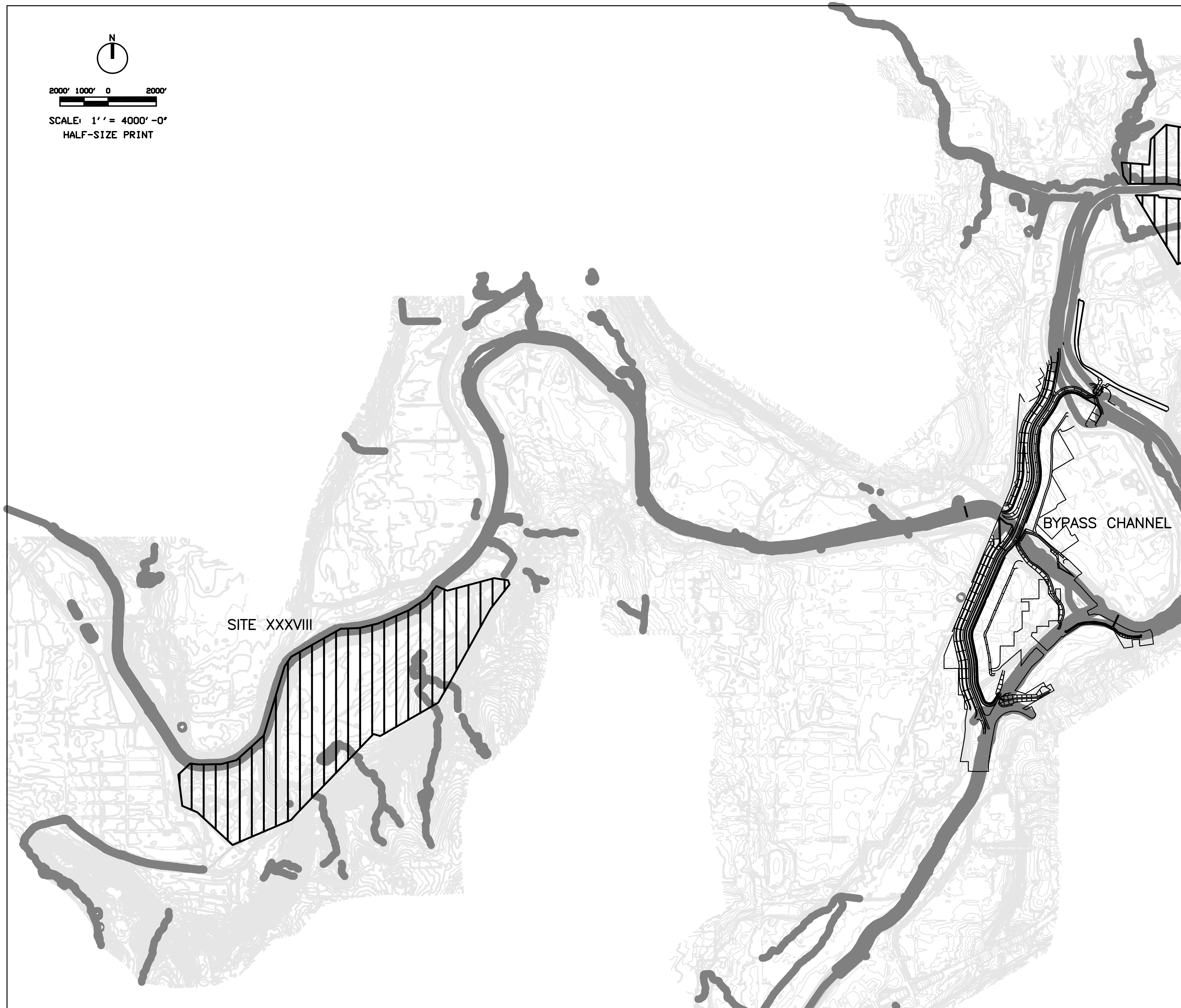


FORT WORTH CENTRAL CITY
APPENDIX A - HYDROLOGY AND HYDRAULICS

FIGURE 3-7
PROPOSED PEDESTRIAN BRIDGE LOCATIONS

DATE: MAY 2005 | SHEET 1 OF 1

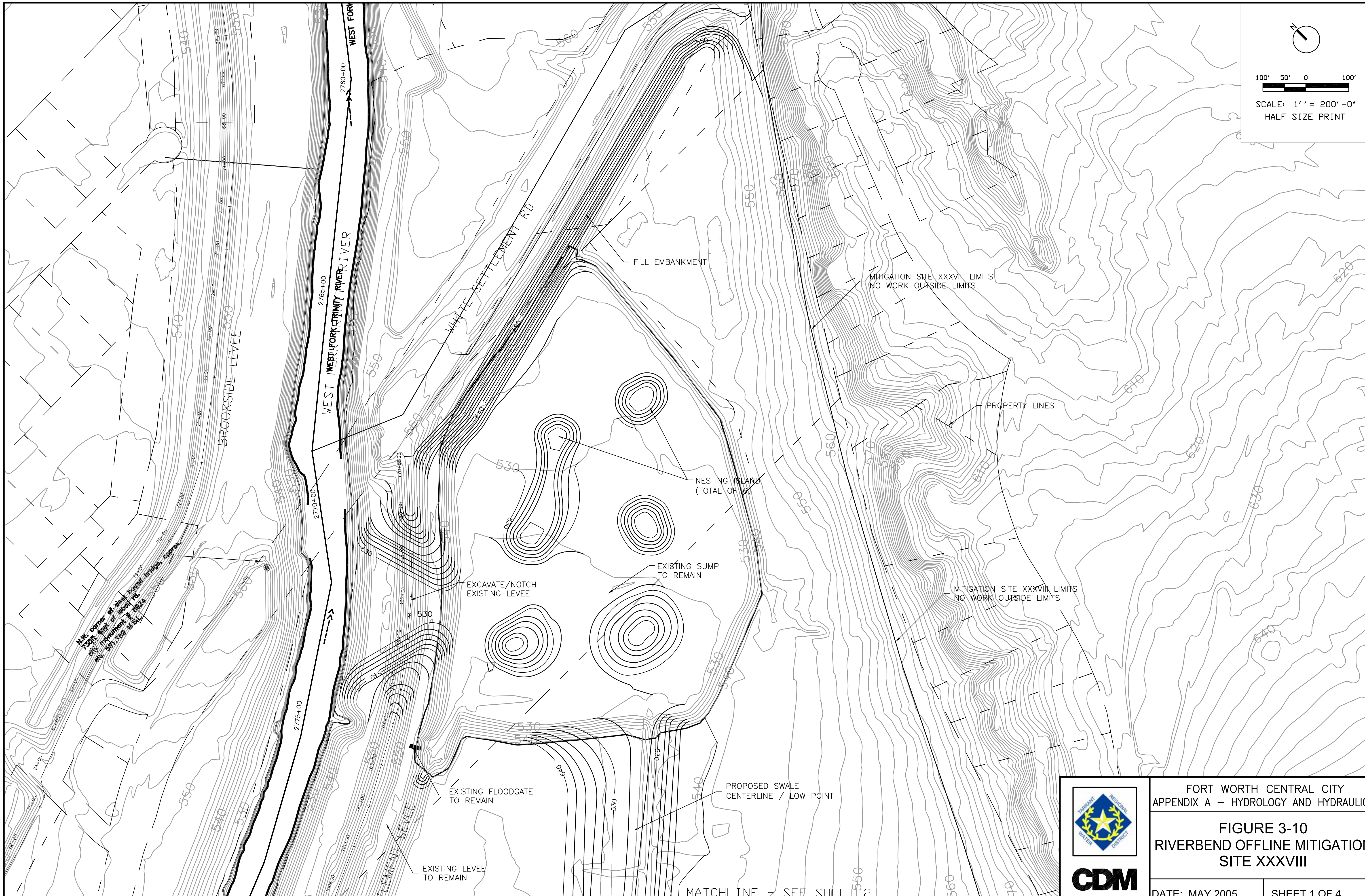

N
S
W
E
0
850
1,700
3,400
SCALE: 1" = 1700'
RIVERSIDE PARK
VALLEY STORAGE MITIGATION AREA
MARINE CREEK
SAMUELS AVE
TRWD GATE
ROCKWOOD PARK
ECOSYSTEM IMPROVEMENT AREA
JACKSBORO HWY
WEST FORK TRINITY RIVER
WEST FORK TRINITY RIVER
MAIN ST
TRINITY POINT GATE
HENDERSON ST
WHITE SETTLEMENT RD
UNIVERSITY DR
CLEAR FORK GATE
CLEAR FORK TRINITY RIVER
RIVERBEND
VALLEY STORAGE MITIGATION /
ECOSYSTEM IMPROVEMENT AREA
35W
LEGEND
BYPASS CHANNEL
ISOLATION GATES
EMERGENT WETLANDS
GRASSLAND
LEVEES (EXISTING AND PROPOSED)
RECREATION
RIPARIAN WOODLANDS (EXISTING AND PROPOSED)
SURFACE WATER (AQUATIC OXBOW)
UPLAND WOODLANDS (EXISTING AND PROPOSED)
CDM
FORT WORTH CENTRAL CITY
APPENDIX A - HYDROLOGY AND HYDRAULICS
FIGURE 3-8
OVERVIEW OF VALLEY STORAGE MITIGATION - ECOSYSTEM IMPROVEMENT AREAS
DATE: MAY 2005
SHEET 1 OF 1



FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-9
MITIGATION SITES
LOCATION MAP

DATE: MAY 2005 | SHEET 1 OF 1



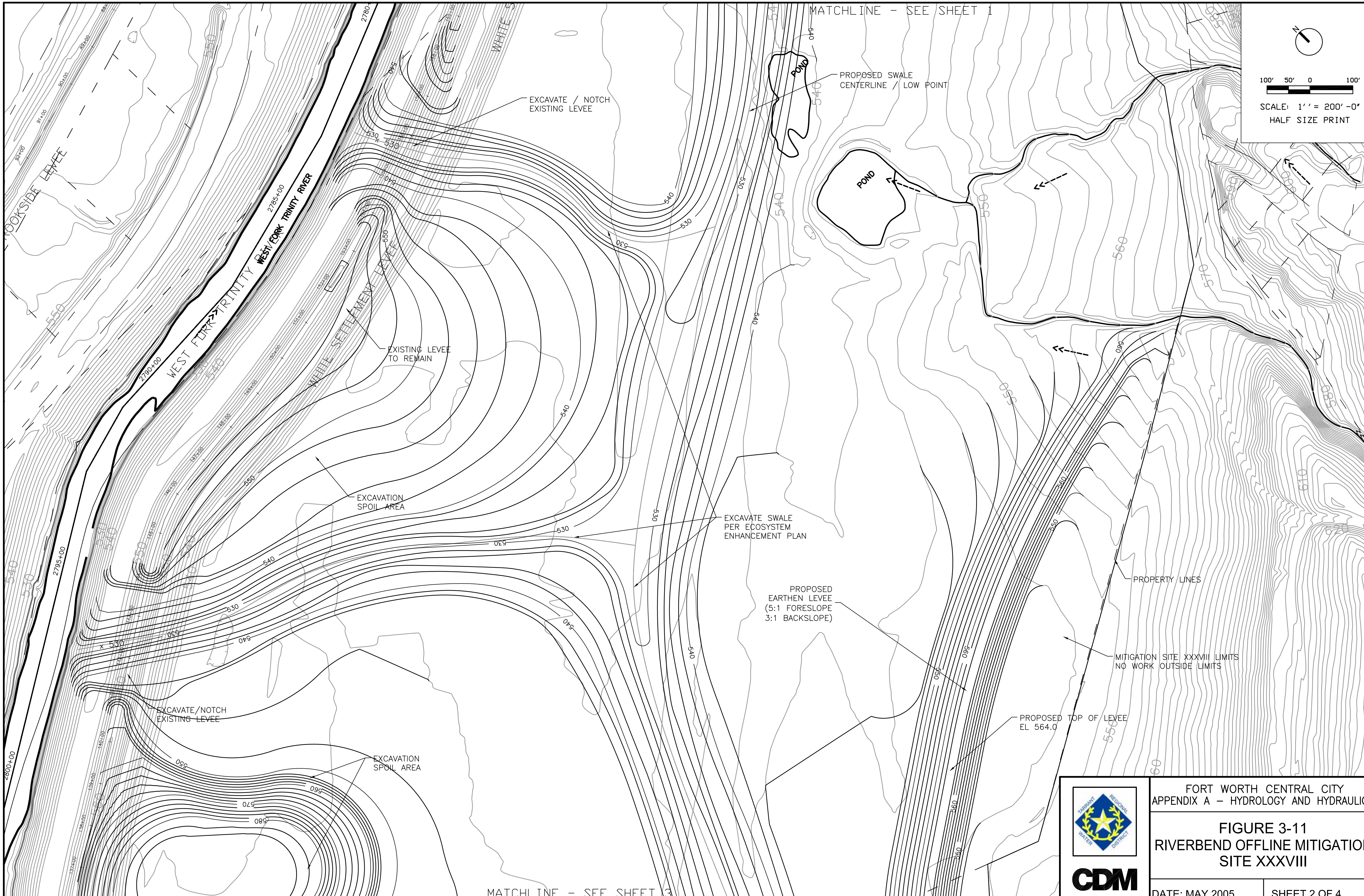
FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-10
RIVERBEND OFFLINE MITIGATION SITE XXXVIII

CDM

DATE: MAY 2005

SHEET 1 OF 4



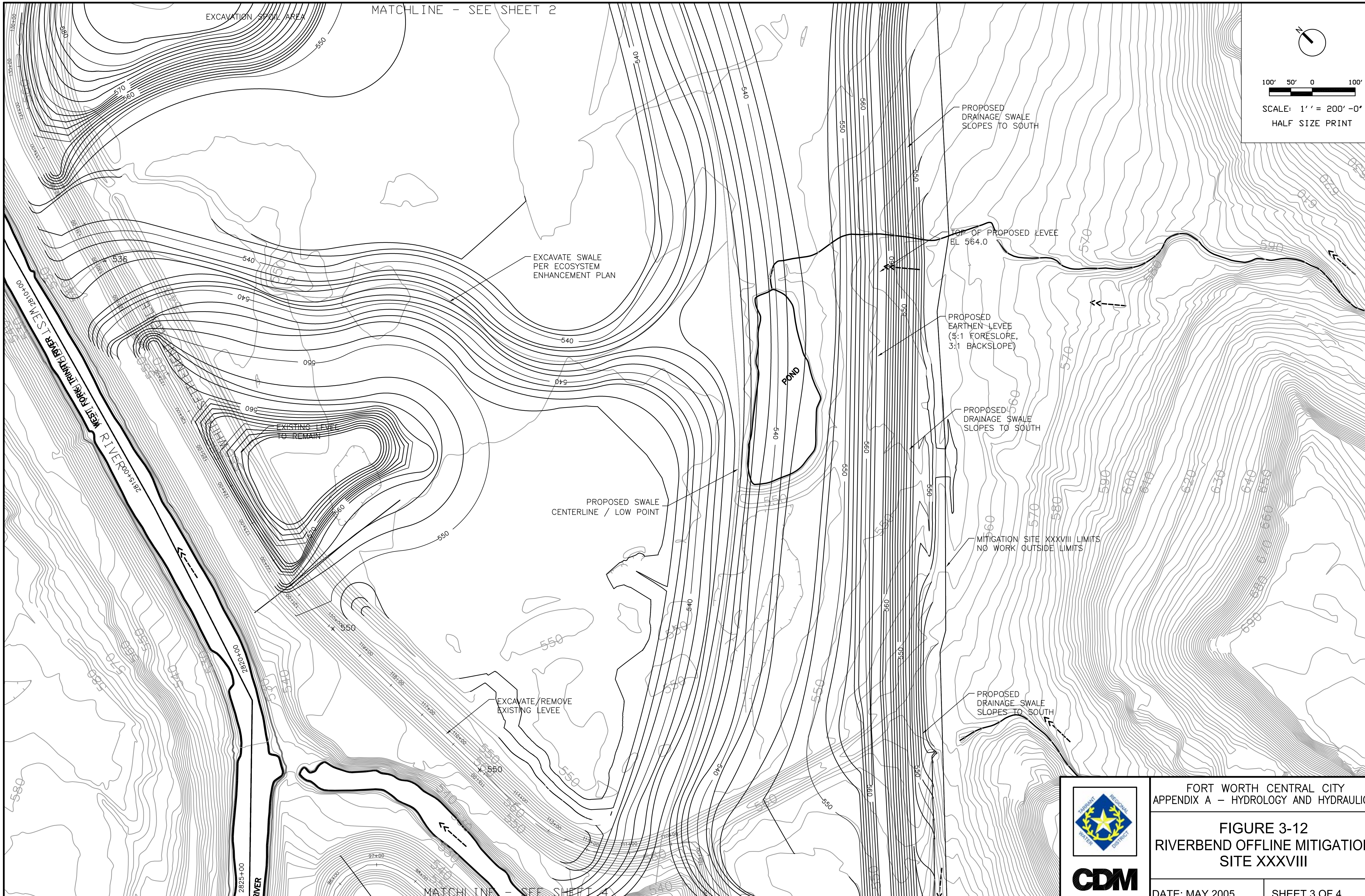
TARRANT REGIONAL WATER DISTRICT

CDM

FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-11
RIVERBEND OFFLINE MITIGATION
SITE XXXVIII

DATE: MAY 2005 | SHEET 2 OF 4



FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-12
RIVERBEND OFFLINE MITIGATION
SITE XXXVIII

CDM

DATE: MAY 2005

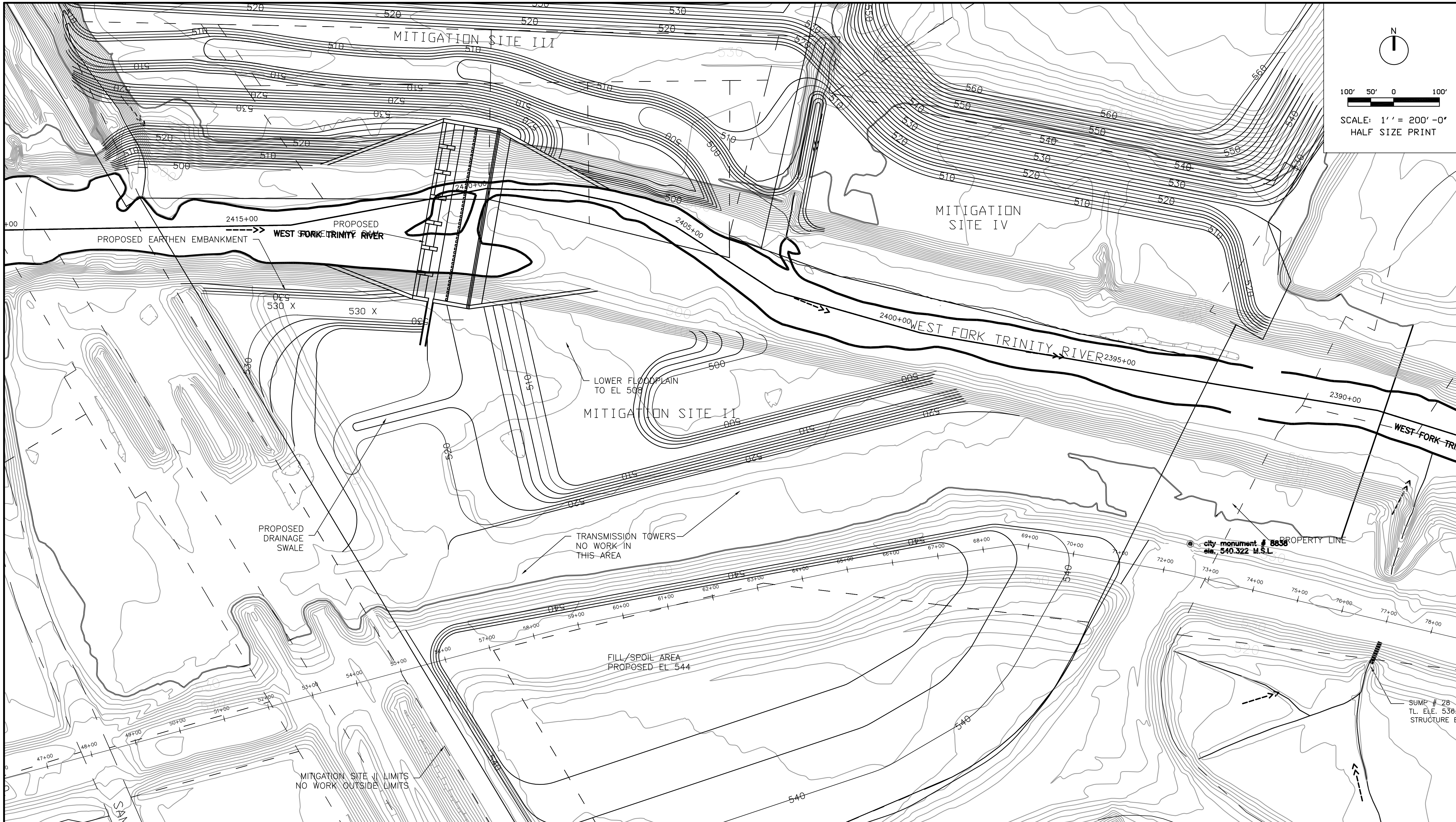
SHEET 3 OF 4

FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-13
RIVERBEND OFFLINE MITIGATION
SITE XXXVIII

DATE: MAY 2005

SHEET 4 OF 4

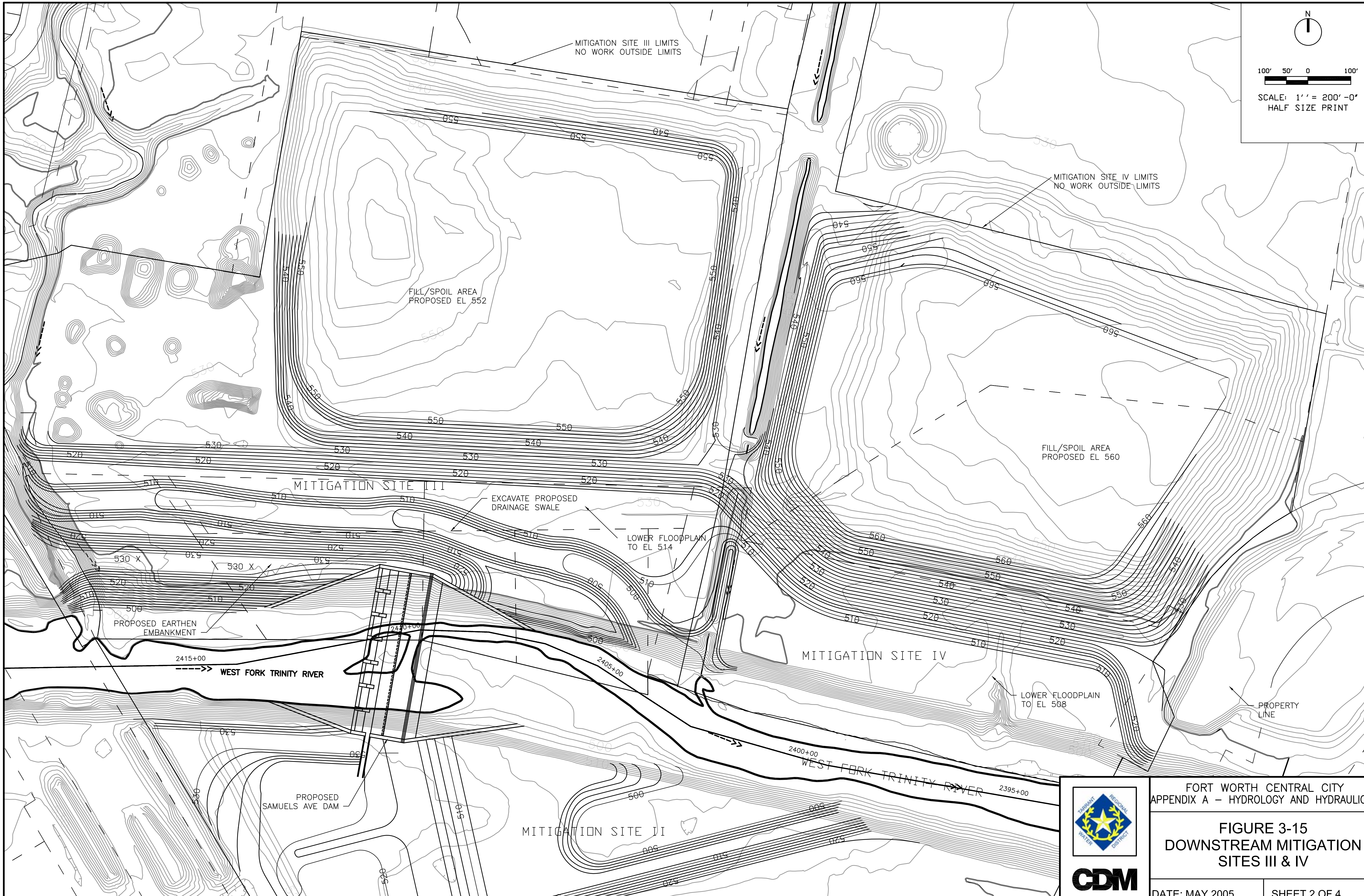


FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-14
DOWNSTREAM MITIGATION
SITE II

DATE: MAY 2005

SHEET 1 OF 4

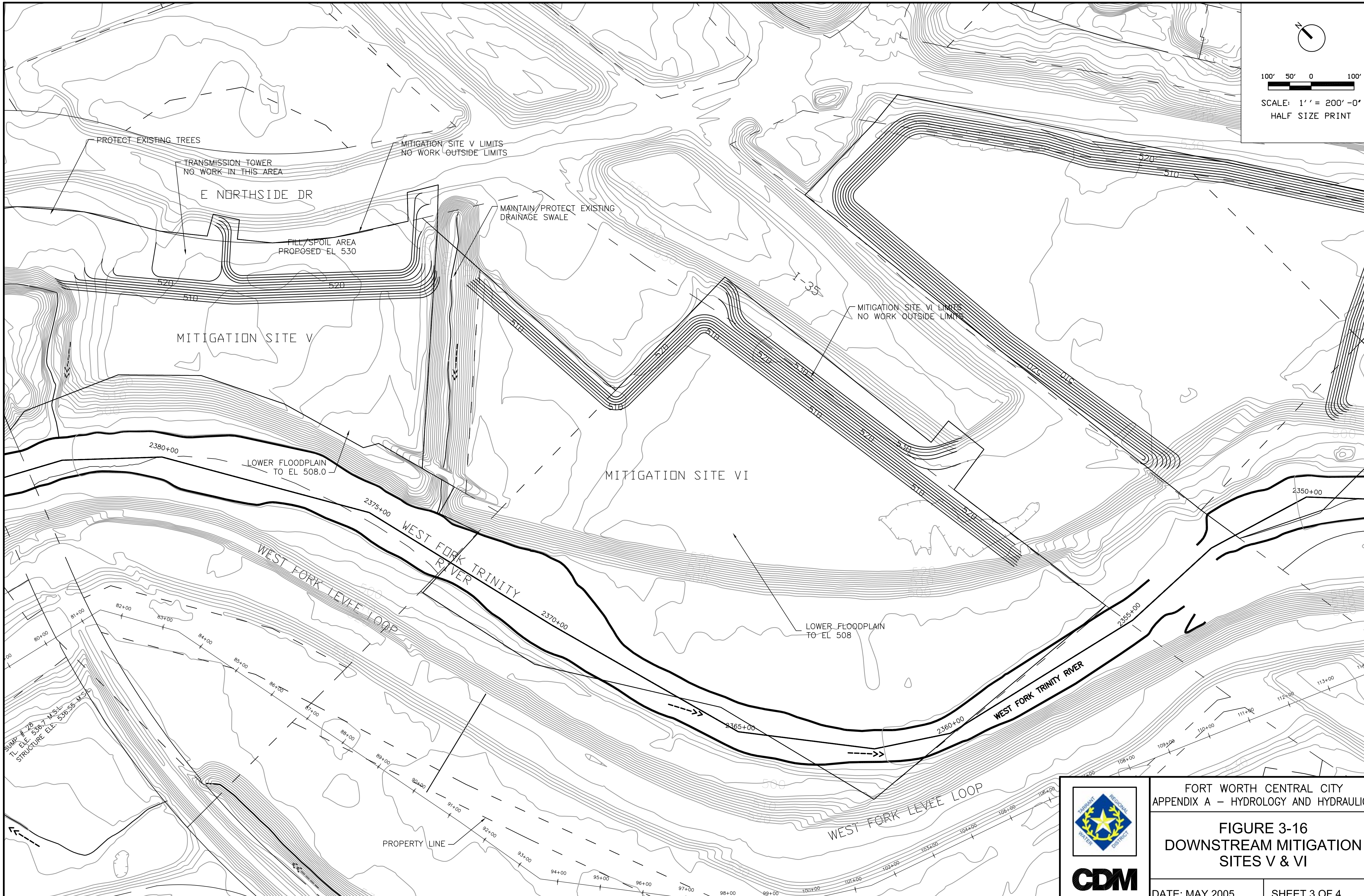


FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-15
DOWNSTREAM MITIGATION
SITES III & IV

DATE: MAY 2005

SHEET 2 OF 4



TARRANT REGIONAL WATER DISTRICT

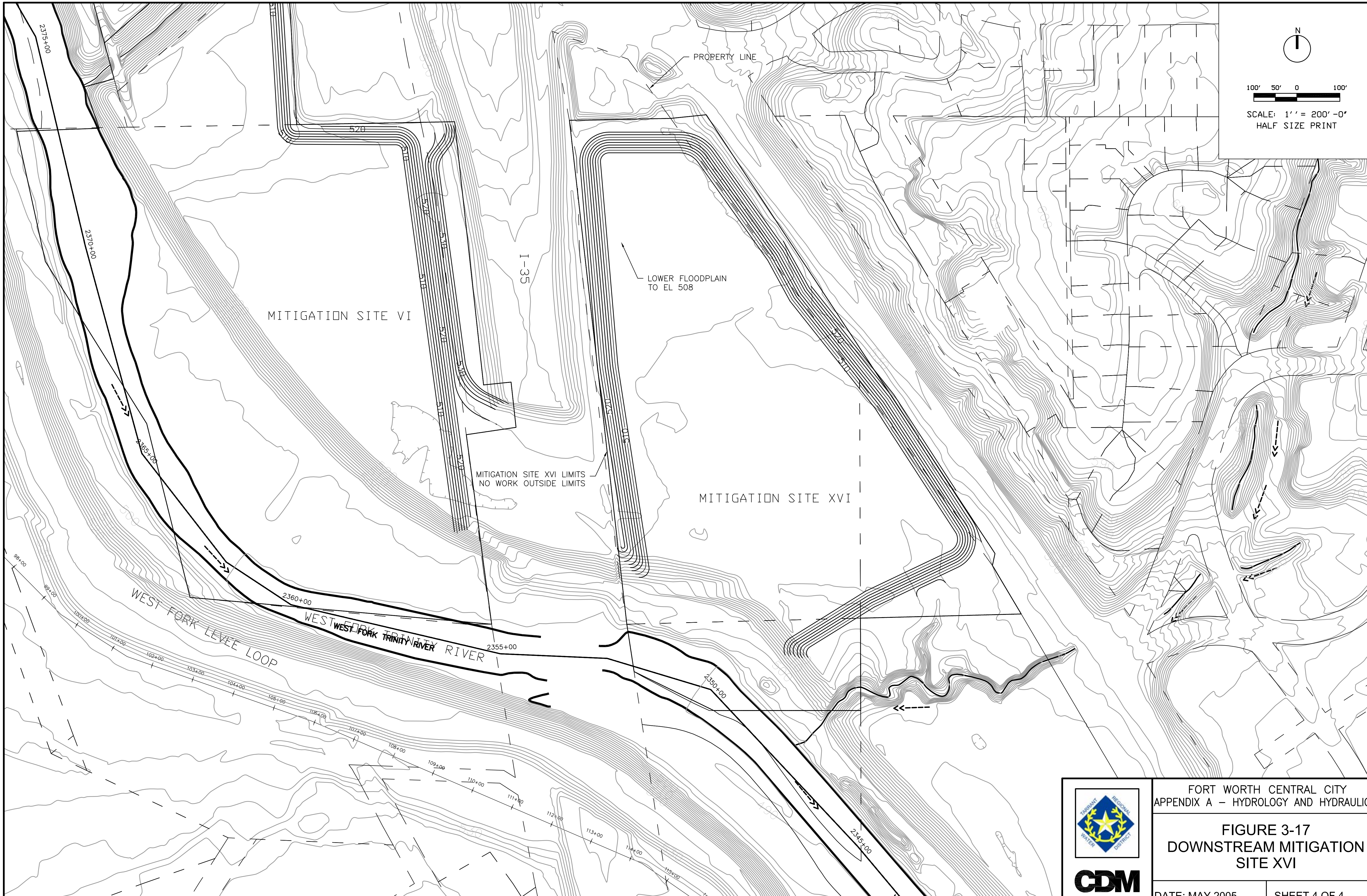
CDM

FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-16
DOWNSTREAM MITIGATION
SITES V & VI

DATE: MAY 2005

SHEET 3 OF 4

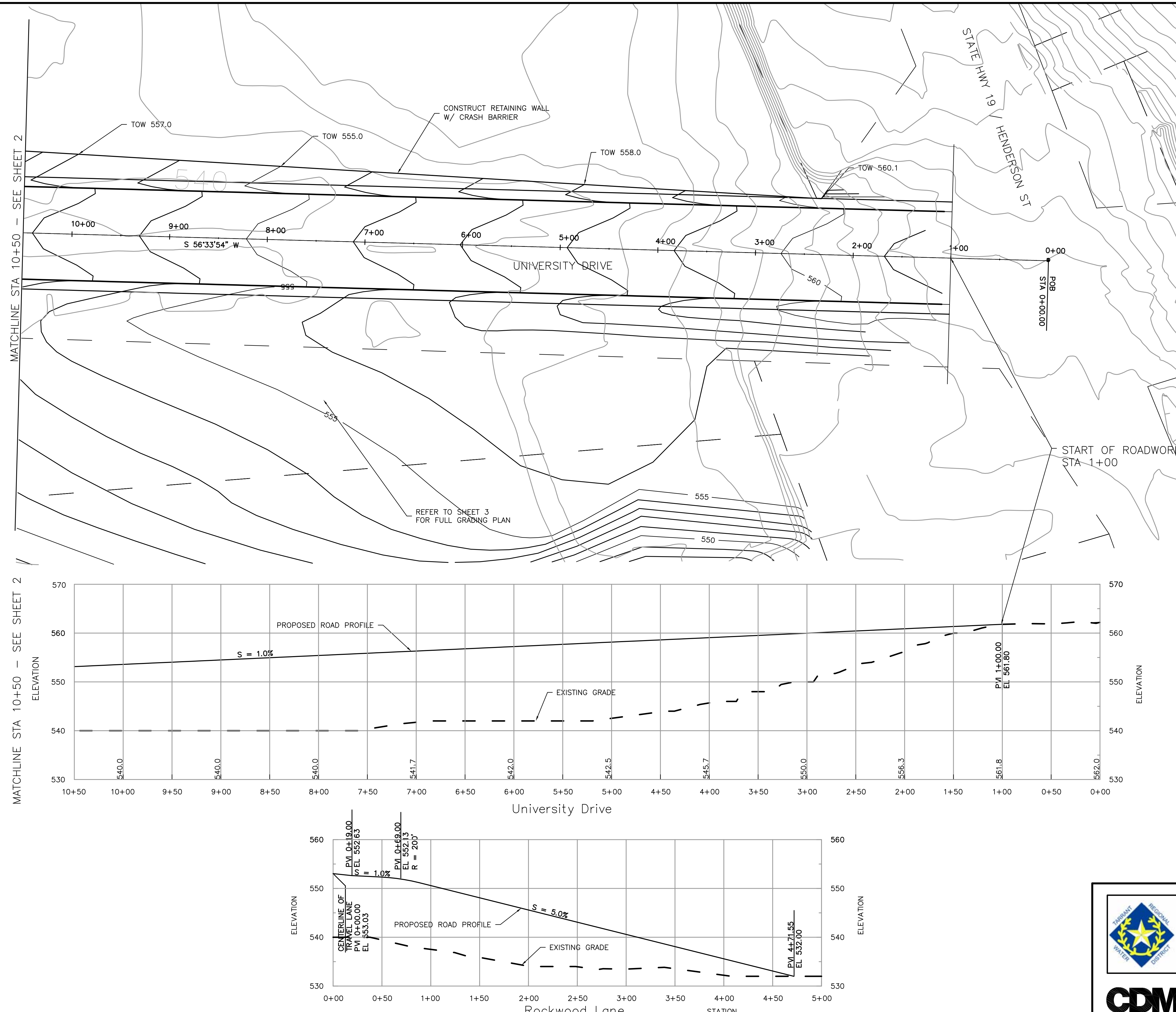


FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-17
DOWNSTREAM MITIGATION
SITE XVI

DATE: MAY 2005

SHEET 4 OF 4



SCALE: 1'' = 100'-0"
HALF-SIZE PRINT

NOTES:

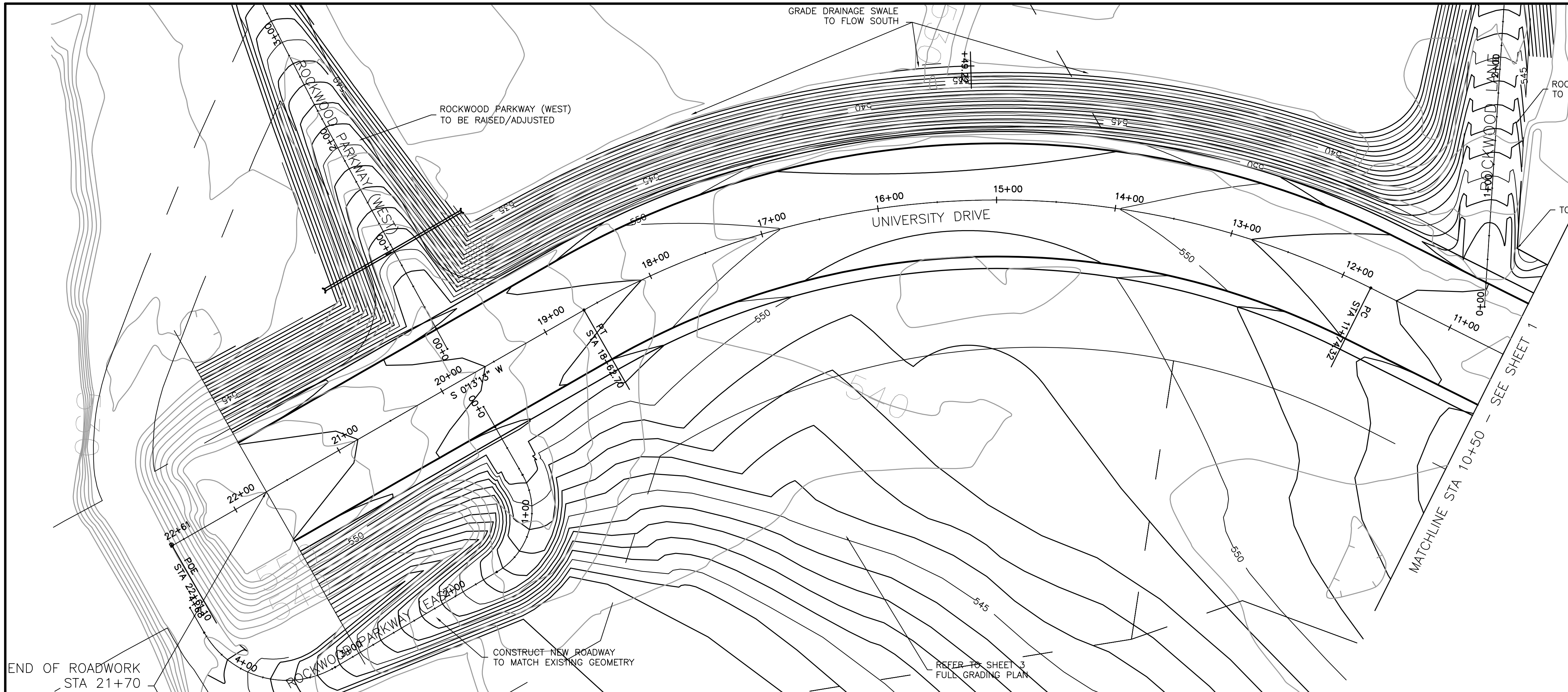
1. REFER TO CU-VS-4 FOR UTILITIES
2. PAVEMENT LINEWORK NOT CURRENTLY SHOWN FOR CLARITY. NEW PAVEMENT TO MATCH EXISTING.

FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-18
UNIVERSITY DR MODIFICATIONS
PLAN AND PROFILE

CDM

DATE: MAY 2005

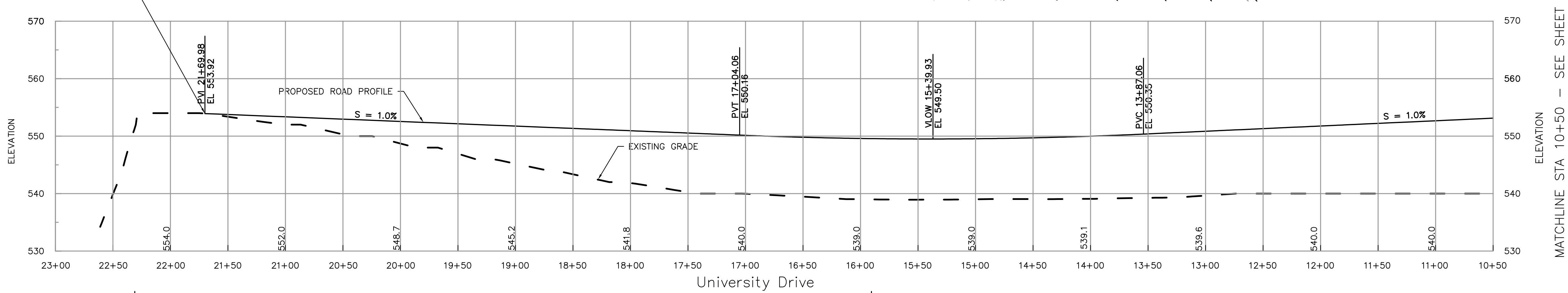


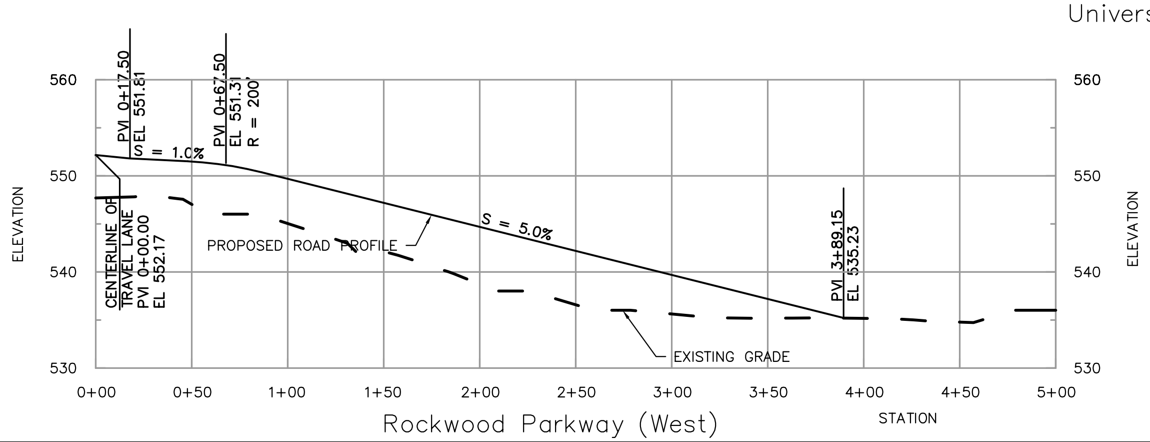
50' 25' 0 50'

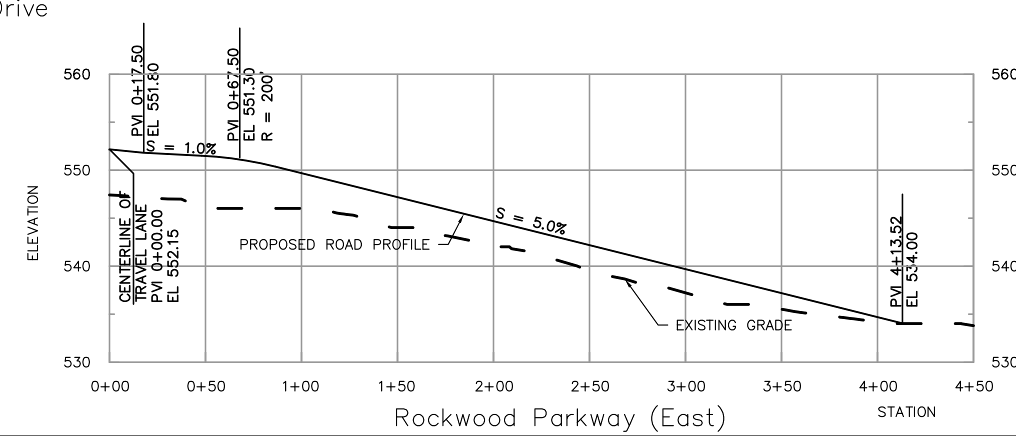
SCALE: 1'' = 100'-0''

NOTES:

1. REFER TO CU-VS-4 FOR UTILITIES
2. PAVEMENT LIFEWORK NOT CURRENTLY SHOWN FOR CLARITY. NEW PAVEMENT TO MATCH EXISTING







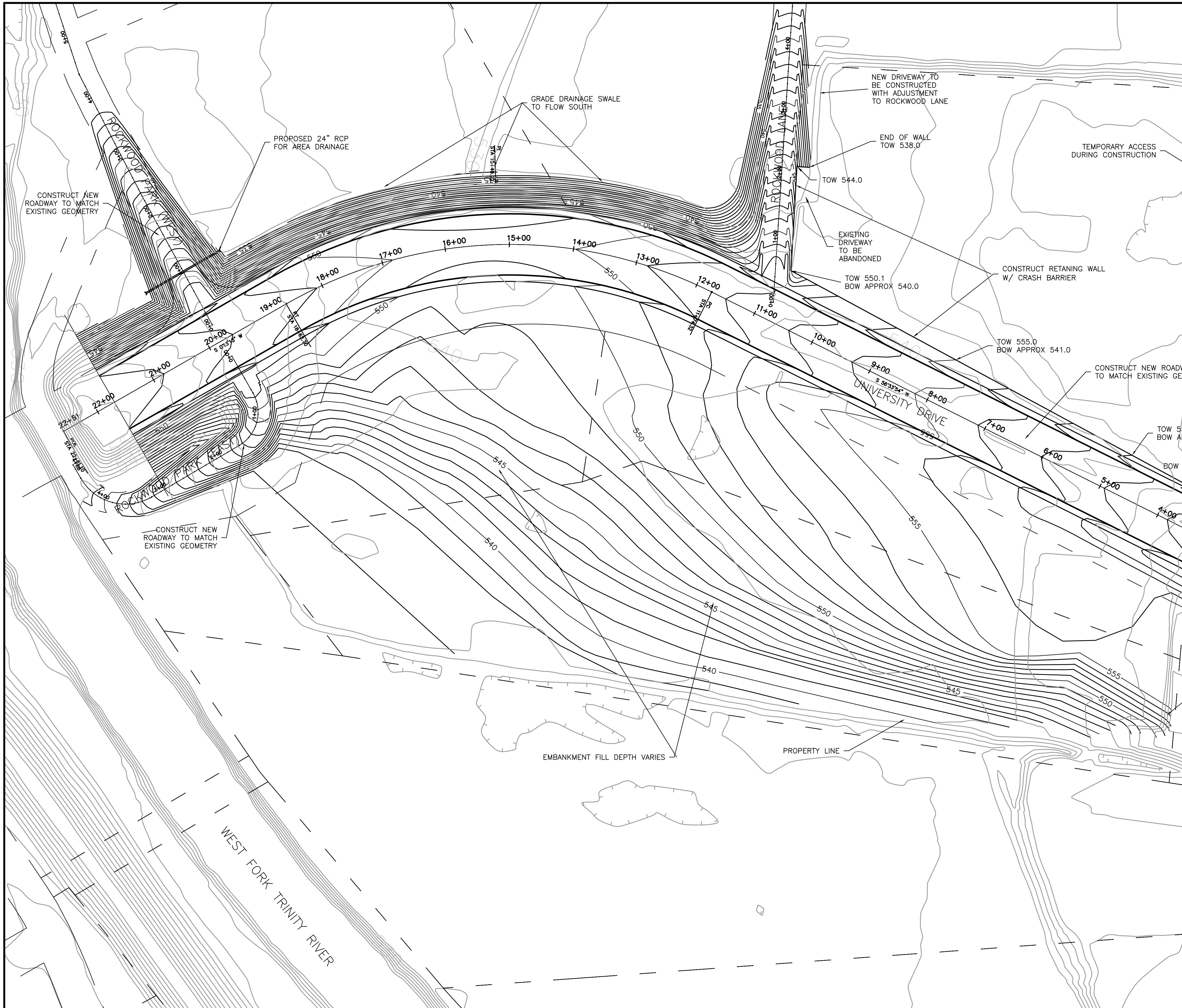
CDM

FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-19
UNIVERSITY DR MODIFICATIONS
PLAN AND PROFILE

DATE: MAY 2005

SHEET 2 OF 3



FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 3-20
UNIVERSITY DR MODIFICATIONS
GRADING PLAN

DATE: MAY 2005

SHEET 3 OF 3

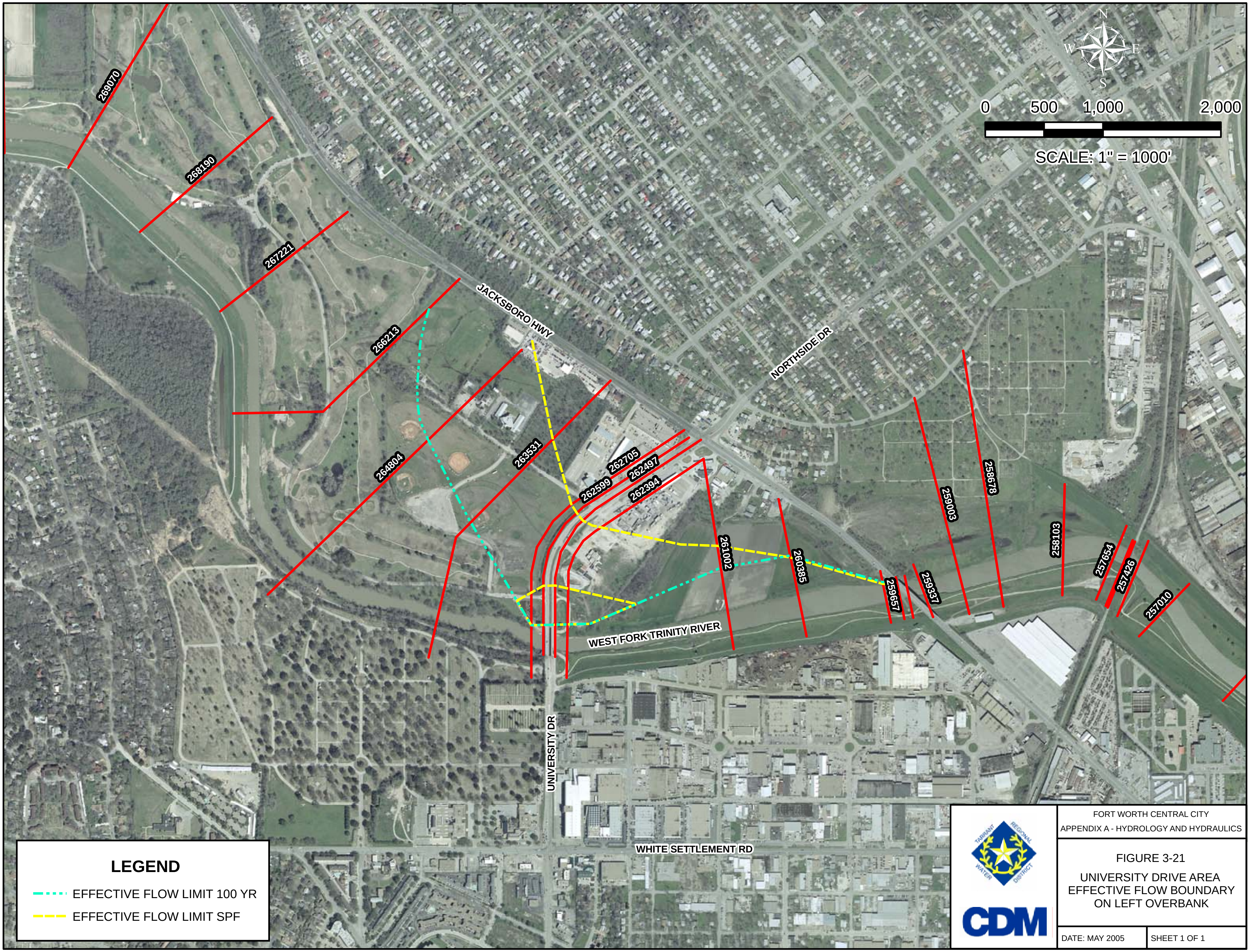
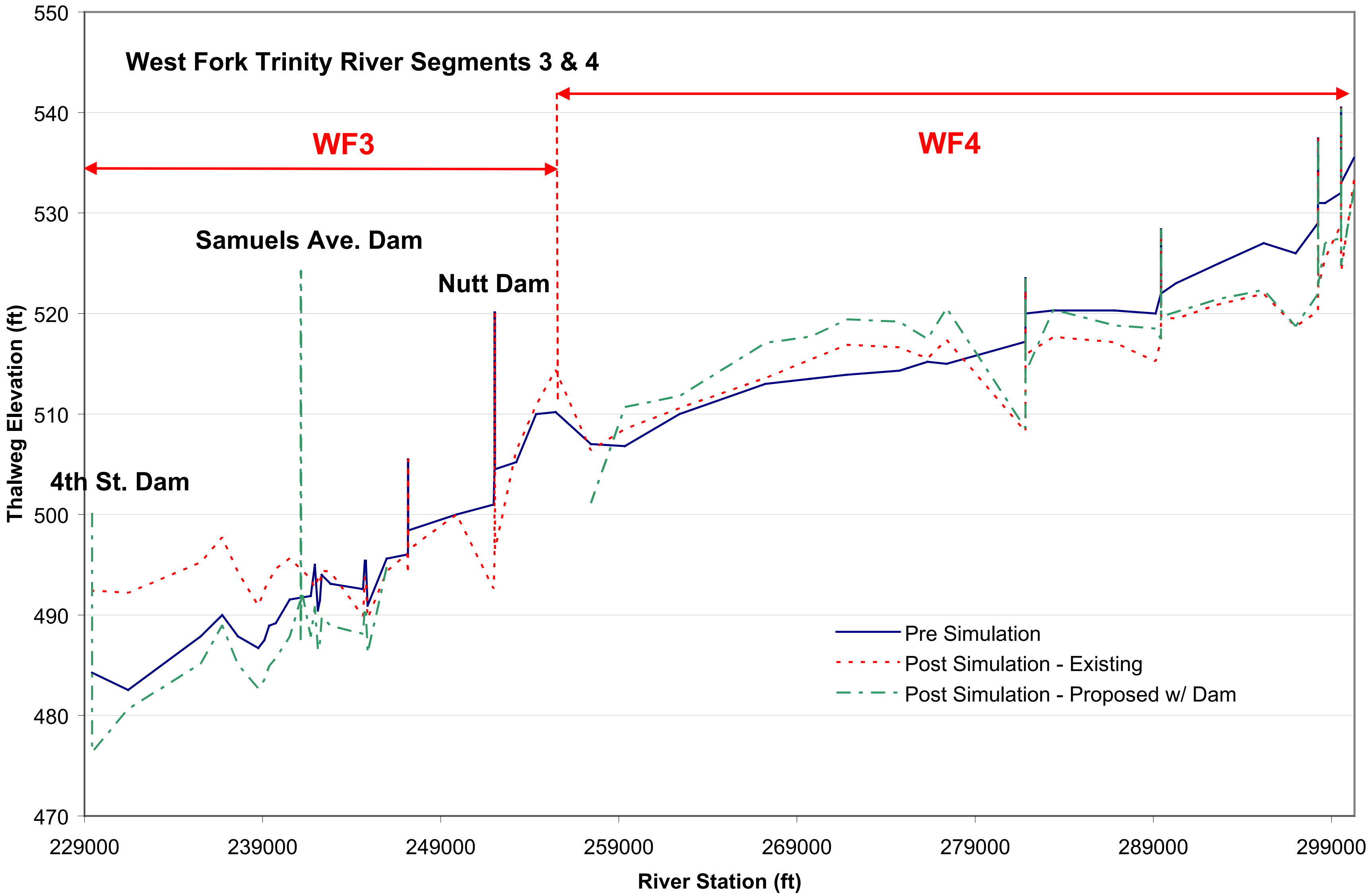


FIGURE 3-21
UNIVERSITY DRIVE AREA EFFECTIVE FLOW BOUNDARY ON LEFT OVERBANK

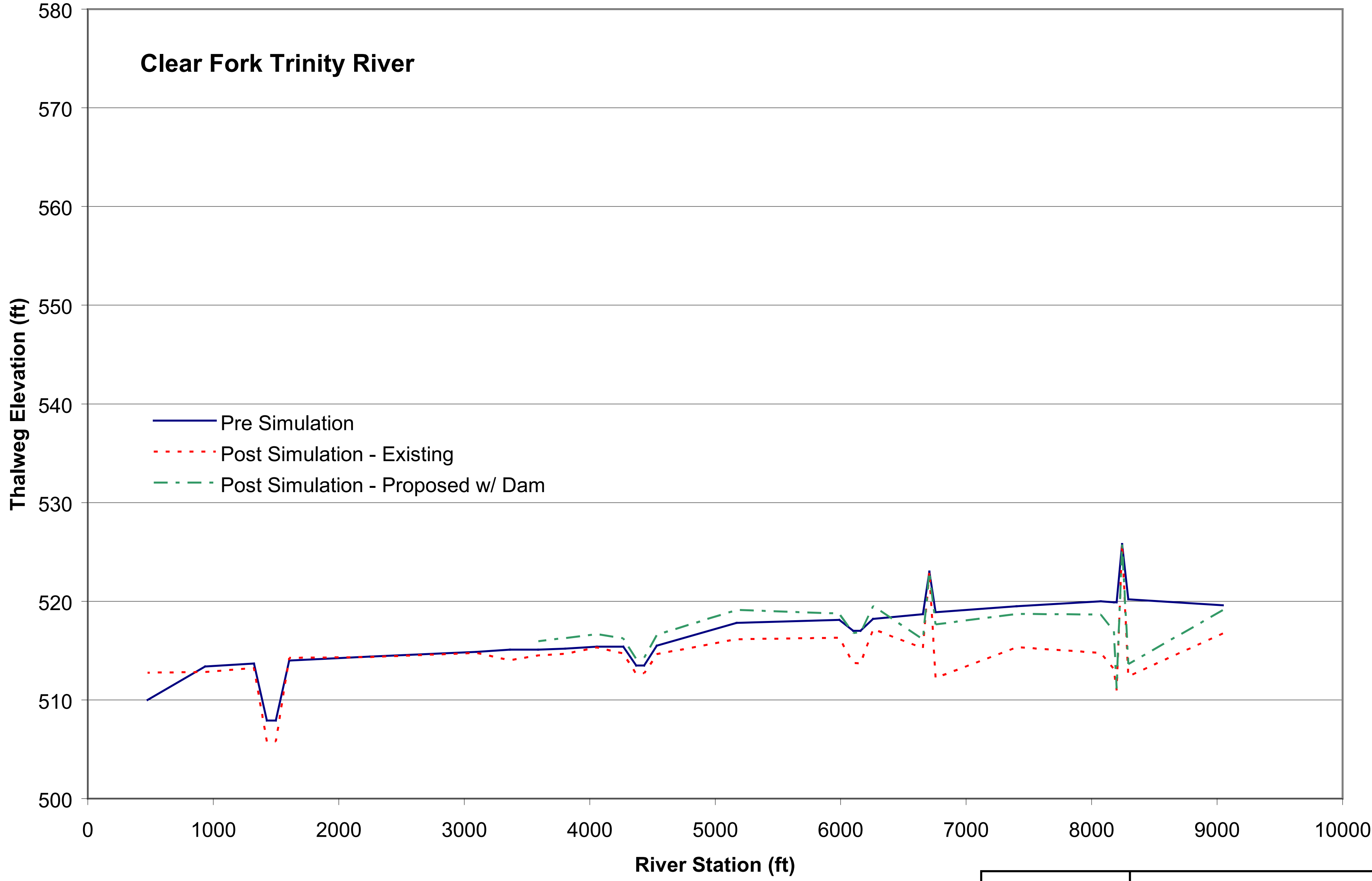


FORT WORTH CENTRAL CITY
APPENDIX A - HYDROLOGY & HYDRAULICS

COMPARISON OF THALWEG FOR EXISTING AND PROPOSED CONDITIONS – WF3 AND WF4

DATE: MAY 2005

FIGURE No. 3-22



FORT WORTH CENTRAL CITY
APPENDIX A - HYDROLOGY & HYDRAULICS

COMPARISON OF THALWEG FOR EXISTING AND PROPOSED CONDITIONS – CLEAR FORK

DATE: MAY 2005

FIGURE No. 3-23

Section 4
Operations and Maintenance

4.1 General Description

This Section discusses the preliminary plan to operate and maintain the proposed bypass channel levee system, Samuels Avenue Dam, three isolation gates, the stormwater pump station, and valley storage mitigation areas.

Channel and levee side slopes are tentatively planned for slopes of 3 horizontal to 1 vertical, similar to what has been successfully used and maintained within the existing floodway. Retaining wall structures are proposed along the east side of the bypass channel in three tiers; lower level interior walls at about normal pool level, mid-level interior walls above normal pool level and below Standard Project Flood (SPF) level, and upper level interior walls above the SPF level.

Control of the water level within the bypass channel and the interior area would be accomplished by the proposed Samuels Avenue Dam and three isolation gates to protect the interior area from flood waters. The isolation gates are planned to control the quiescent river segment of the existing West Fork River channel at the upper, lower, and middle confluences with the bypass channel.

4.2 Existing Operations & Maintenance

Currently the TRWD Operations group performs a variety of maintenance activities, similar to those expected for the proposed project. The equipment and facilities currently maintained by the Fort Worth Operations include building facilities, and equipment used by personnel at the operations. TRWD personnel are engaged in maintaining dam structures, gates and pump stations elsewhere in the District. Therefore, knowledge and expertise for maintaining these types of structures is high.

4.3 Samuels Avenue Dam, Isolation Gates and Pump Station Operations

This following describes operation practices that may be used to coordinate the opening and closing of Samuels Avenue Dam and the isolation gates during periods of operations.

4.3.1 Standard Operations Procedures

Once a final decision has been made on the hydraulic equipment, specific Standard Operating Procedures (SOPs) associated with each piece of equipment would be developed. This information would be part of a comprehensive operations manual which would include equipment manuals, parts specifications and operations procedures.

TRWD has a Computerized Maintenance Management System (CMMS) that has all of the functional capabilities typically provided in a state-of-the-art CMMS software package. For example, the current MAXIMO software program offers TRWD the following asset maintenance and management tools:

- Asset Inventory with asset register tracking relationships between equipment and physical location.
- Document and track equipment specifications, associated costs, histories and failures, to enable effective repair or replace decisions.
- Equipment hierarchies to "roll up" maintenance costs.
- Enter and document work requests from multiple users.
- Enter, record and view detailed planning information, work plans, schedule, costs, labor, materials, equipment, failure analysis, and related documents via the Work Order Tracking screen.
- Automatically issue pre-schedule preventive maintenance work orders.
- Define and sequence work for multiple procedures and assets.
- Attach safety plans, hazards, precautions and lock-out/tag-out to work plans.
- Create purchase requisitions or orders for materials and services.
- Track stocked and non-stocked items through multiple stores.

It is anticipated that TRWD would develop SOPs to provide district personnel with the safety, health, environmental and operational information necessary to perform the work on the new assets properly. This would ensure that operations are performed consistently to maintain quality control of processes and maintenance procedures. The SOPs would also serve as a historical record of the how, why and when of steps in an existing process so there is a factual reason for revising those steps when a process or equipment is changed.

4.3.2 Samuels Avenue Dam Operations

The Samuels Avenue Dam, located on the main stem of the West Fork would be located approximately 1,200 feet downstream from the confluence of Marine Creek and 450 feet downstream from Samuels Avenue Bridge. The dam would maintain the normal water level elevation of 524.3 during non-flooding conditions throughout the upstream area and would have sufficient gate discharge capacity to pass the appropriate design flows, while maintaining flood levels within existing conditions.

The operational assumption of the dam is that multiple gates would be opened partially prior to any single gate being opened fully. This would provide for much smoother and controllable operations, both for the structure and downstream interests. For example, a 2-year flow of 12,100 cubic feet per second (cfs) could be released with no rise in the upstream water level if all seven gates were lowered 4.9 feet. The 5-year flow, or 18,800 cfs, would require all gates to be lowered 6.6 feet.

Initially three operating conditions have been established for the hydraulic structures, as a guide on how to manage the system:

- Normal day-to-day operations of the structures;
- Operations during moderate amounts of rainfall (5-year flows or less); and
- Operations during significant amounts of rainfall (Greater than 5-year flows).

It is also anticipated that a chart would be developed that describes specific actions to be taken during these three operating scenarios.

Normal dry weather operation of the dam would maintain the normal water pool level elevation of 524.3 during non-flooding conditions. The dam would have sufficient gate discharge capacity with the lower regulating gates to pass the appropriate dry weather flows. During the normal operations of the dam, certain preventive maintenance efforts should be planned and scheduled. Any problems that are identified during these inspections should be corrected as soon as possible.

Moderate rainfall would range between 1 to 3 inches of rainfall within a given period of time. Prior to this rainfall, the leaf gates of the dam would be opened to reduce the level by approximately two to five feet in anticipation of the rain event. The operation of the dam would be automatic but may also include provision for manual operation.

During periods of heavy rainfall, it is anticipated that data from upstream rain gauges and water level sensors would feed information to the centralized SCADA system to provide information to lower the dam water level to an appropriate level in anticipation of a significant event. This data would assist the staff at TRWD to operate and maintain the dam. This is to minimize the impact lowering the dam that would overdraft and maintaining at a level.

It is critical to operate and regulate the flow of water through the dam during periods of significant rainfall, but it is equally important not to release unnecessary amounts of water during drought conditions. Optimal operation of the Dam gates requires managing the storage space in anticipation of future inflows and multiple needs for water.

Four -foot wide by six-foot high low flow conduits would be located in each of the three interior piers. Each gate would pass approximately 530 cfs at the normal pool level. This configuration would allow for small rises in the pool to be absorbed and then released through the low flow gates in addition to small flows over the top of the gates. Once the water surface has risen an appropriate amount, at least one of the flood control gates would need to be partially lowered to maintain the normal pool level and flood operational sequences would apply beyond that point. This would minimize the use of the large flood gates and simplify the frequent operations. The smaller gates would also allow for some limited flushing of silt from the bottom of the impoundment.

4.3.3 Samuels Avenue Dam Instrumentation and Monitoring

Instrumentation would be used to operate the hydraulic systems of the bypass channel in the following manner:

- The instrumentation system would provide information to the status of operable portions of the dam structure (e.g. gate hydraulics) and would facilitate immediate corrective actions when necessary.
- Instrumentation would allow the dam to be remotely monitored and operated, reducing the need for personnel to be available on-site.
- Instruments would detect unusual changes, such as water level fluctuations and alter staff..

Operation of the dam will be highly dependent on water level and perhaps flow. Water level at the dam, in the bypass channel, and upstream would be measured by elevation gauges – staff gauges or level sensing devices. Weather and precipitation monitoring at the dam and pershaps in the watershed could provide valuable information about both day-to-day (low flow) performance and impending storm events.

4.3.4 Isolation Gate and Storm Water Pump Station Operation

The three interior isolation gates, Clear Fork, Trinity Point, and TRWD are intended to operate infrequently, only under major flood conditions. The gates would be designed to allow normal boat and pedestrian traffic to pass when in the raised position. The sill elevation would be set at el 520 for small boat passage with adjacent walkways set at el 530. All gates would be similar in design and operation.

It is anticipated that lowering of Samuels Avenue Dam would convey most storm events with little water surface fluctuation within the interior area. Additional hydraulic modeling would be performed prior to final design to determine the resultant water surface conditions from various frequency storm events. This information would be used to determine a more detailed operating plan setting criteria for gate closures. Prior to peak flows associated with a major flooding event, the isolation gates would be lowered. It is anticipated that the operation of the gates would be manual.

The storm water pump station is envisioned to operate under two conditions. The first is during major flood events when the isolation gates are closed. In this condition the pump station would pump storm water from the interior area over the levee to the channel. The second operating condition is to assist in the maintenance of the interior water feature area. In this condition the channel is isolated from the interior either by lowering or shutting the gates, the pump station is then used to lower the water in the interior area.

4.4 Bypass Channel Maintenance

The proposed "soft" edge is located on the western side of the bypass channel, incorporates the earthen levees and is envisioned to be "park-like" or natural. In contrast, the hard edge would be located on the eastern side of the bypass channel and would contain a series of tiered retaining walls, multiple walkways, and landscaping areas.

4.4.1 Soft Edge

The soft edge would contain a recreational trail, sloped vegetation, and access for maintenance and emergency vehicles. The recreational trail would be approximately 20 feet in width and would be located approximately 5-feet above the normal base flow water surface. It would comply to ADA Requirements with a maximum cross slope of 2% and maximum longitudinal slope of 5%. The recreational trail is envisioned to allow bikers, walkers, and roller-blade access to the park like area.

In addition to the recreational trail, an access road would be constructed on top of the levee to provide maintenance access for routine maintenance and during major storm events when the lower recreational trail is unavailable. Ramps or other means of street access would be provided to the top of the levee.

Bermuda grass would be maintained on the soft edge levee side slopes above the recreational trail to improve aesthetics and provide slope erosion protection. Selection of the landscaping in this area would be appropriate and could include a combination of medium to tall shade trees and low lying bushes. Consideration would be given to selecting the landscaping that would be able to survive occasional storm flows in the channel as well as extended dry periods without impairing the integrity of the levee embankment.

Native or Bermuda grasses would be planted on the backside of the levee and maintained in accordance with current operating procedures. The levee toe would be sloped to provide for over land drainage through existing swales where they do not currently exist.

4.4.2 Lower Walkway and Landscape Area

The Lower Walkway and Landscape Area would be 30 feet wide and approximately 8,400 feet long equaling 252,000 square feet. In this area, the walkway area would be approximately 14 feet wide and 8,400 feet long equaling 47,600 square feet and the landscape area would approximately 16 feet wide and 8,400 feet long equaling 134,100 square feet. Similar to the recreational trail on the soft edge, the lower walkway would allow pedestrian access to the "park-like" environment of the channel.

Maintenance activities in the lower walkway and landscape areas would involve maintaining the sidewalks, and shrubs, to be weed free and clean in appearance. Any debris from mowing, trimming, or pruning would be removed after maintenance activities. The landscape area would consist of shrubs and flowers that would need to be thinned and pruned. There would be trees located in the area requiring very little maintenance in the beginning. Application of fertilizer would be required during the growing season to maintain a healthy green color throughout the year. Additionally, lawn herbicides would be applied in areas to control weeds.

4.4.3 Turf Maintenance

Current turf maintenance practices conducted by TRWD's Fort Worth Operations personnel are seasonal, with most activity during the chief growing season, April through November. Current turf maintenance includes mowing, fertilization, repair and renovation. Grass height is maintained according to species and variety of grass. Aeration, reseeding or sodding and weed control are practiced as needed. The cost for mowing and weed abatement is estimated on a cost per acre. Data is currently being tracked using a Computerized Maintenance Management System (CMMS). This system tracks costs on a per acre basis including the equipment being used, fuel, labor and benefits, and any supplies.

It is anticipated that the frequency of mowing of the bypass channel would be 12 times per year, which equals the current mowing frequency performed on the existing levees. However, it is anticipated that this area would attract additional visitors and may require an increase in mowing, if necessary.

4.4.4 Levee Debris Removal

The current debris removal program requires TRWD personnel to provide weekend supervision with a lead position supervising the weekend, both Saturday and Sunday work release program from the Sheriff's Department. The areas along the trails and paths usually are the primary place for debris collection and removal. The current level of debris removal would continue. Larger debris is infrequent and is removed by TRWD staff as necessary.

4.5 Riverbend Site

The purpose of the Riverbend site is to establish valley storage mitigation. This section covers the operation and maintenance of this location, specifically the grasslands, the levees and woodlands in this location. The following are the maintenance requirements:

- Planting of seedlings and irrigation of these trees during the first five years using a temporary irrigation system.
- Debris removal that may occur from visitors at the location.
- Trail maintenance, these would be natural trails that would require maintenance as a result of erosion and wear.
- Levee maintenance to prevent slope failure.

4.5.1 Riverbend Grassland Maintenance

The preliminary design of the ecosystem areas grassland should provide brush cover for small animals. The area would consist of native grasslands, where possible, replacing Bermuda and Johnson grass communities. A mowing schedule in these areas shall not interfere with the tall-grass nesting birds. Mowing of the grasslands would be performed after July 15th of each year, preferably in August or September and be cut back to a one foot height.

Besides mowing, the grassland maintenance performed at the Fort Worth Operations for this area would include minimal fertilization, repair and renovation. The cost for mowing and weed abatement is estimated on a cost per acre. Mowing and maintaining of this turf requires the use of Bat Wing Mowers and small finish mowers to keep areas attractive and meet the districts quality guidelines.

The total grassland area represents approximately 66 acres and would require a combination of maintenance activities from mowing once a year and debris removal approximately three times per year.

4.6 Samuels Avenue Dam, Isolation Gates and Pump Station Maintenance

Routine maintenance would be performed on the Samuels Avenue Dam, the isolation gates and pump station's equipment to ensure operational reliability and to maximize the useful life. The maintenance program would focus on preventive maintenance. The organization and staffing to support the maintenance program would require an understanding of the following types of systems:

- Electrical and electronic systems;
- Mechanical systems; and
- Hydraulic and pneumatic systems.

The maintenance for each of these systems requires a different set of skills and varying levels of knowledge. Because it would be extremely unlikely for any single employee to possess the detailed knowledge required to operate and maintain all such systems, it is typical for an agency to separate or create specialized maintenance groups. Alternatively, agencies establish maintenance contracts with companies with personnel having the skills to perform these specialized tasks.

4.6.1 Inspection Program

An effective inspection program for the Samuels Avenue Dam, isolation gates and pump station would be essential to identify problems early and to provide for safe maintenance of the structures. The inspection program would involve the following three types of inspections:

- Periodic technical inspections which involve inspections with specialists familiar with the design and construction of dams, isolation gates and pump station including assessments of structure safety

- Periodic maintenance inspections which are performed more frequently than technical inspections in order to detect, at an early stage, any detrimental developments in the dam, isolation gates and pump station; they involve assessment of operational capability as well as structural stability.

- Informal observations, which are continuing efforts by onsite personnel and performed in the course of normal duties.

Section 5
Summary and Conclusions

5.1 Conclusions

The project represents a significant change to the hydrologic and hydraulic characteristics of the Trinity River near the confluence of the West and Clear Forks. The assessment of the system characteristics detailed in this report documents that the project can be designed so that no loss in the current level of flood protection occurs either upstream or downstream of the immediate project area. Some benefits to the level of protection from the 100-year and SPF events will accrue within the project area.

The analyses and exhibits in this report demonstrate that it is feasible to design a project that meets all relevant Corridor Development Certificate (CDC) requirements. In addition, it will provide valuable amenities and opportunities within both the urban design features and the required valley storage mitigation sites. The project represents a major advancement in community and federal goals for sustainable development. The relevant criteria for the project derive predominantly from the CDC criteria promulgated through a regional effort between local stakeholders and the USACE.

5.2 Further Analyses

The steady-flow model developed for this submittal demonstrates compliance of the project with the Regional CDC criteria. Additional hydrologic and analysis is needed in the following areas:

- Refinement of the hydraulic model to finalize floodway and vegetation characteristics associated with valley storage mitigation sites;
- Refinement of the hydraulic model to reflect the final treatment surfaces in the critical mitigation areas near Samuels Avenue Dam;
- Refinement of an unsteady flow model of the project for operations analysis;
- Assessment of alternative hydrologic events important to developing adequate dam and gate operating rules.

These and other tasks necessary to advance the analyses beyond preliminary design will be developed jointly with USACE Fort Worth District staff.

Section 6
References

CDM 2004b – Draft Technical Memorandum – Evaluation of Groundwater Issues for the Proposed Trinity River Realignment, Fort Worth, Texas, CDM, November 16,2004.

Corrrel, D. S., and M. C. Johnston; "Manual of the vascular plants of Texas"; Texas Research Foundation; Renner, Texas; 1970.

Diggs, G.M., Jr., B.L. Lipscomb, and R.J. O'Kennon; Shinner's & Mahler's Illustrated Flora of North Central Texas; Botanical Research Institute of Texas; Fort Worth, Texas; 1999.

Dickson, K. L., W.T. Waller, J.H. Kennedy, R.W. Arnold, and J.F. Hall; "A Water Quality and Ecological Survey of the Trinity River"; Proceedings of the 1990 Trinity River Symposium; Water Resources Research Center Special Publication; Texas A&M University Press; College Station, Texas; 1991.

Gould, F. W.; "Texas Plants - a checklist and ecological summary, MP-585"; Texas Agricultural Experiment Station; College Station, Texas; 1975.

Gould, F. W.; "The Grasses of Texas"; Texas A&M University Press, College Station, Texas; 1975.

NCTCOG; "North Central Texas 2030 Demographic Forecast"; North Central Texas Council of Governments; Arlington, Texas; April 2003.

NCTCOG; "2000 Land Use By City for North Central Texas"; North Central Texas Council of Governments; Arlington, Texas; November 2004.

NCTCOG; "Corridor Development Certificate Manual for the Trinity River Corridor of North Central Texas"; North Central Texas Council of Governments; Arlington, Texas; Third Edition, September 2002.

NWS; "Dallas/Fort Worth Climatology (http://www.srh.noaa.gov/fwd/CLIMO/dfw/dfwclimo.html)"; National Weather Service: Fort Worth Weather Forecast Office; Fort Worth, Texas; May 2004.

NRCS; "Soil Survey – Tarrant County, Texas"; U.S. Department of Agriculture, National Resources Conservation Service, Washington, DC; 1981.

TCEQ; "State Implementation Plan: Dallas/Fort Worth Nonattainment Area"; http://www.tnrcc.state.tx.us/oprd/sips/sipdfw.html#SIP;Texas Commission on Environmental Quality, Austin, Texas 2004.

Thomas, W.A, Copeland, R.R., and McComas, D.N.; "SAM Hydraulic Design Package for Channels"; U.S. Army Corps of Engineers; Engineer Research and Development Center, Vicksburg, Mississippi; 2002.

USACE; HEC-6 Scour and Deposition in Rivers and Reservoirs, Users Manual; U.S. Army Corps of Engineers; Hydrologic Engineering Center, Davis, California; 1993.

CDM

Memorandum, CCIV-4

To: *File*

From: *Michael Oleson, CDM*

Date: *January 5, 2004*

Subject: *Riverbend Storage Calculation Procedure and Calculations*

The objective of this task was to calculate the additional valley storage created from site modifications along the upper West Fork at the Riverbend Offline Mitigation Site (283400 to 276562), also referred to as Valley Storage Mitigation Site XXXVIII, by triangular volume measurement using Bentley's Inroads civil design software. Site grading plans were developed for the Riverbend site and are included as Figures 3-8 through 3-11. Included in this memorandum describes the procedure and supporting calculations used to derive at the total storage value.

Procedure- Model Surfaces

Existing topography as provided by the U.S. Army Corp of Engineer's (Corps) in the form of a Micro Station three-dimensional (3D), 2-ft contour file was imported into Inroads and triangulated to create an existing surface digital terrain model (DTM). Using this DTM existing contours where then regenerated and compared to the existing Corp contour file to verify the accuracy of the existing DTM surface. The existing DTM the existing contour file was then used as a baseline to generate a proposed site grading plan.

The proposed site grading plan included the cutting of notches in the existing levee in order to allow the inundation of additional overbank areas in effort increase valley storage. Additional site modifications were made as part of a proposed ecosystem enhancement plan for the site which includes cutting an oxbow in the southern portion of the site and a swale through the northern portion of the site. The excavated material from these two areas was then assumed to be used to construct new levees on the east side of the site to protect low lying areas outside of the property limits. Additional spoil areas were created on the site in order to balance the cut and fill material totals. The proposed contours were then imported into Inroads to create the proposed DTM. The same procedure as was used for the existing DTM was then used to generate new proposed contours and verify the accuracy of the grading plan.

After the generation of the existing and proposed DTM's the proposed HEC-RAS model SPF and 100-yr water surface elevations at each of the model cross section locations were used to create modeled water surface DTM's for the SPF and 100-yr water surface elevation across the entire site. These design surfaces were then used for comparison of the design surface through the use of the Inroads terrain modeler.

Evaluation Procedure

A volumetric evaluation of the increased valley storage created by the site modifications to Riverbend was made by comparing the SPF and 100-yr water surface elevation DTM's to the existing and proposed DTM's. Polygon shapes were created along the boundaries of the existing and proposed levees to avoid counting areas outside of the designated mitigation site. For the existing condition the polygon shape was defined as the centerline of the West Fork to the centerline of the existing levee. The proposed condition polygon was then defined from the same West Fork centerline to the centerline of the new levees or equivalent existing ground surface if above the SPF elevation.

Using the Inroads terrain modeler the existing and proposed condition polygon shapes were then used to compare the triangular volume from the SPF and 100-yr water surface elevations to the existing ground surface and proposed ground surfaces. Assuming the original surface as the water surface (SPF and 100-yr) and the design surface as either the existing or proposed water surface the total cut volume can be interpreted as floodplain storage. Fill volumes were disregarded as these volumes would be above the respective water surface elevation and not applicable to the calculation.

Inroads triangular volume reports for the Riverbend site are included as an attachment to this memorandum. Table 1 is a summary of the Valley Storage capacity at each respective water surface elevation as derived from the triangular volume report.

Table 1: Valley Storage Mitigation Volume Summary

	Average W.S. Elevation	Existing Floodplain Storage	Total Floodplain Storage w/ Site Modifications	New Floodplain Storage
	EL	AC-FT	AC-FT	AC-FT
Site XXXVIII- Riverbend				
Flood Storage (below WS EL)				
SPF	556.54	694	3,940	**3,246**
100yr	549.15	447	2,165	**1,718**

Notes:
1. Existing Floodplain Storage Volume calculated from centerline of West Fork Trinity River to the existing levee centerline.
2. Total Floodplain Storage Volume with Site Modifications calculated from centerline of West Fork Trinity River to proposed levee/ existing ground surface.
3. Volumes based on Bentley InRoads volume report (1/04/05) using Site 38 (1-3).dtm.

Summary

SPF and 100-yr storage volumes of 3,246 acre-ft and 1,718 acre-ft, respectively were found for Riverbend (Site XXXVIII) based on the evaluation of existing to proposed site conditions. Additional refinement of the mitigation site will be necessary as final design progresses.

Attachments

Inroads- Triangle Volume Report(s)- Existing and Proposed Conditions

```
Site XXXVIII- Riverbend
Existing Conditions

Triangular Volume Report from Bentley Inroads (11-10-04)

Triangle Volume

  Triangle Volume Report

Original Surface: Site 38 SPF (11-10)
  Design Surface: TR CoE Existing W University

            Mode: Selected Shapes
      Cut Factor: 1.00
     Fill Factor: 1.00

Level: 30, Color: 5

             Cut: 30227538.84 cu ft
            Fill: 237594.69 cu ft
             Net: 29989944.14 cu ft

             Cut: 1119538.48 cu yd        (694 AC-FT)
            Fill: 8799.80 cu yd
             Net: 1110738.67 cu yd


Triangle Volume

  Triangle Volume Report

Original Surface: Site 38 100 (11-10)
  Design Surface: TR CoE Existing W University

            Mode: Selected Shapes
      Cut Factor: 1.00
     Fill Factor: 1.00

Level: 30, Color: 5

             Cut: 19459274.07 cu ft
            Fill: 1875630.68 cu ft
             Net: 17583643.39 cu ft

             Cut: 720713.85 cu yd         (447 AC-FT)
            Fill: 69467.80 cu yd
             Net: 651246.05 cu yd
```

Site XXXVIII- Riverbend
Proposed Conditions

Triangular Volume Report generated from Bentley Inroads (1-4-05).

Triangle Volume

Triangle Volume Report

Original Surface: Site 38 SPF (11-10)
Design Surface: Site 38 (1-3)

Mode: Selected Shapes
Cut Factor: 1.00
Fill Factor: 1.00

Level: 0, Color: 34

Cut: 171589755.26 cu ft
Fill: 10469200.97 cu ft
Net: 161120554.29 cu ft

Cut: 6355176.12 cu yd (3,940 AC-FT)
Fill: 387748.18 cu yd
Net: 5967427.94 cu yd

Triangle Volume

Triangle Volume Report

Original Surface: Site 38 100 (11-10)
Design Surface: Site 38 (1-3)

Mode: Selected Shapes
Cut Factor: 1.00
Fill Factor: 1.00

Level: 0, Color: 34

Cut: 94281835.43 cu ft
Fill: 24158559.39 cu ft
Net: 70123276.05 cu ft

Cut: 3491919.83 cu yd (2,165 AC-FT)
Fill: 894761.46 cu yd
Net: 2597158.37 cu yd

CDM

Tarrant Regional Water District

Fort Worth Central City Preliminary Design
Hydrology and Hydraulics
Revised Interim LPP Model Submittal 3
Interior Drainage

United States Army Corps of Engineers

May 20, 2005

Revised Preliminary Submittal

Tarrant Regional Water District

Fort Worth Central City Preliminary Design
Hydrology and Hydraulics
Revised Interim LPP Model Submittal 3
Interior Drainage

United States Army Corps of Engineers

May 20, 2005

This document is released for the purpose of interim review under the authority of Eric D. Loucks, Texas PE License 94545 on 13-May-2005. It is not to be used for construction, bidding, permitting or other purposes.

Contents

Figures

Fort Worth Central City Preliminary Interior Drainage Analysis

Section 1 Background

1.1 Introduction

This document provides the preliminary design basis and initial sizing for the facilities that will be needed to manage stormwater drainage (typically referred to as "interior drainage") within the areas affected by the Fort Worth Central City (FWCC) project. Further refinement of the design will occur when the final urban design features are determined including the placement of gates and levees and the size of the interior lake feature. The project might also be impacted by planned improvements at adjacent sump areas.

1.2 Existing Condition

The current drainage area is divided into three sectors (**shown in Figure 1-1**):

1. The downtown area and bluff-face east of the river (Downtown Sector);

2. The interior area north and west of the West Fork (Northwest Sector); and

3. The interior drainage area that lies between the West Fork and the Clear Fork generally southwest of the confluence (Southwest Sector).

These three areas sump or drainage outfall locations are depicted graphically in **Figure 1-1**. Further discussion of these areas is provided below.

1.2.1 Downtown Sector

Most of downtown Fort Worth drains to the east and reaches the West Fork well downstream of the FWCC area. A portion of downtown drains through storm sewers to a major outfall to the Clear Fork located 2000 feet upstream of the confluence, as shown in **Figure 1-1**. An area of approximately 344 acres drains directly to the existing West Fork and Clear Fork from the east and south. This area is mostly undeveloped bluff, but also contains some parking lot and commercial areas. There are no existing impediments to drainage reaching the river along the east side of the river.

1.2.2 Northwest Sector

This is an interior area draining approximately 353 acres behind the West Fork levee, as shown in **Figure 1-1**. An extensive storm sewer network and overland drainage carries all runoff to a Sump 26W located just north of the intersection of Calhoun

Street and NE Eighth Street. An existing 72-inch storm drain carries flow under the levee from the sump to the West Fork. There is no pump, so when gravity discharge is not possible, flow accumulates in the sump. The Fort Worth Central Railroad runs across the Northwest area obstructing the surface drainage in places. However, there is a subsurface drainage system that currently conveys drainage to Sump 26W. No evaluation has been performed to determine the conveyance capacity.

1.2.3 Southwest Sector

Much of the existing 151 acres interior area in this sector will either be eliminated (due to construction of the bypass channel) or shifted to a new drainage location by the proposed FWCC improvements. However, this is an important area because it lies adjacent to the Sump 14W/15W drainage area (shown in **Figure 1-1**) which has had historic drainage problems.

Sump 14W/15W has a fairly extensive floodplain and has documented flooding concerns (USACE 2003). Portions of the low-lying areas served by Sump 14W/15W have ground surface elevations below the 100-year water surface in the West Fork and are therefore an area sensitive to backwater conditions in the river. However, as documented by the USACE in 2003, the area suffers from a flat slopes and low lying areas making it difficult to convey storm flows out of the area. Improvements to the Sump 14W/15W outfalls or tailwater conditions would have only marginal benefits to drainage in this area. Significant upgrades to underlying drainage infrastructure and/or the addition of pumping facilities may be required to solve flooding concerns in this area.

There is currently no interaction between the surface drainage in the FWCC project area and Sump 14W/15W. There is no runoff from FWCC coming toward Sump 14W/15W and the diverted flow from 14W/15W passes to the south of the FWCC project.

1.3 Reference

USACE; Hydrologic Study of the West Fork of the Trinity River Sump 14W/15W in the City of Fort Worth, Texas; US Army Corps of Engineers, Fort Worth District, August 2003.

Section 2
Interior Drainage Analysis

2.1 Proposed Condition

The concept of the FWCC Project is to create a quiescent river segment from just upstream of the confluence of the Clear Fork and the West Fork of the Trinity River to just upstream of Northside Drive and a flood bypass channel to reroute the storm flows around the project area. The vision of a quiescent river segment includes a higher constant water surface along a waterfront adjacent to downtown Fort Worth. To maintain a higher water surface elevation, a stationary dam with variable level control will be constructed downstream of the Union Pacific Railroad Bridge.

The proposed bypass channel and levees relevant to the interior drainage analyses are shown in **Figure 2-1**. The project results in one large interior drainage area (basins CC1 and CC2) in the main Central City area. Two smaller interior areas will remain west of the bypass (basins CC6 and CC8); one north of the West Fork (basin CC7) and a small area in between the West Fork and Clear Fork (basins CC3A and CC3B). The main (eastern) interior area (basins CC1 and CC2) will drain directly into the proposed water feature along with CC4 and CC5 on the other side of the River. The water feature will serve as a sump for the drainage. It is anticipated that a sump will be required for basin CC7 and would be sited and sized at the design stage.

2.1.1 Analysis Approach

The flood hydrology for each interior area was evaluated using the HEC-1 computer program. The study area was delineated into nine subbasins as shown in **Figure 2-1**. Surface runoff was calculated according to the SCS procedure. This method requires the area, runoff curve number and basin travel time for each subbasin. The subbasin parameter calculations are provided in **Figure 2-2**. The HEC-1 model was used to calculate the discharge that must be handled in each drainage area using a combination of storage, pumping or gravity outflow. Various drainage scenarios were evaluated using the HEC-1 model in order to identify the outflow and/or pumping capacities required to provide 100-year level of protection.

Several assumptions were made in order to complete the evaluation. Key assumptions include the following.

1. During the 100-year design storm, there are no overland inflows from adjacent drainage areas.

2. The future development in the FWCC urban design area will have an average curve number of 84.

3. Other land uses in the area will have the following curve numbers:

Open Space	CN = 61
Residential	CN = 80
Commercial	CN = 88
Industrial	CN = 88

4. The basin lag time for each subbasin was calculated as 0.6 times the estimated time of concentration. Times of concentration were determined using the SCS velocity method. The time of concentration worksheets are included in Figure 2-2 and are summarized in Table 1.

Table 1 Subbasin Hydrologic Parameters

Subbasin	Area (acres)	Area (square miles)	Curve Number	Time of Concentration (hours)	Lag Time (hours)
CC1	166.5	0.2602	88	0.99	0.59
CC2	83.0	0.1297	88	0.84	0.50
CC3a	63.4	0.0991	88	0.95	0.57
CC3b	18.9	0.0295	88	0.61	0.37
CC4	117.8	0.1841	86	0.77	0.46
CC5	81.7	0.1277	63	0.46	0.28
CC6	21.3	0.0333	88	0.49	0.29
CC7	122.0	0.1906	86	0.46	0.28
CC8	36.4	0.0569	88	1.23	0.74
Open Water	80.8	0.1262	99	NA	0.05

2.1.2 Design Criteria

Interior drainage facilities typically are designed to provide a full 100-year level of protection given the joint frequency of the interior and exterior events. Extreme River stages in the Central City area can result from heavy rainfall throughout the immediate area or from large releases from upstream reservoirs. Due to the complexity of the system it was decided to use the accepted 100-year flood river elevations to define tailwater conditions for the interior drainage facilities. The use of the 100-year flows and 100-year tailwater will assure that the facilities will provide full protection fro any combination of storms up to the 100-year event.

Because of its historic drainage problems, it was deemed an important design criteria that no drainage resulting from the FWCC project be allowed to impact Sump 14W/15W.

2.2 Proposed Interior Drainage Facilities

Appropriate drainage facilities were designed for each interior area. These are gravity, storage or pumping facilities, depending on the specific need. A summary of the proposed gravity outfalls and 100-year tailwater is provided in **Table 2**. No new drainage facilities are needed or proposed in basins CC4 or CC5.

2.2.1 FWCC Interior Area

The FWCC interior area accepts drainage from sub-basins CC1, CC2, CC3a, CC3b, CC4 and CC5, as shown in **Figure 2**. Of course, the lake feature itself along with immediately adjacent impervious areas (Basin OW) are included. All of these areas either drain directly to or are storm-sewered to the interior water feature (lake). Although CC3b presently slopes slightly toward the bypass channel, the area will be regraded and a conveyance system will be provided to direct drainage to the interior lake.

During major interior storm events drainage will normally be through the TRWD gate into the West Fork. However, under some flood conditions, the gates will be closed, isolating the interior area. In this situation, flow will be pumped from the interior lake effectively using the lake as a storage sump.

Table 2 Proposed Outfall Sizes and Tailwater Elevations for the FWCC Interior Area

Basin	Outfall To	Outfall Size (inches)	100-yr Tailwater (feet)	Proposed Low Ground (feet)
CC1	Interior Lake	72	528.0	530.0
CC2	Interior Lake	Drains to CC1	528.0	530.0
CC3a	Interior Lake	42	528.0	530.0
CC3b	Interior Lake	36	535.9	534.0
CC4	Interior Lake	TBD	528.0	
CC5	Interior Lake	TBD, Surface flow	528.0	Direct
CC6	West Fork Station 259463	36	535.6	538.0
CC7	Bypass Station 2091	36	528.4	534.0
CC8	Bypass Station 8202	60	538.0	540.0

The proposed pump station will have four pumps with 100 cubic feet per second (cfs) capacity per pump. One pump is a standby, as 300 cfs capacity is required to provide the protection needed in the 100-year storm. Flow storage is provided in the interior lake that will cover approximately 68 acres. The sides of the lake will be vertical in most locations, thus the area is essentially constant. The design normal water level of the lake is 524.3 feet. In addition to the expected operating condition (starting WSE at 524.3 feet, all pumps available, TRWD gates closed), several other scenarios were also evaluated. They are:

1. Starting WSE at 525.0 feet;
2. Starting WSE at 526.0 feet;
3. Consecutive 10-year, 24-hour storms;
4. Two pumps unavailable, two pumps operating; and
5. Four pumps unavailable.

Results of these scenarios are provided in **Table 3**. The typical situations, such as the baseline and scenario 1, do not exceed a maximum water level of 528.0 feet, which provides 2.0 feet of freeboard. No scenario exceeds the proposed low slab elevation of 530.0 feet., proposed by the urban design team. Of course, in this situation where all pumps fail, a gate could be opened to drain the interior by gravity.

Table 3 Evaluation of Interior System Under Various Scenarios

Scenario	Storm Event	Starting Lake Elevation Condition (feet)	Peak Lake Elevation (feet)	Maximum Pumping Rate (cfs)	Time to Dewater After End of Storm (hours)
Base	100-yr	524.3	527.69	300	6:35
1	100-yr	525.0	528.00	300	7:25
2	100-yr	526.0	529.00	300	10:15
3	Dual 10-yr	526.13	526.68	200	6:00
4	100-yr	524.3	527.99	200	12:55
5	100-yr	524.3	529.69	0	NA

2.2.2 Northwest Area

The northwest area is defined by basin CC7, as shown in **Figure 2**. The area will be served by existing storm sewers draining to a new 36-inch outfall to the bypass channel. The peak 100-year runoff is estimated at 740 cfs. The 100-year tailwater at the outfall site is estimated to be 528.4 feet. The land surface elevation near the upstream end of the outfall is 534 feet, so the full outfall capacity can be maintained during coincident 100-year interior and exterior events.

2.2.3 West Fork/Clear Fork Area

The FWCC portion of this area is defined by basins CC6 and CC8. Basin CC6 is a proposed fill site and will be filled to an elevation above 538.0 feet. Drainage from this area will be served by a 36-inch outfall located on the north side of Henderson Street discharging into the West Fork. The 100-year stage in the West Fork is estimated to be 533.7 feet. Therefore, it is expected that 100-year flow capacity can be provided during the coincident 100-year interior and exterior events. A similar situation exists in basin CC8. The existing 60-inch outfall near Nebraska Street will be used to provide outlet capacity to this area. Under the proposed design conditions, it is expected that sufficient outfall capacity will be provided for each basin under all design storm conditions.

The 14W/15W sump area lies immediately west of basins CC6 and CC8. Based on this investigation and analysis, it is clear that there will be no drainage interaction or impact between the FWCC project and improvements or changes in the Sump 14W/15W basin. The only likely impact is an approximate 2.0-foot reduction of the tailwater elevation at the Sump 14W outfall to the West Fork. Evaluation of the potential benefit of this tailwater reduction is underway by a USACE contractor.

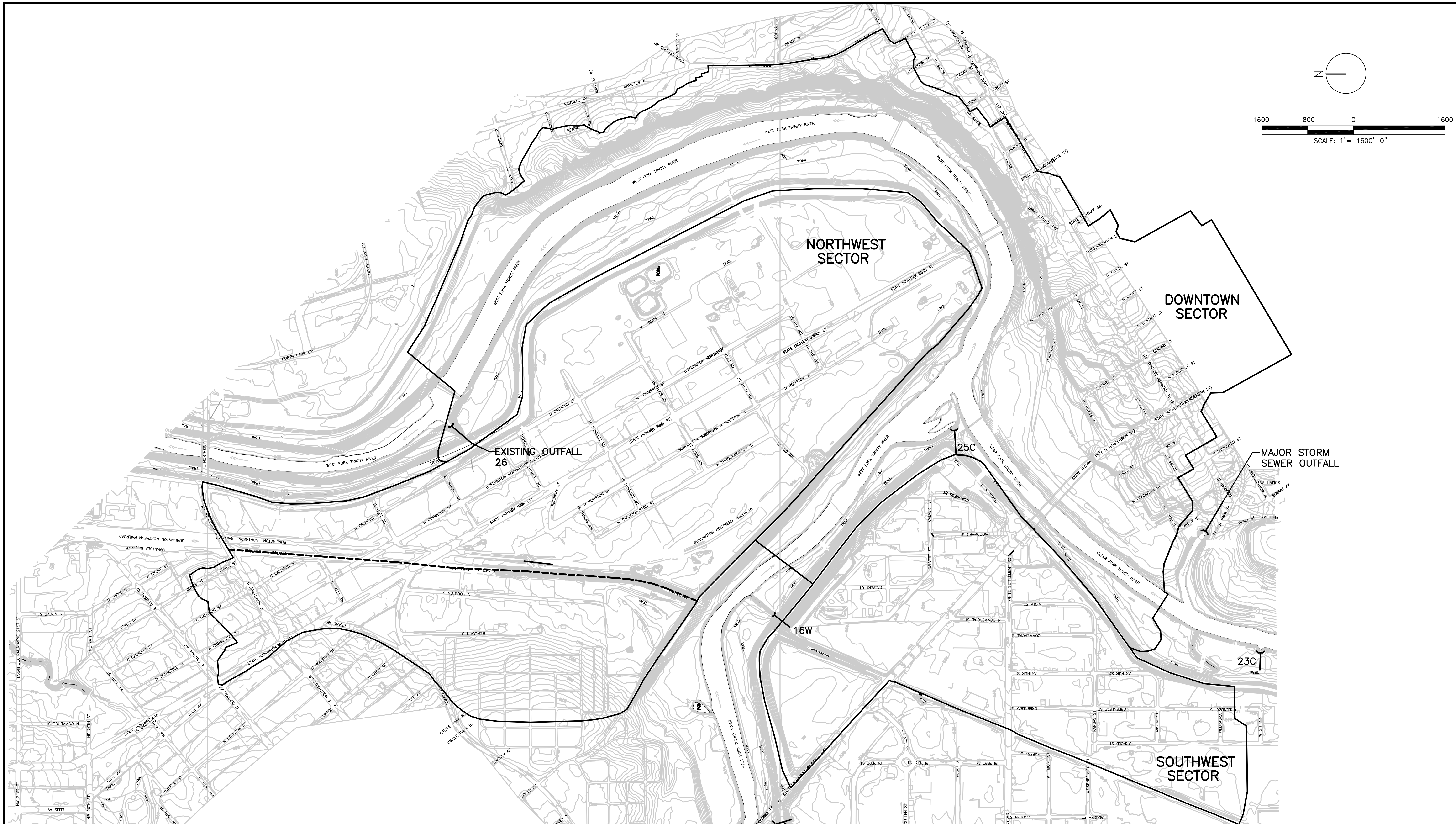
2.3 Changes to Existing Sumps

The FWCC project will impact only a few of the existing sumps in the Central City area of the Trinity River. Impacted and non-impacted sumps are shown in **Table 4**.

Table 4 – FWCC Project Impacts to Area Storm Drainage Sumps

Sump Number	Impacted by FWCC Project? (Yes/No)	Note
14W	No	
15W	No	
16W	Yes	Slightly modified to drain to bypass channel
19C	No	
20C	No	
21C	No	
22C	No	
23C	No	
25C	Yes	Eliminated
26	Yes	Replaced by new/modified sumps in CC1 and CC7
28	No	

29	No	
30	No	
31	No	



FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

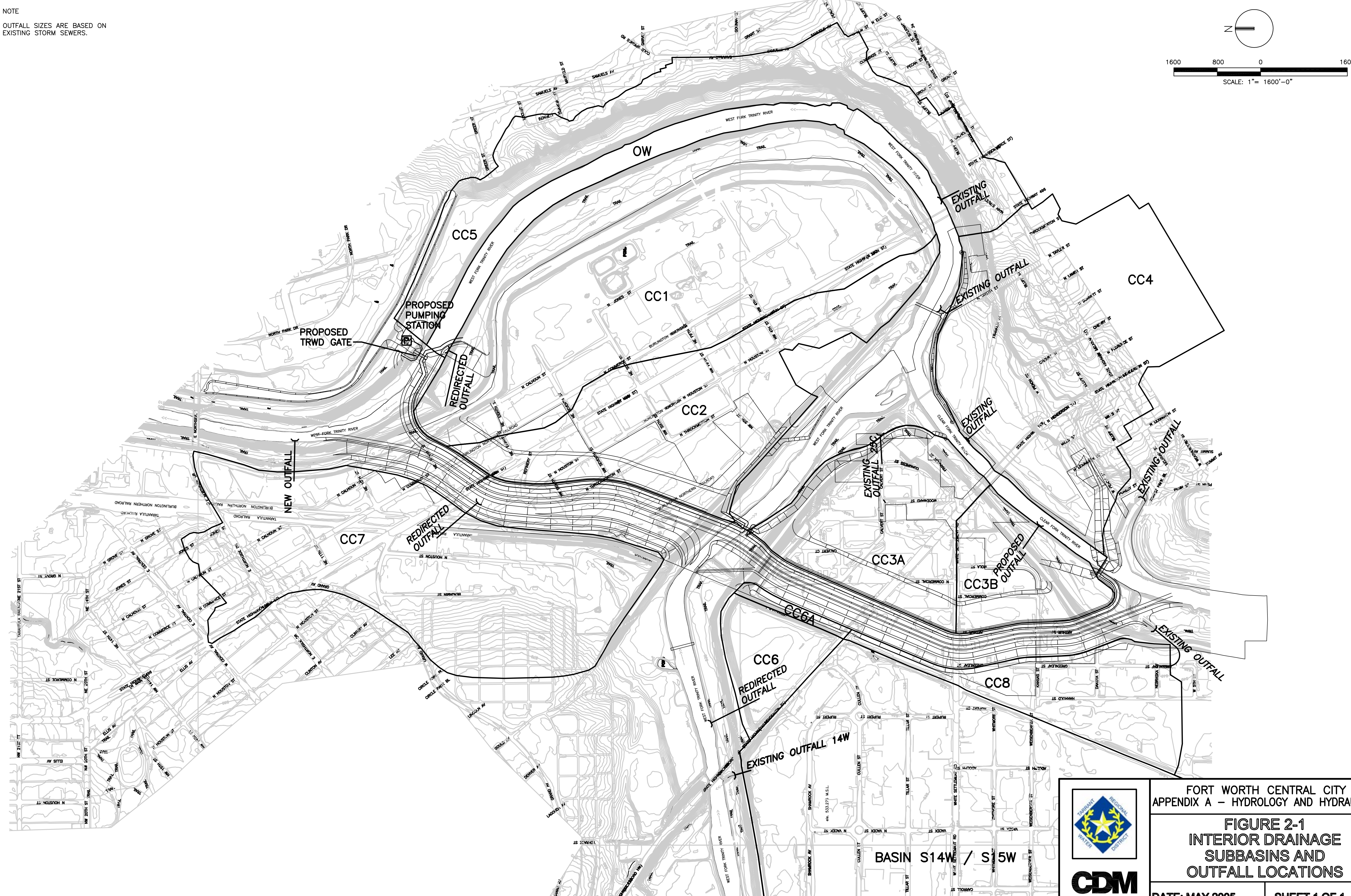
FIGURE 1-1
EXISTING
DRAINAGE
SUBBASINS

DATE: MAY 2005

SHEET 1 OF 1

NOTE

OUTFALL SIZES ARE BASED ON EXISTING STORM SEWERS.



FORT WORTH CENTRAL CITY
APPENDIX A – HYDROLOGY AND HYDRAULICS

FIGURE 2-1
INTERIOR DRAINAGE SUBBASINS AND OUTFALL LOCATIONS

CDM

DATE: MAY 2005

SHEET 1 OF 1

Figure 2-2

Time of Concentration Calculations

9 sub-basins
18 pages totals

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Fort Worth Central City — By APH — Date 12/3/04
Interior CC1 — Checked ______ — Date ______
Circle one: Present / (Developed) / Proposed
Circle one: (T_c) / T_t through subarea CC-1

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Unit	Segment ID: AB		Total
1. Surface description (Table 3-1)		grass		
2. Manning's roughness coeff., n (Table 3-1)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	200		
4. Two-yr 24-hr rainfall, P_2	in	4		
5. Land slope, s	ft/ft	0.009		
6. $T_t = \frac{0.007 (n L)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	0.51		0.51

Shallow concentrated flow	Unit	Segment ID: BC		Total
7. Surface description (paved or unpaved)		unpaved		
8. Flow length, L	ft	100		
9. Watercouse slope, s	ft/ft	0.007		
10. Average velocity, V (Figure 3-1)	ft/s	1.25		
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.02		0.02

Channel flow	Unit	Segment ID		Total
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, r = a/p_w Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = [1.49 r^{2/3} s^{1/2}]/n$ Compute V	ft/s	3.00		
18. Flow length, L	ft	4875		
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.45		0.45

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) — hr — **0.99**

Slope calculations for Worksheet 3

Project Fort Worth Central City — By SEB — Date 4/23/03

Location Interior CC1 — Checked ______ — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC1

Sheet flow (Applicable to T_c only)		Segment ID	AB
5. Land slope, s		ft/ft	0.0088

Shallow concentrated flow		Segment ID	BC
9. Watercouse slope, s		ft/ft	0.0066

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Fort Worth Central City — By APH — Date 12/3/04

Interior CC2 — Checked El — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC-2

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Unit	Segment ID AB		
1. Surface description (Table 3-1)		grass		
2. Manning's roughness coeff., n (Table 3-1)		0.24		
3. Flow length, L (total L $\le$ 300 ft)	ft	200		
4. Two-yr 24-hr rainfall, P_2	in	4		
5. Land slope, s	ft/ft	0.080		
6. $T_t = \frac{0.007 (n L)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	0.21		0.21

Shallow concentrated flow	Unit	Segment ID BC		
7. Surface description (paved or unpaved)		unpaved		
8. Flow length, L	ft	1375		
9. Watercouse slope, s	ft/ft	0.007		
10. Average velocity, V (Figure 3-1)	ft/s	1.25		
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.31		0.31

Channel flow	Unit	Segment ID		
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, r = a/p_w Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = [1.49 r^{2/3} s^{1/2}]/n$ Compute V	ft/s	3.00		
18. Flow length, L	ft	3450		
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.32		0.32

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr **0.84**

Slope calculations for Worksheet 3

Fort Worth Central City — By APH — 12/3/2004

Location Interior CC2 — Checked EI — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC3

Sheet flow (Applicable to T_c only)		Segment ID	AB
5. Land slope, s		ft/ft	(542-540)/25 = 0.08

Shallow concentrated flow		Segment ID	BC
9. Watercouse slope, s		ft/ft	0.0066

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Fort Worth Central City — By APH — Date 12/6/04

Interior CC3A — Checked I — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC-3A

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Unit	Segment ID: AB		
1. Surface description (Table 3-1)		grass		
2. Manning's roughness coeff., n (Table 3-1)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	200		
4. Two-yr 24-hr rainfall, P_2	in	4		
5. Land slope, s	ft/ft	0.007		
6. $T_t = \frac{0.007\,(n\,L)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.57		0.57

Shallow concentrated flow	Unit	Segment ID: BC		
7. Surface description (paved or unpaved)		unpaved		
8. Flow length, L	ft	500		
9. Watercouse slope, s	ft/ft	0.012		
10. Average velocity, V (Figure 3-1)	ft/s	1.68		
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.08		0.08

Channel flow	Unit	Segment ID		
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, r = a/p_w Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = [1.49\, r^{2/3}\, s^{1/2}]/n$ Compute V	ft/s	3.00		
18. Flow length, L	ft	3200		
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.30		0.30

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) — hr — **0.95**

Slope calculations for Worksheet 3

Fort Worth Central City — By APH — 12/3/2004

Location Interior CC3A — Checked I____ Date ____

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC3A

Sheet flow (Applicable to T_c only)		Segment ID	AB
5. Land slope, s		ft/ft	(532-530)/300 = 0.00

Shallow concentrated flow		Segment ID	BC
9. Watercouse slope, s		ft/ft	0.012

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Fort Worth Central City — By APH — Date 12/3/04

Interior CC3B — Checked E — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC-3B

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Unit	Segment ID AB		
1. Surface description (Table 3-1)		grass		
2. Manning's roughness coeff., n (Table 3-1)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	200		
4. Two-yr 24-hr rainfall, P_2	in	4		
5. Land slope, s	ft/ft	0.010		
6. $T_t = \frac{0.007 (n L)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	0.49		0.49

Shallow concentrated flow	Unit	Segment ID BC		
7. Surface description (paved or unpaved)		unpaved		
8. Flow length, L	ft	475		
9. Watercouse slope, s	ft/ft	0.017		
10. Average velocity, V (Figure 3-1)	ft/s	2.10		
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.06		0.06

Channel flow	Unit	Segment ID		
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, r = a/p_w Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = [1.49 r^{2/3} s^{1/2}]/n$ Compute V	ft/s	3.00		
18. Flow length, L	ft	650		
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.06		0.06

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr **0.61**

Slope calculations for Worksheet 3

Fort Worth Central City — By APH — 12/6/2004

Location Interior CC3B — Checked By ______ Date ______

Circle one: Present **(Developed)** Proposed

Circle one: **(T_c)** T_t through subarea CC3B

Sheet flow (Applicable to T_c only)	Segment ID	AB
5. Land slope, s	ft/ft	0.010

Shallow concentrated flow	Segment ID	BC
9. Watercouse slope, s	ft/ft	0.017

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Fort Worth Central City — By APH — Date 12/6/04
Interior CC4 — Checked E — Date ______
Circle one: Present (Developed) Proposed
Circle one: (T_c) T_t through subarea CC-4

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Unit	Segment ID: AB		
1. Surface description (Table 3-1)		grass		
2. Manning's roughness coeff., n (Table 3-1)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	200		
4. Two-yr 24-hr rainfall, P_2	in	4		
5. Land slope, s	ft/ft	0.005		
6. $T_t = \frac{0.007 (n L)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	0.64		0.64

Shallow concentrated flow

	Unit	Segment ID: BC		
7. Surface description (paved or unpaved)		unpaved		
8. Flow length, L	ft	0		
9. Watercouse slope, s	ft/ft	0.005		
10. Average velocity, V (Figure 3-1)	ft/s	1.00		
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.00		0.00

Channel flow

	Unit	Segment ID		
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, r = a/p_w Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = [1.49 r^{2/3} s^{1/2}]/n$ Compute V	ft/s	6.00		
18. Flow length, L	ft	2750		
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.13		0.13

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr **0.77**

Slope calculations for Worksheet 3

Fort Worth Central City — By APH — 12/3/2004

Location Interior CC4 — Checked By ______ Date ______

Circle one: Present **(Developed)** Proposed

Circle one: **(T_c)** T_t through subarea CC4

Sheet flow (Applicable to T_c only)	Segment ID	AB
5. Land slope, s	ft/ft	0.005

Shallow concentrated flow	Segment ID	BC
9. Watercouse slope, s	ft/ft	0.005

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Fort Worth Central City — By APH — Date 12/6/04

Interior CC5 — Checked E — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC-5

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Unit	Segment ID AB		
1. Surface description (Table 3-1)		grass		
2. Manning's roughness coeff., n (Table 3-1)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	300		
4. Two-yr 24-hr rainfall, P_2	in	4		
5. Land slope, s	ft/ft	0.030		
6. $T_t = \frac{0.007 (n L)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	0.44		0.44

Shallow concentrated flow

	Unit	Segment ID BC		
7. Surface description (paved or unpaved)		unpaved		
8. Flow length, L	ft	560		
9. Watercouse slope, s	ft/ft	0.139		
10. Average velocity, V (Figure 3-1)	ft/s	6.00		
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.03		0.03

Channel flow

	Unit	Segment ID		
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = a/p_w$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = [1.49 r^{2/3} s^{1/2}]/n$ Compute V	ft/s	3.00		
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.00		0.00

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) — hr — **0.46**

Slope calculations for Worksheet 3

Fort Worth Central City — By APH — 12/6/2004

Location Interior CC5 — Checked E — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC5

Sheet flow (Applicable to T_c only)		Segment ID	AB
5. Land slope, s		ft/ft	(590-584)/200 = 0.03

Shallow concentrated flow		Segment ID	BC
9. Watercouse slope, s		ft/ft	0.139

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Fort Worth Central City — By APH — Date 12/6/04

Interior CC6 — Checked E — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC-6

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Unit	Segment ID AB		
1. Surface description (Table 3-1)		grass		
2. Manning's roughness coeff., n (Table 3-1)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	200		
4. Two-yr 24-hr rainfall, P_2	in	4		
5. Land slope, s	ft/ft	0.080		
6. $T_t = \frac{0.007 (n L)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	0.21		0.21

Shallow concentrated flow	Unit	Segment ID BC		
7. Surface description (paved or unpaved)		unpaved		
8. Flow length, L	ft	880		
9. Watercouse slope, s	ft/ft	0.003		Use Appendix F for velocity
10. Average velocity, V (Figure 3-1)	ft/s	0.88		
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.28		0.28

Channel flow	Unit	Segment ID		
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, r = a/p_w Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = [1.49 r^{2/3} s^{1/2}]/n$ Compute V	ft/s	3.00		
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.00		0.00

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr **0.49**

Slope calculations for Worksheet 3

Fort Worth Central City — By APH — 12/6/2004

Location Interior CC6 — Checked E — Date ______

Circle one: Present **(Developed)** Proposed

Circle one: **(T_c)** T_t through subarea CC6

Sheet flow (Applicable to T_c only)		Segment ID	AB
5. Land slope, s		ft/ft	(557-541)/200 = 0.08

Shallow concentrated flow		Segment ID	BC
9. Watercouse slope, s		ft/ft	(541-538)/800 = 0.003

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Fort Worth Central City — By APH — Date 12/6/04

Interior CC7 — Checked E — Date ______

Circle one: Present **(Developed)** Proposed

Circle one: **(T_c)** T_t through subarea CC-7

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Unit	Segment ID AB		
1. Surface description (Table 3-1)		grass		
2. Manning's roughness coeff., n (Table 3-1)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	200		
4. Two-yr 24-hr rainfall, P_2	in	4		
5. Land slope, s	ft/ft	0.080		
6. $T_t = \frac{0.007\,(n\,L)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.21		0.21

Shallow concentrated flow

	Unit	Segment ID BC		
7. Surface description (paved or unpaved)		unpaved		
8. Flow length, L	ft	0		
9. Watercouse slope, s	ft/ft	0.000		Use Appendix F for velocity
10. Average velocity, V (Figure 3-1)	ft/s	1.00		
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.00		0.00

Channel flow

	Unit	Segment ID		
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, r = a/p_w Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = [1.49\,r^{2/3}\,s^{1/2}]/n$ Compute V	ft/s	3.00		
18. Flow length, L	ft	2675		
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.25		0.25

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr **0.46**

Slope calculations for Worksheet 3

Fort Worth Central City — By APH — 12/6/2004

Location Interior CC7 — Checked I — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC7

Sheet flow (Applicable to T_c only)	Segment ID	AB
5. Land slope, s	ft/ft	(556-540)/200 = 0.08

Shallow concentrated flow	Segment ID	BC
9. Watercouse slope, s	ft/ft	

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Fort Worth Central City — By APH — Date 12/6/04

Interior CC8 — Checked E — Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC-8

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Unit	Segment ID: AB		
1. Surface description (Table 3-1)		grass		
2. Manning's roughness coeff., n (Table 3-1)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	200		
4. Two-yr 24-hr rainfall, P_2	in	4		
5. Land slope, s	ft/ft	0.005		
6. $T_t = \frac{0.007 (n L)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	0.64		0.64

Shallow concentrated flow	Unit	Segment ID: BC		
7. Surface description (paved or unpaved)		unpaved		
8. Flow length, L	ft	830		
9. Watercouse slope, s	ft/ft	0.001		Use Appendix F for velocity
10. Average velocity, V (Figure 3-1)	ft/s	0.56		
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.41		0.41

Channel flow	Unit	Segment ID		
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, r = a/p_w Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = [1.49 r^{2/3} s^{1/2}]/n$ Compute V	ft/s	3.00		
18. Flow length, L	ft	1900		
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.18		0.18

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr **1.23**

Slope calculations for Worksheet 3

Fort Worth Central City — By APH — 12/6/2004

Location Interior CC8 — Checked E ______ Date ______

Circle one: Present (Developed) Proposed

Circle one: (T_c) T_t through subarea CC8

Sheet flow (Applicable to T_c only)		Segment ID	AB
5. Land slope, s		ft/ft	0.005

Shallow concentrated flow		Segment ID	BC
9. Watercouse slope, s		ft/ft	0.001

Technical Memorandum HH-6

This document is released for the purpose of interim review under the authority of Robert W. Brashear, P.E. 80771 on 27-Jan-2005. It is not to be used for construction, bidding, permitting or purposes other than review.

To: *Michael Danella, USACE*

From: *Bob Brashear, CDM*

Date: *27-Jan-2005*

Subject: *Hydrology and Hydraulics, Interim LPP Model Submittal 4 – Sediment Transport and Scour Analysis*

Status: *Final Draft*

1.0 Introduction

The Tarrant Regional Water District (TRWD) is participating with the U.S. Army Corps of Engineers (USACE), the City of Fort Worth, Tarrant County, and the North Central Texas Council of Governments, in evaluating flood channel improvements in the "Central City" segment of the Clear Fork and West Fork of the Trinity River. The Locally Preferred Plan (LPP) calls for creating a bypass channel to handle flood flows and to create a quiescent river segment on the Trinity River adjacent to downtown Fort Worth. Known as the Fort Worth Central City (FWCC) Project, the quiescent river segment would begin at the confluence of the Clear Fork and the West Fork of the Trinity River to just upstream (south) of the Northside Drive Bridge, generally following the existing river channel.

The pertinent reaches of the Trinity River to the FWCC Project are shown in **Figure 1**. In the vicinity of the Project, the West Fork of the Trinity River flows generally east to the Fort Worth and Western Railroad at which point it heads southeast to its confluence with the Clear Fork. At the confluence, the river makes a sharp meander as it turns and flows north towards the confluence of Marine Creek. At Marine Creek, the West Fork of the Trinity River meanders back south before continuing on in an easterly direction near Riverside Drive.

1.1 Goals and Objectives

A sediment transport analysis of the proposed FWCC project is necessary to support several aspects of the project:

- Prediction of significant erosion and/or depositional impacts to existing infrastructure or ecosystems;
- Input to design considerations associated with the project;

- Definition of operation and maintenance needs of the floodway after project implementation; and
- Support of the environmental impact assessment associated with the project.

As such, the goals of the analyses summarized in this technical memorandum are to:

- Characterize previous studies and data collection efforts pertinent to a sediment transport assessment of the Trinity River associated with the Central City Project;
- Where previous studies and/or data are unable to establish the sediment transport characteristics of the system, establish the existing conditions sediment transport characteristics using generally accepted techniques;
- To the extent practicable, predict the likely changes in sediment transport characteristics imparted by the proposed project relative to existing conditions.

Furthermore, the objectives of the study include:

- Assessment of the sediment transport characteristics of the proposed system during years with significant wet weather flows;
- Development of recommendations regarding subsequent analyses that should be performed to support design and operation and maintenance;
- Development of recommendations regarding future data collection efforts necessary to support subsequent analyses;
- Development of recommendations regarding project design considerations based on sediment transport assessments; and
- Development of recommendations regarding project operation and maintenance considerations based on sediment transport assessments.

For the sediment transport analysis, the UASCE Scour and Deposition in Rivers and Reservoirs (HEC-6) model, developed by the USACE Hydrologic Engineering Center (HEC), was used (USACE 1993).

2.0 Data Collection

2.1 Existing Geologic/Geomorphologic Information

The geological deposits in the Fort Worth area generally date to the Cretaceous Period, during which sea levels rose and fell across the area, leaving behind multiple layers of deposits (Scoggins 1993). During the Tertiary and Quaternary Periods, the Trinity River carved out terraces through these deposits, leaving behind a mix of clays, sands, and gravels.

In order to be useful for sediment transport analyses, sediment data needs to be obtained from the entire depth of flow in a channel. This is usually accomplished by conducting separate sampling for bed load data and for suspended sediment data (Edwards and Glysson, 1998). Suspended sediment data is typically vertically integrated either by sampling technique or by subsequent integration of the results of grab samples at different depths. These requirements are necessary to understand the nature of the sediment moving within a reach i.e., particle size and material classification. Furthermore, it is necessary to have collected such data for many events and ideally for a broad range of event magnitudes. Sampling devices for bed load and vertically integrated suspended sediment sampling are specialized and are configured and sized based on the depths and velocities to be encountered during sampling. Sampling of this nature should occur over an extended period of time in order to fully characterize the study reach hydrologic time series.

2.2 Existing Suspended Sediment and Bed Load Data

An extensive literature search yielded no previous sediment transport studies in the Trinity River reaches potentially affected by the FWCC Project. Additional searches for available bed load or vertically integrated suspended sediment data sources yielded some data. **Table 1** shows sources and amounts of potential suspended sediment and bed load data in the vicinity of the project. As **Table 1** illustrates, the most recent sampling effort in the area (West Fork of the Trinity at Beach Street) ended in early 1995 and, of that sampling, only one instance of bed load sampling was conducting (1992). Since multiple samples were not taken for bed load characterization, this data was not used as a basis for model input. **Figure 2a and 2b** show the suspended sediment data correlated to flow data for this site. Because so few of the samples correlated with wet weather flow, this data was not relied upon for determining grain size distribution for the sediment transport model.

The lack of data necessary to support sediment transport modeling is not unusual. Unless a system is exhibiting significant geomorphic changes or unless significant changes to a system are planned, vertically integrated suspended sediment and bed load data is not generally needed. Also, the highly specialized nature of the equipment and techniques associated with this kind of sampling tends to limit its application on an ongoing basis because of cost. These may be some of the reasons additional suspended sediment and bed load sampling has not occurred over the past decade within or adjacent to the project area.

Since previous studies or sediment data are not available, the best available source of data on likely sediment characteristics is the geotechnical sampling conducted for the project in support of civil and structural preliminary design (TRWD 2004). In the meander at the confluence of the Clear Fork and the West Fork, the geotechnical investigation indicates that bedrock is located five to ten feet below the surface and that the soil composition is primarily silt and clay.

Sediment gradation data, used in both the existing and proposed conditions models, was obtained from the FWCC Project Geotechnical Report (TRWD 2004). Due to the lack of the data, same sediment gradation data were used for all cross sections in the model.

One of the inputs required by HEC-6 is the inflow sediment loads categorized by size. A common source of this data is USGS sampling results, but, as discussed previously, available suspended sediment and bed load data is inadequate for this purpose. Thus, the inflowing sediment loads (i.e., sediment transport capacity at upstream boundary based on the assumption of stable channel) were determined using SAM.sed, which is one of three modules of the Hydraulic Design Package (SAM) and can calculate a sediment discharge rating curve based on hydraulic conditions and bed gradation. SAM is an integrated system of programs developed by the Coastal and Hydraulics Laboratory (CHL) of the USACE Engineering Research and Development Center (ERDC) to aid engineers in analyses associated with designing, operating, and maintaining flood control channel and stream restoration projects (Thomas et al 2002).

The inflowing sediment loads calculated by SAM were then calibrated based on the investigation in the field that currently most of channel beds are stable, which means that the bed elevation changes are as small as possible in the existing conditions model of HEC-6. **Table 2** and **Figures 3a** and **3b** present inflowing sediment entering the model boundaries in the reaches of West Fork upstream of the existing confluence (WF4) and Clear Fork (CF) in tons per day at flow rates from 250 cfs to 16,000 cfs.

2.3 Existing and Proposed Hydrologic and Hydraulic Information

Channel geometry for both the existing and proposed conditions was obtained from the HEC-RAS hydraulic models of the FWCC project submitted to the USACE (TRWD 2004). **Figure 1** illustrates the central portion of the HEC-RAS models.

Since the principal purpose of this modeling is to identify potential concerns that may need to be taken into a consideration in design, it was elected to use hydrologic model inputs were used that consist of recent 10-year period of record 1988-1997. The input flow data was derived from the USGS stream gauge 08048000 (West Fork Trinity River just below the confluence with the Clear Fork of the Trinity River at Ft Worth, Texas). The 1988-1997 flows were selected not only to consider long-term hydrologic variability as a conservative approach, but also to consider the impact of recently constructed structures such as dams and drop structures. For the use in HEC-6 model, normalized annual hydrographs were used instead of measured hydrographs to reduce the amount of input data and compare relative impact of each hydrograph more clearly. Because the flow data was measured at West Fork downstream of the existing confluence (WF3), the flow from CF was assumed to be a third of the flow data measured at WF3.

3.0 Methodology

Existing and proposed conditions models were prepared to determine the impact of the proposed FWCC project on sediment transport characteristics along the Trinity River, downstream of the Samuels Avenue Dam. The USACE HEC-6 program was used for the sediment transport analysis as mentioned above. HEC-6 is a one dimensional, fixed boundary sediment transport model that predicts generalized amounts of bed aggradation or degradation at representative cross-sections. The boundaries of the model were selected to the limits of backwater caused by the project (the grade control structure near Riverbend on the WF4 and the grade control structure at about river station 9000 on CF) and the first grade control structure downstream from Samuels Avenue Dam (the Fourth Street Dam on WF3).

3.1 Existing Conditions Model

The existing conditions sediment transport model is based on channel geometry data contained in the baseline hydraulic model obtained by CDM from the USACE in July 2004. Representative cross-sections throughout the river reach were extracted from HEC-RAS and converted to HEC-6 geometry data sets. Cross sections utilized are listed in **Tables 3**. This geometry combined with previously-described sediment and hydrologic data comprise the HEC-6 input.

3.2 Proposed Conditions Model

Channel geometry data for the proposed conditions model was obtained from the proposed conditions HEC-RAS hydraulic model submitted to the USACE on November 17, 2004. Cross sections utilized are listed in **Tables 4 and 5**. To isolate the effect of Samuels Ave Dam of the proposed conditions model on the channel geometry, two proposed conditions models were suggested.

- *Proposed without dam*: channel geometry data with bypass channel and without Samuels Ave. Dam; and

- *Proposed with dam*: channel geometry data with bypass channel and Samuels Ave. Dam.

4.0 Results

Results from each of the model runs are shown in **Tables 3 through 5** and contain the change in bed elevation (positive for deposition, negative for scour) for each of the cross sections simulated. **Figures 4-10** show these results graphically, partitioned by reach.

5.0 Discussion and Conclusions

This reconnaissance-level analysis is based on existing information that is limited and is necessarily coarse. At this stage, the intent of this analysis is to gauge relative differences between existing and proposed conditions and, within those differences, highlight areas that deserve further attention.

As mentioned in Section 2.2, inflowing sediment calculated from SAM were calibrated so that the bed elevation changes could be as small as possible in the existing conditions model of HEC-6. **Figures 4 and 5** show that the thalweg of the entire system after the 10-year simulation is very close to the initial thalweg with the exception of several cross sections at downstream end of WF3.

In the *proposed without dam* conditions, as shown in **Figures 6 and 7**, the reach including the bypass channel, CF and WF4 is predicted to experience scour conditions and the reach downstream of the bypass channel is predicted to aggrade. This can be explained by the concept that the channel attempts to achieve equilibrium by decreasing the bed slope by upstream degradation and downstream aggradation of the channel when the bed slope of the channel is increased by the factors such as channel cutoff. On the other hand, in the *proposed with dam* conditions, the thalweg of the reach including upper bypass channel (confluence with CF to confluence with WF4), CF, and WF4 does not change much from the initial thalweg, while the reach including lower bypass channel (confluence with WF3 to confluence with WF4) and WF3 is scoured (**Figures 6 and 7**). This is due to backwater effects from the Samuels Avenue Dam; little sediment transport potential exists in the reach upstream of the dam. Therefore, these simulation results indicate that the construction of Samuels Avenue Dam is required to maintain the channel without severe sediment aggradation or degradation after construction of the bypass channel. Building grade control structures to mitigate the degradation of the reaches of lower bypass channel and downstream may also be necessary.

In the *proposed with dam* conditions, the flows from WF4 and CF are equally split into the bypass channel and the interior area at the two confluences; however, if the ratio of flow division at the confluences can be controlled, the degree of degradation may be mitigated as shown in **Figure 8**. Additionally, only flows less than 10,000 cfs were used as input in the *proposed with dam* conditions, because the gates of Samuels Avenue Dam are intended to be opened when the flows are greater than 10,000 cfs, but changing the dam crest elevation according to the flow in the HEC-6 model is not possible. Nevertheless, when considering that only seven cases of the normalized flows (55 days of 3,652 days) are greater than 10,000 cfs, it was judged that the effects of the high flows on channel bed elevation change are so small that the flows greater than 10,000 cfs can be excluded from the modeling.

Finally, **Figures 9 and 10** show that the Thalweg of the entire system of the existing conditions after simulation is so close to that of the *proposed with dam* conditions, with the exception of downstream end of WF3, which shows aggradtion in the existing conditions, but is stable in the *proposed with dam* conditions.

6.0 Recommendations

Due to the significant changes to the flow regime of the Trinity River associated with the FWCC Project, additional analyses are recommended. Sediment behavior should be studied in greater detail and, as such, additional information should be developed to support these analyses. A short- and long-term sediment and bed load monitoring program should be initiated to develop an adequate database to refine these analyses. Furthermore, sediment transport should be linked with anticipated hydrodynamic analyses that will be conducted in support of project design. These analyses will be needed not only to focus design efforts, but to develop a long-term operations and maintenance plan. Additional analyses with the models and data sets developed under this effort should be undertaken to assess system sensitivity to various parameters.

7.0 References

Edwards, T.K., and Glysson, G.D.; Field Methods for Measurement of Fluvial Sediment; USGS Techniques of Water-Resources Investigations, Book 3, Chapter C2, U.S. Geological Survet; Reston, Virginia, 1998.

Thomas, W.A, Copeland, R.R., and McComas, D.N.: SAM Hydraulic Design Package for Channels; U.S. Army Corps of Engineers; Engineer Research and Development Center, Vicksburg, MS; 2002.

TRWD; Phase I Geotechnical Investigation Fort Worth Central City; Submitted to the USACE, Ft. Worth District; Tarrant Regional Water District; Fort Worth, Texas; October 2004.

TRWD; Hydrology and Hydraulics Interim LPP Model Submittal 2; Submitted to the USACE, Ft. Worth District, Tarrant Regional Water District; Fort Worth, Texas; November, 2004.

Scoggins, Phil; Surface Geology of Dallas and Tarrant Counties, Texas; Dallas Paleontological Society; 1993.

Thomas, W.A, Copeland, R.R., and McComas, D.N.; "SAM Hydraulic Design Package for Channels"; U.S. Army Corps of Engineers; Engineer Research and Development Center, Vicksburg, Mississippi; 2002

USACE; HEC-6 Scour and Deposition in Rivers and Reservoirs, Users Manual; U.S. Army Corps of Engineers; Hydrologic Engineering Center, Davis, California; 1993.

USACE; Sedimentation Investigations of Rivers and Reservoirs, ENG 1787; EM 1110-2-4000, Change 1; U.S. Army Corps of Engineers; October 1995

8.0 Attachments

Tables

Table 1 – Available Suspended Sediment Data in Reasonable Proximity to the Fort Worth Central City Project

Table 2 – Estimated Sediment Transport Capacity entering the model boundaries in the reaches of WF4 and CF in tons/day

Table 3 – HEC-6 Results for Existing Conditions

Table 4 – HEC-6 Results for Proposed Without Dam Conditions

Table 5 – HEC-6 Results for Proposed With Dam Conditions

Figures

Figure 1 – Trinity River Segments Associated with the Central Project Analyzed for Sediment Transport

Figure 2 (a&b) – Suspended Sediment Data for the West Fork Trinity River at Beach Street, Fort Worth, TX (Station 08048543) for Years 1993 and 1994

Figure 3 (a&b) – Estimated Sediment Transport Capacity entering the model boundaries in the reaches of WF4 and CF in tons/day

Figure 4 –Thalweg Elevation changes for Existing Conditions – WF3 and WF4

Figure 5 – Thalweg Elevation changes for Existing Conditions – CF

Figure 6 – Thalweg Elevation changes for Proposed Conditions – WF3, Bypass Channel, and CF

Figure 7 – Thalweg Elevation changes for Proposed Conditions – WF4

Figure 8 – Effect of Flow Division at the Confluences – WF3, Bypass Channel, and CF

Figure 9 – Comparison of Existing and Proposed Conditions – WF3 and WF4

Figure 10 – Comparison of Existing and Proposed Conditions – CF

cc: Moosub Eom
Erin Ansell
Eric Loucks
Ted Johnson
Don Funderlic
Ginger Croom

Table 1 - Available Suspended Sediment Data in Reasonable Proximity to the Fort Worth Central City Project

Station I.D. Number	Station Name	Records containing suspended sediment concentration (80154) paired with water discharge (00061)			Records containing sample method of collection code (82398) for suspended sediment (80154) *A blank entry indicated that no value was entered.*		Range in instantaneous water discharge values (00061) when associated with a measurement of suspended sediment concentration		Records containing particle size distribution of suspended sediment (70331 or 70342)			Records containing bedload discharge (tons/day) (80225)			Records containing particle-size distribution of bed material (80157 through 80175)		
		Number	First Date	Last Date	Number Discharge Integrated	Number Non Discharge Integrated	Minimum (cfs)	Maximum (cfs)	Number	First Date	Last Date	Number	First Date	Last Date	Number	First Date	Last Date
8046020	CLEAR FORK TRINITY RIVER ABV BENBROOK, TX	2	01-02-94	16-05-94	2		45.1	767	2	01-02-94	16-05-94						
8047500	CLEAR FORK TRINITY RIVER AT FORT WORTH, TX	1	02-02-94	02-02-94	1		262	262	1	02-02-94	02-02-94						
8048542	SYCAMORE PARK, FORT WORTH, TX	7	09-02-95	20-07-95	5		0.3	200	7	09-02-95	20-07-95				1	15-10-92	15-10-92
8048543	WEST FORK TRINITY R AT BEACH ST, FORT WORTH, TX	36	13-04-93	28-08-95	29		16	5780	36	13-04-93	28-08-95				1	15-10-92	15-10-92

Table 2 – Sediment Transport Potential in tons/day in the Fort Worth Central City Project Area

WF4	Flow Rate (cfs)						
Grain Size (mm)	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**16000**
0.088	1.47E-04	2.98E-01	1.08E+01	1.93E+02	1.99E+03	1.72E+04	4.12E+04
0.177	9.00E-05	1.01E-01	3.60E+00	5.88E+01	5.54E+02	4.32E+03	1.03E+04
0.354	6.90E-10	9.60E-03	4.22E-01	6.52E+00	5.63E+01	4.00E+02	9.47E+02
0.707	1.71E-10	2.91E-05	7.34E-02	1.21E+00	9.85E+00	6.43E+01	1.51E+02
1.414	4.80E-11	4.80E-11	1.53E-02	3.39E-01	2.72E+00	1.66E+01	3.89E+01
2.828	7.20E-11	7.20E-11	7.20E-11	1.80E-03	2.04E-02	1.12E-01	1.66E-01
5.657	1.77E-11	1.77E-11	1.77E-11	3.00E-09	5.70E-03	4.76E-02	7.46E-02

CF	Flow Rate (cfs)					
Grain Size (mm)	**250**	**500**	**1000**	**2000**	**4000**	**8000**
0.088	1.30E-08	1.30E-08	4.59E-01	1.79E+01	3.13E+02	3.46E+03
0.177	1.20E-08	1.20E-08	1.80E-01	6.51E+00	1.05E+02	1.06E+03
0.354	2.30E-09	2.30E-09	2.00E-02	8.41E-01	1.28E+01	1.19E+02
0.707	5.70E-10	5.70E-10	8.50E-04	1.65E-01	2.65E+00	2.31E+01
1.414	1.60E-10	1.60E-10	1.60E-10	4.40E-02	8.62E-01	7.13E+00
2.828	2.40E-10	2.40E-10	2.40E-10	2.40E-10	1.20E-02	1.24E-01
5.657	5.90E-11	5.90E-11	5.90E-11	5.90E-11	8.40E-04	4.30E-02

Table 3 - HEC-6 Results for Existing Conditions

Existing Conditions			
WF4-WF3			
		Thalweg	
Cross	Bed Change	Pre-Simulation	Post-Simulation
Section	(ft)	(ft)	(ft)
300278	(2.22)	535.50	533.28
299546	(8.80)	533.00	524.20
299545	0.00	540.50	540.50
299540	0.00	540.50	540.50
299539	(3.07)	532.00	528.93
298645	(5.49)	531.00	525.51
298260	(8.37)	531.00	522.63
298259	0.00	537.40	537.40
298249	0.00	537.40	537.40
298248	(8.76)	529.00	520.24
296992	(7.29)	526.00	518.71
295195	(5.02)	527.00	521.98
292711	(4.08)	525.00	520.92
290271	(3.50)	523.00	519.50
289442	(2.36)	522.00	519.64
289441	0.00	528.40	528.40
289429	0.00	528.40	528.40
289428	(4.68)	522.00	517.32
289136	(4.75)	520.00	515.25
286808	(3.15)	520.30	517.15
283400	(2.62)	520.30	517.68
281832	(4.07)	520.00	515.93
281831	0.00	523.50	523.50
281821	0.00	523.50	523.50
281820	(8.92)	517.20	508.28
277391	2.39	515.00	517.39
276325	0.33	515.20	515.53
274754	2.34	514.30	516.64
271794	2.99	513.90	516.89
269743	1.93	513.50	515.43
267221	0.59	513.00	513.59
262394	0.60	510.00	510.60
259337	1.72	506.80	508.52
257426	(0.59)	507.00	506.41
255442	4.22	510.20	514.42
254346	0.93	510.00	510.93
253240	1.20	505.20	506.40
252043	(7.98)	504.50	496.52
252042	0.00	520.10	520.10
252023	0.00	520.10	520.10
252022	(9.08)	504.50	495.42
251970	(8.39)	501.00	492.61
249891	0.02	500.00	500.02
247173	(1.92)	498.40	496.48
247172	0.00	505.50	505.50
247157	0.00	505.50	505.50
247156	(1.89)	496.00	494.11
247106	0.11	496.00	496.11
245960	(1.25)	495.60	494.35
244898	(1.22)	490.92	489.70
244797	(2.11)	495.41	493.30
244735	(1.57)	495.41	493.84
244635	(2.67)	492.56	489.89
242813	1.19	493.11	494.30
242318	0.42	494.00	494.42
242222	1.69	491.47	493.16
242099	3.20	490.45	493.65
241927	(2.29)	495.00	492.71
241708	1.72	491.88	493.60
240517	4.12	491.53	495.65
239744	5.44	489.19	494.63
239369	4.54	488.93	493.47
239095	5.06	487.48	492.54
238751	4.26	486.70	490.96
237615	6.43	487.87	494.30
236729	7.75	490.00	497.75
235522	7.38	487.86	495.24
231452	9.69	482.54	492.23

Existing Conditions			
Clear Fork			
		Thalweg	
Cross	Bed Change	Pre-Simulation	Post-Simulation
Section	(ft)	(ft)	(ft)
9045	(2.84)	519.60	516.76
8293	(7.80)	520.20	512.40
8243	0.00	525.80	525.80
8200	(8.93)	519.90	510.97
8178	(6.77)	519.90	513.13
8073	(5.24)	520.00	514.76
7400	(4.16)	519.50	515.34
6757	(6.67)	518.90	512.23
6707	0.00	523.00	523.00
6656	(3.44)	518.70	515.26
6258	(1.03)	518.20	517.17
6158	(3.28)	517.00	513.72
6101	(3.27)	517.00	513.73
5990	(1.80)	518.10	516.30
5170	(1.66)	517.80	516.14
4535	(0.86)	515.50	514.64
4433	(0.78)	513.50	512.72
4371	(0.83)	513.50	512.67
4267	(0.69)	515.40	514.71
4057	(0.09)	515.40	515.31
3803	(0.53)	515.20	514.67
3590	(0.57)	515.10	514.53
3365	(1.08)	515.10	514.02
3100	(0.11)	514.88	514.77
2249	(0.05)	514.40	514.35
1605	0.26	514.00	514.26
1499	(2.09)	507.90	505.81
1427	(2.09)	507.90	505.81
1324	(0.47)	513.70	513.23
935	(0.56)	513.40	512.84
477	2.77	510.00	512.77

Table 4 - HEC-6 Results for Proposed Conditions Without Dam

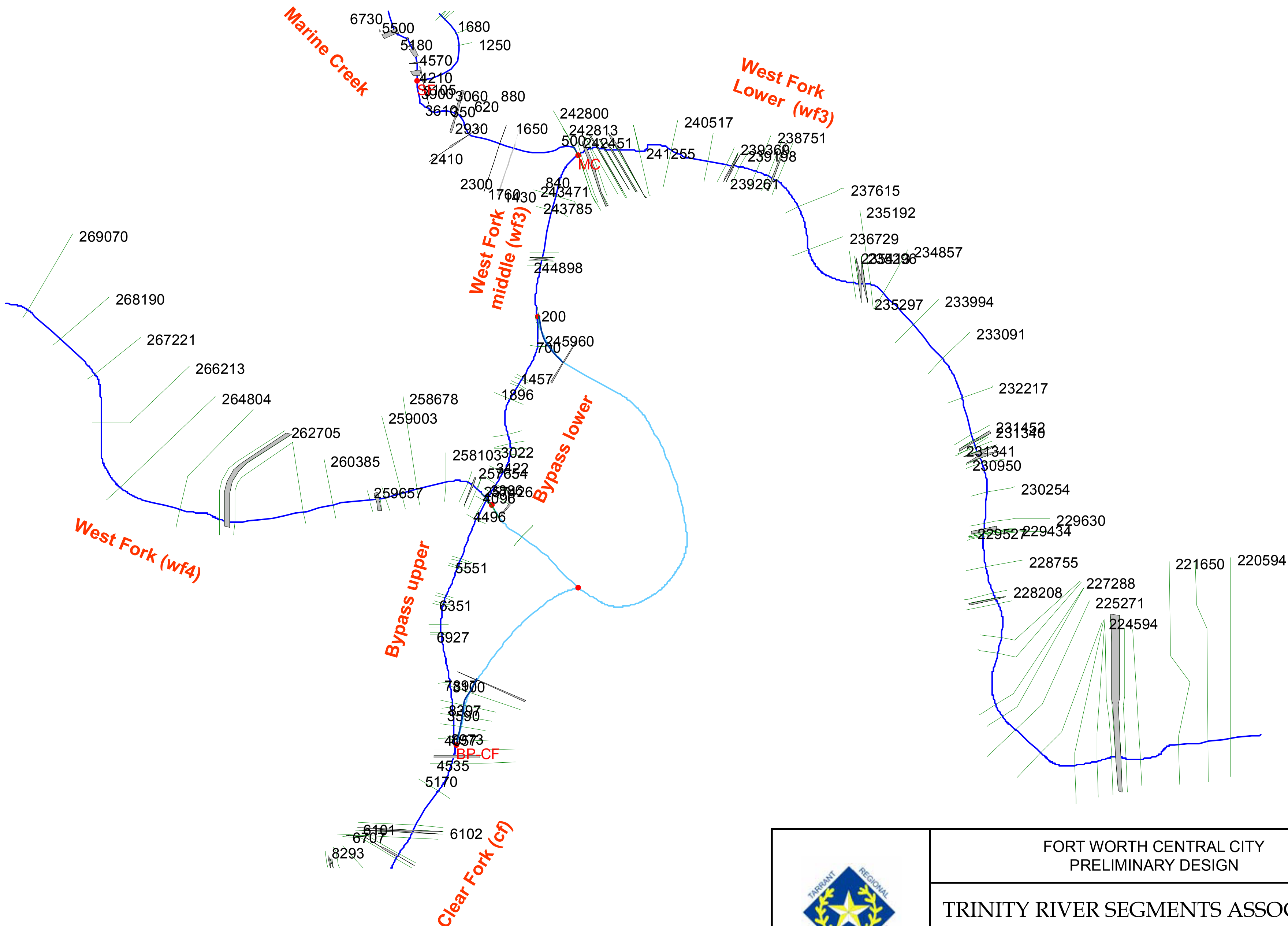
Proposed w/o Dam Conditions			
Clear Fork			
		Thalweg	
Cross	Bed Change	Pre-Simulation	Post-Simulation
Section	(ft)	(ft)	(ft)
9045	(2.84)	519.60	516.76
8293	(7.80)	520.20	512.40
8243	0.00	525.80	525.80
8200	(9.07)	519.90	510.83
8178	(7.81)	519.90	512.09
8073	(6.61)	520.00	513.39
7400	(5.86)	519.50	513.64
6757	(7.43)	518.90	511.47
6707	0.00	523.00	523.00
6656	(9.04)	518.70	509.66
6258	(7.38)	518.20	510.82
6158	(9.29)	517.00	507.71
6101	(9.37)	517.00	507.63
5990	(7.32)	518.10	510.78
5170	(7.55)	517.80	510.25
4535	(6.45)	515.50	509.05
4433	(5.58)	513.50	507.92
4371	(7.79)	513.50	505.71
4267	(6.80)	515.40	508.60
4057	(6.51)	515.40	508.89
3803	(6.61)	515.20	508.59
3590	(6.82)	515.10	508.28
Bypass Channel			
8421	(7.31)	515.10	507.79
8202	(9.08)	514.70	505.62
7829	(9.08)	514.09	505.01
7517	(9.08)	513.56	504.48
7199	(9.08)	513.02	503.94
6724	(9.08)	512.22	503.14
6511	(9.08)	511.85	502.77
6311	(9.08)	511.51	502.43
6004	(9.08)	510.99	501.91
5804	(9.08)	510.65	501.57
5531	(9.08)	510.19	501.11
5266	(9.08)	509.74	500.66
5051	(9.08)	509.37	500.29
4616	(8.99)	508.63	499.64
4391	(8.73)	508.25	499.52
4096	(8.59)	507.75	499.16
3656	(8.94)	507.00	498.06
3426	(8.86)	506.54	497.68
3026	(8.93)	505.74	496.81
2826	(8.77)	505.34	496.57
2580	(8.75)	504.85	496.10
2360	(9.00)	504.41	495.41
2091	(8.76)	503.87	495.11
1621	(6.89)	502.93	496.04
1260	(7.41)	502.21	494.80
900	1.16	496.92	498.08
660	(0.17)	496.50	496.33
440	0.92	496.00	496.92
220	4.18	495.60	499.78
WF3			
245960	3.77	495.60	499.37
244898	5.57	490.92	496.49
244797	2.79	495.41	498.20
244735	1.94	495.41	497.35
244635	1.22	492.56	493.78
242813	4.57	493.11	497.68
242318	2.90	494.00	496.90
242222	4.41	491.47	495.88
242099	5.71	490.45	496.16
241927	1.10	495.00	496.10
241708	4.29	491.88	496.17
240517	6.22	491.53	497.75
239744	7.87	489.19	497.06
239369	6.92	488.93	495.85
239095	7.44	487.48	494.92
238751	7.01	486.70	493.71
237615	8.48	487.87	496.35
236729	9.10	490.00	499.10
235522	8.57	487.86	496.43
231452	12.61	482.54	495.15

Proposed w/o Dam Conditions			
WF4			
		Thalweg	
Cross	Bed Change	Pre-Simulation	Post-Simulation
Section	(ft)	(ft)	(ft)
300278	(2.60)	535.50	532.90
299546	(8.88)	533.00	524.12
299545	0.00	540.50	540.50
299540	0.00	540.50	540.50
299539	(3.07)	532.00	528.93
298645	(5.82)	531.00	525.18
298260	(8.33)	531.00	522.67
298259	0.00	537.40	537.40
298249	0.00	537.40	537.40
298248	(8.93)	529.00	520.07
296992	(7.58)	526.00	518.42
295195	(5.23)	527.00	521.77
292711	(4.63)	525.00	520.37
290271	(4.15)	523.00	518.85
289442	(2.26)	522.00	519.74
289441	0.00	528.40	528.40
289429	0.00	528.40	528.40
289428	(5.05)	522.00	516.95
289136	(6.38)	520.00	513.62
286808	(4.27)	520.30	516.03
283400	(4.32)	520.30	515.98
281832	(2.51)	520.00	517.49
281831	0.00	523.50	523.50
281821	0.00	523.50	523.50
281820	(8.82)	517.20	508.38
277391	(8.05)	515.00	506.95
276325	(7.43)	515.20	507.77
274754	(5.54)	514.30	508.76
271794	(5.65)	513.90	508.25
269743	(7.06)	513.50	506.44
267221	(8.26)	513.00	504.74
262394	(8.45)	510.00	501.55
259337	(6.08)	506.80	500.72
257426	(9.07)	507.00	497.93

Table 5 - HEC-6 Results for Proposed Conditions With Dam

Proposed w/ Dam Conditions			
Clear Fork			
		Thalweg	
Cross Section	Bed Change (ft)	Pre-Simulation (ft)	Post-Simulation (ft)
9045	(0.52)	519.60	519.08
8293	(6.56)	520.20	513.64
8243	0.00	525.80	525.80
8200	(8.75)	519.90	511.15
8178	(3.07)	519.90	516.83
8073	(1.46)	520.00	518.54
7400	(0.86)	519.50	518.64
6757	(1.36)	518.90	517.54
6707	0.00	523.00	523.00
6656	(2.64)	518.70	516.06
6258	1.09	518.20	519.29
6158	(0.19)	517.00	516.81
6101	(0.23)	517.00	516.77
5990	0.48	518.10	518.58
5170	1.28	517.80	519.08
4535	1.16	515.50	516.66
4433	0.84	513.50	514.34
4371	0.73	513.50	514.23
4267	0.88	515.40	516.28
4057	1.19	515.40	516.59
3803	1.02	515.20	516.22
3590	0.29	515.10	515.39
Bypass Channel			
8421	(1.17)	515.10	513.93
8202	(0.10)	514.70	514.60
7829	(0.84)	514.09	513.25
7517	(0.82)	513.56	512.74
7199	(0.75)	513.02	512.27
6724	(0.70)	512.22	511.52
6511	(0.68)	511.85	511.17
6311	(0.61)	511.51	510.90
6004	(0.57)	510.99	510.42
5804	(0.56)	510.65	510.09
5531	(0.54)	510.19	509.65
5266	(0.53)	509.74	509.21
5051	(0.51)	509.37	508.86
4616	(0.51)	508.63	508.12
4391	(0.50)	508.25	507.75
4096	(0.50)	507.75	507.25
3656	(5.52)	507.00	501.48
3426	(5.47)	506.54	501.07
3026	(5.37)	505.74	500.37
2826	(5.34)	505.34	500.00
2580	(5.32)	504.85	499.53
2360	(5.30)	504.41	499.11
2091	(5.29)	503.87	498.58
1621	(5.29)	502.93	497.64
1260	(5.27)	502.21	496.94
900	(5.15)	496.92	491.77
660	(5.07)	496.50	491.43
440	(5.04)	496.00	490.96
220	(5.03)	495.60	490.57
WF3			
245960	(0.84)	495.60	494.76
244898	(4.74)	490.92	486.18
244797	(4.74)	495.41	490.67
244735	(4.68)	495.41	490.73
244635	(4.44)	492.56	488.12
242813	(4.17)	493.11	488.94
242318	(4.19)	494.00	489.81
242222	(4.21)	491.47	487.26
242099	(3.97)	490.45	486.48
241927	(4.12)	495.00	490.88
241708	(4.04)	491.88	487.84
241255	(4.04)	496.00	491.96
241179	(4.09)	496.00	491.91
241164	(6.56)	496.00	489.44
241163	0.00	524.30	524.30
241135	0.00	524.30	524.30
241134	(8.56)	496.00	487.44
241119	(4.56)	496.00	491.44
240517	(3.66)	491.53	487.87
239744	(3.47)	489.19	485.72
239369	(3.98)	488.93	484.95
239095	(3.91)	487.48	483.57
238751	(4.02)	486.70	482.68
237615	(2.79)	487.87	485.08
236729	(1.00)	490.00	489.00
235522	(2.70)	487.86	485.16
231452	(1.88)	482.54	480.66
229429	(7.89)	484.25	476.36

Proposed w/ Dam Conditions			
WF4			
		Thalweg	
Cross Section	Bed Change (ft)	Pre-Simulation (ft)	Post-Simulation (ft)
300278	(3.17)	535.50	532.33
299546	(8.21)	533.00	524.79
299545	0.00	540.50	540.50
299540	0.00	540.50	540.50
299539	(4.48)	532.00	527.52
298645	(3.97)	531.00	527.03
298260	(8.13)	531.00	522.87
298259	0.00	537.40	537.40
298249	0.00	537.40	537.40
298248	(7.04)	529.00	521.96
296992	(7.26)	526.00	518.74
295195	(4.66)	527.00	522.34
292711	(3.54)	525.00	521.46
290271	(2.85)	523.00	520.15
289442	(2.30)	522.00	519.70
289441	0.00	528.40	528.40
289429	0.00	528.40	528.40
289428	(4.52)	522.00	517.48
289136	(1.50)	520.00	518.50
286808	(1.50)	520.30	518.80
283400	0.11	520.30	520.41
281832	(5.83)	520.00	514.17
281831	0.00	523.50	523.50
281821	0.00	523.50	523.50
281820	(8.61)	517.20	508.59
277391	5.56	515.00	520.56
276325	2.27	515.20	517.47
274754	4.90	514.30	519.20
271794	5.52	513.90	519.42
269743	4.19	513.50	517.69
267221	4.09	513.00	517.09
262394	1.79	510.00	511.79
259337	3.89	506.80	510.69
257426	(5.86)	507.00	501.14

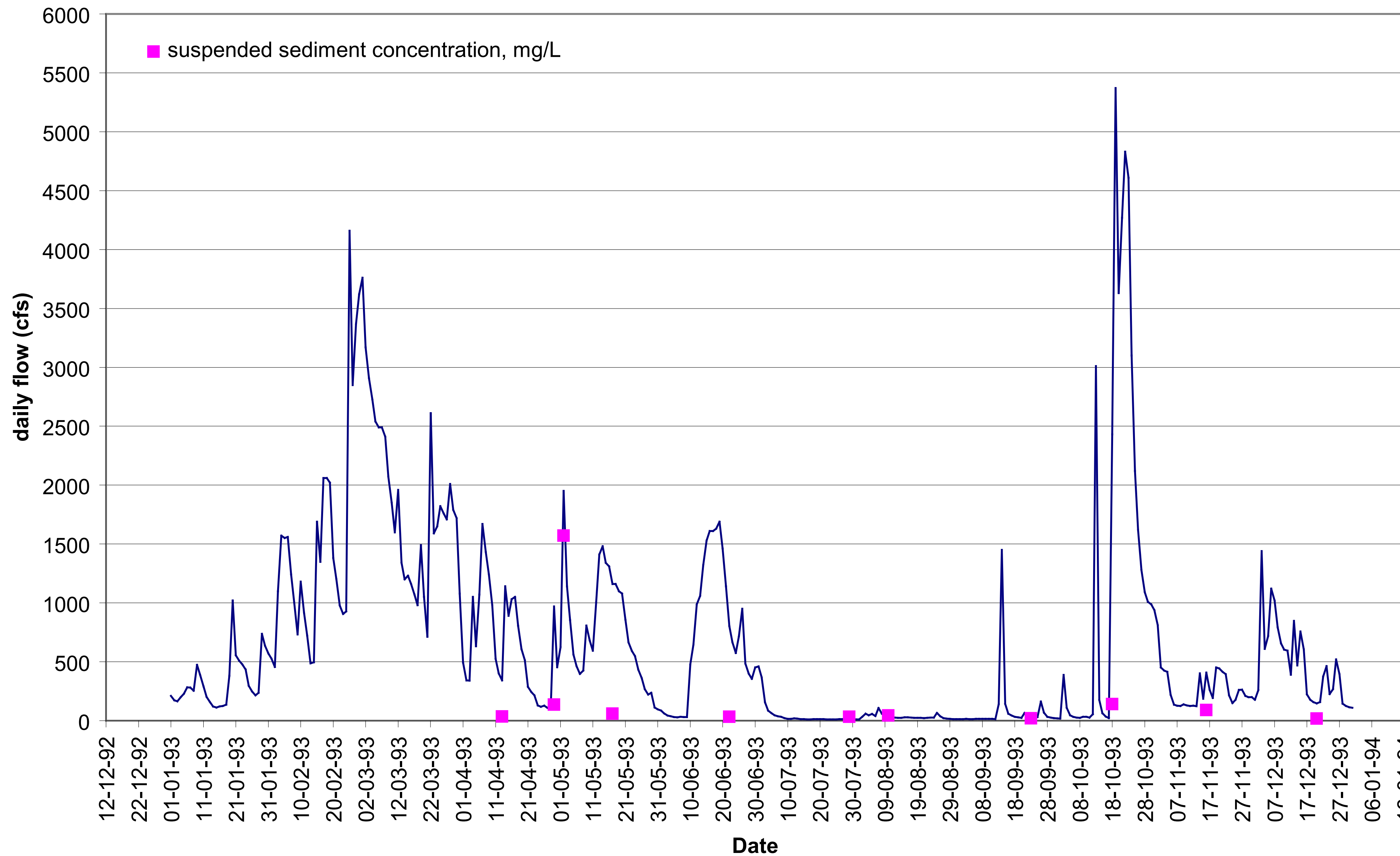


FORT WORTH CENTRAL CITY
PRELIMINARY DESIGN

TRINITY RIVER SEGMENTS ASSOCIATED WITH THE CENTRAL PROJECT ANALYZED FOR SEDIMENT TRANSPORT

DATE: JANUARY 2005

FIGURE No. 1

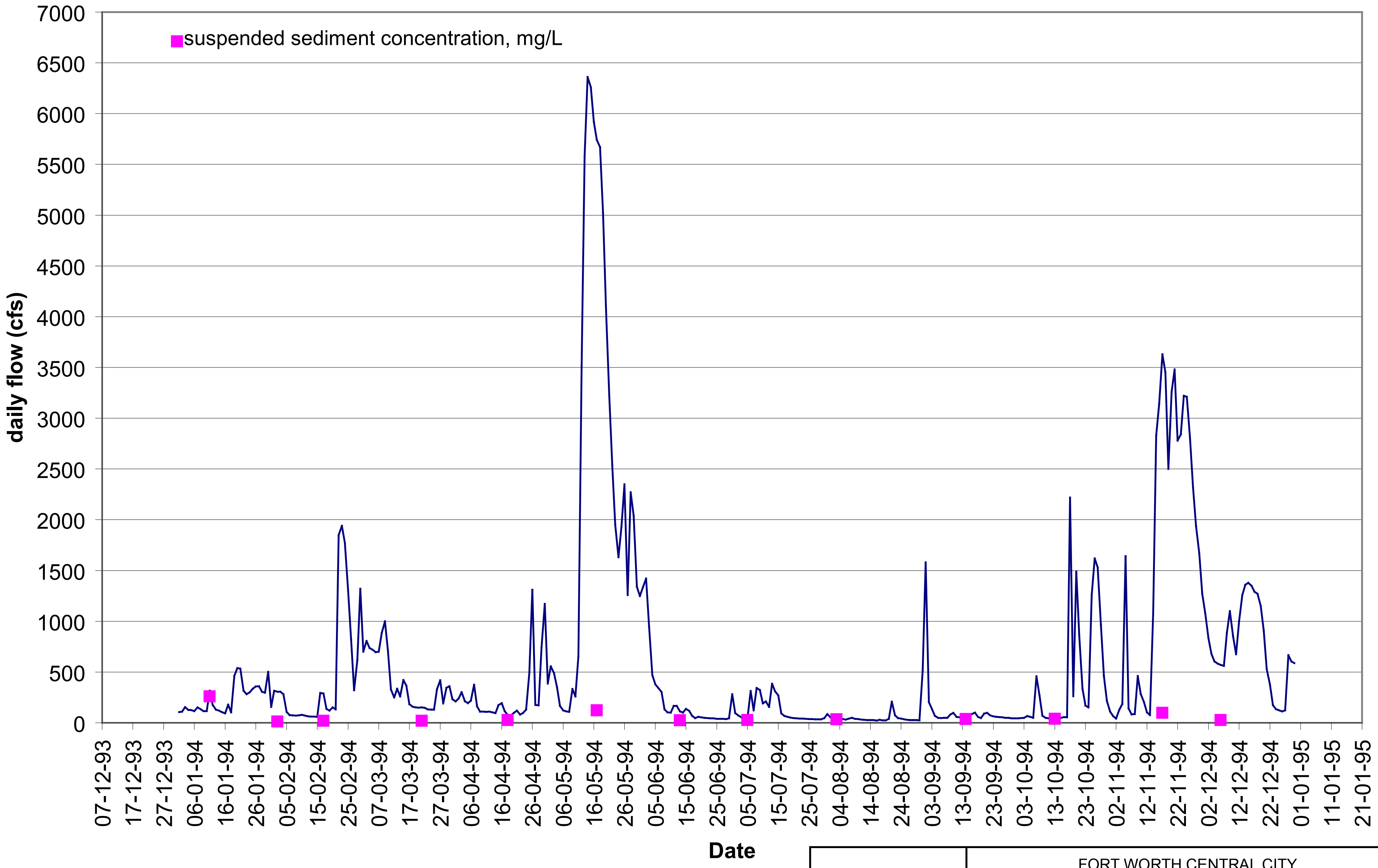


FORT WORTH CENTRAL CITY
PRELIMINARY DESIGN

SUSPENDED SEDIMENT DATA FOR THE WEST FORK TRINITY RIVER AT BEACH STREET, FORT WORTH, TEXAS (STATION 08048543) FOR YEAR 1993

DATE: JANUARY 2005

FIGURE No. 2a

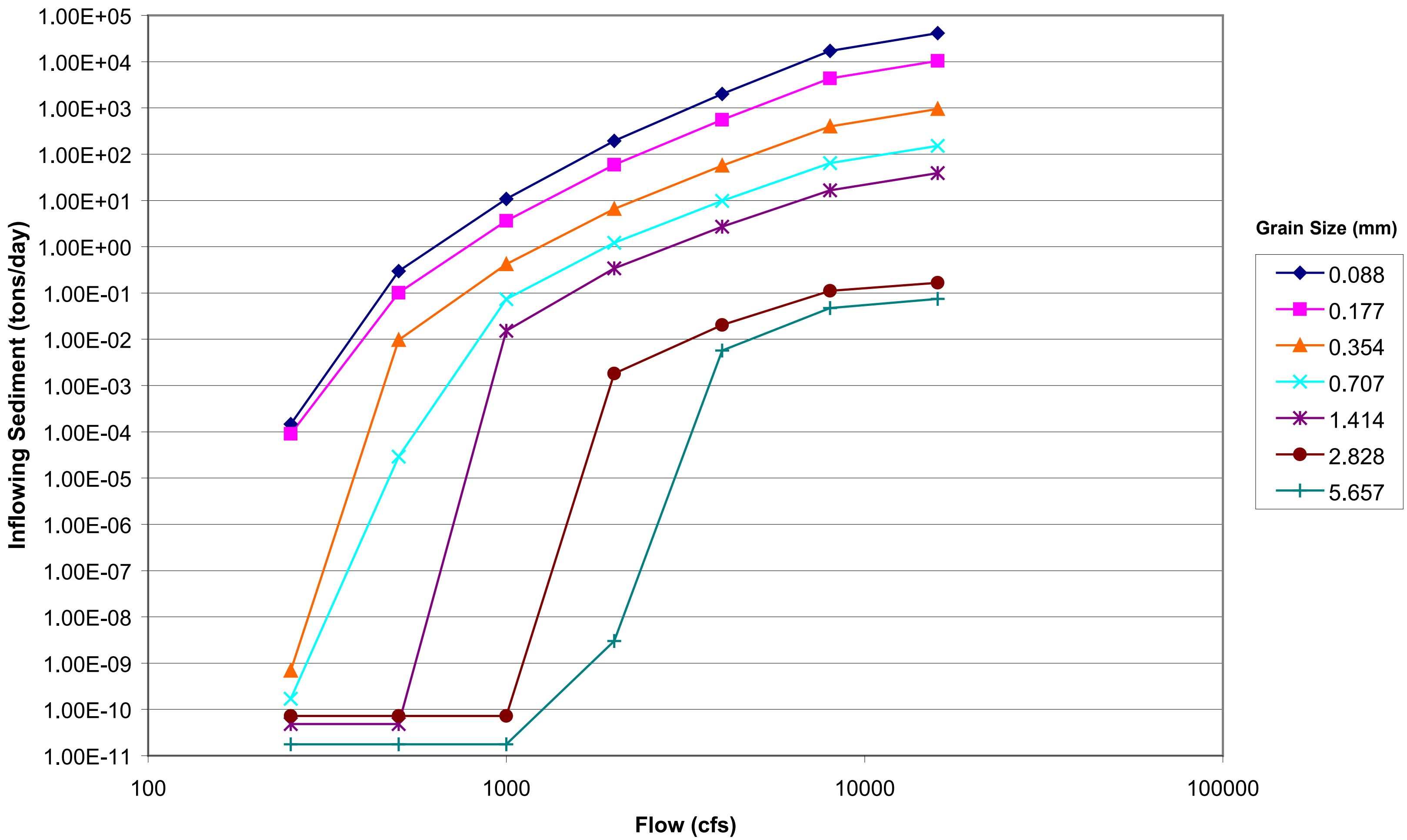


FORT WORTH CENTRAL CITY
PRELIMINARY DESIGN

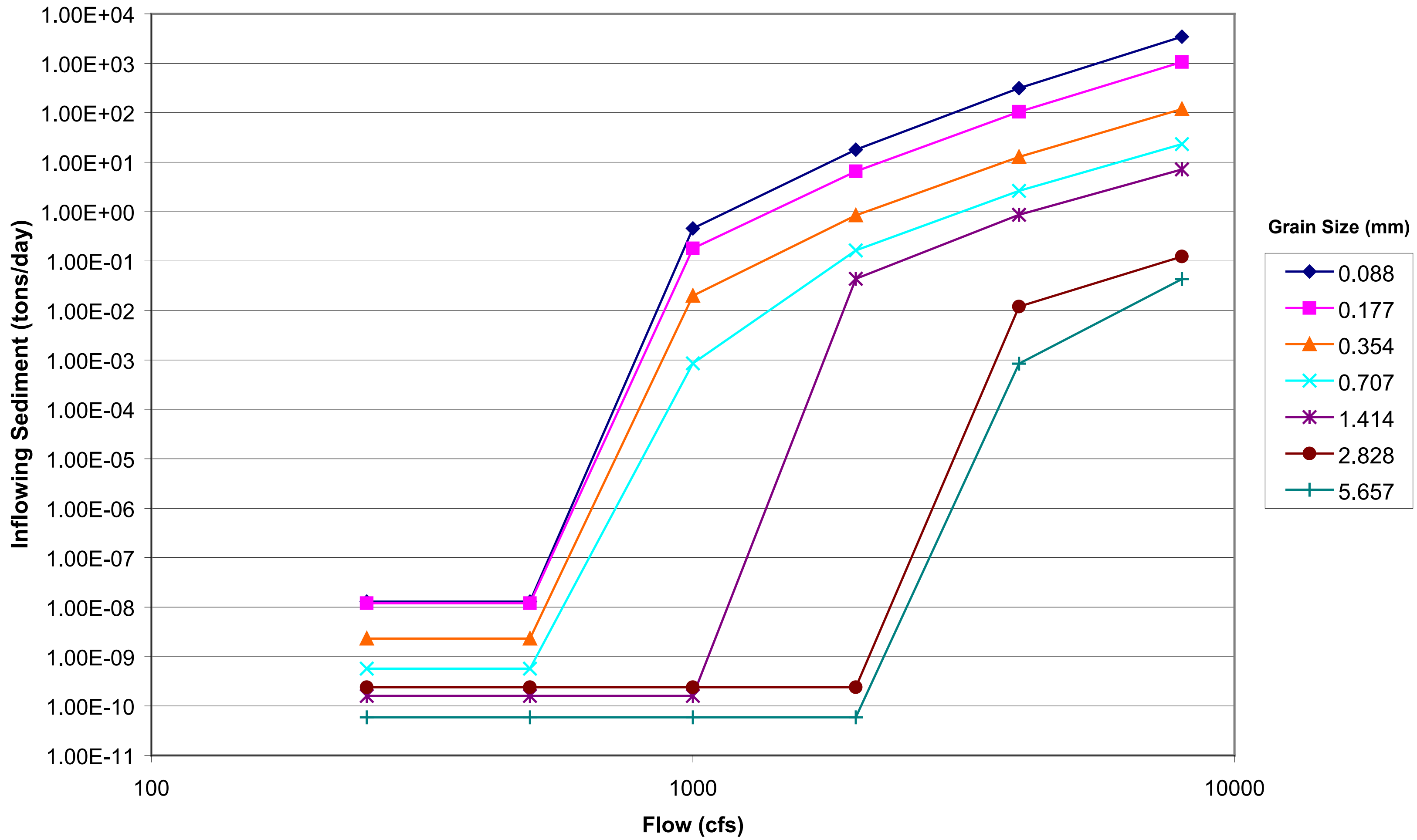
SUSPENDED SEDIMENT DATA FOR THE WEST FORK TRINITY RIVER AT BEACH STREET, FORT WORTH, TEXAS (STATION 08048543) FOR YEAR 1994

DATE: JANUARY 2005

FIGURE No. 2b



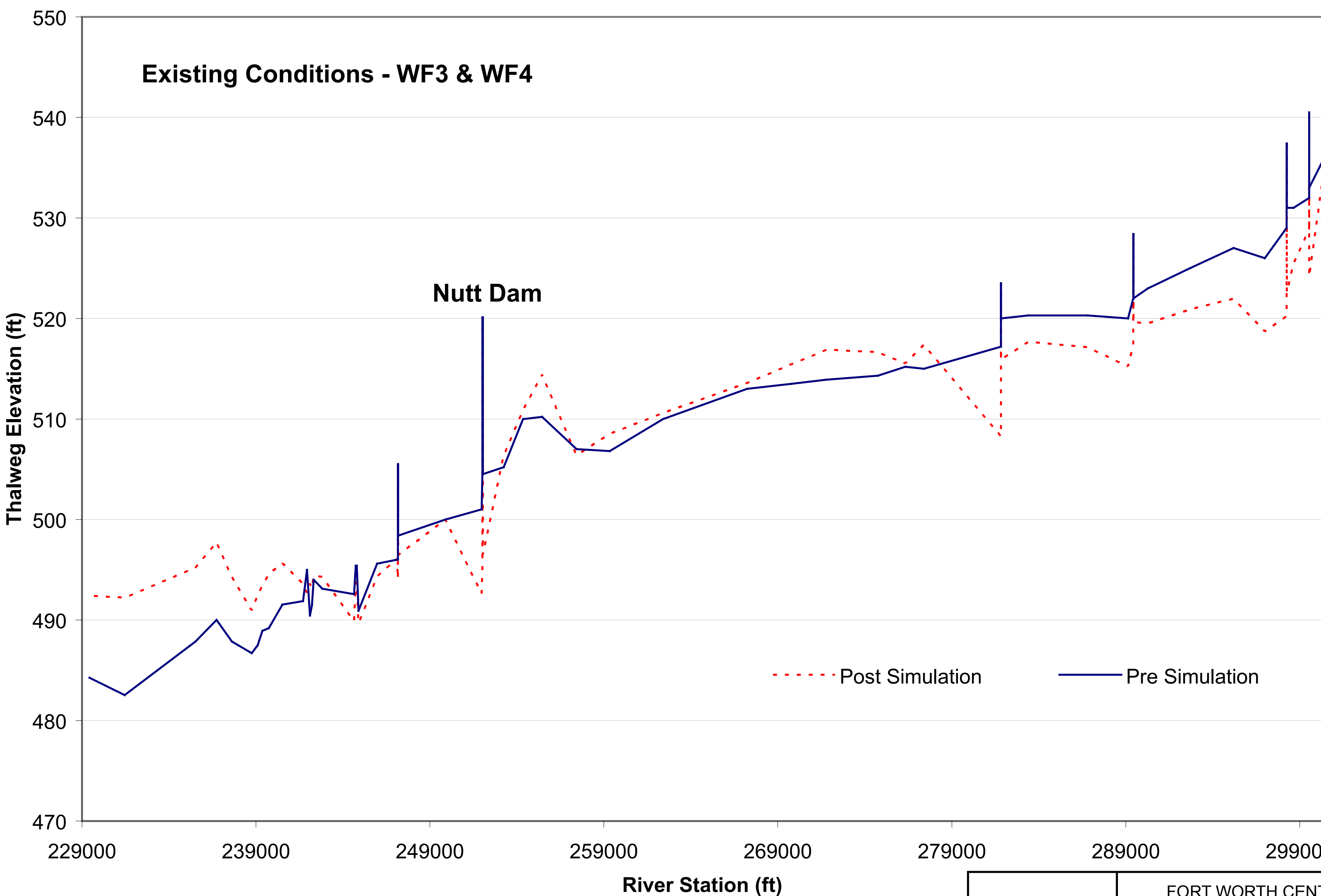
FORT WORTH CENTRAL CITY PRELIMINARY DESIGN	
INFLOWING SEDIMENT ENTERING THE MODEL BOUNDARY ON THE WEST FORK (WF4)	
DATE: JANUARY 2005	FIGURE No. 3a



FORT WORTH CENTRAL CITY
PRELIMINARY DESIGN

INFLOWING SEDIMENT ENTERING THE MODEL BOUNDARY ON THE CLEAR FORK (CF)

DATE: JANUARY 2005 | FIGURE No. 3b

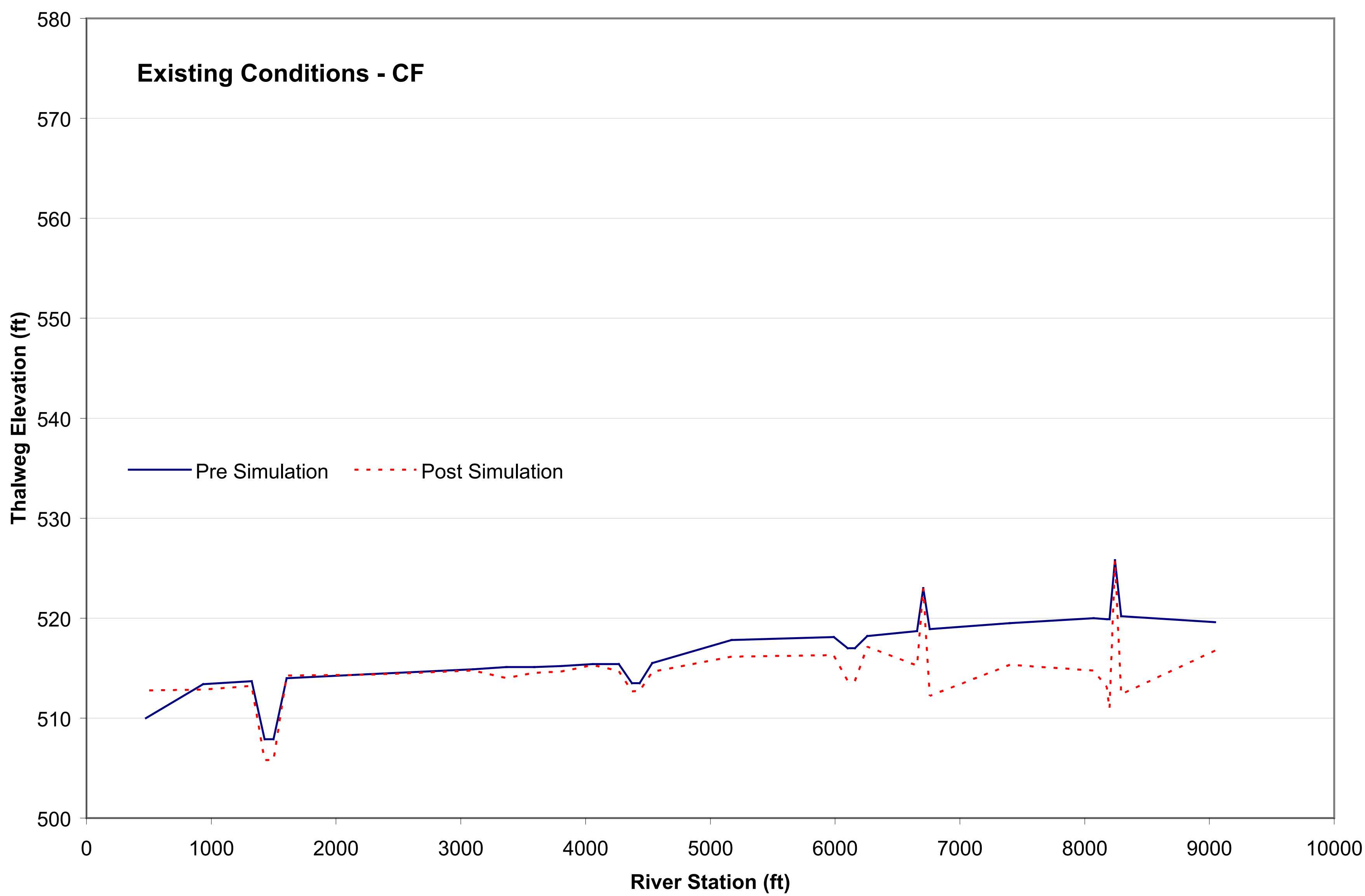


FORT WORTH CENTRAL CITY
PRELIMINARY DESIGN

THALWEG ELEVATION CHANGES FOR EXISTING CONDITIONS – WF3 AND WF4

DATE: JANUARY 2005

FIGURE No. 4

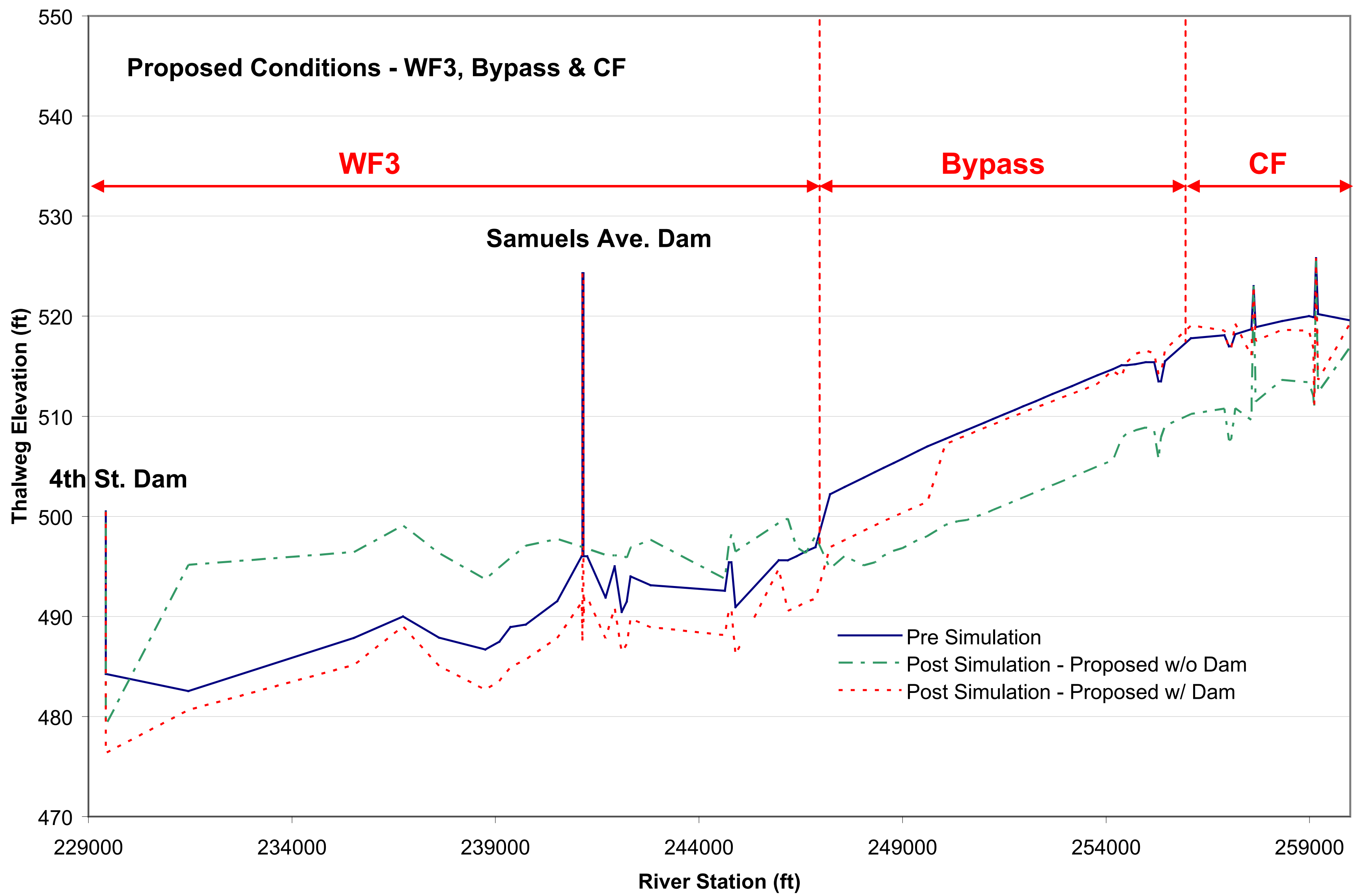


FORT WORTH CENTRAL CITY
PRELIMINARY DESIGN

THALWEG ELEVATION CHANGES FOR EXISTING CONDITIONS – CLEAR FLORK (CF)

DATE: JANUARY 2005

FIGURE No. 5

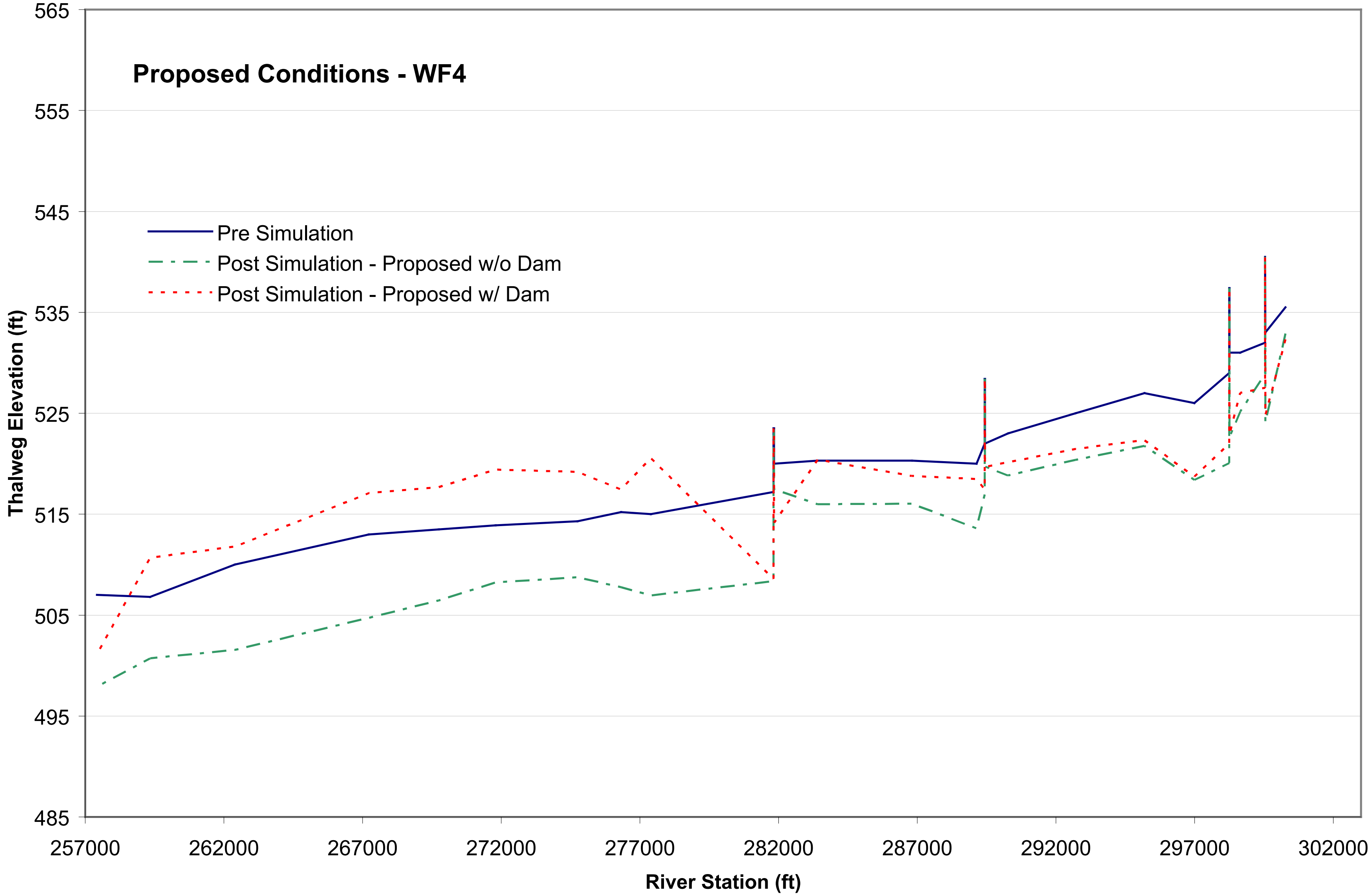


FORT WORTH CENTRAL CITY
PRELIMINARY DESIGN

THALWEG ELEVATION CHANGES FOR PROPOSED CONDITIONS – WF3, BYPASS CHANNEL, AND CF

DATE: JANUARY 2005

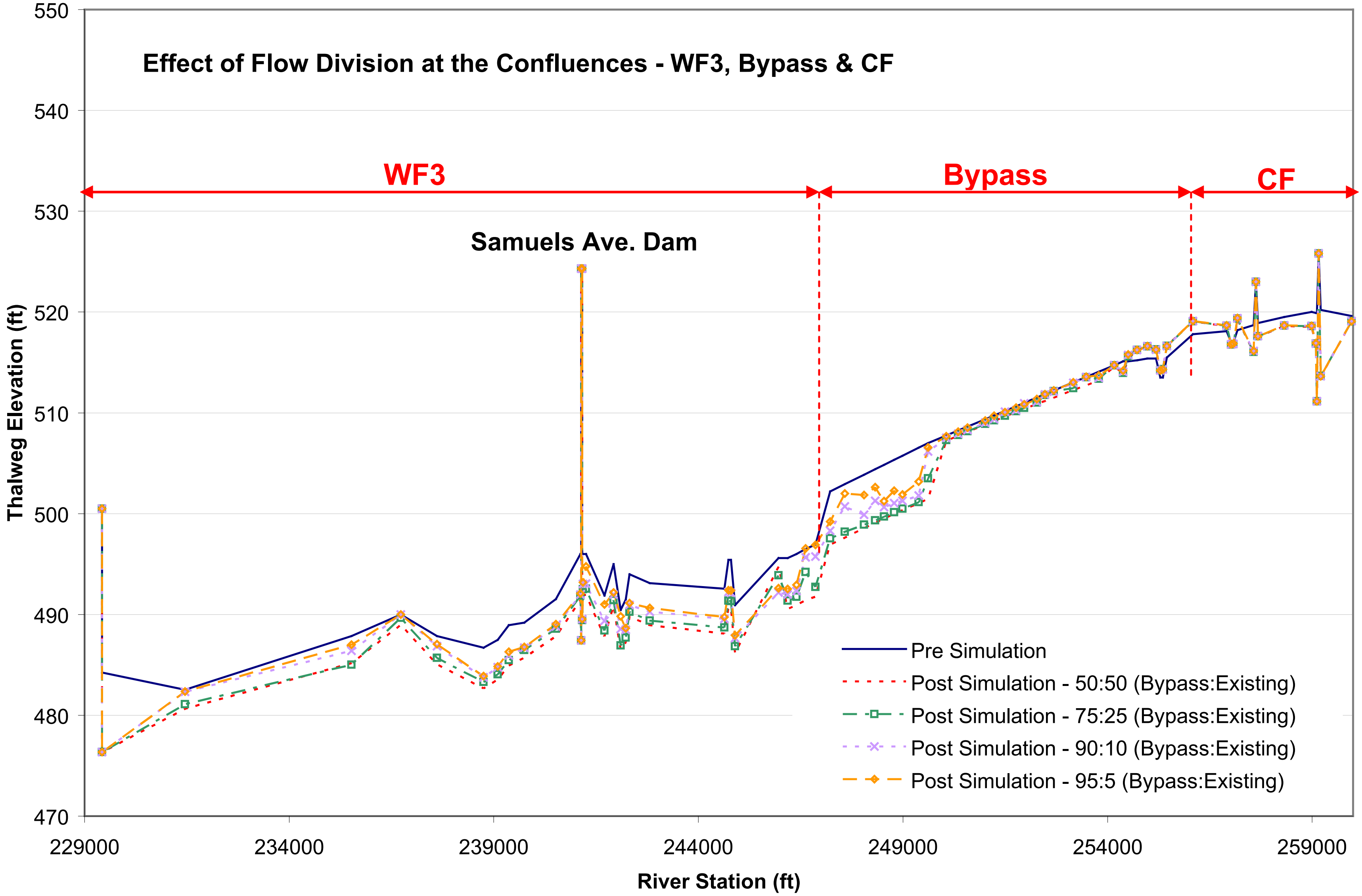
FIGURE No. 6



FORT WORTH CENTRAL CITY
PRELIMINARY DESIGN

THALWEG ELEVATION CHANGES FOR PROPOSED CONDITIONS – WF4

DATE: JANUARY 2005 | FIGURE No. 7

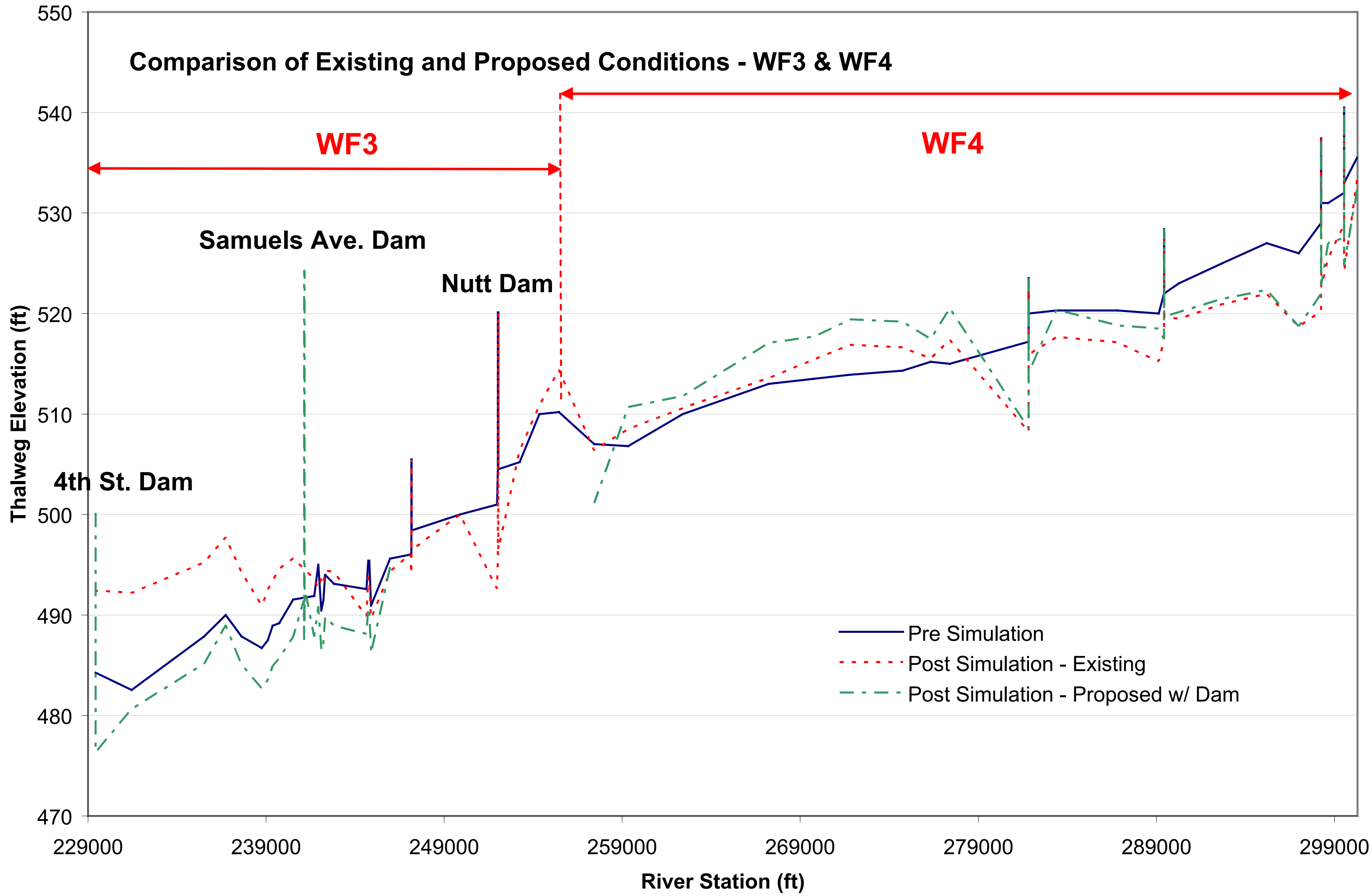


FORT WORTH CENTRAL CITY
PRELIMINARY DESIGN

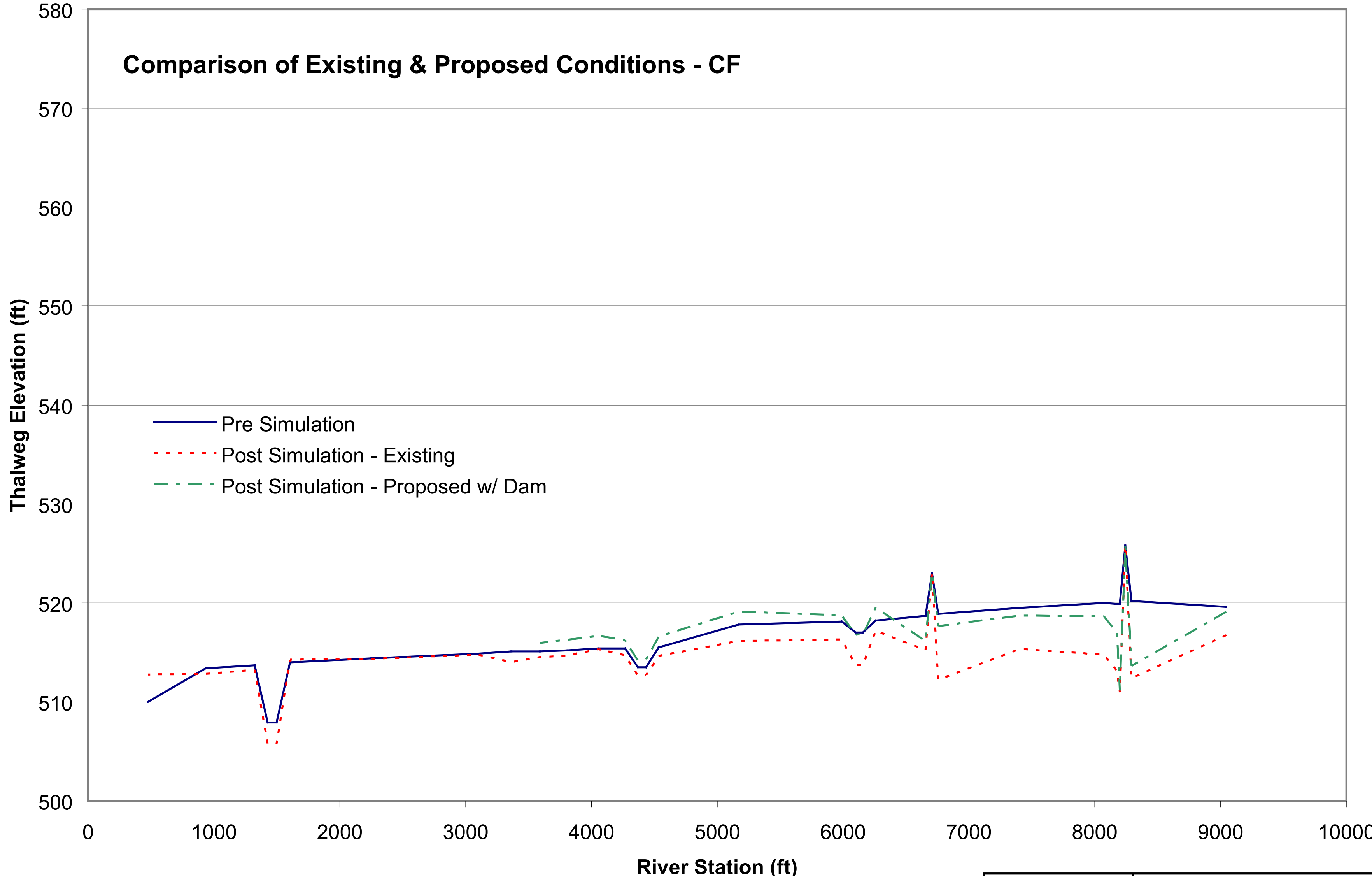
EFFECT OF FLOW DIVISION AT THE CONFLUENCES – WF3, BYPASS CHANNEL, AND CF

DATE: JANUARY 2005

FIGURE No. 8



FORT WORTH CENTRAL CITY PRELIMINARY DESIGN	
COMPARISON OF EXISTING AND PROPOSED CONDITIONS – WF3 AND WF4	
DATE: JANUARY 2005	FIGURE No. 9



FORT WORTH CENTRAL CITY PRELIMINARY DESIGN	
COMPARISON OF EXISTING AND PROPOSED CONDITIONS – WF3 AND WF4	
DATE: JANUARY 2005	FIGURE No. 10