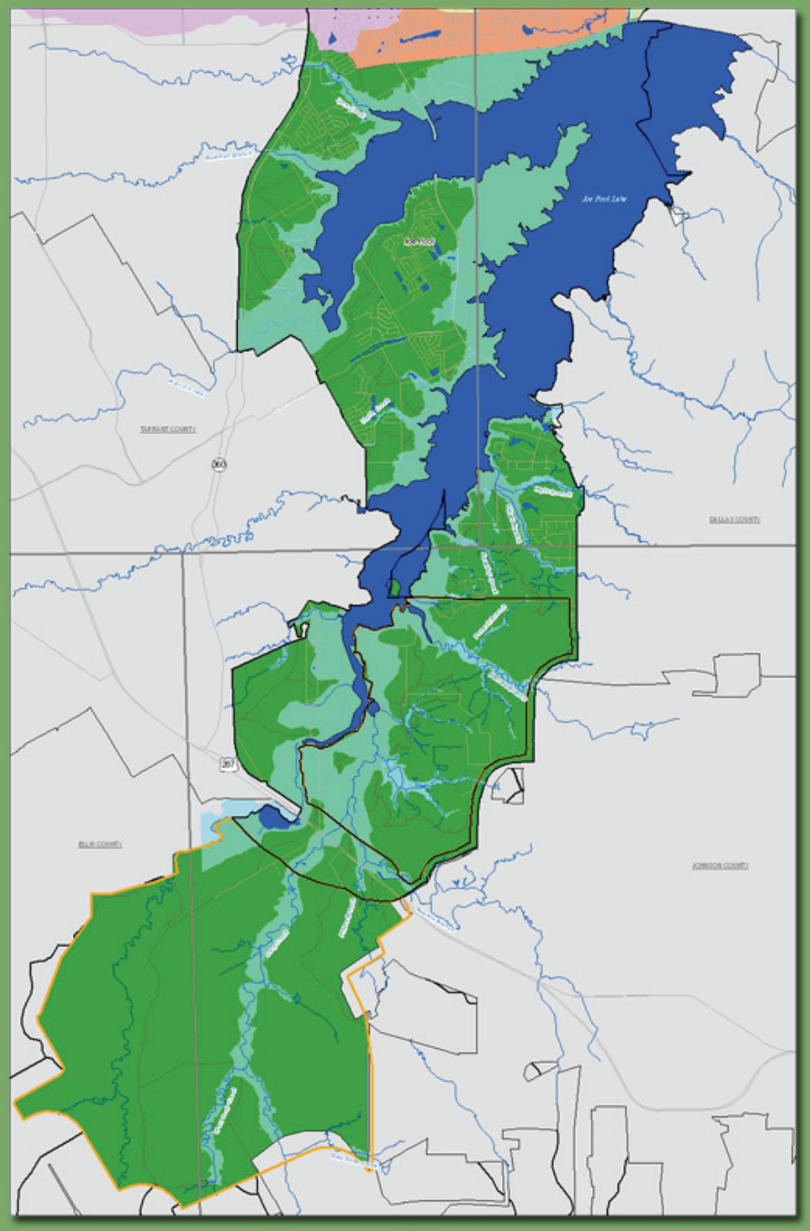
City of Grand Prairie City-Wide Drainage Master Plan for Joe Pool Lake



February 2011

Prepared by

HALFF

Grand Prairie TEXAS

RESOLUTION NO. 4477-2011

A RESOLUTION APPROVING THE CITY OF GRAND PRAIRIE'S "CITY-WIDE DRAINAGE MASTER PLAN FOR JOE POOL LAKE"

WHEREAS, the "City-Wide Drainage Master Plan for Joe Pool Lake" (the Plan) provides comprehensive, updated technical data for the management of the Joe Pool Lake watershed tributaries and storm water infrastructure; and

WHEREAS, the Plan addresses existing flooding, erosion, and sedimentation problems within the watershed and provides planning alternatives and design concepts to help alleviate potential flood damages; and

WHEREAS, the Plan provides the City of Grand Prairie with the necessary updated drainage information to coordinate future development according to the City's drainage requirements to help minimize existing and potential flood damages within the Joe Pool Lake watershed; and

WHEREAS, any revisions to the floodplain and the floodways identified in these studies shall also include ultimate development conditions and shall be for the whole creek as determined in these studies and not for portions of it to ensure that there are no downstream adverse effects; required submittals to FEMA shall be for the whole creek (as determined in these studies) and not for portions of it; and

WHEREAS, the recommendations of this report shall be incorporated for all future development as well as CIP budget considerations;

NOW THEREFORE, BE IT RESOLVED, BY THE CITY COUNCIL OF THE CITY OF GRAND PRAIRIE, TEXAS THAT:

SECTION 1. That the City of Grand Prairie, Texas, having developed the "City-Wide Drainage Master Plan for Joe Pool Lake" to cost-effectively manage flood or storm waters within budgeting constraints, approves and adopts the "City-Wide Drainage Master Plan for Joe Pool Lake" thereby setting the standard for future drainage master plans, addressing existing flooding problems and providing planning recommendation, alternatives and design concepts for future development, to include CIP as well as possible developer participation projects.

PASSED AND APPROVED BY THE CITY COUNCIL OF THE CITY OF GRAND PRAIRIE, TEXAS, ON THIS THE 15TH DAY OF FEBRUARY, 2011.

APPROVED:

Charles England, Mayor

ATTEST:

City Secretary

APPROVED AS TO FORM:

City Attorney

HALFF

March 31, 2011
AVO 26418

Mr. Romin Khavari, P.E., CFM
City Engineer
City of Grand Prairie
206 W. Church Street
P.O. Box 534045
Grand Prairie, TX 75053-4045

Re: **City-wide Drainage Master Plan for Joe Pool Lake (W.O. 581.40)**
Final Report

Dear Mr. Khavari:

Transmitted herewith is the Final Report for the City-wide Drainage Master Plan for Joe Pool Lake (W.O. 581.40), including technical data and exhibits. This report compiles existing and newly developed technical data for the Joe Pool Lake watershed into a single comprehensive document. The report also includes a CD-ROM containing HEC-HMS hydrologic models, HEC-RAS hydraulic models, StormCad v8i storm drain models, PDFs, and GIS data for City use.

Please do not hesitate to call me, Cindy, or Ben if you have questions or concerns regarding the CWDMP for Joe Pool Lake watershed.

Sincerely,

HALFF ASSOCIATES, INC.

Stephen B. Crawford

Stephen Crawford, PE, CFM
Project Manager

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EXECUTIVE SUMMARY

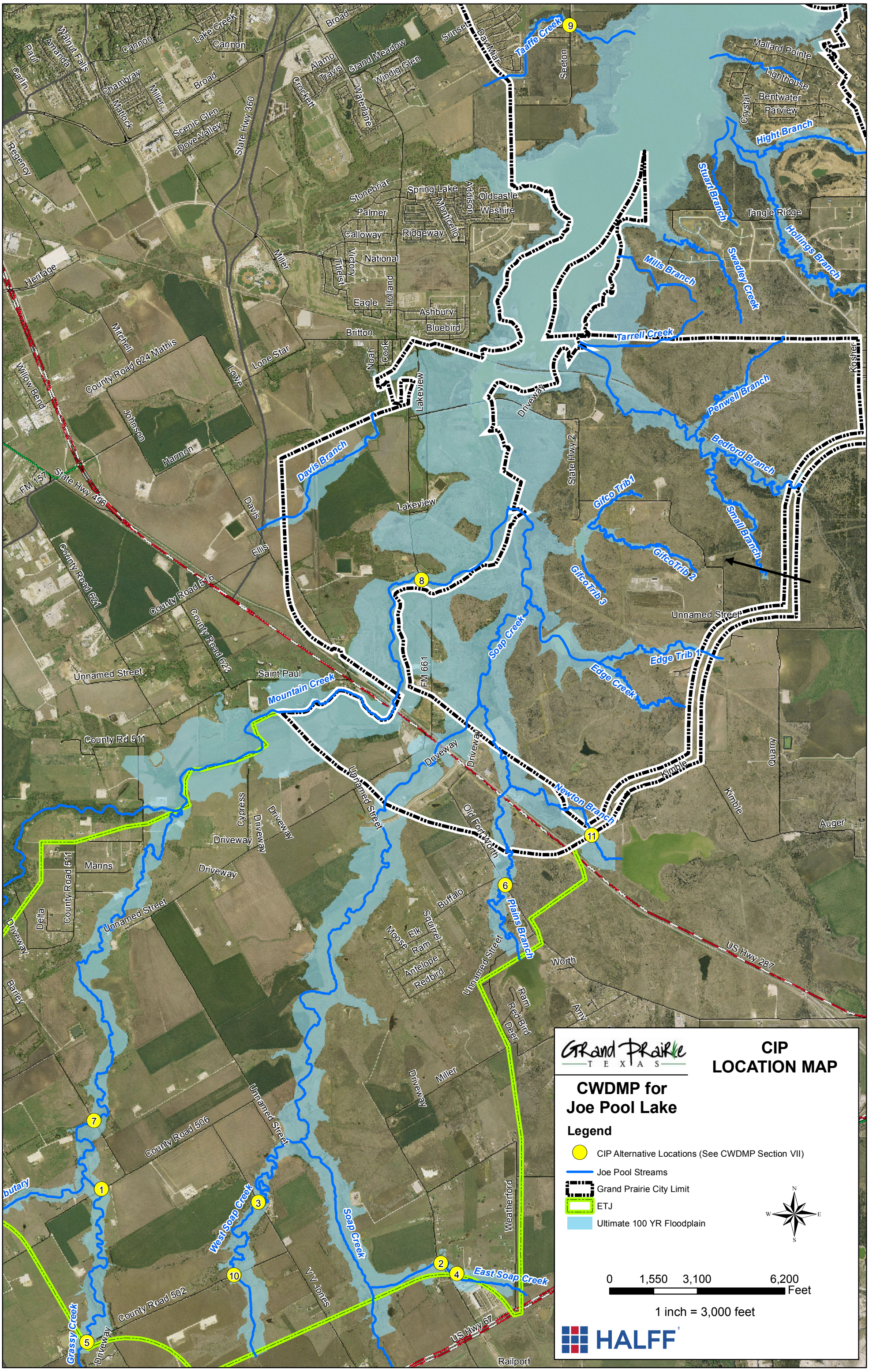
The City-wide Drainage Master Plan for Joe Pool Lake provides comprehensive, updated technical data for the management of the Joe Pool Lake watershed tributaries and storm water infrastructure. This report addresses existing flooding, erosion, and sedimentation problems within the watershed and provides planning alternatives and design concepts to help alleviate potential flood damages. The information presented in this report will provide the City of Grand Prairie with the necessary updated drainage information to coordinate future development and help minimize exiting and potential flood damages within the Joe Pool Lake watershed. This study is in compliance with the requirements set forth in the "City-wide Drainage Master Plan Roadmap." The City Council of Grand Prairie passed Resolution No. 4477-2011 approving this study on February 15, 2011.

A relatively small number of structures are currently inundated by the 100-year floodplain in the Joe Pool Lake watershed. The majority of the watershed is currently undeveloped, except for the peninsula area near the Mira Lagos development. The watershed offers an opportunity for the City to plan future development in a way that will reduce flood losses, protect residents and infrastructure, improve water quality for Joe Pool Lake, and reduce unnecessary capital expenditures in the future. The stream and open channel alternatives included in this report are all roadway improvements that are considered long-term Capital Improvement Projects. These projects are not likely to be economically justifiable until development in the watershed requires additional infrastructure improvements. Halff recommends the overtopped roadways in the watershed be incorporated into the City's flood warning system. For the small watersheds, signage is likely the only option to warn motorists about the flood dangers. For the larger watersheds, rain gages and flood warning are recommended alternatives for the short-term protection of these overtopped roadways. See the following pages for a summary of the prioritization rankings and a location map.

This report includes structural stream stability alternatives that are recommended only on an "as-needed" basis. As development occurs, the Floodplain Workmaps should be utilized to determine whether a site is in a high risk area for bank erosion or channel degradation. If so, then stream bank stability alternatives should be considered.

Maintenance for detention ponds and storm drain outfalls was considered and issues were prioritized based on need of repair. Halff recommends maintenance and continued inspection of the watershed on a regular basis to ensure the integrity of the drainage system.

This report is intended to be a living document that can be updated as additional information becomes available.



CIP Location Map

Preliminary Short-Term & Long-Term Implementation Plan

Joe Pool Lake Watershed

	Capital Improvement Project	Project Size & Short-Term/Long-Term	Step 1 - Initial Ranking Factor - Estimate of Probable Cost vs. # Structures Benefited [1]			Step 2 - Second Ranking Factor - Cost to Benefit of Roadway Number of Citizens Impacted [2]							Step 3 - Tax Value of Benefited Property Structures [7]		Sum of 1st, 2nd, and 3rd Factors - Step 4	Initial Rank - Step 4	100-Year Ultimate Discharge at CIP Location - Step 5		Final Rank - Step 6
			# Structures	Cost	1st Factor [1]	Type	Roadway Flood Event Protection	Roadway % Citizens Protected [3]	Roadway % Citizens Impacted [4]	Roadway # Citizens Impacted [5]	Cost to Benefit Roadway # Citizens Impacted [6]	2nd Factor	Tax Value of Property Structures Benefited	3rd Factor	Total	Rank [8]	Ultimate Q_{100}	Sorting [9]	Rank [10]
1	**Alt. 1 -** CR 506 at Grassy Creek	Medium/Long-Term	0	$1,183,000	4	P4D	1	0%	100%	7800	$151.67	2	$0	20	26	2	7,730		1
2	**Alt. 2 -** Miller Road at East Soap Creek	Medium/Long-Term	0	$675,000	4	P4D	10	50%	50%	3900	$173.08	3	$0	20	27	3	6,100		2
3	**Alt. 3 -** Jones Road at West Soap Creek	Medium/Long-Term	0	$1,327,000	4	M3U	1	0%	100%	5070	$261.74	4	$0	20	28	4	7,500		3
4	**Alt. 4 -**Turner Road at East Soap Creek	Medium/Long-Term	0	$659,000	4	C2U	2	15%	85%	2320.5	$283.99	5	$0	20	29	5	5,500		4
5	**Alt. 5 -** CR 502 at Grassy Creek	Large/Long-Term	0	$1,685,000	5	M3U	1	0%	100%	5070	$332.35	6	$0	20	31	6	7,000	5	5
6	**Alt. 6 -** Old Fort Worth Road at Plains Branch	Large/Long-Term	0	$1,685,000	5	M3U	1	0%	100%	5070	$332.35	6	$0	20	31	6	4,800	6	6
7	**Alt. 7 -** CR 619 at Grassy Creek	Large/Long-Term	0	$1,924,000	5	M3U	1	0%	100%	5070	$379.49	8	$0	20	33	8	10,740		7
8	**Alt. 8 -** FM 661 at Mountain Creek	Large/Long-Term	0	$2,616,000	5	P4D	2	15%	85%	6630	$394.57	9	$0	20	34	9	39,320	8	8
9	**Alt. 9 -** Seeton Road at Taaffe Creek	Small/Long-Term	0	$433,000	3	C2U	25	70%	30%	819	$528.69	11	$0	20	34	9	2,090	9	9
10	**Alt. 10 -** CR 502 at West Soap Creek	Large/Long-Term	0	$2,017,000	5	M3U	1	0%	100%	5070	$397.83	10	$0	20	35	11	7,500		10
11	**Alt. 11 -** Kimble Road at Newton Branch	Medium/Long-Term	0	$1,449,000	4	C2U	2	15%	85%	2320.5	$624.43	12	$0	20	36	12	6,600		11

1 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 1
2 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 2
3 Based on approximation, using logarithmic chart, with 1-Year Event coverage protecting 0% of traffic volume and 100-Year Event coverage protecting 100% of traffic volume
4 Percent Impacted = 100% minus % of Roadway Citizens Protected (approximate)
5 Number Impacted = % Impacted multiplied by [No. Lanes * 4 Hours Impacted * Hourly Volume Per Lane * Level of Service "C" Traffic Volume]
6 Cost of CIP divided by Roadway # Citizens Impacted
7 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 3
8 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 4
9 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 5
10 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 6

Additional Notes:

a. Phased projects shall be ranked in order of Phasing (i.e. Phase 1 shall be ranked higher than Phase 2, etc.)

b. In Step 5, when comparing projects between two different watersheds: If two projects have same rank in Step 4 and need to be sorted, but have similar 100-Year Ultimate Discharges, then projects should be ranked in order of lowest cost estimate

I. Introduction

I. INTRODUCTION

A. ACKNOWLEDGMENTS

Halff Associates would like to acknowledge the significant contributions of all City of Grand Prairie staff in preparation of the City-Wide Drainage Master Plan. In particular, the following individuals have provided invaluable input and assistance:

Romin Khavari – City Engineer
Joe Sherwin and Gabriel Johnson – Floodplain Administrators
Chris Agnew – Storm Drainage Engineer

B. PURPOSE OF STUDY

This study is in compliance with the requirements set forth in the "City-wide Drainage Master Plan Road Map." The purpose of the Joe Pool Lake Drainage Master Plan is to provide comprehensive, updated technical data for the management of the Joe Pool Lake watershed tributaries and storm water infrastructure. This report addresses existing flooding, erosion, and sedimentation problems within the watershed and provides planning alternatives and design concepts to help alleviate potential flood damages. The information presented in this report will provide the City of Grand Prairie with the necessary updated drainage information to coordinate future development according to the City's drainage requirements (see Section I.C) and help minimize existing and potential flood damages within the Joe Pool Lake watershed.

This report compiles existing and newly developed data for the Joe Pool Lake watershed into one document. This report also provides a summary of the procedures used in the technical analyses, a summary of results, illustrative exhibits, and supporting technical data.

Specific objectives of the City-wide Drainage Master Plan for Joe Pool Lake for the City of Grand Prairie, Texas include:

1. Compile pertinent existing engineering data and newly developed information into a comprehensive report to include: an up-to-date, existing conditions and fully urbanized watershed (hereafter known as ultimate

conditions) and to delineate the existing 100-yr, existing 500-yr and ultimate 100-yr floodplains for the Joe Pool Lake Studied Tributaries.

2. Prepare detailed descriptions of alternative improvement solutions (structural and non-structural) to help reduce or eliminate flooding problems for streams and open channels within the study watershed.

3. Perform a Channel Stability Assessment/Erosion Hazard Analysis to analyze factors influencing stream stability and formulate alternatives to help stabilize stream banks.

4. Evaluation of existing and future roadway crossings utilizing the City Master Thoroughfare Plan.

5. Perform a Storm Water Infrastructure Analysis to identify potential urban flooding locations by converting record plans to StormCAD V8i.
6. Locate and provide detailed description of dams/levees/detention, include table of existing drainage plan reviews, and include associated plans, photos, and descriptions of potential problems associated with these features.

7. Utilize the City's Storm Drain Outfall Assessment to provide detailed descriptions of locations where maintenance needs to occur.

8. Evaluate and Prioritize proposed alternative improvement projects and describe the methodology utilized to phase and implement the proposed alternative improvement projects.

9. Determine Short Term and Long Term Plan to prioritize proposed alternative improvement projects including benefit-cost analysis ratios.

C. CITY ORDINANCES AND DEVELOPMENT REQUIREMENTS

As part of this City-wide Drainage Master Plan study, the City Drainage Design Manual and existing development requirements were reviewed to determine their adequacy to prevent future flooding issues. The Joe Pool Lake watershed is substantially undeveloped at this time and proper drainage requirements and responsible development of the watershed will help prevent future flood damage and unnecessary capital improvement costs.

The City of Grand Prairie is especially progressive in their storm water management program. The City's Drainage Design Manual was updated as recently as October of 2010 and is intended to "…protect the general health, safety, and welfare of the

public by reducing flooding potential, controlling excessive runoff, minimizing erosion and siltation problems, and eliminating damage to public facilities resulting from uncontrolled storm water runoff."

Articles 14 and 15 of the Unified Development Code, included in the City's Drainage Design Manual, contain the City ordinances for Drainage and Floodplain Management, respectively. Requirements include the elevation of new construction a minimum of one foot above the ultimate 100-year floodplain or two feet above the existing conditions floodplain, whichever is higher. Construction of detention basins is required when downstream facilities are not adequately sized to convey a design storm based on current City criteria for hydraulic capacity. Post project peak flows are not allowed to exceed the existing conditions peak flows unless sufficient downstream capacity above existing discharge conditions is available. When required, detention facilities are to be designed such that peak discharges or velocities are not increased when compared to pre-project conditions for the 2-, 10- and 100-year floods.

The City ordinances allow for responsible development of the watershed such that flood risks to future structures can be minimized. The ordinances also allow for protection of existing structures so that future development will not increase the flooding hazard in areas that do not have the capacity to convey increased flood discharges. Upon review of the City's Drainage Design Manual and existing development requirements, it has been determined that the requirements in combination with the technical data provided in this report are adequate to properly manage the watershed going forward.

D. WATERSHED DESCRIPTION

Joe Pool Lake is the major water feature in the Joe Pool Lake watershed. The lake impounds water in two arms primarily fed by Mountain Creek and Walnut Creek. Joe Pool Lake Dam is located at river mile 11.2 on Mountain Creek, which is a tributary of the West Fork of the Trinity River. The Mountain Creek headwaters begin in the northern part of Johnson County near the City of Alvarado. The total Mountain Creek watershed is 304 sq. mi.; 232 sq. mi. drain into Joe Pool Lake and the other 74 sq. mi. flow into Mountain Creek downstream of the Joe Pool Lake dam. Of these 232 sq. mi., approximately 105 sq. mi. drain through the City of Grand Prairie. This report focuses on the 105 sq. mi. of drainage area that is affecting the City’s streams. The Joe Pool Lake watershed comprises parts of Dallas,

Ellis, Johnson, and Tarrant counties. Multiple cities are located within the Joe Pool Lake watershed including the City of Arlington, Mansfield, Grand Prairie, Dallas, Cedar Hill, and Midlothian. Development within the Joe Pool Lake watershed has increased over the past decade but the watershed is still approximately 75% undeveloped. The Overall Watershed Map found in the Figures section of this report shows the Joe Pool Lake watershed and the studied tributaries with their locations in regards to the City of Grand Prairie and adjacent communities.

1. Major Streams and Tributaries

The Joe Pool Lake watershed contains approximately 55 linear miles of major streams and tributaries. Table I-1 lists these streams along with their date of study, FEMA designation, and length.

Table I-1 - Joe Pool Lake Studied Tributaries

Stream Name	Date of Hydrologic Study	Date of Hydraulic Study	Proposed FEMA Designation	Length (ft)*
Bedford Branch	2006	2006	Zone A	15,370
Bowman Branch	1986	2002	Zone AE	3,910
Davis Branch	2010	2010	Zone A	6,280
East Soap Creek Tributary	2002	2010	Zone AE	6,110
Edge Creek	2006	2006	Zone A	10,910
Edge Creek Tributary	2006	2006	Zone A	5,925
Foster Branch	2010	2010	Zone A	3,160
Foster Branch Tributary	2010	2010	Zone A	1,260
Gifco Tributary 1	2006	2006	Zone A	2,875
Gifco Tributary 2	2006	2006	Zone A	6,282
Gifco Tributary 3	2006	2006	Zone A	1,873
Grassy Creek	2010	2010	Zone AE	31,850
Grassy Creek Tributary	2010	2010	Zone A	4,480
Hanger Creek	2010	2010	Zone A	2,340
Hight Branch	2003	2005	Zone AE	7,200
Hollings Branch	2001/2003	2005	Zone AE	13,400
Loyd Branch	2010	2010	Zone A	5,640
Lynn Creek	1985	2011	Zone AE	6,580
Lynn Creek Tributary	2010	2010	Zone A	1,020
Mills Branch	2006	2006	Zone A	3,970
Mountain Creek	2010	2010	Zone AE	24,380
Newton Branch	2002	2010	Zone AE	8,670
North Hanger Creek	2010	2010	Zone A	2,930
Penwell Branch	2006	2006	Zone A	6,320
Plains Branch	2002	2010	Zone AE	9,870
Small Branch	2006	2006	Zone A	7,870
Soap Creek	2002	2010	Zone AE	39,840
Stuart Branch	2006	2006	Zone A	4,740
Swadley Creek	2006	2006	Zone A	6,810
Taaffe Creek	2006	2006	Zone A	6,940
Tarrell Creek	2006	2006	Zone A	5,000
Ten Branch	2010	2010	Zone A	5,800
Unidentified Tributary	2010	2010	Zone A	3,800
Webb Branch	2010	2010	Zone A	3,940
West Soap Creek Tributary	2002	2010	Zone AE	15,240

* Note: These lengths were taken from centerline data in GIS and are based on stream lengths within the city limits of Grand Prairie.

2. Unique Attributes of Watershed

The most unique attribute of the Joe Pool Lake watershed is Joe Pool Lake. Joe Pool Lake is a 7,500 acre impoundment located in the southern part of the Dallas-Fort Worth Metroplex in Dallas, Tarrant, and Ellis Counties. Most of the lake is located between State Highway 360 and FM 1382, about one mile south of Interstate Highway 20. Joe Pool Lake is a multi-purpose lake for flood control, water supply, recreation, and fish and wildlife. There are 64 miles of shoreline along the normal conservation pool elevation of 522 feet (mean sea level or msl). The maximum lake depth is approximately 75 feet. Four developed parks are located along the lake, including Britton Park, Cedar Hill Park, Loyd Park, and Lynn Creek Park. Additional parks are planned for Estes Park, Low Branch Park, and Pleasant Valley Park. All parks were established as outgrants to City or State Agencies.

The most prominent topographical feature within the Joe Pool Lake watershed is the White Rock Escarpment located one-half mile from the Joe Pool Lake Dam's right abutment. Some of the streams on the east side of Joe Pool Lake watershed have steep reaches from the elevation drop caused by the White Rock Escarpment. The majority of streams in the watershed fall within flat undeveloped land. Many of the creeks are dry and are experiencing significant geomorphologic changes as the streams erode and evolve during the cyclical wet and dry periods, characteristic of the region.

E. PRINCIPAL FLOODING PROBLEMS

The City of Grand Prairie's floodplain management has helped prevent flooding problems for much of the new development within the Joe Pool Lake watershed. Storm drain systems designed according to the standards detailed in the City's Drainage Criteria Manual have minimized drainage complaints to only a few localized areas. Some flooding issues exist in the rural areas of the watershed; specifically, many of the roads are undersized and will be overtopped by nearly any significant rainfall event.

1. Drainage Complaint Database

Halff Associates, Inc. obtained the latest information from the City of Grand Prairie's Drainage Complaint Database and evaluated all current drainage

complaints up to February 2010. Twenty seven (27) drainage complaints at twenty three (23) different locations have been filed with the City of Grand Prairie within the Joe Pool Lake watershed. Of these complaints, six (6) were erosion problems, six (6) were street ponding problems, fifteen (15) were lot-to-lot property flooding problems (primarily water standing in the yard due to grading issues), and none were structure flooding problems. There were no complaints coinciding with potential flooding locations identified during the Storm Water Infrastructure review (Refer to Section VIII of this report).

2. Hot Spot Locations

No hot spot locations, based on drainage complaints, were identified for watersheds within the Joe Pool Lake study area. The new watershed studies revealed only a few dispersed locations of flood damage and no new hot spot locations were found.

F. PERTINENT STUDY AND TECHNICAL DATA RELATED TO WATERSHED PRIOR TO JOE POOL LAKE DRAINAGE MASTER PLAN PREPARATION

1. Existing Data

i. *2002 CTP Study of Soap Creek and Tributaries*

Halff Associates worked in conjunction with the City of Grand Prairie in 2002 to develop hydrologic and hydraulic models for Soap Creek and 4 of its tributaries as part of a Cooperating Technical Partnership with the Federal Emergency Management Agency (FEMA). The City was responsible for the hydrologic modeling. Halff performed the hydraulic modeling. The hydraulic modeling was updated again in 2010. Pertinent data related to this study has been included in this report.

ii. *2002 Bowman Branch LOMR 03-06-1010P*

Bowman Branch was partially restudied as part of the FEMA Letter of Map Revision (LOMR) 03-06-1010P which became effective on July 22, 2003. The LOMR was prepared to incorporate the placement of fill in the 100-year floodplain which resulted in a revised delineation of the floodway and increased/decreased Base Flood Elevations (BFEs) in the vicinity of Webb Ferrell Road in the City of Arlington. Current

Effective hydrology data from the 1986 USACE Flood Insurance Study for the City of Arlington was utilized.

iii. *2005 Hollings and Hight Branch Watershed Study*

The 2003 Watershed Study for Hollings Branch and Hight Branch included a detailed ultimate landuse conditions hydrologic study performed by the City of Grand Prairie and Halff Associates and a detailed hydraulic study performed by Halff Associates. In 2005, Halff Associates was contracted by the City of Grand Prairie to perform an update to the floodplain for Hollings Branch for the FEMA Map Modernization Program. The final current effective model utilizes hydrologic data for Hollings Branch from the 2001 LOMR 01-06-806P prepared by Turner, Collie & Braden, Inc. for existing conditions and hydrologic data from the 2003 Watershed Study for the ultimate conditions. Pertinent data related to the Hollings and Hight Branch watershed has been included in this report.

iv. *2006 Hydrology and Hydraulics Summary Joe Pool Lake Drainage Master Plan*

Halff Associates was contracted in 2006 to develop hydrologic and hydraulic models for 13 tributaries as part of the Joe Pool Lake Drainage Master Plan (W.O. #540.26). The study included channel stability analysis and stream bank stability alternatives. Pertinent data related to this study has been included in this report.

2. Ongoing/Future Studies

i. *Taaffe Creek Master Drainage Plan*

Halff Associates was contracted in June 2010 by the City of Mansfield to prepare an update to the Taaffe Creek Master Drainage Plan. As part of this update, Halff will incorporate updated hydrologic and routing data to develop existing and ultimate discharges for the upper Taaffe Creek watershed in the City of Mansfield. **Upon completion of this study, the updated discharges will need to be incorporated into the Taaffe Creek hydraulic model and updates will need to be included as an addendum to this report.**

ii. *Hollings Branch Letter of Map Revision (LOMR)*

AquaTerra has submitted a LOMR to the City of Grand Prairie to incorporate revisions to the model and mapping for the Gleneagles Drive crossing at Hollings Branch.

iii. *Lynn Creek Letter of Map Revision (LOMR)*

Teague, Nall and Perkins, Inc. is preparing a LOMR for Lynn Creek that will include updated geometry and cross section data within the City of Grand Prairie. It is anticipated that the hydrology data prepared by the USACE in 1985 as part of the City of Arlington Flood Insurance Study will be utilized.

iv. *2010 CWDMP for Joe Pool Lake*

As part of the CWDMP for Joe Pool Lake, Halff Associates was contracted to develop new and/or updated hydrologic and hydraulic models. Major Streams included Grassy Creek and Mountain Creek. Minor streams included Loyd Branch, Ten Branch, Davis Branch, N. Hanger Creek, Hanger Creek, Webb Branch, and Foster Branch. The study also included updates to the 2002 Soap Creek watershed hydraulic models. Refer to Sections II. – IV of this report for more information.

II. Hydrologic Studies

II. HYDROLOGIC STUDIES

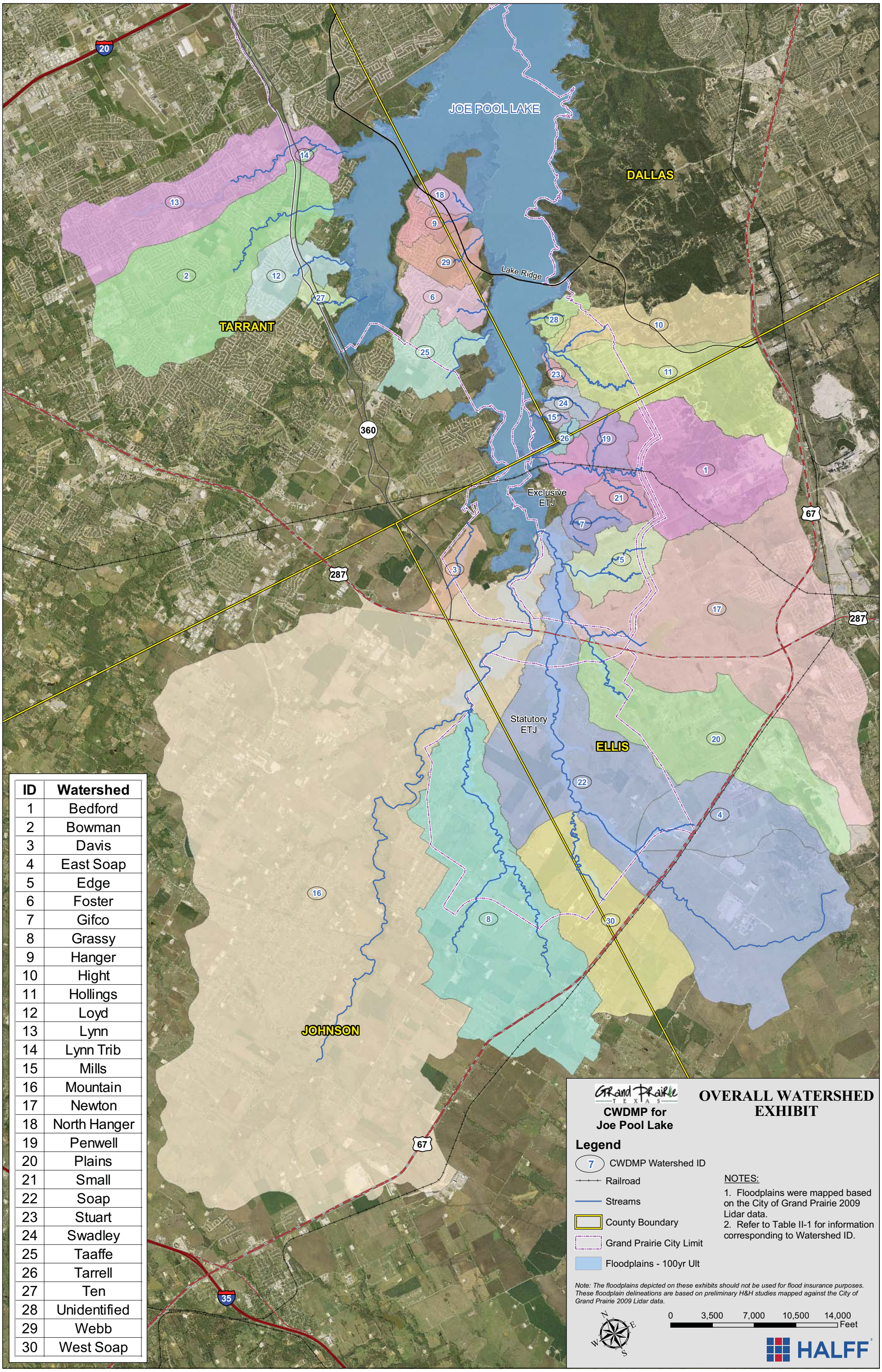
A. GENERAL

Hydrologic analyses have been conducted for every major watershed in the Joe Pool Lake watershed. The City of Grand Prairie developed hydrologic models in 2002 for the Soap Creek watershed using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) HEC-1 Hydrologic Modeling System. Turner, Collier & Braden, Inc. developed the current effective hydrologic models for the Hollings and Hight Branch watershed in 2001. Halff Associates, in conjunction with the City of Grand Prairie, studied the ultimate land use conditions hydrology for the Hollings and Hight Branch watershed in 2003. The current effective existing conditions hydrology data for Hollings and Hight Branch is from the 2001 study and the ultimate conditions is from the 2003 study. The Lynn Creek and Bowman Branch current effective hydrology models were developed by the USACE in 1985 and 1986, respectively. Halff Associates conducted hydrologic analyses for all other study watersheds included within the CWDMP for Joe Pool Lake in 2 phases. The first phase completed in 2006 utilized USACE Hydrologic Modeling System (HEC-HMS, Version 2.2.2) and the second phase completed at the time of this report (2010) utilized HEC-HMS Version 3.4. Refer to Table II-1 for a list of the Joe Pool Lake hydrologic models, the date of study, and other hydrologic data.

The Joe Pool Lake watershed HEC-HMS models, with the exception of Lynn Creek and Bowman Branch, include the following hydrologic scenarios:

1. Existing Land Use Conditions
2. Ultimate Land Use Conditions

Significant rainfall events considered for the hydrologic models were the 10-, 50-, 100- and 500-year frequency floods. Detailed watershed delineations, existing and ultimate land use determinations, and the hydrologic soil coverage were used to develop HEC-HMS hydrologic computer models for the respective tributaries' watershed. The City of Grand Prairie's current Drainage Design Manual (November 2009) along with Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55) Second Edition were used as guidelines for the new 2010 hydrologic analyses. The appropriate City Drainage Design Manual was used for each watershed study referenced in this report, based on the date of the respective study.



ID	Watershed
1	Bedford
2	Bowman
3	Davis
4	East Soap
5	Edge
6	Foster
7	Gifco
8	Grassy
9	Hanger
10	Hight
11	Hollings
12	Loyd
13	Lynn
14	Lynn Trib
15	Mills
16	Mountain
17	Newton
18	North Hanger
19	Penwell
20	Plains
21	Small
22	Soap
23	Stuart
24	Swadley
25	Taaffe
26	Tarrell
27	Ten
28	Unidentified
29	Webb
30	West Soap

Figure II-1 Watersheds

Table II-1 - Joe Pool Lake Hydrologic Studies

ID	Watershed	Study Date	Loss Method	Synthetic Hydrograph	Frequency Storm Events		Software	Detention
					Existing	Ultimate		
1	Bedford Branch	2006	SCS CN	SCS	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	No
2	Bowman Branch[2]	1986	----	----	10-, 50-, 100-, 500-year	----	HEC-1	Yes
3	Davis Branch	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	No
4	East Soap Creek Tributary	2002	SCS CN	Snyder	2-, 5-, 10-, 25-, 50-, 100-, 500-year	100-year	HEC-HMS v2.1.3	No
5	Edge Creek	2006	SCS CN	SCS	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	Yes
6	Foster Branch	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	Yes
7	Gifco Creek	2006	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v2.2.2	Yes
8	Grassy Creek	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	Yes
9	Hanger Creek	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	Yes
10	Hight Branch[1]	2003	SCS CN	Snyder	2-, 10-, 25-, 50-, 100-, 500-year	2-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	No
11	Hollings Branch[1]	2001/2003	SCS CN	Snyder	10-, 50-, 100-, 500-year	2-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	Yes
12	Loyd Branch	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	No
13	Lynn Creek[2]	1985	----	----	10-, 50-, 100-, 500-year	----	HEC-1	Yes
14	Lynn Creek Tributary	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	No
15	Mills Branch	2006	SCS CN	SCS	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	No
16	Mountain Creek	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	No

Table II-1 - Joe Pool Lake Hydrologic Studies (continued)

ID	Watershed	Study Date	Loss Method	Synthetic Hydrograph	Frequency Storm Events		Software	Detention
					Existing	Ultimate		
17	Newton Branch	2002	SCS CN	Snyder	2-, 5-, 10-, 25-, 50-, 100-, 500-year	100-year	HEC-HMS v2.1.3	Yes
18	North Hanger Creek	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	Yes
19	Penwell Branch	2006	SCS CN	SCS	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	No
20	Plains Branch	2002	SCS CN	Snyder	2-, 5-, 10-, 25-, 50-, 100-, 500-year	100-year	HEC-HMS v2.1.3	Yes
21	Small Branch	2006	SCS CN	SCS	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	No
22	Soap Creek	2002	SCS CN	Snyder	2-, 5-, 10-, 25-, 50-, 100-, 500-year	100-year	HEC-HMS v2.1.3	No
23	Stuart Branch	2006	SCS CN	SCS	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	No
24	Swadley Creek	2006	SCS CN	SCS	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	No
25	Taaffe Creek	2006	SCS CN	SCS	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	Yes
26	Tarrell Creek	2006	SCS CN	SCS	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-HMS v2.2.2	No
27	Ten Branch	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	No
28	Unidentified Tributary	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	Yes
29	Webb Branch	2010	SCS CN	SCS	10-, 50-, 100-, 500-year	100-year	HEC-HMS v3.4	Yes
30	West Soap Creek Tributary	2002	SCS CN	Snyder	2-, 5-, 10-, 25-, 50-, 100-, 500-year	100-year	HEC-HMS v2.1.3	No

[1] Hollings and Hight Branch current effective 2001 existing conditions model is HEC-1. 2003 MapMOD model is HEC-HMS.
[2] Watershed delineation used in current effective model was not available.

B. WATERSHEDS

The Joe Pool Lake watershed has been subdivided into thirty (30) watersheds as part of the CWDMP for Joe Pool Lake report. A general description of each watershed and the streams contained within each watershed can be found below. Drainage areas listed include all upstream area draining to the creeks including their tributaries.

1. Bedford Branch

Bedford Branch is a tributary to Joe Pool Lake and is located in southeastern Grand Prairie in Ellis County. Bedford Branch originates just west of Highway 67 in Midlothian, and generally flows west before entering Joe Pool Lake. The total contributing watershed draining to Bedford Branch is about 5.48 square miles or approximately 3,510 acres.

Bedford Branch is approximately 2.91 miles in length through the study area with an average slope of 0.2%. The lower 6,200 linear feet of Bedford Branch is within the current 100-year floodplain of Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Bedford Branch overbanks consist of open range land with brush and trees.

The Bedford Branch watershed was sub-divided into twenty-three (23) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

2. Bowman Branch

Bowman Branch is a tributary to Joe Pool Lake and is located in southeastern Grand Prairie in Tarrant County. Bowman Branch originates just west of Matlock Road in Arlington, and generally flows east before entering Joe Pool Lake. The total contributing watershed draining to Bowman Branch is about 5.89 square miles or approximately 3,770 acres.

Bowman Branch is approximately 0.45 miles in length through the City of Grand Prairie with an average slope of 0.2%. The stream is generally a natural earthen channel with some vegetation. The Bowman Branch overbanks consist primarily of trees and vegetation with some open space.

The Bowman Branch watershed was studied by the USACE sometime in 1986. The hydrology model and hydrologic parameter data were not available at the time of this study and have not been included in this report.

3. Davis Branch

Davis Branch is a tributary to Joe Pool Lake and is located in southwestern Grand Prairie in Ellis and Johnson counties. Davis Branch originates just north of U.S. Highway 287 in Mansfield, and generally flows northeast to the confluence with Harmon Branch. The total contributing watershed draining to Davis Branch is about 0.60 square miles or approximately 385 acres. The stream is generally a natural earthen channel with some vegetation and the overbanks consist primarily of open range land.

Bedford Branch is approximately 1.19 miles in length through the study area with an average slope of 0.8%.

The Davis Branch watershed was sub-divided into three (3) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

4. East Soap Creek Tributary

East Soap Creek Tributary is approximately 1.16 miles in length through the study area with an average slope of 0.5%. It is located in southeastern Grand Prairie within the Statutory ETJ in Ellis County. East Soap Creek Tributary originates just north of U.S. Highway 67 in Midlothian, and generally flows west to the confluence with Soap Creek. The total contributing watershed draining to East Soap Creek Tributary is about 2.40 square miles or approximately 1,535 acres. The stream is generally a natural earthen channel with some vegetation. The overbanks consist of open range, brush, and trees with various industrial structures in the upper reach.

The East Soap Creek Tributary watershed was sub-divided into six (6) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

5. Edge Creek

There are two studied streams within the Edge Creek watershed; Edge Creek and Edge Creek Tributary. Edge Creek is a tributary to Soap Creek and is located in southeastern Grand Prairie in Ellis County. Edge Creek originates north of Highway 287 near Midlothian, and generally flows west before joining Soap Creek.

The total contributing watershed draining to Edge Creek is about 1.28 square miles or approximately 820 acres. Most of the watershed drains through a large pond before reaching Soap Creek.

Edge Creek is approximately 1.93 miles in length through the study area with an average slope of 1.0%. The lower 1,690 linear feet of Edge Creek is within the current 100-year floodplain of Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Edge Creek overbanks consist of open range land with brush and trees.

Edge Creek Tributary is approximately 0.96 miles in length with an average slope of 0.80%. This branch is located north of Edge Creek and flows west to the confluence with Edge Creek. The total contributing watershed draining to Edge Creek Tributary is about 0.67 square miles or approximately 430 acres. The Edge Creek Tributary overbanks also consist of open range land with brush and trees.

The Edge Creek watershed was sub-divided into eight (8) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

6. Foster Branch

There are two studied streams within the Foster Creek watershed; Foster Branch and Foster Branch Tributary. Foster Branch is a tributary to Joe Pool Lake and is located in southwestern Grand Prairie in Tarrant and Dallas counties. Foster Branch originates south of Grand Peninsula Blvd. in Grand Prairie, and generally flows southeast before entering Joe Pool Lake. The total contributing watershed draining to Foster Branch is about 0.94 square miles or approximately 600 acres. Most of the watershed drains through a series of detention ponds before entering Joe Pool Lake.

Foster Branch is approximately 0.60 miles in length through the study area with an average slope of 1.6%. The Foster Branch existing 100-year floodplain is primarily backwater from Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Foster Branch overbanks consist of open range land with brush and trees.

Foster Branch Tributary is approximately 0.24 miles in length through the study area with an average slope of 1.9%. The Foster Branch existing 100-year floodplain is primarily backwater from Joe Pool Lake. The stream is generally a natural earthen

channel with some vegetation. The Foster Branch overbanks consist of brush and trees. The total contributing watershed draining to Foster Branch Tributary is about

The Foster Branch watershed was sub-divided into eleven (11) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

7. Gifco Creek

Gifco Tributaries are three tributaries to Joe Pool Lake and are located in southeastern Grand Prairie in Ellis County. The tributaries originate west of Gifco Road and generally flow west before entering a pond that outfalls to Joe Pool Lake. The total contributing watershed draining to Gifco Creek is about 0.54 square miles or approximately 346 acres.

Gifco Tributary 1 is approximately 0.54 miles in length through the study area with an average slope of 1.30%. Gifco Tributary 2 is approximately 1.19 miles in length through the study area with an average slope of 1.33%. Gifco Tributary 3 is approximately 0.35 miles in length through the study area with an average slope of 1.66%. The streams are generally natural earthen channels with some vegetation. The overbanks consist of open range land with brush and trees.

The Gifco Tributaries' watershed was sub-divided into four (4) sub-basins (one sub-basin for each tributary and one sub-basin for the downstream receiving pond). Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

8. Grassy Creek

There are two studied streams within the Grassy Creek watershed; Grassy Creek and Grassy Creek Tributary. Grassy Creek is a tributary to Mountain Creek and is located in southwestern Grand Prairie within the Statutory ETJ in Johnson County. Grassy Creek originates north of U.S. Highway 67 near Venus, Texas, and generally flows north to the confluence with Mountain Creek. The total contributing watershed draining to Grassy Creek is about 8.94 square miles or approximately 5,720 acres.

Grassy Creek is approximately 6.03 miles in length through the study area with an average slope of 0.2%. The stream is generally a natural earthen channel with some

vegetation. The Grassy Creek overbanks consist of open range land with brush and trees.

Grassy Creek Tributary is approximately 0.98 miles in length through the study area with an average slope of 0.4%. Grassy Creek Tributary originates just north of County Road 506 and generally flows east to the confluence with Grassy Creek. The total contributing watershed draining to Grassy Creek Tributary is about 1.99 square miles or approximately 1,275 acres. The stream is generally a natural earthen channel with some vegetation. The Grassy Creek Tributary overbanks consist of open range land with brush and trees.

The Grassy Creek watershed was sub-divided into eighteen (18) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

9. Hanger Creek

Hanger Creek is a tributary to Joe Pool Lake and is located in southern Grand Prairie in Tarrant and Dallas counties. Hanger Creek originates south of Hanger Lowe Road in Grand Prairie, and generally flows east before entering Joe Pool Lake. The total contributing watershed draining to Hanger Creek is about 0.49 square miles or approximately 310 acres. Most of the watershed drains through a series of detention ponds before entering Joe Pool Lake. The upper watershed area is fully developed with high density residential and educational structures.

Hanger Creek is approximately 0.60 miles in length through the study area with an average slope of 1.0%. The Hanger Creek existing 100-year floodplain is primarily backwater from Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Hanger Creek overbanks consist of open range land with brush and trees.

The Hanger Creek watershed was sub-divided into four (4) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

10. Hight Branch

Hight Branch is a tributary to Hollings Branch and is located in southeastern Grand Prairie in Dallas County. Hight Branch originates east of Lakeridge Parkway in Cedar Hill, and generally flows west through the Tangle Ridge Golf Course until the

confluence with Hollings Branch approximately 1,500 feet upstream of Joe Pool Lake. The total contributing watershed draining to Hollings Branch is about 2.02 square miles or approximately 1,290 acres. The majority of the contributing watershed lies to the east of Grand Prairie's City limits in the City of Cedar Hill.

Hight Branch is approximately 1.43 miles in length through the City of Grand Prairie with an average slope of 0.6%.

In 2003, Halff Associates, Inc. performed an ultimate land use conditions Watershed Study of Hight Branch for the City of Grand Prairie that will become the basis of the MapMOD models. Results of the 2003 watershed study can be found in Section IV of this report.

11. Hollings Branch

Hollings Branch is a tributary to Joe Pool Lake and is located in southeastern Grand Prairie in Dallas County. Hollings Branch originates in Cedar Hill just west of U.S. Highway 67 in the southernmost portion of Dallas County. The total contributing watershed draining to Hollings Branch is about 4.18 square miles or approximately 2,680 acres. The majority of the contributing watershed lies to the east of Grand Prairie's City limits in the City of Cedar Hill.

Hollings Branch is approximately 2.55 miles in length through the City of Grand Prairie with an average slope of 0.4%.

The current effective Hollings Branch watershed model was prepared by Turner, Collier & Braden, Inc. in October 2001 as part of LOMR 01-06-806P. In 2003, Halff Associates along with the City of Grand Prairie performed a Watershed Study for the ultimate land use conditions for Hollings Branch. However, the model being incorporated into the Dallas and Ellis County MapMOD utilizes the flows from the 2001 LOMR while the fully developed conditions model included with this report uses flows from the 2003 Watershed Study. The hydrology model and hydrologic parameter data were not available for the 2001 LOMR and have not been included in this report. Results of the 2003 watershed study can be found in Section IV of this report.

12. Loyd Branch

Loyd Branch is a tributary to Joe Pool Lake and is located in southwestern Grand Prairie in Tarrant County. Loyd Branch originates west of State Highway 360 in

Arlington, and generally flows east before entering Joe Pool Lake. The total contributing watershed draining to Loyd Branch is about 1.18 square miles or approximately 760 acres. The upper watershed area is primarily high density residential and educational structures.

Loyd Branch is approximately 0.44 miles in length through the study area with an average slope of 0.8%. The lower 2,500 linear feet of Loyd Branch is within the existing 100-year floodplain of Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Loyd Branch overbanks consist of open range land with brush and trees.

The Loyd Branch watershed was sub-divided into four (4) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

13. Lynn Creek

Lynn Creek is located in southwestern Grand Prairie in Tarrant County. Lynn Creek originates just east of State Highway 157 in the City of Arlington, and generally flows east to the confluence with Joe Pool Lake. The upper watershed is almost fully developed with residential properties. The stream is generally a natural earthen channel with some vegetation. The total contributing watershed draining to Lynn Creek is about 5.43 square miles or approximately 3475 acres.

Lynn Creek is approximately 0.90 miles in length through the City of Grand Prairie with an average slope of 0.5%. The stream is generally a natural earthen channel with some vegetation.

The Lynn Creek watershed was studied by the USACE sometime in 1985. The hydrology model and hydrologic parameter data were not available at the time of this study and have not been included in this report.

14. Lynn Creek Tributary

Lynn Creek Tributary is approximately 0.19 miles through the study area with an average slope of 3%. It is located in southwestern Grand Prairie in Tarrant County. Lynn Creek Tributary originates just east of State Highway 360 in Grand Prairie, and generally flows east to the confluence with Lynn Creek. The total contributing watershed draining to Lynn Creek Tributary is about 0.04 square miles or approximately 25 acres. The stream is generally a natural earthen channel with

some vegetation. The overbanks consist primarily of open range with some shrub and brush.

The Lynn Creek Tributary watershed was sub-divided into three (3) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

15. Mills Branch

Mills Branch is a tributary to Joe Pool Lake and is located in southeastern Grand Prairie, in Dallas and Tarrant counties. Mills Branch originates east of the county line and generally flows west before entering Joe Pool Lake. The total contributing watershed draining to Mills Branch is about 0.11 square miles or approximately 70 acres.

Mills Branch is approximately 0.75 miles in length through the study area with an average slope of 1.40%. The stream is generally a natural earthen channel with some vegetation. The Mills Branch overbanks consist of open range land with brush and trees.

The Mills Branch watershed was sub-divided into three (3) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

16. Mountain Creek

Mountain Creek is a tributary to Joe Pool Lake and is located in southern Grand Prairie in Johnson and Ellis counties. Mountain Creek originates just north of U.S. Highway 67 near Alvarado, and generally flows northeast before entering Joe Pool Lake. The total contributing watershed draining through the Mountain Creek study area is about 40.64 square miles or approximately 26,000 acres.

Mountain Creek is approximately 4.62 miles in length through the study area with an average slope of 0.1%. The lower 2,200 linear feet of Mountain Creek is within the existing 100-year floodplain of Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Mountain Creek overbanks consist of open range, brush, and trees with sporadic low density residential and industrial structures.

The Mountain Creek watershed was sub-divided into seven (7) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

17. Newton Branch

Newton Branch is approximately 1.64 miles through the study area with an average slope of 0.3%. It is located in southern Grand Prairie in Ellis County. Newton Branch originates just north of U.S. Highway 287 in Midlothian, and generally flows northwest to the confluence with Soap Creek. The total contributing watershed draining to Newton Branch is about 10.24 square miles or approximately 6,560 acres. Most of the watershed drains through the Padera Lake Dam before entering Soap Creek. The stream is generally a natural earthen channel with some vegetation. The overbanks consist of open range, brush, and trees with industrial structures at the confluence of Plains Branch.

The Newton Branch watershed was sub-divided into eleven (11) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

18. North Hanger Creek

North Hanger Creek is a tributary to Joe Pool Lake and is located in southern Grand Prairie in Tarrant and Dallas counties. North Hanger Creek originates just east of Lake Ridge Parkway in Grand Prairie, and generally flows south before entering Joe Pool Lake. The total contributing watershed draining to North Hanger Creek is about 0.39 square miles or approximately 250 acres. A portion of the upper watershed drains through a detention pond before entering North Hanger Creek.

North Hanger Creek is approximately 0.56 miles in length through the study area with an average slope of 0.8%. The North Hanger Creek existing 100-year floodplain is primarily backwater from Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The North Hanger Creek overbanks consist primarily of brush and trees.

The North Hanger Creek watershed was sub-divided into six (6) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

19. Penwell Branch

Penwell Branch is located in southeast Grand Prairie in Ellis County. Penwell Branch is north of Bedford Branch and flows southwest to the confluence with Bedford Branch, approximately 300 feet downstream of the Southern Pacific Railroad. Penwell Branch is approximately 1.20 miles in length with an average slope of 1.04%. The total contributing watershed draining to Penwell Branch is about 0.62 square miles or approximately 400 acres. Penwell Branch is generally natural earthen channels with some vegetation and the overbanks consist of open range land with brush and trees, similar to Bedford Branch.

The Penwell Branch watershed was sub-divided into five (5) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

20. Plains Branch

Plains Branch is approximately 1.87 miles in length through the study area with an average slope of 0.3%. It is located in southern Grand Prairie primarily within the Statutory ETJ in Ellis County. Plains Branch originates just south of U.S. Highway 67 in Midlothian, and generally flows northwest to the confluence with Newton Branch. The total contributing watershed draining to Plains Branch is about 4.87 square miles or approximately 3,120 acres. Most of the watershed drains through the Soil Conservation Service Site 9 Reservoir before entering Newton Branch. The stream is generally a natural earthen channel with some vegetation. The overbanks consist of open range, brush, and trees with some low density residential structures.

The Plains Branch watershed was sub-divided into six (6) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

21. Small Branch

Small Branch is located in southeast Grand Prairie in Ellis County. Small Branch is south of Bedford Branch and flows northwest to the confluence with Bedford Branch. Small Branch is approximately 1.49 miles in length with an average slope of 1.30%. The total contributing watershed draining to Small Branch is about 0.48 square miles or approximately 310 acres. Small Branch is generally natural earthen channels with some vegetation and the overbanks consist of open range land with brush and trees, similar to Bedford Branch.

The Small Branch watershed was sub-divided into four (4) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

22. Soap Creek

Soap Creek is a tributary to Mountain Creek and is located in southern Grand Prairie primarily within the Statutory ETJ in Ellis County. Soap Creek originates just north of U.S. Highway 67 near Midlothian, and generally flows north before entering Mountain Creek. The total contributing watershed draining to Soap Creek is about 34.44 square miles or approximately 22,050 acres. Soap Creek is approximately 7.55 miles in length through the study area with an average slope of 0.2%. The stream is generally a natural earthen channel with some vegetation. The Soap Creek overbanks consist of open range, brush, and trees.

The Soap Creek watershed was sub-divided into twenty one (21) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

23. Stuart Branch

Stuart Branch is a tributary to Joe Pool Lake and is located in southeastern Grand Prairie, in Dallas County. Stuart Branch originates south of the Texas Plume Road and generally flows north before entering Joe Pool Lake. The total contributing watershed draining to Stuart Branch is about 0.14 square miles or approximately 90 acres.

Stuart Branch is approximately 0.90 miles in length through the study area with an average slope of 1.36%. The stream is generally a natural earthen channel with some vegetation. The Stuart Branch overbanks consist of open range land with brush and trees.

The Stuart Branch watershed was sub-divided into two (2) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

24. Swadley Creek

Swadley Branch is a tributary to Joe Pool Lake and is located in southeastern Grand Prairie, in Dallas County. Swadley Branch originates just north of the Dallas/Ellis

county line and generally flows northwest/west before entering Joe Pool Lake. The total contributing watershed draining to Swadley Creek is about 0.32 square miles or approximately 200 acres.

Swadley Branch is approximately 1.27 miles in length through the study area with an average slope of 0.96%. The stream is generally a natural earthen channel with some vegetation. The Swadley Branch overbanks consist of open range land with brush and trees.

The Swadley Branch watershed was sub-divided into four (4) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

25. ***Taaffe Creek***

Taaffe Creek is a tributary to Joe Pool Lake and is located in south Grand Prairie, in Tarrant County. Taaffe Creek originates downstream of Day Miar Road and generally flows east before entering Joe Pool Lake. The total contributing watershed draining to Taaffe Creek is about 1.30 square miles or approximately 835 acres. Approximately 0.46 square miles or 295 acres of the Taaffe Creek watershed drains to a large detention pond located on the left overbank, approximately 2,930 feet upstream of Joe Pool Lake.

Taaffe Creek is approximately 1.31 miles in length through the study area with an average slope of 0.53%. The upstream portion of Taaffe Creek was rerouted around the Mira Lagos development. This grass-lined channel is trapezoidal in shape. The upstream overbanks consist of residential structures and some open range land. The downstream portion of the stream is a natural earthen channel with some vegetation. The downstream overbanks consist of open range land with brush and trees and some residential structures.

The Taaffe Creek watershed was sub-divided into four (4) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

26. ***Tarrell Creek***

Tarrell Creek is a tributary to Joe Pool Lake and is located in southeastern Grand Prairie, in Dallas and Ellis counties. Tarrell Creek originates in Dallas County and generally flows southwest before entering Joe Pool Lake in Ellis County. The total

contributing watershed draining to Tarrell Creek is about 0.15 square miles or approximately 100 acres.

Tarrell Creek is approximately 0.96 miles in length through the study area with an average slope of 1.50%. The stream is generally a natural earthen channel with some vegetation. The Tarrell Creek overbanks consist of open range land with brush and trees.

The Tarrell Branch watershed was sub-divided into three (3) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

27. Ten Branch

Ten Branch is a tributary to Joe Pool Lake and is located in southwestern Grand Prairie in Tarrant County. Ten Branch originates west of State Highway 360 in Arlington, and generally flows east before entering Joe Pool Lake. The total contributing watershed draining to Ten Branch is about 0.32 square miles or approximately 210 acres. The upper watershed area drains through a pond that has been reduced in size recently by a large amount of fill before entering Joe Pool Lake.

Ten Branch is 1.10 miles in length through the study area with an average slope of 0.8%. The lower 2,350 linear feet of Ten Branch is within the existing 100-year floodplain of Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Ten Branch overbanks consist of open range land with brush and trees.

The Ten Branch watershed was sub-divided into three (3) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

28. Unidentified Tributary

Unidentified Tributary is a tributary to Joe Pool Lake and is located in southeastern Grand Prairie in Dallas County. Unidentified Tributary originates west of Fossil Ridge Drive in Grand Prairie, and generally flows west before entering Joe Pool Lake. The total contributing watershed draining to the Unidentified Tributary is about 0.137 square miles or approximately 90 acres. The majority of the watershed drains through a series of detention ponds before entering Joe Pool Lake.

There are two additional streams included in the Unidentified Tributary watershed that flow directly into Joe Pool Lake but were considered too minor to study. These streams were almost entirely within the existing 100-year floodplain of Joe Pool Lake.

Unidentified Tributary is 0.72 miles in length through the study area with an average slope of 2.0%. The lower 1,600 linear feet of Unidentified Tributary is within the existing 100-year floodplain of Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Unidentified Tributary overbanks consist of open range land with brush and trees.

The Unidentified Tributary watershed was sub-divided into eight (8) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

29. Webb Branch

Webb Branch is a tributary to Joe Pool Lake and is located in southern Grand Prairie in Dallas and Tarrant counties. Webb Branch originates west of Lake Ridge Parkway in Grand Prairie, and generally flows east before entering Joe Pool Lake. The total contributing watershed draining to Webb Branch is about 0.87 square miles or approximately 560 acres. The majority of the watershed drains through a series of detention ponds before entering Joe Pool Lake.

Webb Branch is 0.75 miles in length through the study area with an average slope of 0.7%. The Webb Branch existing 100-year floodplain is primarily backwater from Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Webb Branch overbanks consist of open range land with brush and trees.

The Webb Branch watershed was sub-divided into eight (8) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

30. West Soap Creek Tributary

West Soap Creek Tributary is approximately 2.89 miles in length through the study area with an average slope of 0.2%. It is located in southern Grand Prairie within the Statutory ETJ in Ellis and Johnson counties. West Soap Creek Tributary

originates just north of U.S. Highway 67 outside of Midlothian, and generally flows north to the confluence with Soap Creek. The total contributing watershed draining to West Soap Creek Tributary is about 4.29 square miles or approximately 2,750 acres. The stream is generally a natural earthen channel with some vegetation. The overbanks consist of open range with brush and trees.

The West Soap Creek Tributary watershed was sub-divided into three (3) sub-basins. Watershed characteristics such as drainage area, land use, soil type, and lag time can be found under Hydrologic Study Results in Section IV of this report.

C. LAND USE

Land usage for the Joe Pool Lake watershed has been determined for both existing and ultimate conditions.

1. Existing Land Use

Existing land use conditions were based on the date of each study. Refer to Table II-1 for the date of each study.

The Joe Pool Lake watershed existing land use consists almost entirely of open pasture or range land with small low density residential areas scattered throughout. Many natural gas well pad sites are scattered throughout the Joe Pool Lake watershed and were designated as industrial land use for the new 2010 studies. The upper Bedford Branch and part of upper Soap Creek watersheds contain a large rock quarry. The Foster, Hanger, Loyd, Taaffe, and Webb watersheds include areas of relatively new, high density residential development. A portion of the Ten Branch Watershed includes a large pond that shows signs of being filled in recent years. The Existing Conditions Land Use Map found in the Figures section of this report illustrates the existing conditions land use for all of the Joe Pool Lake watersheds with the exception of Soap Creek, East Soap Creek Tributary, West Soap Creek Tributary, Newton Branch, Plains Branch, Hollings Branch, Hight Branch, Bowman Branch, and Lynn Creek; land use data was not available for these watersheds.

2. Ultimate Land Use

Ultimate land use conditions were based on various sources depending on the date each watershed was studied. Portions of the Joe Pool Lake watershed extend into the Cities of Cedar Hill, Midlothian, Mansfield, and Arlington as well as unincorporated Johnson and Ellis counties. Available ultimate land use data was acquired for each of these respective communities.

The majority of the Mountain Creek Watershed and portions of the Grassy Creek Watershed included portions of unincorporated Johnson County where future planning data was not available. For these areas, the ultimate land use was determined by the following procedure: maintain the existing land use for areas already developed as industrial and roadway; assign the 100-year floodplain as open space; include future master thoroughfare Loop 9 with a 500 foot commercial buffer applied to each side of the roadway; and attribute the remaining land use area as unknown. Unknown land use areas were assigned an impervious percentage of 75 based on the recommendations of the City of Grand Prairie. The Ultimate Conditions Land Use Map included in the Figures section of this report illustrates the anticipated ultimate conditions land use for all of the Joe Pool Lake watersheds with the exception of Soap Creek, East Soap Creek Tributary, West Soap Creek Tributary, Newton Branch, Plains Branch, Bowman Branch, and Lynn Creek; land use data was not available for these watersheds.

D. IMPERVIOUS COVERAGE

Percent impervious is a function of the various land uses within a watershed basin. The specific land uses and their corresponding percent impervious values varied depending on the date each watershed was modeled. Impervious values were not available for the Bowman Branch and Lynn Creek. For stream watersheds studied in 2003, 2006, and 2010 a composite percentage of impervious area was computed for each sub-basin for both existing and ultimate conditions. The percent impervious values input into the HEC-HMS model represent the corresponding amount of existing or anticipated development. For stream watersheds studied in 2002, the percent imperviousness of the sub-basins was included in the Curve Number (CN) values. Tables II-2, II-3, and II-4 provide the specific land use

ID	Watershed
1	Bedford
2	Bowman
3	Davis
4	East Soap
5	Edge
6	Foster
7	Gifco
8	Grassy
9	Hanger
10	Hight
11	Hollings
12	Loyd
13	Lynn
14	Lynn Trib
15	Mills
16	Mountain
17	Newton
18	North Hanger
19	Penwell
20	Plains
21	Small
22	Soap
23	Stuart
24	Swadley
25	Taaffe
26	Tarrell
27	Ten
28	Unidentified
29	Webb
30	West Soap

JOE POOL LAKE

DALLAS

TARRANT

ELLIS

JOHNSON

Lake Ridge

20 360 287 67 35

Grand Prairie TEXAS

CWDMP for Joe Pool Lake

EXISTING LANDUSE EXHIBIT

Legend

- Railroad
- Streams
- County Boundary
- Grand Prairie City Limit
- Joe Pool Watersheds
- Floodplains - 100yr Ult
- 7 CWDMP Watershed ID

Existing Landuse

- Commercial
- Dedicated Parks
- Government/Education
- High Density Residential
- Industrial
- Low Density Residential
- Multi-family Residential
- Open Space
- Roadway
- Single Family Residential
- Under Construction
- Utilities
- Water-2006
- Water-2010

NOTES:

1. Floodplains were mapped based on the City of Grand Prairie 2009 Lidar data.

2. Refer to Table II-1 for information corresponding to Watershed ID.

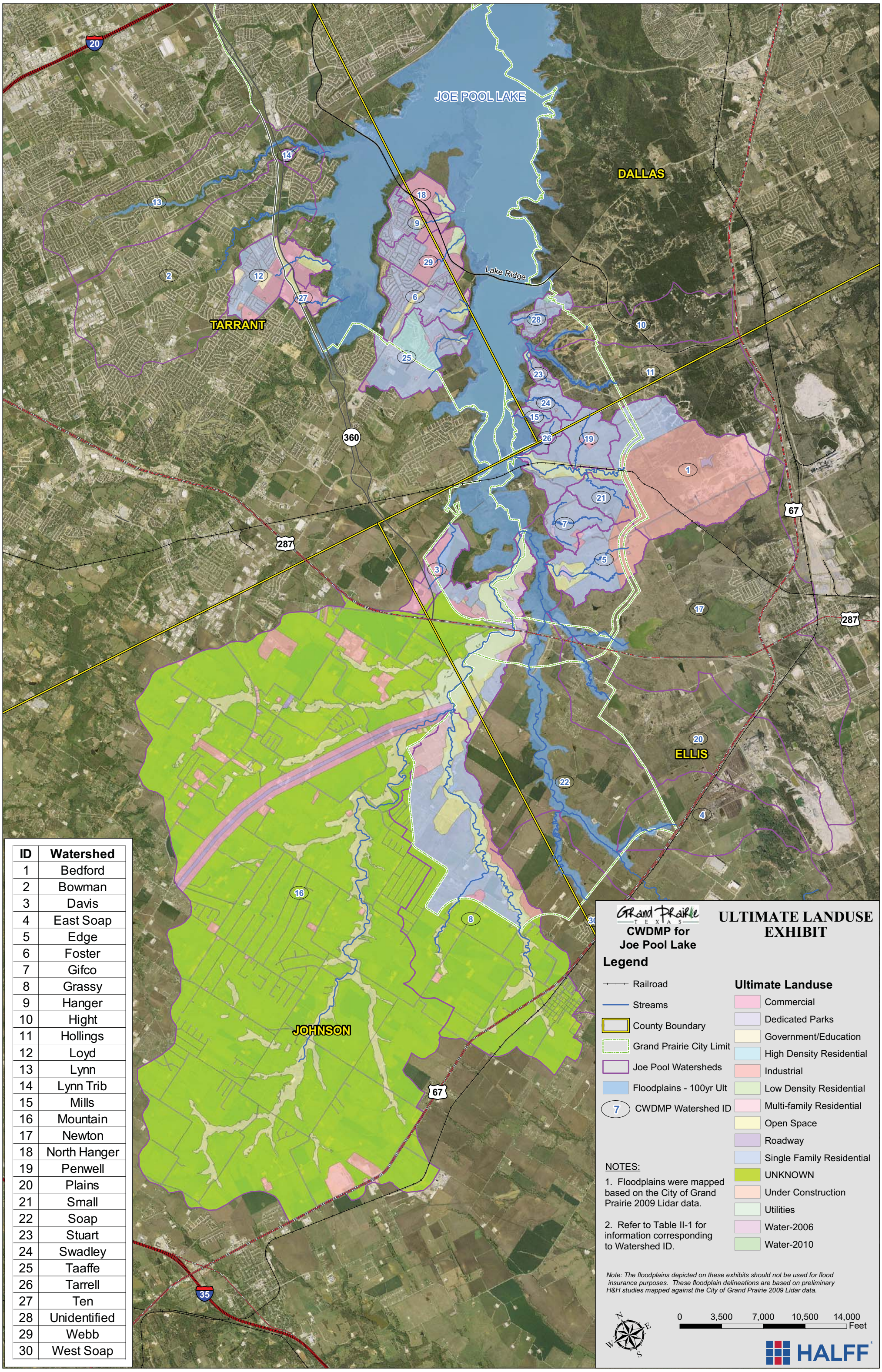
Note: The floodplains depicted on these exhibits should not be used for flood insurance purposes. These floodplain delineations are based on preliminary H&H studies mapped against the City of Grand Prairie 2009 Lidar data.

N E S W

0 3,500 7,000 10,500 14,000 Feet

HALFF

Figure II-2 Existing Landuse



ID	Watershed
1	Bedford
2	Bowman
3	Davis
4	East Soap
5	Edge
6	Foster
7	Gifco
8	Grassy
9	Hanger
10	Hight
11	Hollings
12	Loyd
13	Lynn
14	Lynn Trib
15	Mills
16	Mountain
17	Newton
18	North Hanger
19	Penwell
20	Plains
21	Small
22	Soap
23	Stuart
24	Swadley
25	Taaffe
26	Tarrell
27	Ten
28	Unidentified
29	Webb
30	West Soap

Figure II-3 Ultimate Landuse

classifications and the corresponding percent impervious values that were used for each study. Refer to Section II.C.2 for an explanation of unknown impervious percentage value.

Table II-2 – Imperviousness for Land Uses (2002 Study)

Land Use Classification	Characteristic Imperviousness
Undeveloped, Agricultural	2%
Parks, Permanent Open Space, Playgrounds	15%
Single Family Residential (less than 3 lots per acre)	20%
Single Family Residential	35%
Multi-Family Residential, Schools	75%
Commercial/Industrial/Manufacturing	85%
Central Business District (CBD), Strip Centers	95%
For Watersheds: East Soap, Newton, Plains, Soap, West Soap	
Ref: Unknown	

Table II-3 – Imperviousness for Land Uses (2003 Study)

Land Use Classification	Characteristic Imperviousness
Undeveloped, Agricultural	2%
Parks and Golf Course	5%
Single Family Residential – Low Density	45%
Schools, Churches	30%
Commercial/Industrial/Manufacturing	85%
Pavement	100%
For Watersheds: Holling, Hight	
Ref: Unknown	

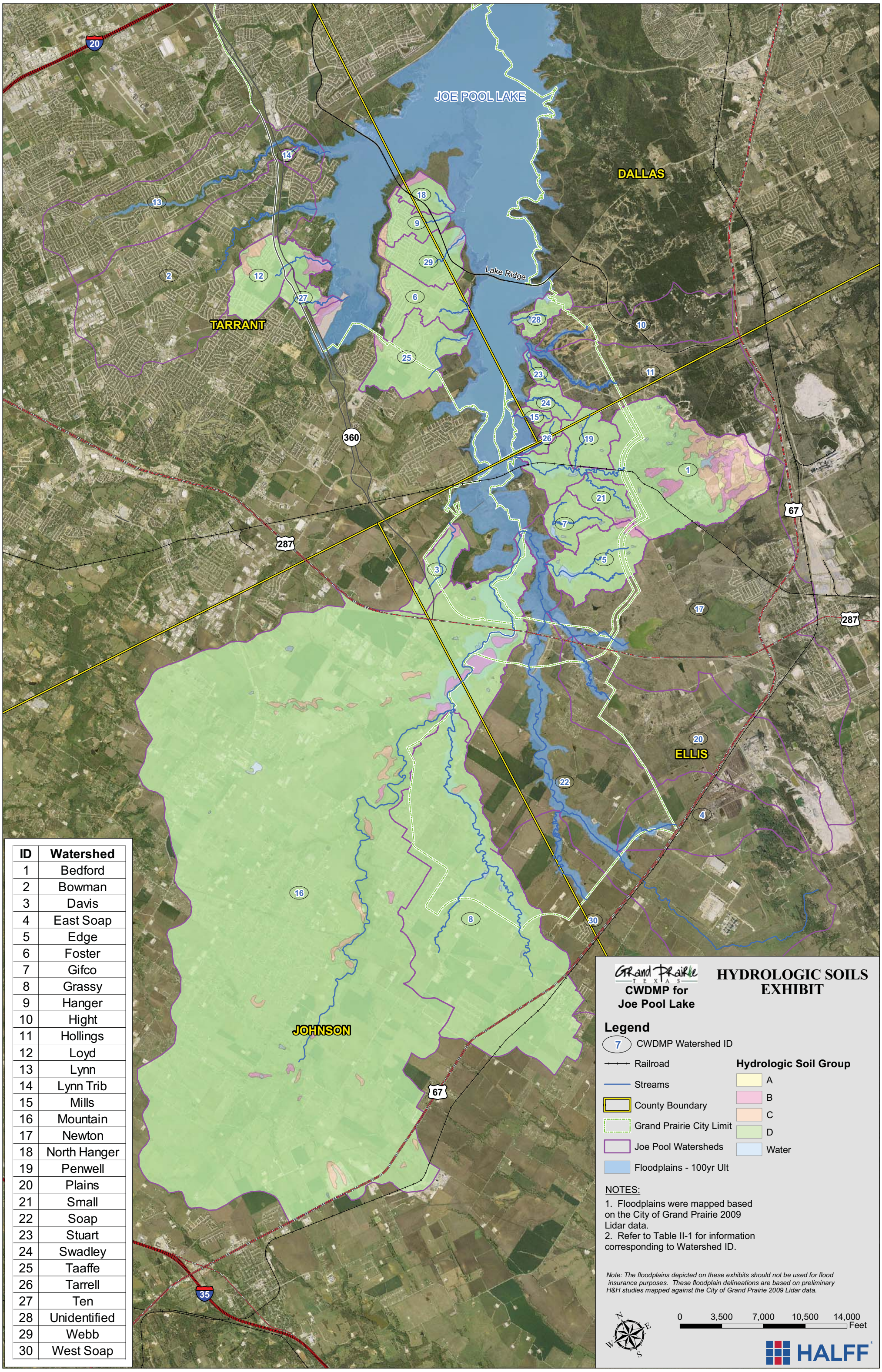
Table II-4 - Imperviousness for Land Uses (2006 & 2010 Studies)

Land Use Classification	Characteristic Imperviousness
Open Space/Dedicated Parks	0%
Commercial	85%
Industrial	72%
Government/Education	72%
High-Density Residential	65%
Low Density Residential	20%
Multi-Family Residential	65%
Single Family Residential	50%
Roadway	98%
Under Construction	15%
Utilities	40%
Unknown	75%
Water-2006	98%
Water-2010	100%
For Watersheds: Davis, Foster, Grassy, Hanger, Loyd, Lynn Tributary, Mountain, North Hanger, Ten, Unidentified, Webb, Bedford, Edge, Gifco, Mills, Penwell, Small, Stuart, Swadley, Taffee, Tarrell	
Ref: City of Grand Prairie Drainage Design Manual (November 2009) Table 4.1a, Table 4.1c	

E. SOIL TYPES

The Natural Resource Conservation Service (NRCS) Soil Survey of Dallas County, Soil Survey of Ellis County, Soil Survey of Johnson County, and Soil Survey of Tarrant County, dated February 1980, were used to evaluate the hydrologic soils in the Joe Pool Lake watershed. Most of the watershed is almost entirely Group D soils which are defined as clayey with slow infiltration rates and a high potential for runoff. Group A soils are defined as having high infiltration rates and low runoff potential. Group B soils indicate soils having some content of gravelly sand with moderate infiltration rates and a low/moderate runoff potential. Group C soils indicate soils having moderately fine to fine texture and slow infiltration rates. The hydrologic soils for all of the Joe Pool Lake watersheds are illustrated in the Soils Map found in the Figures section of this report.

The antecedent moisture condition (AMC) defines the soil moisture condition prior to a storm. AMC-II, average soil moisture conditions, was used for the 2002, 2003, 2006, and 2010 watershed studies.



ID	Watershed
1	Bedford
2	Bowman
3	Davis
4	East Soap
5	Edge
6	Foster
7	Gifco
8	Grassy
9	Hanger
10	Hight
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13	Lynn
14	Lynn Trib
15	Mills
16	Mountain
17	Newton
18	North Hanger
19	Penwell
20	Plains
21	Small
22	Soap
23	Stuart
24	Swadley
25	Taaffe
26	Tarrell
27	Ten
28	Unidentified
29	Webb
30	West Soap

Figure II-4 Soils

F. LOSS RATES

The loss rate of rainfall, caused by evaporation, interception, depression, storage, and infiltration, is typically evaluated and subtracted from the rainfall to determine rainfall excess for each time increment of a storm. For each of the hydrology studies included in this report, the SCS Curve Number Method, developed by the Natural Resources Conservation Service (NRCS), was used to compute peak flood discharges based on land use, soil classification, and antecedent moisture conditions.

For the 2003, 2006, and 2010 studies, Halff Associates computed SCS Curve Numbers that were representative of each of the following watersheds: Bedford Branch, Edge Creek, Gifco Tributaries, Mills Branch, Penwell Branch, Small Branch, Stuart Branch, Swadley Creek, Taffee Creek, Tarrell Creek, Davis Branch, Foster Branch, Grassy Creek, Hanger Creek, Hollings Branch, Hight Branch, Loyd Branch, Lynn Creek Tributary, Mountain Creek, North Hanger Creek, Ten Branch, Unidentified Tributary, and Webb Branch. Baseline Curve Numbers were obtained from TR-55, Table 2.2c, for pasture, grassland, or range for AMC-II, average soil moisture conditions (See Appendix B). Curve Numbers were computed based on a composite percentage of soil types within each sub-basin. Group A soils were defined as having CN as 39, Group B soils were defined as having CN as 61, Group C soils were defined as having CN as 74, and Group D soils were defined as having CN as 80. Percent impervious values calculated based on land use were used in addition to Curve Numbers for hydrologic computations (Refer to Section II.D).

For the 2002 Soap Creek watershed study, the City of Grand Prairie computed SCS Curve Numbers for the East Soap Creek Tributary, Newton Branch, Plains Branch, Soap Creek, and West Soap Creek Tributary watersheds. The percent impervious of the sub-basins for each watershed was included in the computed Curve Number values to create a composite CN.

The initial abstraction (I.A.) for all watersheds was computed for AMC-II, average soil conditions using the following equation from TR-55:

$$IA = 0.2\left(\frac{1000}{CN} - 10\right)$$

A summary of Curve Numbers, percent impervious values and initial abstractions is included in Table IV-1 and IV-2, Hydrologic Parameters for the Joe Pool Lake watersheds.

G. SYNTHETIC UNIT HYDROGRAPH METHODS

The unit hydrograph technique is used to transform rainfall excess to sub-basin runoff. The hydrologic models included in this report used one of two different Synthetic Unit Hydrograph Methods:

1. SCS Dimensionless Unit Hydrograph

The SCS Dimensionless Unit Hydrograph was used for the 2006 and 2010 studied watersheds: Bedford Branch, Edge Creek, Gifco Tributaries, Mills Branch, Penwell Branch, Small Branch, Stuart Branch, Swadley Creek, Taaffe Creek, Tarrell Creek, Davis Branch, Foster Branch, Grassy Creek, Hanger Creek, Loyd Branch, Lynn Creek Tributary, Mountain Creek, North Hanger Creek, Ten Branch, Unidentified Tributary, and Webb Branch watersheds. A single parameter, lag time (t_P), is used to determine the shape of the dimensionless unit hydrograph.

Computed lag times for the SCS Dimensionless Unit Hydrograph used the following equation:

$$t_P = 0.6\, time\, of\ concentration$$

Time of concentration was computed separately for existing and ultimate conditions. Both were based on TR-55 methodology for overland flow (sheet flow and shallow concentrated flow) and with Manning's equation to compute travel times through the underground storm sewer system. Overland flow length was limited based on existing and ultimate land use conditions. Overland flow was limited to 100 feet for undeveloped and residential land use and 50 feet for industrial/commercial land use. Ultimate conditions shallow concentrated flow was assumed to be all paved.

2. Snyder's Unit Hydrograph

The Snyder Unit Hydrograph was used for the 2002 and 2003 studied watersheds: East Soap Creek Tributary, Hollings Branch, Hight Branch, Newton Branch, Plains Branch, Soap Creek, and West Soap Creek Tributary. Two parameters, Snyder's lag time (T_p) and peaking coefficient

(C_p), were used to determine the peak flow, time of peak, and widths of the unit hydrograph at 50 percent and 75 percent of the peak flow.

For the Hollings and Hight Branch Unit Watershed Study, the City of Grand Prairie provided the unit hydrograph parameters for each sub-basin which Halff incorporated into the HEC-HMS model.

Values for C_p, presented in Table II-5, are based on the slope and amount of storm sewers in the sub-basin.

Table II-5 - Snyder's Peaking Coefficient (C_P)

Sub-basin Characteristics	C_P
Sparsely Storm Sewered Area	
Flat Basin Slope (less than 0.5%)	0.55
Moderate Basin Slope (0.5% to 0.8%)	0.58
Steep Basin Slope (greater than 0.8%)	0.61
Moderately Storm Sewered Area	
Flat Basin Slope (less than 0.5%)	0.63
Moderate Basin Slope (0.5% to 0.8%)	0.66
Steep Basin Slope (greater than 0.8%)	0.69
Highly Storm Sewered Area	
Flat Basin Slope (less than 0.5%)	0.70
Moderate Basin Slope (0.5% to 0.8%)	0.71
Steep Basin Slope (greater than 0.8%)	0.72

The Dallas-Fort Worth urbanization curve method was used to calculate Snyder's lag time (t_P). To determine (t_P) using the Dallas-Fort Worth urbanization curve method, first determine the percent urbanization of the sub-basin (use 100 percent for fully developed) and a sub-basin parameter, *N*; where:

$$N = L\frac{L_{ca}}{S_{st}^{0.5}}$$

where:

N = Sub-basin parameter;
L = Stream distance from the downstream point of design to the upper limit of the sub-basin, mi.;

L_{ca} = Stream distance from the downstream point of design to the centroid of the sub-basin, mi.;

$S_{st} = \frac{E_{85} - E_{10}}{L}$ = Weighted slope of the flow path from the elevation, E_{10}, at *0.10L* to elevation, EL_{85} , at *0.85L*, ft/mi.

T_p values for clay and sandy soils as a function of *N* and percent urbanization are calculated as follows:

$$T_p = 10^{0.3833 \times \log_{10}(N) + I_p - \frac{BW \times \%URB}{100}}$$

where:

I_p = -0.02687 for clay soils and 0.24304 for sandy soils, these are the calibration points defined as the log of T_p where $\log_{10}(L \times \frac{L_{ca}}{S_{ss}} \times 0.5) = 1$ and *URB* = 0%, hrs;

BW = 0.30103 for clay soils and 0.26991 for sandy soils, these are the log of the width between each 20 percent urbanization line; and

%*URB* = Percent urbanization within the sub-basin.

If the sub-basin has both clay and sandy soils, an area-weighted value of T_p should be used. Separate calculations were made for the existing and ultimate values of T_p and C_P for the watershed studies that utilized Snyder's Unit Hydrograph method. A summary of the calculated T_p and C_P parameters for each sub-basin can be found in Table IV-1.

H. RAINFALL

The standard 24-hr duration storm event, for watersheds larger than 500 acres (0.78 sm), was utilized to establish rainfall parameters. The 2002, 2003, 2006, and 2010 watershed studies all used the same rainfall depths as the current Drainage Design Manual (November 2009), Table 5.4B and are listed in Table II-6.

Table II-6 - Rainfall Depth / Duration for the Joe Pool Lake Study Area

Return Period	Point Rainfall Depths (inches) for Joe Pool Lake Study Area							
(years)	5-min	15-min	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr
2 yr	0.49	1.04	1.85	2.22	2.45	2.91	3.45	3.95
5 yr	0.57	1.22	2.45	3.00	3.30	3.90	4.70	5.40
10 yr	0.63	1.36	2.86	3.55	3.85	4.65	5.50	6.40
25 yr	0.73	1.56	3.35	4.15	4.55	5.45	6.50	7.50
50 yr	0.80	1.71	3.82	4.65	5.15	6.20	7.35	8.52
100 yr	0.87	1.87	4.25	5.20	5.70	6.92	8.40	9.55
500 yr	1.00	2.20	5.40	6.60	7.40	8.80	10.50	12.00

Ref: City of Grand Prairie Storm Design Manual (November 2009) Table 5.4B

I. FLOOD ROUTING

The Modified Puls routing method was utilized for 2002, 2003, 2006, and 2010 watershed studies. The routing was used to establish storage-outflow relationships from steady-flow water surface profiles using the HEC-RAS hydraulic analyses. Storage-outflow relationships were determined for existing channel and floodplain conditions.

J. DETENTION & DIVERSIONS

Twenty-one (21) detention ponds were identified from City plans in the Joe Pool Lake watershed. These ponds were within the city limits and were designed specifically for detention with appropriate outlet structures and emergency overflow. These twenty-one detention ponds were evaluated as part of this report and the results of that evaluation are included in Section X.

In addition to these 21 detention ponds, other ponds were discovered that were either outside the city limits or appeared to serve a purpose other than detention. These ponds were still included in the hydrology models either through elevation-area-discharge tables or through the routing data. Refer to Table II-1 for a list of the watersheds where some type of detention pond was found in the watershed. The outlet structure rating curves and storage volumes were typically taken from City design plans if the data was available.

The peninsula streams (Foster Branch, Hanger Creek, North Hanger Creek, and Webb Branch) included a number of detention ponds. Some of these ponds were in series and included tailwater controlled designs. These detention ponds were modeled outside of HEC-HMS using HEC-RAS unsteady flow. The resulting hydrographs from the unsteady flow model were referenced in the HEC-HMS hydrology models to determine the peak discharge downstream.

There were no diversions identified or modeled in the Joe Pool Lake watershed.

III. Hydraulic Studies

III. HYDRAULIC STUDIES

A. HYDRAULIC ANALYSES

This report compiles hydraulic data and models from four separate studies into one comprehensive document for the entire Joe Pool Lake watershed, with the exception of Lynn Creek which will have to be added to the report later as an attachment (refer to Section I.D). Freese and Nichols, Inc. submitted the LOMR model which is now the current effective model for Bowman Branch. Halff Associates, Inc. prepared the rest of the detailed hydraulic studies in the Joe Pool watershed and methodology was relatively consistent for each of these. The following sections describe some of the unique aspects of each study such as the software and topographic data that was utilized.

1. 2002 Bowman Branch LOMR 03-06-1010P

Freese and Nichols, Inc. prepared the 2002 LOMR for Bowman Branch to incorporate the impact of fill placed in the 100-year floodplain which resulted in a revised delineation of the floodway and reduction in the 100-year floodplain. The affect from the fill impacted Bowman Branch from just upstream of Webb Ferrell Road to approximately 1,625 feet downstream of Webb Ferrell Road in the City of Arlington. The original hydraulic model was created by the USACE using the HEC2 computer program as part of the City of Arlington Flood Insurance Study in 1985. As part of this report, the HEC2 model was converted to HEC-RAS v4.0. The model remains outdated as it appears that a road is included (Ragland Extension) in the model that no longer exists. The model was never updated to include State Highway 360.

2. 2005 Hollings and Hight Branch Watershed Study

Halff Associates prepared a detailed HEC-RAS hydraulic computer model for the reaches of Hollings and Hight Branch within the Grand Prairie City limits. The HEC-RAS model was developed using the existing conditions (2001) hydrology data prepared by Turner, Collier and Braden, Inc. and the ultimate conditions hydrology data prepared as part of the Hollings and Hight Watershed Study (2003). Manning's "n" values of 0.065 for channels and 0.080 for overbanks were used for the heavily vegetated areas.

Manning's "n" values of 0.065 for channels and 0.030 for overbanks were used for the well maintained portions of the Tangle Ridge Golf Course. A Manning's "n" value of 0.016 was also used for a concrete pilot channel that runs through the eastern potion of the golf course. One (1) bridge and three (3) culverts along the golf course were incorporated into the HEC-RAS model for the Hight Branch reach. Hydraulic modeling of these bridges and culverts were in accordance with field surveys conducted by Halff Associates. Field surveys conducted by Halff revealed that crossings over Hollings Branch at both Texas Plume Road and Boss Cope Road were nonexistent; therefore, not reflected in the HEC-RAS model. Future construction at these crossings would necessitate revisions to the hydraulic HEC-RAS model. Normal depth was used for the downstream boundary condition based on the slope of the downstream reach.

3. 2006 Joe Pool Lake Drainage Master Plan

Halff Associates prepared detailed HEC-RAS hydraulic computer models for 10 streams and tributaries as part of the 2006 Joe Pool Lake Drainage Master Plan. The streams were located predominately along the southeastern portion of Joe Pool Lake in Ellis County. Refer to the Overall Watershed Map in the Figures section of this report to locate the 2006 studies streams. The 2006 studies utilized the 1999 City of Grand Prairie digital topographic maps, aerial digital orthophotography, field surveys, and field observations. Some minor adjustments were made in 2010 to a few of the 2006 hydraulic models where significant discrepancies were found between the models and the 2009 City of Grand Prairie Lidar. Computed profiles for the studies were developed using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS, Version 3.1.3). Existing Conditions models were based on 2006 Land Use Conditions. Hydraulic cross-sections were extracted from the 1999 two-foot contour interval digital 3D topography using the USACE HEC-GeoRas (Version 3.1.1) computer program. HEC-GeoRas utilizes geographic information systems (GIS) technology for extraction. The extracted hydraulic cross-sections were supplemented with field survey data performed by Halff (2005) and record bridge/culvert and channel plans (primarily Taaffe Creek). Normal depth was used for the downstream boundary condition based on the slope of the downstream reach.

4. 2010 City-Wide Drainage Master Plan for Joe Pool Lake

Halff Associates prepared HEC-RAS hydraulic models for 16 streams and tributaries of Joe Pool Lake as part of the City-Wide Drainage Master Plan for Joe Pool Lake. The study included new hydraulic models for five (5) streams within the Soap Creek Watershed which were previously studied in 2002. The Soap Creek streams utilized existing (2002) and ultimate discharges from HEC-HMS hydrology models prepared by the City of Grand Prairie. All other models incorporated existing (2010) and ultimate discharges from HEC-HMS hydrology models prepared as part of the 2010 City-Wide Master Drainage Plan for Joe Pool Lake. Computed flood profiles for all streams were developed using the USACE HEC-RAS version 4.0 computer program. Hydraulic cross-sections were extracted from the 2009 City of Grand Prairie one-foot contour interval Lidar data using the USACE HEC-GeoRAS (Version 4.2.92) computer program. Detailed (Zone AE) studies were supplemented with field surveys conducted by Halff Associates in December 2008 and December 2009. A known water surface elevation was used as the starting boundary condition for most of the 2010 hydraulic models. The known water surface elevation was taken from the peak water surface elevations for the coincident peak flood event downstream. For streams flowing directly into Joe Pool Lake, normal depth was used based on the slope of the downstream reach. The 2002 current effective Soap Creek hydraulic models used normal depth as the downstream boundary condition and that was maintained in the revised hydraulic models during the 2010 re-study.

The locations of hydraulic cross-sections for each Joe Pool Lake hydraulic study are displayed on the Floodplain Workmaps in the Figures section of this report. Channel roughness factors (Manning's "n" values) were assigned on the basis of field inspections of floodplain areas and aerial orthophotos. All elevations are measured from the North American Vertical Datum of 1988 (NAVD 88).

Computed peak discharges from each stream's HEC-HMS model for the existing 10-, 50-, 100-, and 500-year and ultimate 100-year frequency floods were included in the existing conditions and ultimate conditions hydraulic models, respectively. The hydraulic results, including computed water surface elevations and profiles, for each studied stream are also discussed in Section IV.B – Hydraulic Study Results. Table III-1 provides a summary of the hydraulic models included in the watershed.

Table III-1 - Joe Pool Lake Hydraulic Studies

Stream Name	Date of Hydraulic Study	Proposed FEMA Designation	Length (ft)*	Frequency Storm Event		Software
				Existing	Ultimate	
Bedford Branch	2006	Zone A	15,370	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Bowman Branch	2002	Zone AE	3,910	10-, 50-, 100-, 500-year		HEC-2
Davis Branch	2010	Zone A	6,280	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
East Soap Creek Tributary	2010	Zone AE	6,110	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Edge Creek	2006	Zone A	10,910	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Edge Creek Tributary	2006	Zone A	5,925	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Foster Branch	2010	Zone A	3,160	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Foster Branch Tributary	2010	Zone A	1,260	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Gifco Tributary 1	2006	Zone A	2,875	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Gifco Tributary 2	2006	Zone A	6,282	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Gifco Tributary 3	2006	Zone A	1,873	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Grassy Creek	2010	Zone AE	31,850	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Grassy Creek Tributary	2010	Zone A	4,480	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Hanger Creek	2010	Zone A	2,340	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Hight Branch	2005	Zone AE	7,200	10-, 50-, 100-, 500-year	2-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Hollings Branch	2005	Zone AE	13,400	10-, 50-, 100-, 500-year	2-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Loyd Branch	2010	Zone A	5,640	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Lynn Creek	2011	Zone AE	6,580	10-, 50-, 100-, 500-year	----	HEC-RAS v4.0
Lynn Creek Tributary	2010	Zone A	1,020	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Mills Branch	2006	Zone A	3,970	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3

Table III-1 - Joe Pool Lake Hydraulic Studies (continued)

Stream Name	Date of Hydraulic Study	Proposed FEMA Designation	Length (ft)*	Frequency Storm Event		Software
				Existing	Ultimate	
Mountain Creek	2010	Zone AE	24,380	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Newton Branch	2010	Zone AE	8,670	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
North Hanger Creek	2010	Zone A	2,930	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Penwell Branch	2006	Zone A	6,320	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Plains Branch	2010	Zone AE	9,870	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Small Branch	2006	Zone A	7,870	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Soap Creek	2010	Zone AE	39,840	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Stuart Branch	2006	Zone A	4,740	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Swadley Creek	2006	Zone A	6,810	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Taaffe Creek	2006	Zone A	6,940	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Tarrell Creek	2006	Zone A	5,000	2-, 5-, 10-, 25-, 50-, 100-, 500-year	2-, 5-, 10-, 25-, 50-, 100-, 500-year	HEC-RAS v3.1.3
Ten Branch	2010	Zone A	5,800	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Unidentified Tributary	2010	Zone A	3,800	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
Webb Branch	2010	Zone A	3,940	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0
West Soap Creek Tributary	2010	Zone AE	15,240	10-, 50-, 100-, 500-year	100-year	HEC-RAS v4.0

* Note: These lengths were taken from cent*Note: These lengths were taken from centerline data in GIS and are based on stream lengths within the city limits of Grand Prairie.

Floodway models have been developed for all Zone AE detailed study streams (East Soap Creek Tributary, Grassy Creek, Mountain Creek, Newton Branch, Plains Branch, Soap Creek, and West Soap Creek Tributary). The floodway models were optimized with the maximum encroachment that would not cause a rise of 1-foot or greater at any point along the stream.

A CD-ROM containing copies of all hydraulic computer models, GIS shapefiles, and figures used in preparation of this report is included in Appendix I.

IV. Hydrologic and Hydraulic Study Results

IV. HYDROLOGIC AND HYDRAULIC STUDY RESULTS

A. HYDROLOGIC STUDY RESULTS

This section of the City-Wide Drainage Master Plan for Joe Pool Lake report compiles the results of detailed hydrologic computer models for the Joe Pool Lake watersheds. Hydrologic parameter data was not available for Lynn Creek or Bowman Branch.

The Joe Pool Lake watersheds were typically modeled using either the SCS Unit Hydrograph method or Snyder's Unit Hydrograph method. Snyder's Unit Hydrograph method was used for the Soap Creek watershed and the Hollings and Hight Branch watershed modeling. The SCS method was used for all other watersheds. Hydrologic parameter data for all watersheds modeled is included in Appendix B. Detailed time of concentration calculations are included in hardcopy in Appendix B and on the CD-ROM in Appendix I of this report for the 2006 and 2010 studied watersheds.

Detailed HMS hydrologic computer models have been prepared for all of the major watersheds impacting the City of Grand Prairie streams and tributaries in the Joe Pool Lake Watershed. The Lynn Creek and Bowman Branch watersheds have only limited hydrologic data that was available to be incorporated. The Hollings Branch and Hight Branch watersheds had only ultimate conditions hydrologic data from the 2003 Watershed Study available to be included with this report. For all other watersheds, the existing and ultimate land use conditions were analyzed with channel flood routing data based on existing channels and bridges. Peak flood discharges include the 10, 50-, 100-, and 500-year flood frequencies. Tables IV-3 contains available peak flood discharge information for existing and ultimate conditions at key locations along each Joe Pool Lake studied stream.

B. HYDRAULIC STUDY RESULTS

This section of the CWDMP for Joe Pool Lake compiles hydraulic results for the studied streams in the watershed. Lynn Creek has been excluded from this section since it is currently being restudied and will later be included as an attachment to this report. The Bowman Branch current effective hydraulic model was originally developed using the USACE HEC2 software. For this report, the hydraulic model was converted to the HEC-RAS v4.0 software. The results for Bowman Branch

included in this section are from the converted model; though it should be noted that the model is still based on older modeling procedures and the results are not consistent with the current effective FEMA Flood Insurance Study.

The computed peak flood discharges from each Joe Pool Lake studied stream were used in their respective HEC-RAS hydraulic model to compute existing water surface elevations for the 10, 50-, 100-, and 500-year flood frequencies and ultimate water surface elevations for the 100-year flood frequency. Refer to Appendix B for a comparison between existing and ultimate conditions 100-year computed flood elevations for each Joe Pool Lake studied stream. Water surface elevations increased on average by one-half foot between existing and ultimate conditions for the overall Joe Pool Lake watershed. The increase varied significantly across the watershed though with greater increases in watersheds that are mostly undeveloped and less of an increase in watersheds that are nearing fully developed conditions. The stream with the greatest average increase in water surface elevations between existing and ultimate conditions was Soap Creek with a maximum increase of 2.2 feet.

The HEC-RAS hydraulic computer models for each Joe Pool Lake studied stream and the City of Grand Prairie Lidar data (2009) were used to delineate the existing conditions 100-year and 500-year floodplains and the future (ultimate) conditions 100-year floodplain (Refer to the Figures Section of this report). A CD-Rom included in Appendix I contains all of the hydraulic models and mapping shapefiles developed as part of this report. Flood profiles and flood profile output comparisons (existing and ultimate conditions) are included in Appendix B of this report. The existing 10-, 50-, 100, 500-year frequency events and the ultimate 100-year frequency event are shown for all profiles.

C. QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance / quality control for the 2010 hydrologic and hydraulic studies was performed by a third party reviewer (Pacheco Koch) in May/June of 2010. The QC comments and responses are included in Appendix B of this report.

Table IV-1 - Summary of Discharges for the Joe Pool Lake Streams

Location	Area (mi2)	10-Year		50-Year		100-Year		500-Year	
		Existing	Ultimate	Existing	Ultimate	Existing	Ultimate	Existing	Ultimate
Bedford Branch									
Downstream of confluence of Penwell Branch	4.940	3,140	4,660	4,900	6,770	5,740	7,690	7,900	10,130
Upstream of confluence of Penwell Branch	4.317	2,700	4,070	4,150	5,790	4,860	6,520	6,570	8,390
Downstream of confluence of Small Branch	4.284	2,720	4,090	4,160	5,810	4,870	6,550	6,580	8,400
Upstream of confluence of Small Branch	3.806	2,270	3,520	3,490	4,950	4,080	5,550	5,490	7,070
Downstream of Southern Pacific Railroad	3.734	2,250	3,500	3,460	4,880	4,030	5,460	5,400	6,930
Upstream of Southern Pacific Railroad	3.554	2,060	3,230	3,150	4,490	3,680	5,040	5,210	6,820
Approx. 830 feet upstream of Southern Pacific Railroad	3.356	1,970	2,910	3,060	4,330	3,580	4,940	5,080	6,670
Bowman Branch									
At confluence with Joe Pool Lake	5.890	4,800	------	6,950	------	8,050	------	10,150	------
Downstream of Arlington Webb Britton Road	5.190	4,600	------	6,650	------	7,600	------	9,450	------
Davis Branch									
Upstream of Confluence with Harmon Branch	0.610	460	------	760	------	890	1,070	1,210	------
Approx. 3,000 feet downstream of State Highway 360	0.340	310	------	440	------	500	630	650	------
Downstream of State Highway 360	0.179	270	------	390	------	440	570	570	------
East Soap Creek									
Upstream of Confluence with Soap Creek	2.399	2,000	------	3,000	------	3,500	5,700	4,900	------
Upstream of Miller Road	2.210	2,000	------	3,000	------	3,400	6,100	5,000	------
Upstream of Turner Road	2.025	1,800	------	2,700	------	3,200	5,500	4,600	------
Downstream of Weatherford Road	1.802	1,900	------	2,900	------	3,400	5,800	4,700	------
Edge Creek									
Upstream of confluence with Soap Creek	1.284	140	180	200	390	320	630	870	1,310
Downstream of SCS Reservoir #11 Spillway	1.196	140	90	160	380	300	600	830	1,260
Upstream of SCS Reservoir #11 Spillway	0.990	950	1,570	1,670	2,420	2,020	2,780	2,850	3,620
Downstream of confluence with Edge Creek Tributary	0.912	1,010	1,610	1,670	2,430	2,010	2,780	2,770	3,590
Upstream of confluence with Edge Creek Tributary	0.245	190	290	360	560	470	680	720	950
Approx. 4,250 feet upstream of Confluence of Edge Creek Tributary	0.143	240	380	350	510	400	570	530	700
Approx. 6,200 feet upstream of Confluence of Edge Creek Tributary	0.031	50	90	80	110	90	120	120	150
Edge Creek Tributary									
Upstream of confluence with Edge Creek	0.667	890	1,420	1,350	1,950	1,550	2,180	2,060	2,720
Upstream of an Unnamed Street	0.280	430	790	630	1,050	720	1,160	950	1,430
Foster Branch									
Upstream of confluence with Joe Pool Lake	0.260	470	------	670	------	760	820	990	------
Downstream of Mansfield Road	0.137	250	------	350	------	400	440	510	------
Foster Branch Tributary									
Upstream of confluence with Joe Pool Lake	0.676	510	------	750	------	850	890	1,080	------
Downstream of Mansfield Road	0.657	490	------	720	------	810	870	1,020	------
Gifco Tributary 1									
Upstream of XS 323	0.129	240	------	340	------	380	450	490	------
Gifco Tributary 2									
Upstream of XS 471	0.277	360	------	530	------	600	740	790	------
Gifco Tributary 3									
Upstream of XS 122	0.091	180	------	260	------	290	360	370	------
Grassy Creek									
Upstream of confluence with Mountain Creek	8.939	5,370	------	8,530	------	9,910	11,360	13,610	------
Approx. 3,800 feet downstream of confluence of an unnamed tributary of Grassy Creek	8.760	5,380	------	8,540	------	9,920	11,350	13,580	------
Approx. 2,500 feet downstream of confluence of an unnamed tributary of Grassy Creek	8.545	5,360	------	8,510	------	9,890	11,310	13,520	------
Downstream of confluence of an unnamed tributary of Grassy Creek	8.336	5,350	------	8,490	------	9,860	11,270	13,460	------
Upstream of confluence of an unnamed tributary of Grassy Creek	7.402	5,160	------	8,160	------	9,470	10,900	12,830	------
Downstream of County Road 619	6.870	5,220	------	8,180	------	9,470	10,850	12,730	------
Upstream of County Road 619	6.653	5,210	------	8,150	------	9,440	10,800	12,650	------
Downstream of confluence of Grassy Creek Tributary	6.376	5,280	------	8,160	------	9,410	10,720	12,530	------
Upstream of County Road 506	4.383	3,780	------	5,740	------	6,620	7,760	8,820	------
Approx. 3,200 feet downstream of County Road 502	4.015	3,740	------	5,630	------	6,470	7,740	8,570	------
Upstream of County Road 502	3.349	3,400	------	4,990	------	5,710	7,000	7,510	------
Grassy Creek Tributary									
Upstream of confluence with Grassy Creek	1.993	2,000	------	3,020	------	3,530	4,460	4,880	------
Approx. 3,100 feet downstream of FM 157	1.573	1,620	------	2,760	------	3,180	4,080	4,230	------
Approx. 2,000 feet downstream of FM 157	1.342	1,620	------	2,370	------	2,730	3,530	3,630	------
Hanger Creek									
Upstream of confluence with Joe Pool Lake	0.499	510	------	920	------	1,140	1,100	1,750	------
Upstream of Lake Ridge Parkway	0.436	450	------	810	------	1,000	1,000	1,540	------
Downstream of Hanger Lowe Road	0.361	370	------	660	------	810	840	1,290	------
Hight Branch									
At confluence with Hollings Branch	------	------	2,600	------	3,900	------	4,490	------	6,010
Upstream of confluence with Hollings Branch	------	------	2,690	------	4,040	------	4,680	------	6,270
Approx. 600 feet upstream of the City of Grand Prairie city limits	------	------	2,870	------	4,090	------	4,640	------	6,050

Table IV-1 - Summary of Discharges for the Joe Pool Lake Streams

Location	Area (mi2)	10-Year		50-Year		100-Year		500-Year	
		Existing	Ultimate	Existing	Ultimate	Existing	Ultimate	Existing	Ultimate
Hollings Branch									
Downstream of confluence of Hight Branch	------	------	6,220	------	9,470	------	10,990	------	15,010
Upstream of confluence of Hight Branch	------	------	3,620	------	5,570	------	6,500	------	9,000
Downstream of Tangle Ridge Drive	------	------	3,820	------	5,800	5,818	6,740	------	9,410
At downstream 3,900 feet of boundary of the City of Cedar Hill and City of Grand Prairie	------	------	------	------	------	4,539	------	------	------
Approx. 2,250 feet upstream of the City of Grand Prairie city limts			4,030	------	6,000	------	6,960	------	9,410
At Downstream 740 feet of Ellis Road	------	------	------	------	------	3,366	------	------	------
At Upstream 2,900 feet of Ellis Road	------	------	------	------	------	3,308	------	------	------
Loyd Branch									
Upstream of confluence with Joe Pool Lake	1.181	1,670	------	2,400	------	2,710	2,850	3,510	------
Upstream of Ragland Road	0.982	1,500	------	2,120	------	2,400	2,590	3,120	------
Upstream of State Highway 360	0.885	1,370	------	1,930	------	2,190	2,450	2,850	------
Downstream of Webb Ferrell Road	0.621	990	------	1,410	------	1,590	1,770	2,050	------
Lynn Creek									
At confluence with Walnut Creek	5.430	3,600	------	5,500	------	6,450	------	8,300	------
Approximately 1,750 feet downstream of Ragland Road extension	4.620	3,300	------	4,850	------	5,650	------	7,350	------
Immediately downstream of Webb Lynn Road	2.950	2,600	------	3,700	------	4,200	------	5,300	------
Lynn Creek Tributary									
Upstream of confluence with Lynn Creek	0.040	100	------	130	------	150	160	190	------
Approx. 750 feet upstream of confluence with Lynn Creek	0.030	70	------	100	------	120	130	140	------
Approx. 1,180 feet upstream of confluence with Lynn Creek	0.012	30	------	40	------	50	50	60	------
Mills Branch									
Upstream of confluence with Joe Pool Lake	0.110	140	165	185	210	210	230	245	270
Upstream of XS 1807	0.072	60	65	65	70	70	70	75	80
Upstream of XS 1954	0.072	130	180	190	240	210	260	270	320
Upstream of XS 3480	0.020	50	70	70	90	80	100	100	120
Mountain Creek									
Upstream of confluence of Soap Creek	85.224	24,200	------	41,610	------	49,780	57,400	71,570	------
Upstream of FM 661	49.574	18,460	------	29,150	------	34,440	38,800	48,780	------
Upstream of U.S. Highway 287	48.505	18,870	------	29,700	------	35,050	39,300	49,580	------
Downstream of confluence of an unnamed tributary of Mountain Creek	47.069	19,020	------	29,950	------	35,370	39,610	50,480	------
Upstream of confluence of an unnamed tributary of Mountain Creek	44.522	18,580	------	29,200	------	34,450	38,680	49,130	------
Downstream of confluence of Grassy Creek	44.204	18,590	------	29,200	------	34,430	38,670	49,130	------
Downstream of County Road 511	29.845	13,470	------	21,320	------	25,100	28,590	35,540	------
Newton Branch									
Downstream of confluence of Plains Branch	14.862	2,600	------	6,100	------	7,800	10,500	12,300	------
Upstream of Kimble Road	9.054	1,500	------	3,600	------	4,700	6,600	7,600	------
North Hanger Creek									
Upstream of confluence with Joe Pool Lake	0.373	480	------	710	------	810	1,090	1,070	------
Approx. 2,240 feet upstream of confluence with Joe Pool Lake	0.284	350	------	520	------	600	830	780	------
Penwell Branch									
Upstream of confluence with Bedford Branch	0.623	980	1,350	1,450	1,860	1,650	2,080	2,160	2,630
Upstream of XS 2956	0.394	660	920	970	1,260	1,110	1,410	1,450	1,770
Upstream of XS 4877	0.114	220	310	320	420	370	470	470	580
Upstream of XS 6527	0.040	80	120	120	160	130	170	170	210
Plains Branch									
Upstream of confluence with Newton Branch	4.867	1,300	------	2,500	------	3,100	4,000	4,700	------
Downstream of an Unnamed Street	4.491	1,300	------	2,700	------	3,500	4,800	5,500	------
Downstream of SCS Reservoir #9	4.066	1,400	------	2,700	------	3,500	4,800	5,400	------
Small Branch									
Upstream of confluence with Bedford Branch	0.478	620	980	950	1,410	1,110	1,590	1,500	2,020
Upstream of XS 1348	0.462	610	980	950	1,400	1,100	1,570	1,470	2,000
Upstream of XS 3139	0.303	450	710	670	980	770	1,090	1,010	1,360
Upstream of XS 7355	0.072	140	250	200	330	230	360	300	430

Table IV-1 - Summary of Discharges for the Joe Pool Lake Streams

Location	Area (mi2)	10-Year		50-Year		100-Year		500-Year	
		Existing	Ultimate	Existing	Ultimate	Existing	Ultimate	Existing	Ultimate
Soap Creek									
Downstream of confluence of Edge Creek	34.879	9,900	------	19,500	------	24,300	33,500	36,700	------
Upstream of confluence of Edge Creek	33.659	9,700	------	19,200	------	23,900	33,100	36,000	------
Downstream of confluence of Newton Branch	33.298	10,100	------	19,800	------	24,600	34,400	37,000	------
Downstream of U.S. Highway 287	18.189	8,200	------	14,000	------	16,800	24,200	24,700	------
Upstream of Prairie Ridge Drive	17.808	8,900	------	15,100	------	18,300	26,900	26,300	------
Approx. 4,268 feet upstream of Prairie Ridge Drive	17.217	8,900	------	15,300	------	18,500	28,000	27,000	------
Approx. 1.09 miles upstream of Prairie Ridge Drive	16.660	9,100	------	15,700	------	18,600	28,600	27,600	------
Approx. 1.33 miles upstream of Prairie Ridge Drive	16.030	9,000	------	15,400	------	18,300	28,300	27,000	------
Approx. 1.62 miles downstream of Confluence of West Soap Creek	15.887	9,200	------	15,500	------	18,800	29,000	26,800	------
Approx. 1.10 miles downstream of Confluence of West Soap Creek	14.916	8,900	------	14,800	------	18,100	28,100	25,900	------
Approx. 4,860 feet downstream of Confluence of West Soap Creek	14.694	9,100	------	15,200	------	18,000	28,700	26,100	------
Approx. 2,340 feet downstream of Confluence of West Soap Creek	14.007	8,700	------	14,600	------	17,400	28,100	25,000	------
Downstream of confluence of West Soap Creek	13.542	8,900	------	15,000	------	17,800	28,900	25,000	------
Upstream of confluence of West Soap Creek	9.248	6,600	------	10,700	------	12,600	20,700	17,600	------
Approx. 2,300 feet upstream of Confluence of West Soap Creek	9.034	6,700	------	10,700	------	12,600	21,300	17,800	------
Approx. 1,650 feet downstream of confluence of East Soap Creek	8.719	6,500	------	10,400	------	12,300	20,900	17,400	------
Downstream of confluence of East Soap Creek	8.387	6,900	------	10,900	------	12,700	22,300	17,500	------
Upstream of confluence of East Soap Creek	5.989	4,900	------	8,000	------	9,400	17,100	12,800	------
Downstream of U.S. Highway 67	5.397	4,700	------	7,300	------	8,600	16,000	11,700	------
Stuart Branch									
Upstream of confluence with Joe Pool Lake	0.140	270	380	390	510	440	560	570	690
Upstream of Tangle Ridge Drive	0.024	60	80	90	120	100	130	120	150
Swadley Creek									
Upstream of confluence with Joe Pool Lake	0.318	470	590	680	760	740	830	920	1,000
Upstream of Tangle Ridge Drive	0.306	470	580	660	740	730	810	900	960
Upstream of Koscher Drive	0.179	310	430	460	590	520	680	700	850
Approx. 2,960 feet upstream of Koscher Drive	0.044	80	120	120	160	140	180	180	220
Taffee Creek									
Upstream of confluence with Joe Pool Lake	1.304	1,010	1,360	1,520	1,950	1,750	2,210	2,330	2,890
Upstream of Seeton Road	1.214	970	1,290	1,450	1,840	1,670	2,090	2,230	2,730
Downstream of Day Miar Road	0.667	630	920	920	1,280	1,060	1,440	1,410	1,860
Tarrell Creek									
Approx. 2,080 feet upstream of confluence with Joe Pool Lake	0.153	175	190	235	255	260	280	320	335
Approx. 2,850 feet upstream of confluence with Joe Pool Lake	0.105	75	80	85	95	90	100	100	105
Approx. 3,360 feet upstream of confluence with Joe Pool Lake	0.105	180	200	250	280	280	320	350	390
Approx. 4,970 feet upstream of confluence with Joe Pool Lake	0.035	90	100	120	140	140	160	170	200
Ten Branch									
Upstream of confluence with Joe Pool Lake	0.320	440	------	750	------	880	1,080	1,150	------
Approx. 600 feet downstream of State Highway 360	0.238	520	------	740	------	770	960	970	------
Downstream of State Highway 360	0.162	350	------	490	------	550	660	690	------
Unidentified Tributary									
Upstream of confluence with Joe Pool Lake	0.137	340	------	480	------	540	580	670	------
Upstream of Bentwater Parkway	0.092	240	------	320	------	360	390	440	------
Approx. 380 feet upstream of Bentwater Parkway	0.049	150	------	200	------	220	240	270	------
Downstream of Fossil Ridge Drive	0.008	30	------	40	------	50	50	60	------
Webb Branch									
Upstream of confluence with Joe Pool Lake	0.868	790	------	1,160	------	1,350	1,600	1,790	------
Upstream of Lake Ridge Parkway	0.642	460	------	700	------	820	930	1,090	------
Approx. 880 feet upstream of Lake Ridge Parkway	0.258	290	------	470	------	560	670	760	------
West Soap Creek									
Downstream of Jones Road	4.294	2,400	------	4,300	------	5,200	8,200	7,400	------
Upstream of County Road 502	3.268	2,400	------	4,100	------	4,700	7,500	6,500	------

V. Floodplain Mapping

V. FLOODPLAIN MAPPING

As part of the City-Wide Drainage Master Plan for Joe Pool Lake, Halff Associates, Inc. re-mapped all streams (with the exception of Lynn Creek and Bowman Branch) on the City of Grand Prairie 2009 Lidar data. Cross-Section locations were not available for Lynn Creek or Bowman Branch and floodplains could not be delineated for these streams. Mapping included delineations for the existing 100-year, existing 500-year, and ultimate 100-year floodplains. Ultimate Base Flood Elevations (BFEs) were delineated for all study streams. Floodways and existing conditions Base Flood Elevations (BFEs) were delineated for Zone AE detailed study streams. Refer to the Figures section of this report for Floodplain Mapping Exhibits of all Joe Pool Lake studied streams incorporated in this report. Floodplain shapefiles are included on the CD-ROM in Appendix I.

A. LOMR SUBMITTAL

At the time of this report, the method of incorporating the results of the CWDMP for Joe Pool Lake into the FEMA FIRM maps was still uncertain. The data for Johnson and Ellis Counties was submitted as an appeal to the preliminary DFIRMs but no information has been received yet confirming whether the appeals will be accepted. If the appeals are not accepted, then the other option would be to submit a Letter of Map Revision (LOMR). The LOMR or MapMOD incorporation would only include the current effective and existing conditions models for the studied streams. There would be no man-made changes being proposed as part of the study and therefore it would be likely that FEMA could wave the review fee.

Floodplain data in Dallas County will be submitted as an appeal after the preliminary DFIRMs are released and the period begins. The Tarrant county streams (Loyd Branch, Ten Branch, Webb Branch, Foster Branch, Hanger Creek) will need to be submitted through a LOMR Physical Map Revision. It is intended that these streams be submitted to FEMA for incorporation along with the planned RiskMap stream studies, if possible.

Grand Prairie TEXAS

CWDMP for Joe Pool Lake

FLOODPLAIN WORKMAPS

Joe Pool Lake - 1 of 6

LEGEND

- BFE (Ultimate)
- Mapping XS
- USACE Flowage Easement
- Potential Bank Erosion
- Potential Channel Erosion
- Potential Deposition
- Potential Bank Erosion (USACE Property)
- Potential Channel Erosion (USACE Property)
- Potential Deposition (USACE Property)
- Stream CL
- Floodway
- Existing 500 Yr Floodplain
- Existing 100 Yr Floodplain
- Ultimate 100 Yr Floodplain
- Grand Prairie City Limit
- Railroad

HALFF

NOTES:

1. Limits of foodplains are based on the City of Grand Prairie 2009 Lidar data.

DATUM:

NAD 83 Texas State Plane North Central Zone NAVD 88

0 300 600 1,200 Feet

MAP INDEX

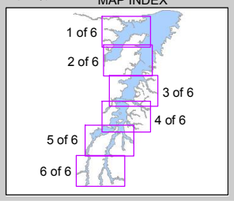


Figure V-1 Floodplain Workmap

Grand Prairie TEXAS

CWDMP for Joe Pool Lake

FLOODPLAIN WORKMAPS

Joe Pool Lake - 2 of 6

NOTES:

1. Limits of foodplains are based on the City of Grand Prairie 2009 Lidar data.

DATUM:

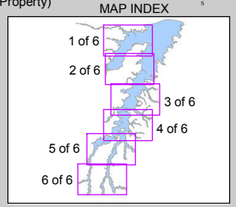
NAD 83 Texas State Plane
North Central Zone
NAVD 88

0 300 600 1,200 Feet

LEGEND

- BFE (Ultimate)
- Mapping XS
- USACE Flowage Easement
- Potential Bank Erosion
- Potential Channel Erosion
- Potential Deposition
- Potential Bank Erosion (USACE Property)
- Potential Channel Erosion (USACE Property)
- Potential Deposition (USACE Property)
- Stream CL
- Floodway
- Existing 500 Yr Floodplain
- Existing 100 Yr Floodplain
- Ultimate 100 Yr Floodplain
- Grand Prairie City Limit
- Railroad

MAP INDEX



HALFF

Figure V-2 Floodplain Workmap

Grand Prairie TEXAS

CWDMP for Joe Pool Lake

FLOODPLAIN WORKMAPS

Joe Pool Lake - 3 of 6

NOTES:

1. Limits of foodplains are based on the City of Grand Prairie 2009 Lidar data.

DATUM:

NAD 83 Texas State Plane North Central Zone
NAVD 88

0 300 600 1,200 Feet

LEGEND

- BFE (Ultimate)
- Mapping XS
- USACE Flowage Easement
- Potential Bank Erosion
- Potential Channel Erosion
- Potential Deposition
- Potential Bank Erosion (USACE Property)
- Potential Channel Erosion (USACE Property)
- Potential Deposition (USACE Property)
- Stream CL
- Floodway
- Existing 500 Yr Floodplain
- Existing 100 Yr Floodplain
- Ultimate 100 Yr Floodplain
- Grand Prairie City Limit
- Railroad

MAP INDEX

1 of 6
2 of 6
3 of 6
4 of 6
5 of 6
6 of 6

HALFF

Figure V-3 Floodplain Workmap

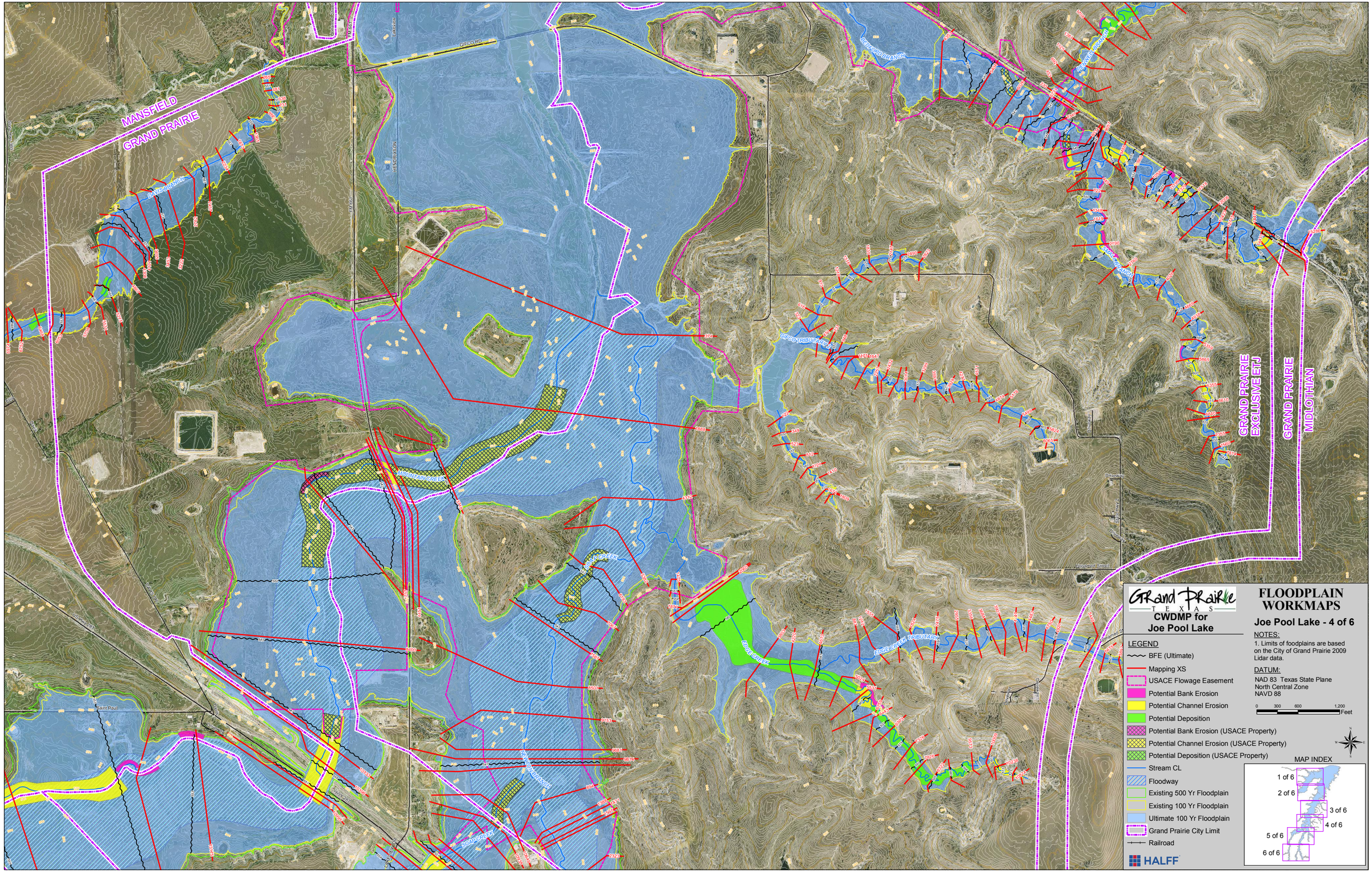


Figure V-4 Floodplain Workmap

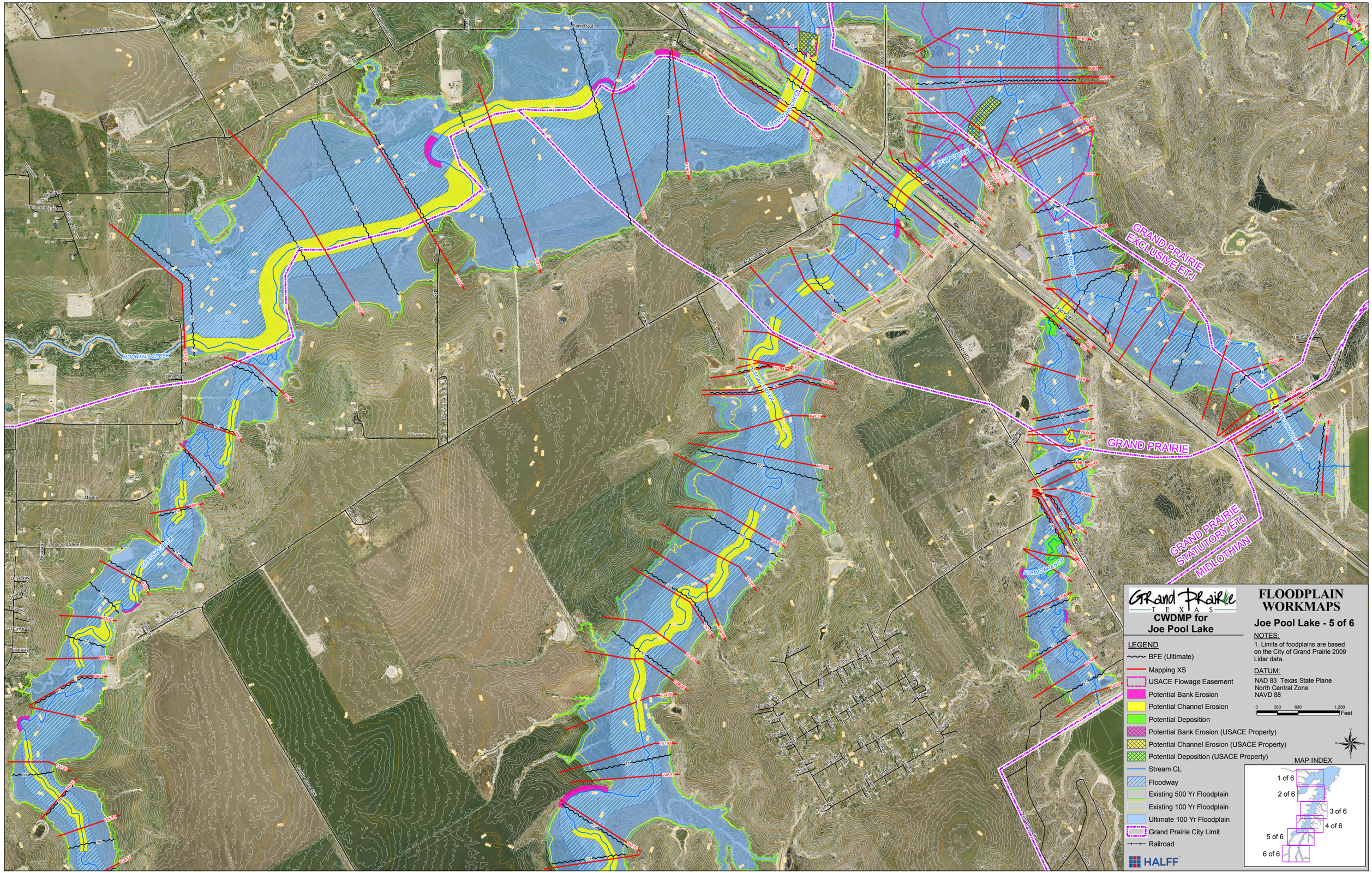


Figure V-5 Floodplain Workmap

GRAND PRAIRIE TEXAS

CWDMP for Joe Pool Lake

FLOODPLAIN WORKMAPS

Joe Pool Lake - 6 of 6

NOTES:

1. Limits of foodplains are based on the City of Grand Prairie 2009 Lidar data.

DATUM:

NAD 83 Texas State Plane North Central Zone
NAVD 88

0 300 600 1,200 Feet

LEGEND

- BFE (Ultimate)
- Mapping XS
- USACE Flowage Easement
- Potential Bank Erosion
- Potential Channel Erosion
- Potential Deposition
- Potential Bank Erosion (USACE Property)
- Potential Channel Erosion (USACE Property)
- Potential Deposition (USACE Property)
- Stream CL
- Floodway
- Existing 500 Yr Floodplain
- Existing 100 Yr Floodplain
- Ultimate 100 Yr Floodplain
- Grand Prairie City Limit
- Railroad

HALFF

MAP INDEX

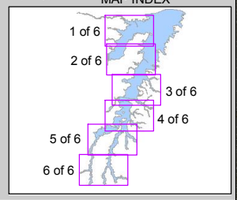
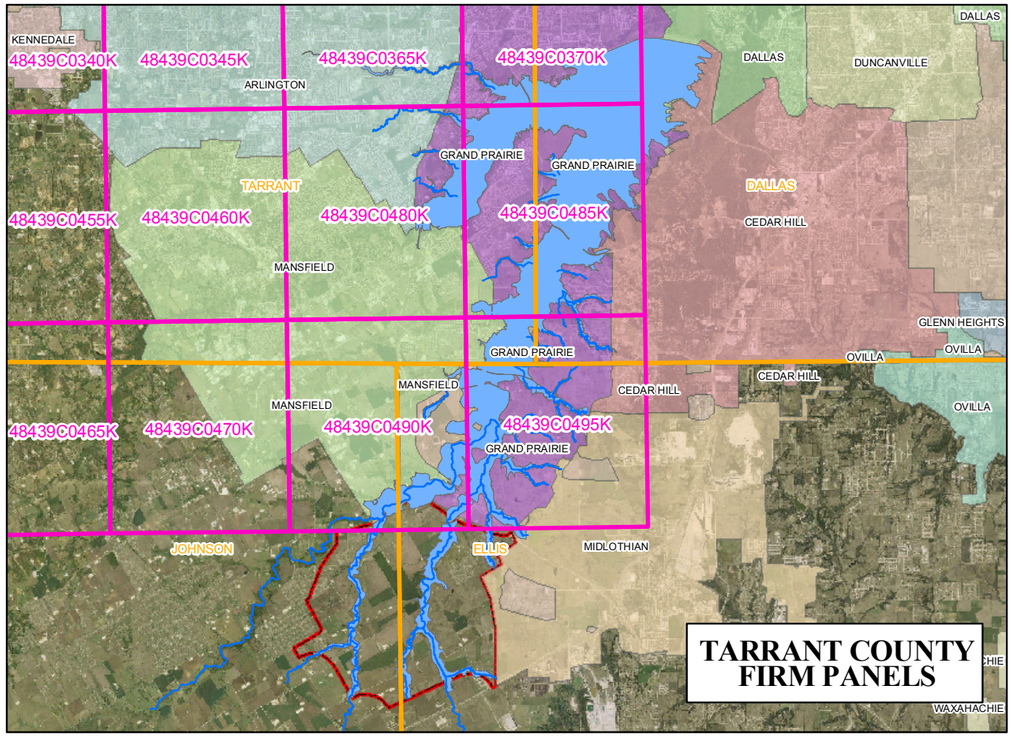


Figure V-6 Floodplain Workmap



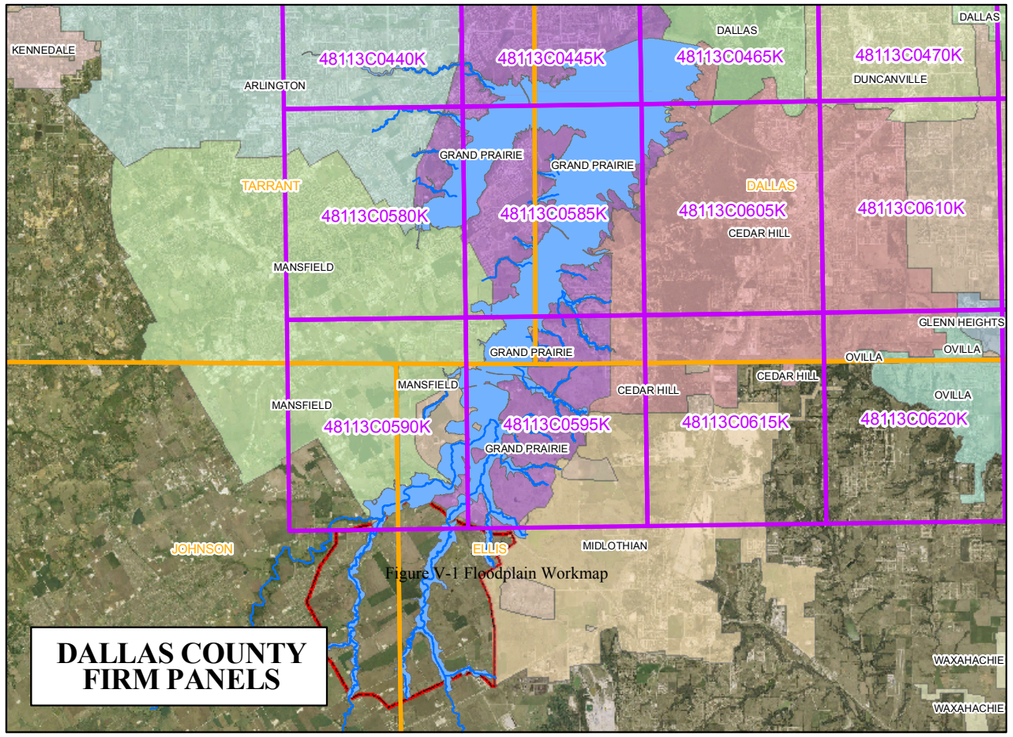
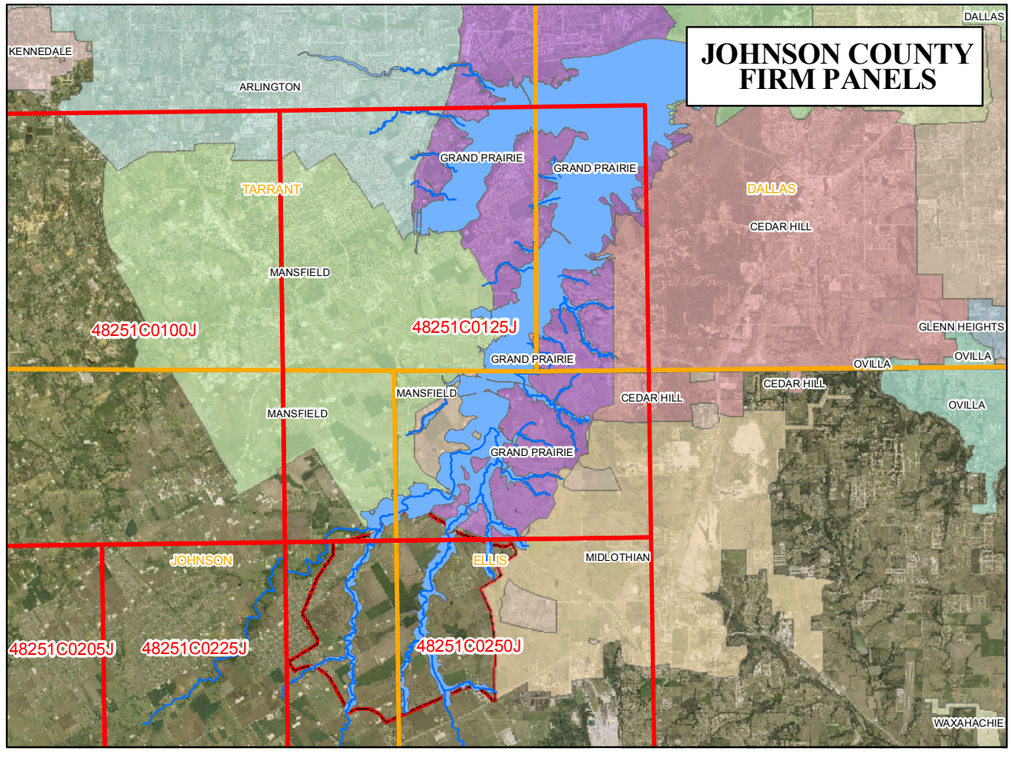


Figure V-1 Floodplain Workmap



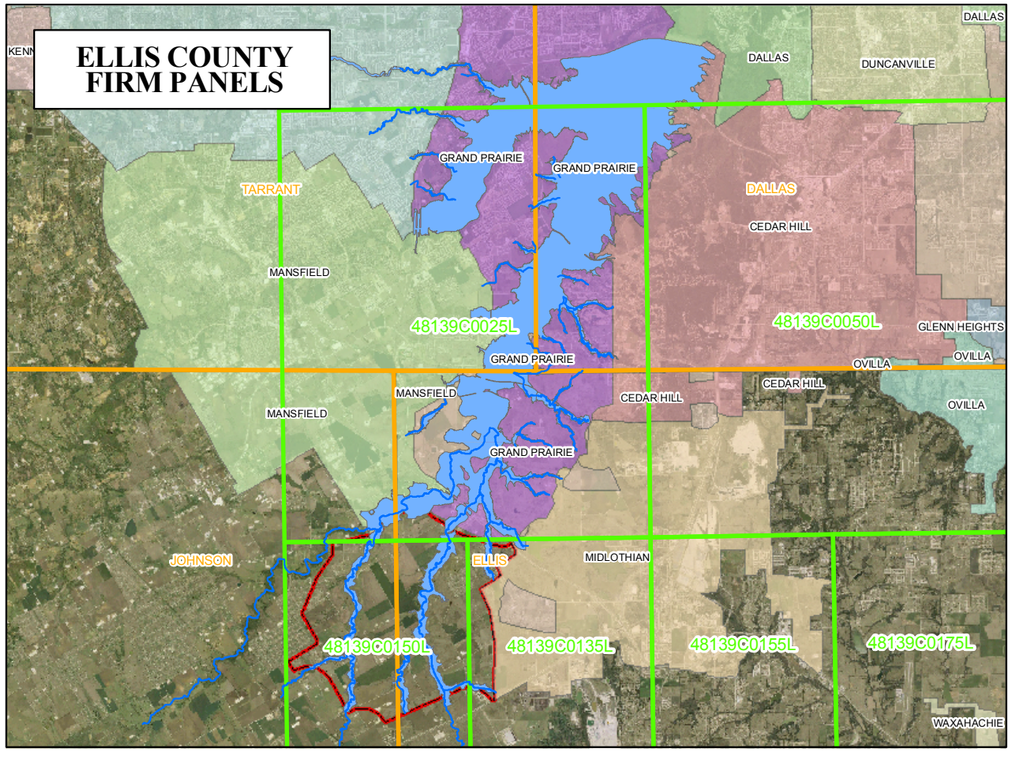


Figure V-7 FEMA Affected FIRM Panels

Grand Prairie TEXAS

CWDMP for Joe Pool Lake

LEGEND

- Tarrant FIRM Panel
- Dallas FIRM Panel
- Johnson FIRM Panel
- Ellis FIRM Panel
- County Boundary
- Ultimate 100 Yr Floodplain
- Stream CL

AFFECTED FIRM PANELS

DALLAS COUNTY (PRELIM)

48113C0265L 48113C0385L
48113C0270L 48113C0390L
48113C0290L 48113C0395L
48113C0380L 48113C0405L

ELLIS COUNTY (PRELIM)

48139C0025L 48139C0135L
48139C0050L 48139C0150L

JOHNSON COUNTY (PRELIM)

48251C0125J
48251C0250J

TARRANT COUNTY (CE)

48439C0365K 48439C0490K
48439C0370K 48439C0495K
48439C0480K
48439C0485K

FEMA FIRM PANELS

N
W E
S

NO SCALE

HALFF

VI. Roadway Crossings

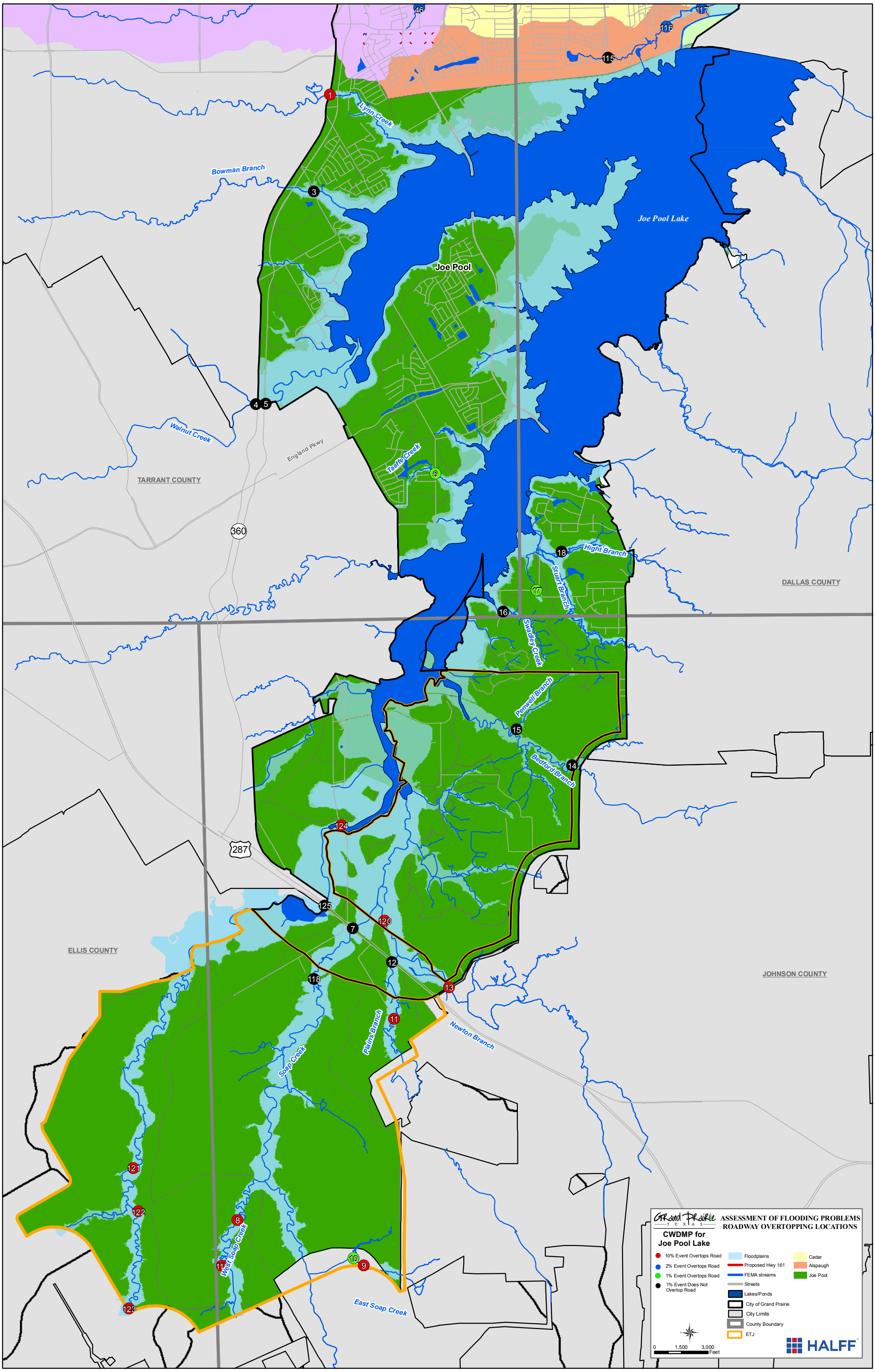


Figure VI-1 Roadway Crossings

VI. ROADWAY CROSSINGS

A. EVALUATION OF EXISTING ROADWAY CROSSINGS

Existing roadway crossings along detailed study streams were evaluated on their level of protection against the existing 10%, 2%, and 1% (10-year, 50-year, and 100-year) chance flood events. The following tables include the current hydraulic model, the station and description of the roadway crossing, and if the roadway crossing is overtopped by the existing 10%, 2%, or 1% chance flood event. All shown WSEL refer to the upstream face of the structure.

Bowman Branch was partially restudied as part of the FEMA Letter of Map Revision (LOMR) 03-06-1010Pwhich became effective on July 22, 2003. Bowman Branch LOMR 03-06-1010P revised the 1985 City of Arlington Flood Insurance Study performed by the U.S. Army Corps of Engineers. Arlington Webb Britton Road was the only existing bridge crossing on Bowman Branch which was evaluated for its level of protection against the existing 10%, 2%, and 1% (10-year, 50-year, and 100-year) chance flood events as part of this report. The Ragland Extension is no longer a crossing on Bowman Branch and State Highway 360 was not included in the Bowman Branch LOMR model.

Table VI-1 - Existing Bridge Crossings

Stream: Lynn Creek						
Model: D20LYNN (HEC-2)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
1.	18835	*Webb Lynn Road*	552.60	Yes WSEL=553.77	Yes WSEL=554.98	Yes WSEL=555.41
Note: Since time of HEC-2 model, Webb-Lynn Road no longer crosses Lynn Creek in Grand Prairie. Location is now SH 360. A new Lynn Creek model (currently under FEMA review) should include new bridge/culvert locations in Grand Prairie and Arlington. Roadway names/stations need to be verified for future master plan models.						

Stream: Bowman Branch						
Model: D20BOW (HEC-2)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
3.	7812.5	*Arlington Webb Britton*	539.00	No WSEL=530.90	No WSEL=532.59	No WSEL=533.20
Note: Roadway names/stations need to be verified for future master plan models.						

Stream: Walnut Creek						
Model: WC.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
4.	10120	*SH 360 Frontage SB*	542.00	No WSEL=536.27	No WSEL=540.10	No WSEL=541.85
5.	9730	*SH 360 Frontage NB*	542.00	No WSEL=536.03	No WSEL=539.73	No WSEL=541.30
Note: SH 360 crosses Walnut Creek in the City of Mansfield. No roadway crossings in City of Grand Prairie.						

Stream: Taaffe Creek						
Model: TAAFFE_CREEK.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
6.	2703	*Seeton Road*	537.13	No WSEL=535.05	Yes WSEL=537.15	Yes WSEL=537.76
Note: Bridge data for Seeton Road will be updated after the City of Mansfield Master Drainage Study of Taaffe Creek is completed						

Stream: Soap Creek						
Model: Soap_Creek.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
118.	16420	*Prairie Ridge*	558.43	No WSEL=553.33	No WSEL=555.88	No WSEL=557.00
7.	12060	*SH 287*	555.34	No WSEL=548.05	No WSEL=549.80	No WSEL=549.81

Stream: West Soap Creek						
Model: West_Soap_Creek.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
119.	12117	*County Road 502*	594.46	Yes WSEL=596.78	Yes WSEL=597.49	Yes WSEL=597.66
8.	6727	*Jones Road*	582.40	Yes WSEL=585.73	Yes WSEL=587.01	Yes WSEL=587.50

Stream: East Soap Creek						
Model: East_Soap_Creek.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
9.	3816	*Turner Road*	609.34	Yes WSEL=610.58	Yes WSEL=611.07	Yes WSEL=611.31
10.	2740	*Miller Road*	605.00	No WSEL=602.78	Yes WSEL=605.86	Yes WSEL=606.16

Stream: Plains Branch						
Model: Plains_Branch.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
11.	5078	*Old Fort Worth Road*	561.21	Yes WSEL=562.54	Yes WSEL=563.24	Yes WSEL=563.56
12.	400	*SH 287*	554.48	No WSEL=549.20	No WSEL=550.47	No WSEL=550.98

Stream: Newton_Branch						
Model: Newton_Branch.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
13.	8676	*Kimble Road*	559.80	Yes WSEL=561.63	Yes WSEL=562.71	Yes WSEL=563.14
120.	1520	*Private Drive*	541.00	Yes WSEL=541.36	Yes WSEL=543.07	Yes WSEL=543.61

Stream: Bedford Branch						
Model: BEDFORD_BRANCH.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
14.	14443	*Railroad*	570.15	No WSEL=564.77	No WSEL=566.23	No WSEL=566.89

Stream: Penwell Branch						
Model: PENWELL_BRANCH.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
15.	297	*Railroad*	548.70	No WSEL=542.20	No WSEL=543.20	No WSEL=543.59

Stream: Swadley Creek						
Model: SWADLEY_BRANCH.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
16.	689	*Tangle Ridge Road*	539.26	No WSEL=533.25	No WSEL=535.23	No WSEL=535.97

Stream: Stuart Branch						
Model: STUART_BRANCH.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
17.	3965	*Tangle Ridge Road*	566.72	No WSEL=566.40	Yes WSEL=567.19	Yes WSEL=567.31
Note: Crossing at Tangle Ridge Road is a perched culvert. Minimum top of road is not at actual stream crossing.						

Stream: Hight Branch						
Model: HollingHightBranchJoePool.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
18.	1925	*TRA Aerial Crossing (non-roadway)*	553.05	No WSEL=538.63	No WSEL=539.33	No WSEL=539.66

Stream: Grassy Creek						
Model: Mountain_Creek.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
121.	18546	*County Road 619*	594.58	Yes WSEL=601.06	Yes WSEL=602.32	Yes WSEL=602.83
122.	23244	*County Road 506*	606.84	Yes WSEL=609.77	Yes WSEL=610.57	Yes WSEL=610.95
123.	31737	*County Road 502*	621.20	Yes WSEL=624.23	Yes WSEL=625.07	Yes WSEL=625.43

Stream: Mountain Creek						
Model: Mountain_Creek.prj (HEC-RAS)						
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**10% Event Overtops Road**	**2% Event Overtops Road**	**1% Event Overtops Road**
124.	4672	*FM 661*	537.13	Yes WSEL=538.93	Yes WSEL=540.79	Yes WSEL=541.54
125.	10720	*US Highway 287*	554.44	No WSEL=546.52	No WSEL=548.94	No WSEL=550.00

Overtopped roadways were resized for the ultimate 1% (100-year) annual chance flood event. A summary of the roadway improvement alternatives is included in Table VI-2. Roadways where flood elevations are controlled by the Joe Pool Lake backwater were not evaluated. Refer to Section VII for detailed descriptions of proposed conceptual existing roadway crossing improvements.

Table VI-2 – Existing Roadway Proposed Alternatives

Stream Name	Roadway	Approx. River Station	100-Year Ultimate Discharge	Existing Crossing	Minimum Top of Road Elevation		Approx. Bridge Span/Improvement	100-Year Ult WSEL at US XS	Change in WSEL
					Existing	Proposed			
			(cfs)	(ft)			(ft)	(ft)	(ft)
East Soap Creek	Miller Road	27+40	6,100	40’ Span	605.00	609	100	607.06	-0.16
East Soap Creek	Turner Road	38+16	5,500	1 – 60” Steel Cul. 1 – 96” Steel Cul. 3 – 84” Steel Cul.	609.34	611	125	609.16	-2.96
Grassy Creek	County Road 619	185+46	10,740	2 Elliptical Cul. 5.5’ span 6’ rise	594.58	606	400	603.76	0.60
Grassy Creek	County Road 506	232+44	7,730	50’ Span	606.84	613.5	275	611.31	-0.06
Grassy Creek	County Road 502	317+37	7,000	60’ Span	621.20	628	350	626.06	0.20
Mountain Creek	FM 661	46+72	39,320	300’ Span	537.00	545	500	543.01	1.73
Newton Branch	Kimble Road	86+76	6,600	2 – 60” CMP	559.80	563	375	560.13	-2.86
Plains Branch	Old Fort Worth Road	50+78	4,800	2 Elliptical Cul. 9’ span 5’ rise	561.21	566	350	563.74	-0.30
Stuart Branch	Tangle Ridge Road	39+65	130	1 – 48” RCP	566.72	566.72	Add 1 – 48” RCP	566.58	-0.95
Taaffe Creek	Seeton Road	27+03	1,670	4 – 8’x5’ RBC	537.13	537.13	4 – 8’x8’ RBC	534.58	-2.47
West Soap Creek	Jones Road	67+27	7,500	1 – 42” CMP	582.40	591	350	589.57	0.73
West Soap Creek	County Road 502	121+17	7,500	15’ Span	594.46	600	450	598.10	-0.32

B. EVALUATION OF PROPOSED AND FUTURE ROADWAY CROSSINGS

According to the City of Grand Prairie's Master Thoroughfare Plan, there are multiple, planned major thoroughfares within the Joe Pool Lake watershed, including Principal Arterials, Minor Arterials, and Collector streets. Refer to the Figures section of this report for a map of the current Master Thoroughfare plan included in the Overall Watershed Workmap. Table VI-3 is a list of the studied tributaries that would have a future crossing (or crossings) under the current thoroughfare plan.

Table VI-3 - Joe Pool Lake Studied Tributaries with Future Thoroughfare Crossings

Tributary Name	Master Thoroughfare Crossing
Bedford Branch	Prairie View Blvd.
Davis Branch	Miller Road
Edge Creek	Miller Road
Edge Creek Tributary	Loop 9 Prairie View Blvd.
Grassy Creek	Loop 9 Unnamed Road 1 Unnamed Road 2
Grassy Creek Tributary	Unnamed Road 1
Mills Branch	Parkridge Drive
Mountain Creek	Miller Road
Plains Branch	Loop 9
Small Branch	Loop 9 Miller Road
Soap Creek	Miller Road Loop 9 Wyatt Road Unnamed Road 2
Tarrell Creek	Parkridge Drive
West Soap Creek	Wyatt Road

Design of Future Thoroughfare Crossings

Future thoroughfare crossings of the Joe Pool Lake studied tributaries shall be designed to pass the ultimate 100-year flood frequency event and to not create adverse impacts to upstream or downstream structures and adjacent property owners (caused by increases in 100-year computed water surface elevations). It would be desirable for roadway crossings to span the entire 100-year future floodplain;

however, if this cannot be achieved, it would be desirable for the future crossing to minimize encroachment, thus minimizing impacts to upstream reaches.

Halff Associates prepared preliminary conceptual sizes for bridge openings to pass the 100-year ultimate flow without overtopping the roadway for each of the planned future thoroughfare crossings. The peak discharge at each crossing dictated the necessity for a culvert or bridge span design. Table VI-4 provides a summary of the bridge parameters calculated for the master thoroughfare crossing conceptual sizings. These conceptual bridge sizes are not for design but are intended only to give an approximate bridge opening flow area needed to pass the 100-year ultimate discharge and indicate potential adverse impacts upstream. The top of road elevation was set 5' above the 100-year ultimate water surface elevation for each conceptual bridge design to allow for adequate freeboard and deck width above the water surface. The bridge span should be considered approximate and was selected based on similar existing roadways in the watershed. All roadways were sized assuming a 1% slope and 0.05 roughness coefficient. Flow areas were increased by a minimum of 10% to help allow for losses due to piers and other obstructions that were not included in these preliminary calculations. Mitigation alternatives were not considered in conjunction with the bridge designs, but could be incorporated with the final bridge design.

Table VI-4 - Master Thoroughfare Crossing Design Analysis

Stream Name	Roadway	Approx. River Station	100-Year Ultimate Discharge	Min Top of Road	Approx. Bridge Span	Bridge Opening Flow Area
			(cfs)	Elev	(ft)	(sqft)
Bedford Branch	Prairieview Blvd	60+26	7,690	547	200	1,200
Davis Branch	Miller Rd	39+88	620	585	200	200
Edge Creek	Miller Rd	11+50	600	634	4 - 10'x5' RBC	200
Edge Creek Tributary	Prairieview Blvd	40+00	1,160	590	100	250
Edge Creek Tributary	Loop 9	41+50	1,160	590	100	250
Grassy Creek	Loop 9	73+88	11,260	584	300	1,600
Grassy Creek	TP0027	115+65	11,230	592	300	1,600
Grassy Creek	TP0029	165+45	10,800	604	200	1,600
Grassy Creek Tributary	TP0027	27+62	3,690	624	150	650
Mills Branch	Parkridge Dr	40+20	90	585	2 - 4' RCP	25
Mountain Creek	Miller Rd	76+48	39,790	550	500	4,500
Plains Branch	Loop 9	75+58	4,800	573	200	800
Small Branch	Loop 9	70+20	360	637	50	70
Small Branch	Miller Rd	51+90	1,090	591	100	250
Soap Creek	Wyatt Rd	377+50	20,900	598	300	2,500
Soap Creek	Loop 9	201+38	28,000	569	400	3,500
Soap Creek	TP0029	296+90	28,700	585	400	3,500
Soap Creek	Miller Rd	64+85	33,100	550	500	3,800
Tarrell Creek	Parkridge Dr	47+25	160	586	2 - 5'x4' RBC	40
West Soap Creek	Wyatt Rd	130+88	7,500	604	300	1,200

VII. Alternatives for Streams and Open Channels

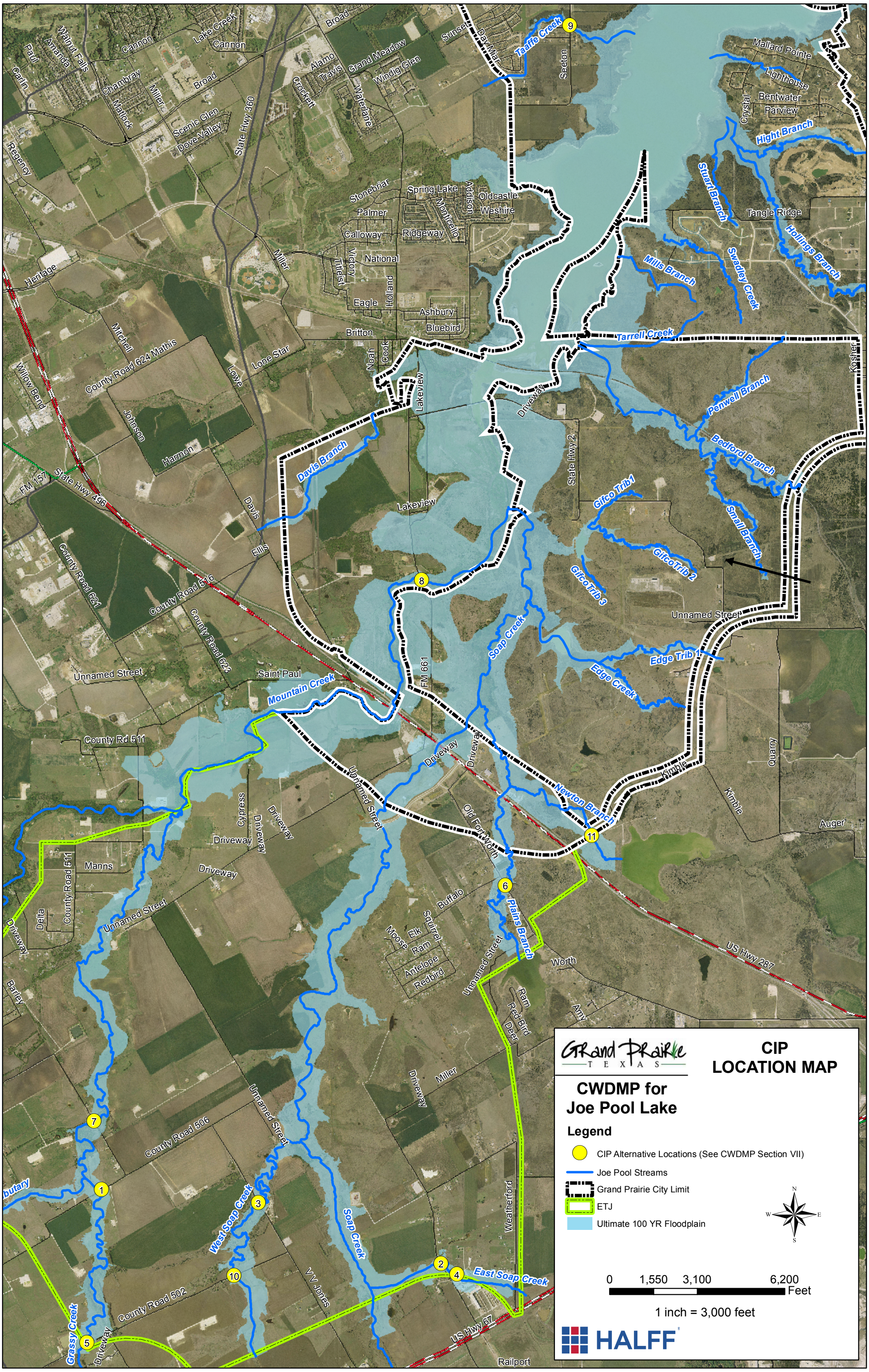


Figure VII-1 CIP Location Map

VII. ALTERNATIVES FOR STREAMS AND OPEN CHANNELS

Non-structural and structural measures were considered for proposed alternatives to mitigate flood damages in the City of Grand Prairie. Halff Associates determined proposed alternatives for structures inundated by the ultimate 100-year flood event and existing roadway crossings overtopped by the existing 100-year flood event within the Joe Pool Lake watershed. Regional storm water detention alternatives were also considered to mitigate the effects of future development and provide additional developable property.

The City of Grand Prairie 2009 Lidar data deliverables included a shapefile for buildings that were identified during the data acquisition. This building shapefile was intersected with the delineated ultimate 100-year floodplain to identify potentially flooded structures. A total of twenty-one (21) structures were identified. Of these structures, eleven (11) were considered significant, enclosed structures that qualify as insurable structures. The City of Grand Prairie requested Halff Associates survey and prepare elevation certificates for these structures. Elevation certificates were prepared for each of the structures from which Right of Entry (ROE) forms or verbal approval was given by property owners to access the property. Five structures, all manufactured homes, were found to be above the ultimate 100-year floodplain elevation based on the surveyed finish floor elevations. The remaining structures inundated by the ultimate 100-year flood event consisted primarily of secondary structures such as barns, workshops, and manufactured structures. Flood protection alternatives were not considered economically feasible and buyouts would not be recommended for these structures.

Proposed bridge alternatives were considered for all existing roadway crossings modeled within the Joe Pool Lake watershed that were overtopped by the existing 100-year flood event. Each proposed bridge alternative was designed to pass the 100-year ultimate discharge so that the roadway was not overtopped. The limits of the proposed bridge openings were set at the floodway boundaries unless the proposed bridge opening width was economically unfeasible and the increase in water surface elevations did not negatively impact any existing, insurable structures. Mitigation was not considered for proposed bridge alternatives but could be used to reduce the required bridge span and/or height for the final design. Detailed cost estimates for each flood control alternative can be found in Section XII of this report. The total annual cost given with the cost estimate is based on a 50-year project life and a 7% discount rate.

Any improvements (including bridge piers) encroaching into a FEMA mapped floodway which result in a rise in water surface elevation will require submittal of a FEMA Conditional Letter of Map Revision (CLOMR) including the following information:

- An evaluation of alternatives, which would not result in a BFE increase above that permitted demonstrating why these alternatives are not feasible;
- Documentation of individual legal notice to all affected property owners within and outside of the community, explaining the impact of the proposed action on their property;
- Concurrence of the Chief Executive Officer (CEO) and any other communities affected by the proposed actions; and
- Certification that no structures are located in areas that would be impacted by the increased base flood elevation.

All of the Joe Pool streams and tributaries are considered waters of the United States. Construction of improvements within the waters of the United States requires permitting by the U.S. Army Corps of Engineers (USACE) under Section 404 of the Clean Water Act. Bridge improvements can typically be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements. Refer to Appendix G for more information regarding Section 404 Permits.

The following is a brief description of the proposed conceptual improvements within the Joe Pool Lake watershed. Refer to Table VI-2 for a summary of proposed conceptual existing bridge crossing improvements.

1. COUNTY ROAD 506 AT GRASSY CREEK (STREAM STATION 232+44)

The existing bridge opening at County Road 506 is approximately 50’ wide and is overtopped by the 2-year storm event with the ultimate 100-year storm event overtopping the roadway by more than four feet.

Stream: Grassy Creek									
Model: Mountain_Creek.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
122.	23244	*County Road 506*	606.84	Yes WSEL= 608.29	Yes WSEL= 609.37	Yes WSEL= 609.77	Yes WSEL= 610.17	Yes WSEL= 610.57	Yes WSEL= 610.95

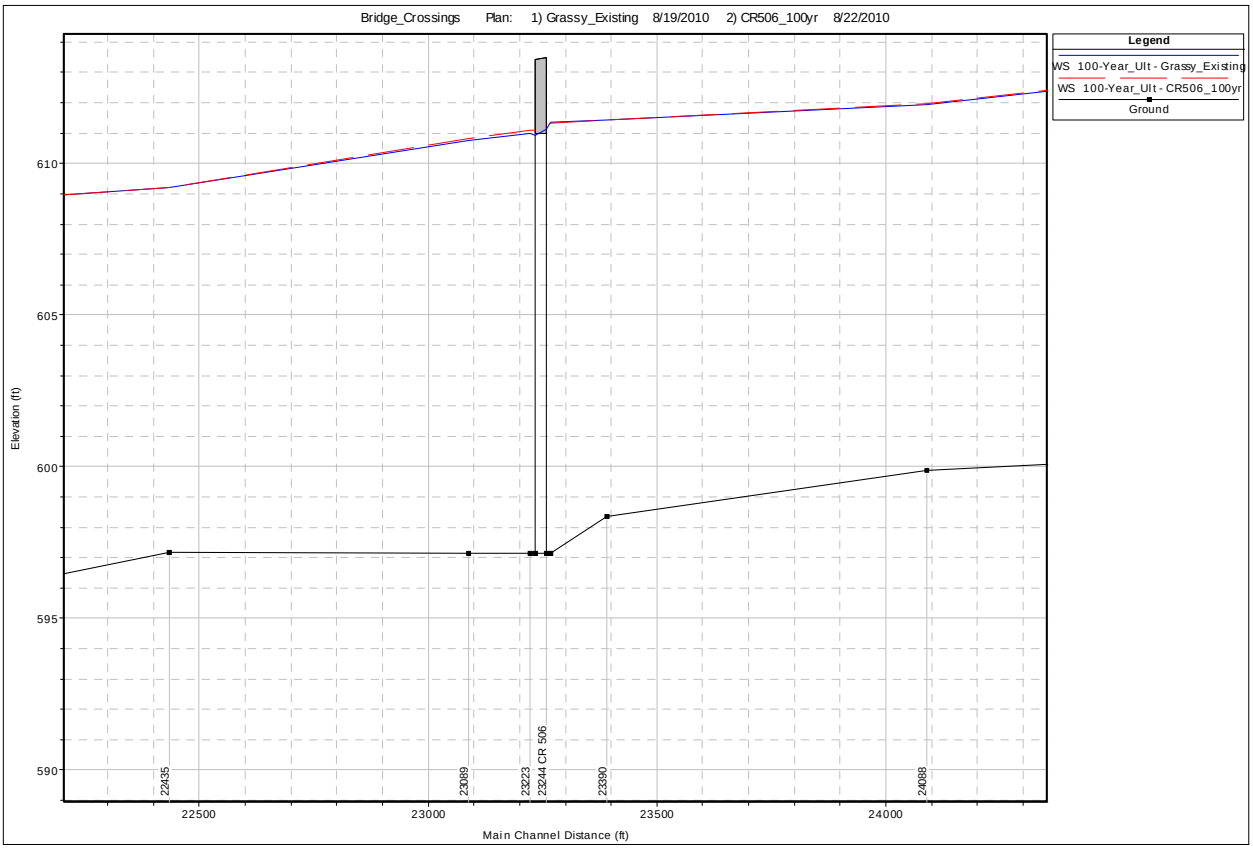
Alternative 1

- Elevate minimum Top of Road to 613.5'
- Widen bridge span opening to 275'

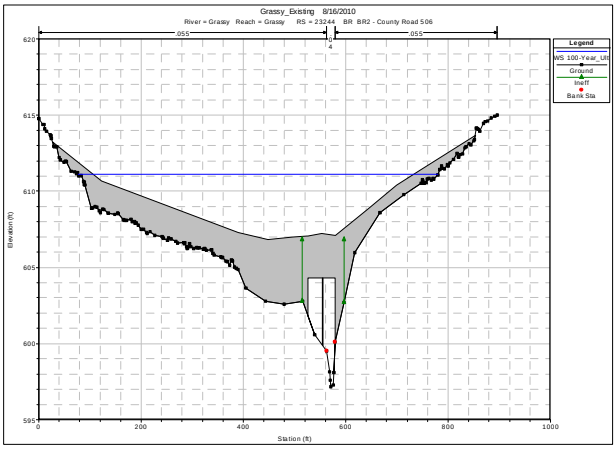
STATEMENT OF PROBABLE COST - 2010	
Subtotal	$860,000
25% Contingency	$215,000
CONSTRUCTION TOTAL	**$1,075,000**
10% for Engineering and Survey	$107,500
TOTAL	**$1,180,000**

Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. If the Alternative 1 improvements at County Road 506 were implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations are lowered up to 0.06' upstream of County Road 506 as a result of the proposed improvements; however, no existing structures benefit from the decrease in water surface elevations. A major cost of the alternate will be the amount of fill needed to elevate the roadway on each side of the bridge to the 609.0' elevation and the repaving of the elevated roadway. Valley storage loss should be minimal, but will need to be checked for the final bridge design and mitigation plan prior to construction. A zero-rise certificate could potentially be completed to satisfy the requirements for construction within a floodway. A LOMR will be necessary after construction of the improvements to incorporate floodplain and floodway mapping revisions into the FEMA mapping. Alternative 1 would require construction within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

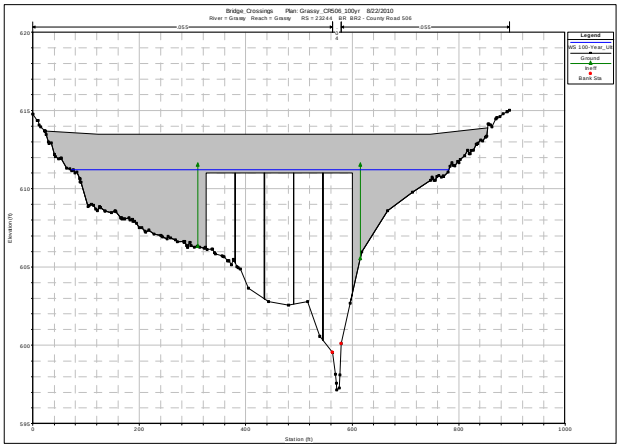
County Road 506 Alternative 1 Profile Comparison



County Road 506 Alternative 1 Bridge Comparison



Existing



Proposed

2. MILLER ROAD AT EAST SOAP CREEK (STREAM STATION 27+40)

The existing bridge opening at Miller Road is approximately 40' wide and only has the capacity to pass the existing 10-year storm event without the roadway being overtopped. Miller Road is overtopped by the existing 25-year storm event with the ultimate 100-year storm event overtopping the roadway by more than two feet.

Stream: East Soap Creek									
Model: East_Soap_Creek.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
10.	2740	*Miller Road*	605.00	No WSEL= 599.70	No WSEL= 601.55	No WSEL= 602.78	Yes WSEL= 605.22	Yes WSEL= 605.86	Yes WSEL= 606.16

Alternative 1

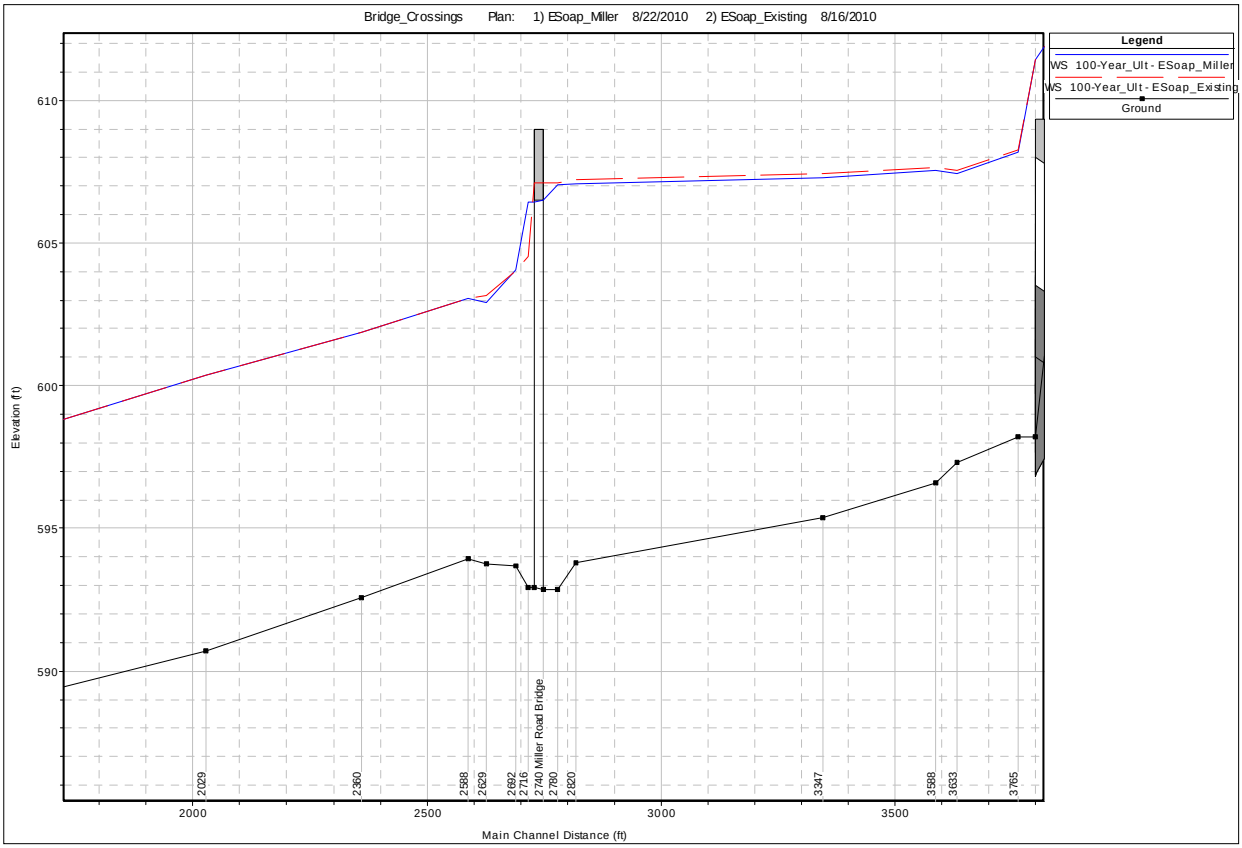
- Elevate minimum Top of Road to 609.0'
- Widen bridge span opening to 100'

STATEMENT OF PROBABLE COST - 2010	
Subtotal	$491,000
25% Contingency	$122,800
CONSTRUCTION TOTAL	**$614,000**
10% for Engineering and Survey	$61,400
TOTAL	**$680,000**

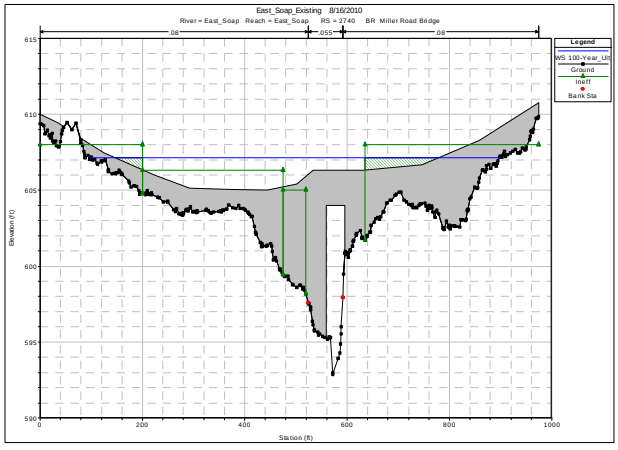
Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. If the Alternative 1 improvements at Miller Road were implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations are lowered up to 0.16' upstream of Miller Road as a result of the proposed improvements; however, no existing structures benefit from the decrease in water surface elevations. A major cost of the alternative will be the amount of fill needed to elevate the roadway on each side of the bridge to the 609.0' elevation and the repaving of the elevated roadway. Valley storage loss should be minimal, but will need to be checked for the final bridge design and mitigation plan prior to construction. A zero-rise certificate could potentially be completed to satisfy the requirements for construction within a floodway. A Letter of Map Revision (LOMR) will be necessary after construction of the

improvements to incorporate floodplain and floodway mapping revisions into the FEMA mapping. Alternative 1 would require construction within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

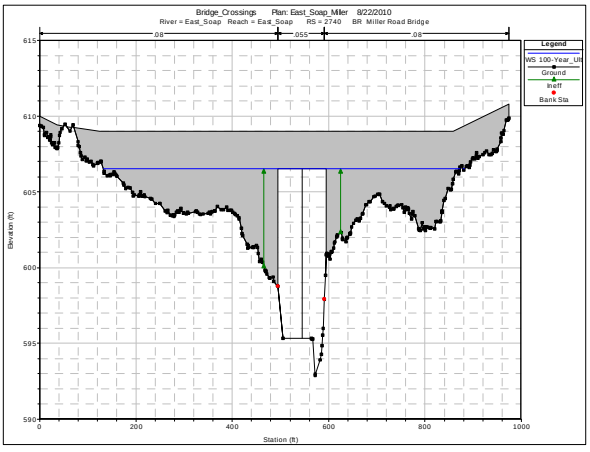
Miller Road Alternative 1 Profile Comparison



Miller Road Alternative 1 Bridge Comparison



Existing



Proposed

3. JONES ROAD AT WEST SOAP CREEK (STREAM STATION 67+27)

The existing bridge crossing at Jones Road consists of one 3.5' diameter culvert. Jones Road is overtopped by the existing 2-year storm event with the ultimate 100-year storm event overtopping the roadway by almost four feet.

Stream: West Soap Creek									
Model: West_Soap_Creek.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
8.	6727	*Jones Road*	582.40	Yes WSEL= 583.92	Yes WSEL= 585.03	Yes WSEL= 585.73	Yes WSEL= 586.47	Yes WSEL= 587.01	Yes WSEL= 587.50

Alternative 1

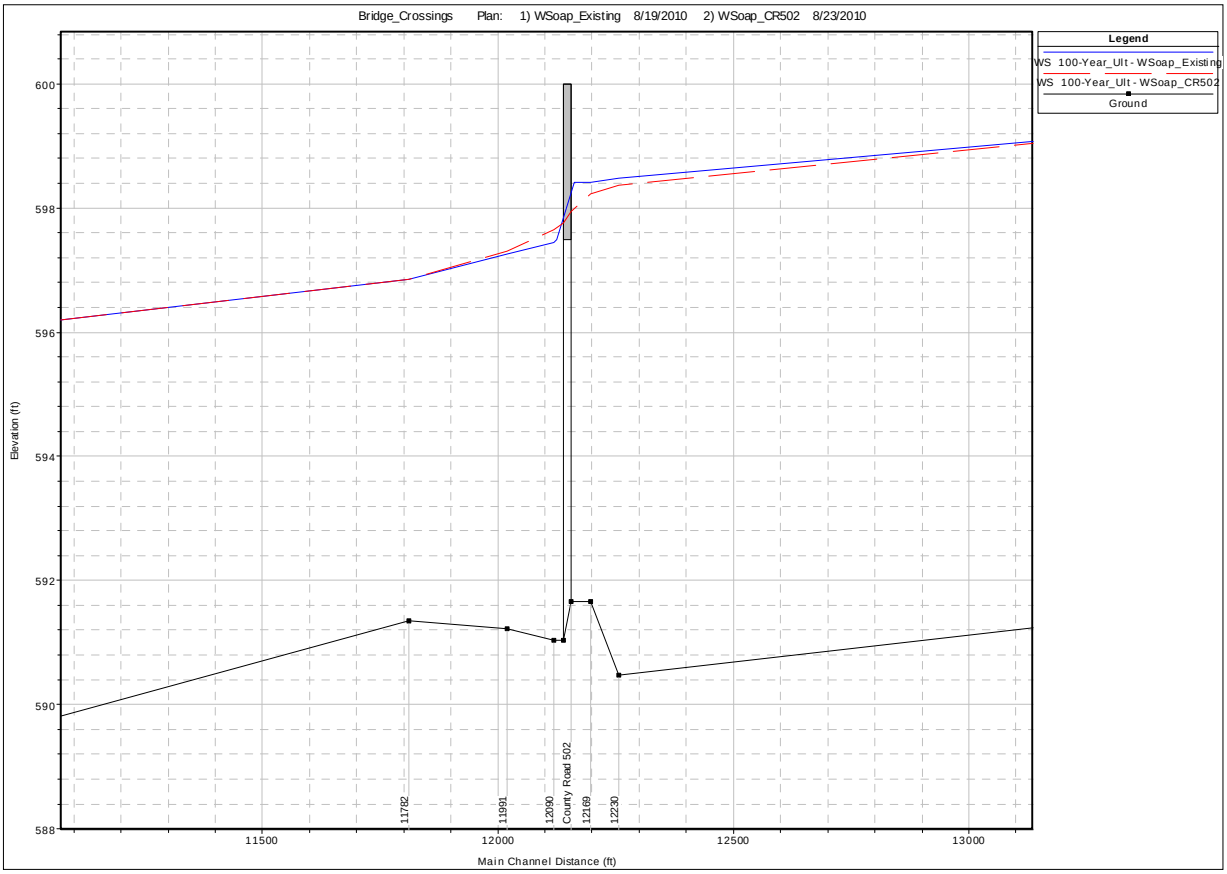
- Elevate minimum Top of Road to 591'
- Construct 350' bridge span opening

STATEMENT OF PROBABLE COST - 2010	
Subtotal	$965,100
25% Contingency	$241,300
CONSTRUCTION TOTAL	**$1,206,000**
10% for Engineering and Survey	$120,600
TOTAL	**$1,330,000**

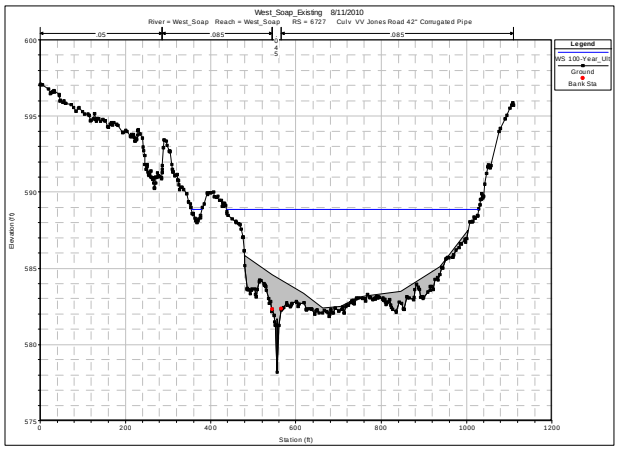
Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. If the Alternative 1 improvements at Jones Road were implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations increase up to 0.73' upstream of Jones Road as a result of the proposed improvements, but no existing structures are adversely affected by the increase in water surface elevations. Valley storage should not be negatively impacted, but will need to be checked for the final bridge design and mitigation plan prior to construction. Some mitigation alternatives will likely need to be considered to alleviate the rise caused by the improvements. The City may require a CLOMR if there is a rise caused by construction in the floodway. A LOMR will be necessary after construction of the improvements to incorporate floodplain mapping revisions into the FEMA mapping. Alternative 1 would require construction within the waters of the United States which can be permitted under

Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

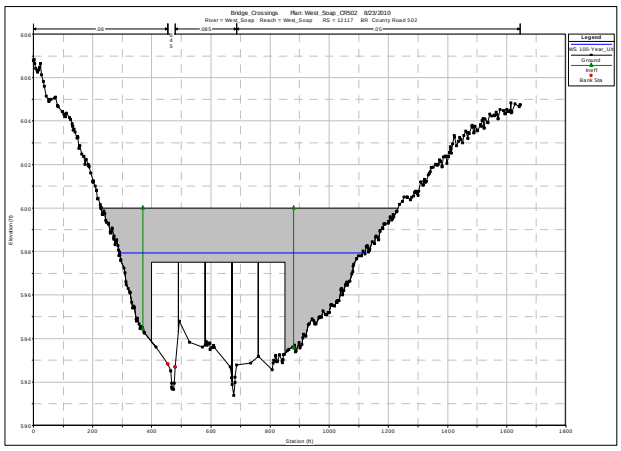
Jones Road Alternative 1 Profile Comparison



Jones Road Alternative 1 Bridge Comparison



Existing



Proposed

4. TURNER ROAD AT EAST SOAP CREEK (STREAM STATION 38+16)

The existing bridge crossing at Turner Road is comprised of three different sizes of steel culverts: one 5' culvert, one 8' culvert, and three 7' culverts. Each existing culvert has been disfigured from its original form and is partially blocked by a concrete slab in the bottom of the channel on the upstream side. Turner Road is overtopped by the existing 2-year storm event with the ultimate 100-year storm event overtopping the roadway by more than two feet.

Stream: East Soap Creek									
Model: East_Soap_Creek.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
9.	3816	*Turner Road*	609.34	No WSEL= 607.53	Yes WSEL= 610.24	Yes WSEL= 610.58	Yes WSEL= 610.86	Yes WSEL= 611.07	Yes WSEL= 611.31

Alternative 1

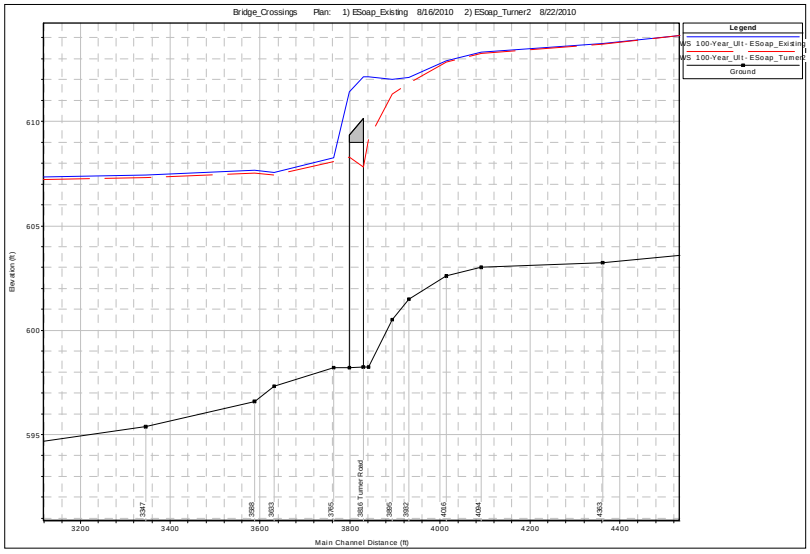
- Elevate minimum Top of Road to 611'
- Construct 125' bridge span opening
- Remove concrete and grade channel flowline upstream of Turner Road

STATEMENT OF PROBABLE COST - 2010	
Subtotal	$479,500
25% Contingency	$119,900
CONSTRUCTION TOTAL	**$599,000**
10% for Engineering and Survey	$59,900
TOTAL	**$660,000**

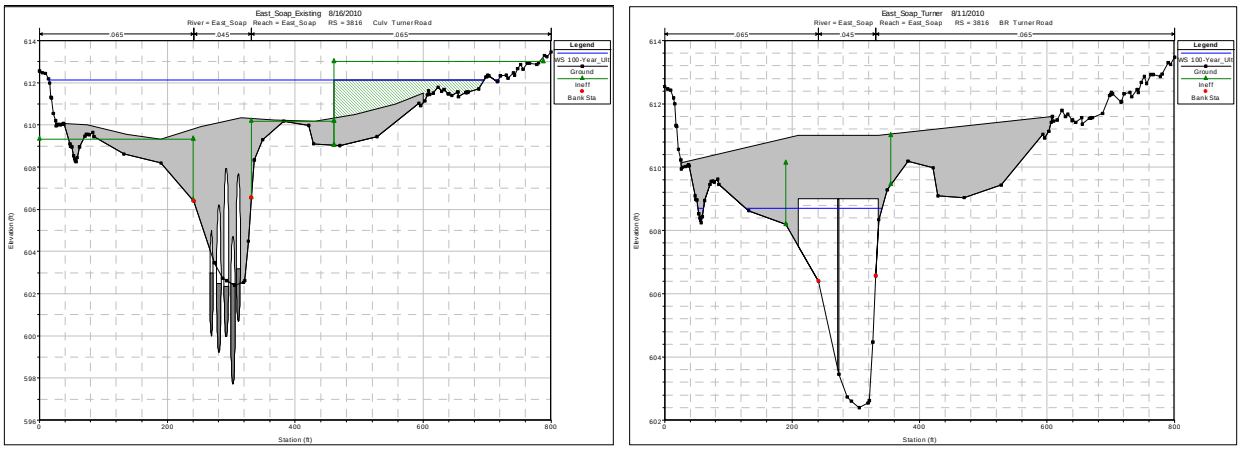
Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. The roadway elevation at the new bridge opening must be elevated to 611' to allow a large enough flow area to pass the ultimate 100-year discharge without the roadway being overtopped. The existing concrete upstream of the roadway appears to serve as toe protection for the existing culverts. If the new bridge is constructed, this concrete should be removed and the channel flowline graded to provide additional conveyance. The improvements at Turner Road are not dependent on any downstream improvements. If the Alternative 1 improvements at Turner Road were implemented the roadway would no

longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations are lowered up to 2.96' upstream of Turner road as a result of the proposed improvements. The improvements would benefit the area upstream of Turner Road; however, no existing structures benefit from the decrease in water surface elevations. Valley storage loss could be significant, but there are no structures downstream at this time that would be negatively impacted. Before construction of the improvements, a downstream impact assessment will need to be performed based on the final bridge design and any mitigation plan. This bridge will not span the entire existing floodway, but the improvements should allow for a revised floodway that will be within the limits of the proposed bridge span. A zero-rise certificate could potentially be completed to satisfy the requirements for construction within a floodway, but a LOMR would be needed to incorporate the revisions to the floodway. Alternative 1 would require construction within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

Turner Road Alternative 1 Profile Comparison



Turner Road Alternative 1 Bridge Comparison



Existing **Proposed**

5. COUNTY ROAD 502 AT GRASSY CREEK (STREAM STATION 317+37)

The existing bridge opening at County Road 502 is approximately 60' wide and is overtopped by the existing 2-year storm event with the ultimate 100-year storm event overtopping the roadway by almost five feet.

Stream: Grassy Creek									
Model: Mountain_Creek.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
123.	31737	*County Road 502*	621.20	Yes WSEL= 622.66	Yes WSEL= 623.85	Yes WSEL= 624.23	Yes WSEL= 624.69	Yes WSEL= 625.07	Yes WSEL= 625.43

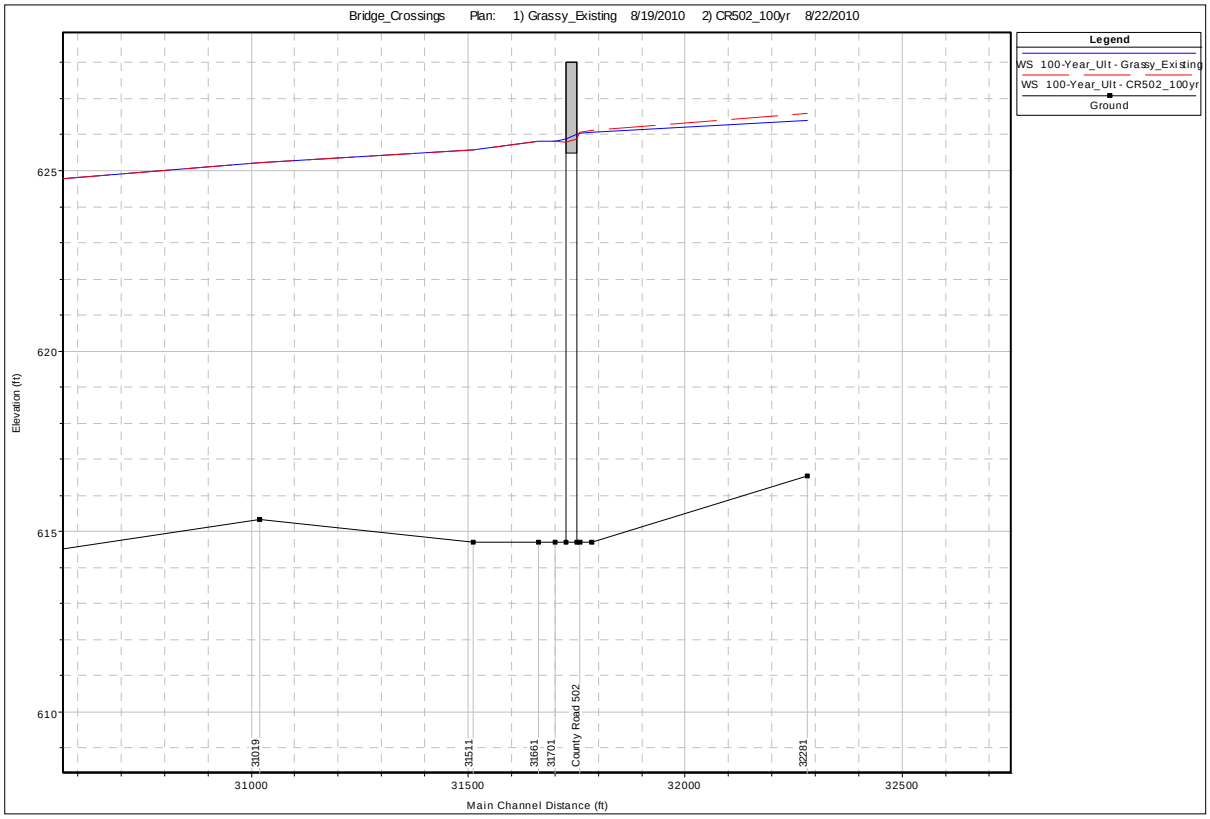
Alternative 1

- Elevate minimum Top of Road to 628'
- Widen bridge span opening to 350'

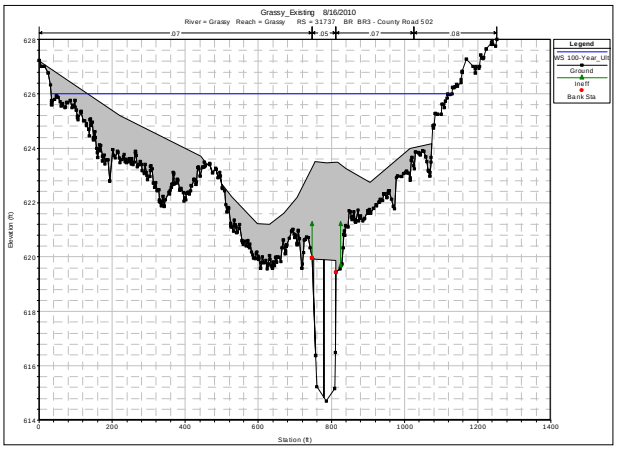
STATEMENT OF PROBABLE COST - 2010	
Subtotal	$1,225,250
25% Contingency	$306,300
CONSTRUCTION TOTAL	**$1,532,000**
10% for Engineering and Survey	$153,200
TOTAL	**$1,690,000**

Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. If the Alternative 1 improvements at County Road 502 were implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations increase up to 0.20' upstream of County Road 502 as a result of the proposed improvements. No existing structures inside the study area are adversely affected by the increase in water surface elevations, but there are structures just beyond the study area in Ellis County that would need to be evaluated regarding flood impacts prior to finalization of the bridge design. Valley storage should not be negatively impacted but will need to be checked for the final bridge design and mitigation plan prior to construction. Unless mitigation is implemented, the City may require a CLOMR due to the rise in water surface elevation as a result of construction in the floodway. A LOMR will be necessary after construction of the improvements to incorporate floodplain and floodway mapping revisions into the FEMA mapping. Alternative 1 would require construction within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

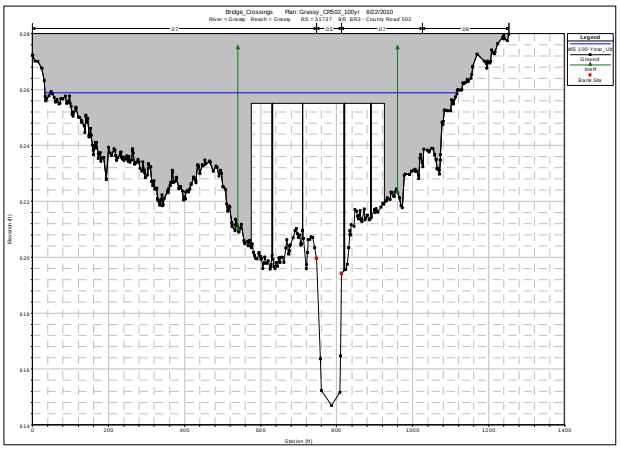
County Road 502 Alternative 1 Profile Comparison



County Road 502 Alternative 1 Bridge Comparison



Existing



Proposed

6. OLD FORT WORTH ROAD AT PLAINS BRANCH (STREAM STATION 50+78)

The existing bridge crossing at Old Fort Worth Road consists of one elliptical culvert with a 9' span and a 5' rise. Old Fort Worth Road is overtopped by the existing 2-year storm event with the ultimate 100-year storm event overtopping the roadway by more than two feet.

Stream: Plains Branch									
Model: Plains_Branch.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
11.	5078	*Old Fort Worth Road*	561.21	Yes WSEL= 561.52	Yes WSEL= 562.14	Yes WSEL= 562.54	Yes WSEL= 562.98	Yes WSEL= 563.24	Yes WSEL= 563.56

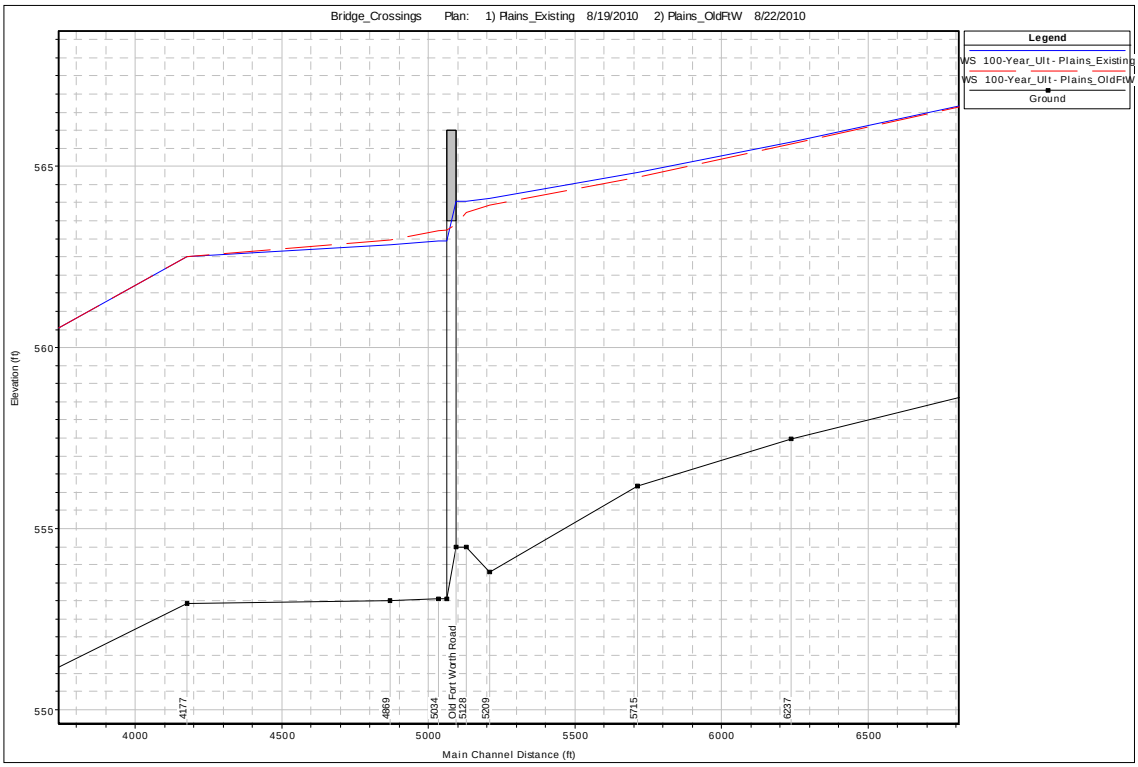
Alternative 1

- Elevate minimum Top of Road to 566'
- Construct 350' bridge span opening

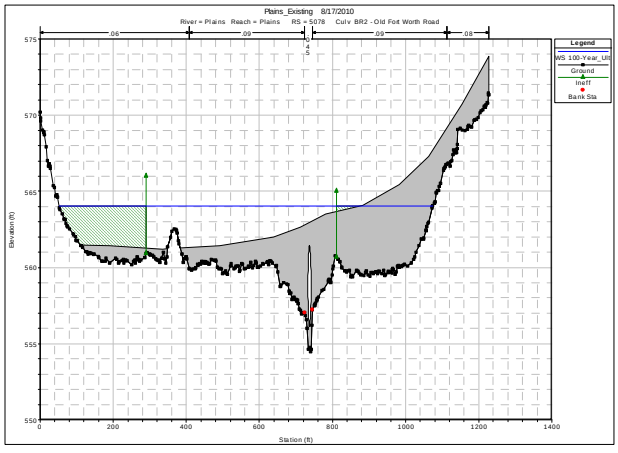
STATEMENT OF PROBABLE COST - 2010	
Subtotal	$1,225,375
25% Contingency	$306,300
CONSTRUCTION TOTAL	**$1,532,000**
10% for Engineering and Survey	$153,200
TOTAL	**$1,690,000**

Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. The Alternative 1 improvements require a long segment of roadway embankment in the left overbank to raise the top of road elevation high enough to prevent it from being overtopped by the ultimate 100-year flood event. If the Alternative 1 improvements at Old Fort Worth Road were implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations decrease by 0.30' at most upstream of Old Fort Worth Road as a result of the proposed improvements; however, only a few secondary structures benefit from the decrease in water surface elevations. Valley storage loss should be minimal, but will need to be checked for the final bridge design and mitigation plan prior to construction. A zero-rise certificate could potentially be completed to satisfy the requirements for construction within a floodway. A LOMR will be necessary after construction of the improvements to incorporate floodplain and floodway mapping revisions into the FEMA mapping. Alternative 1 would require construction within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

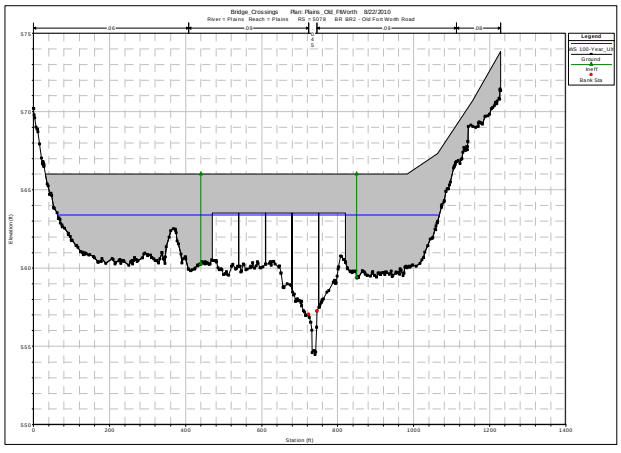
Old Fort Worth Road Alternative 1 Profile Comparison



Old Fort Worth Road Alternative 1 Bridge Comparison



Existing



Proposed

7. COUNTY ROAD 619 AT GRASSY CREEK (STREAM STATION 185+46)

The existing bridge crossing at County Road 619 consists of two elliptical culverts with a 5.5' span and a 6' rise. The existing roadway is only slightly elevated at the culvert crossing. County Road 619 is easily overtopped by the existing 2-year storm event with the ultimate 100-year storm event overtopping the roadway by more than eight feet.

Stream: Grassy Creek									
Model: Mountain_Creek.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
121.	18546	*County Road 619*	594.58	Yes WSEL= 598.92	Yes WSEL= 600.37	Yes WSEL= 601.06	Yes WSEL= 601.88	Yes WSEL= 602.32	Yes WSEL= 602.83

Alternative 1

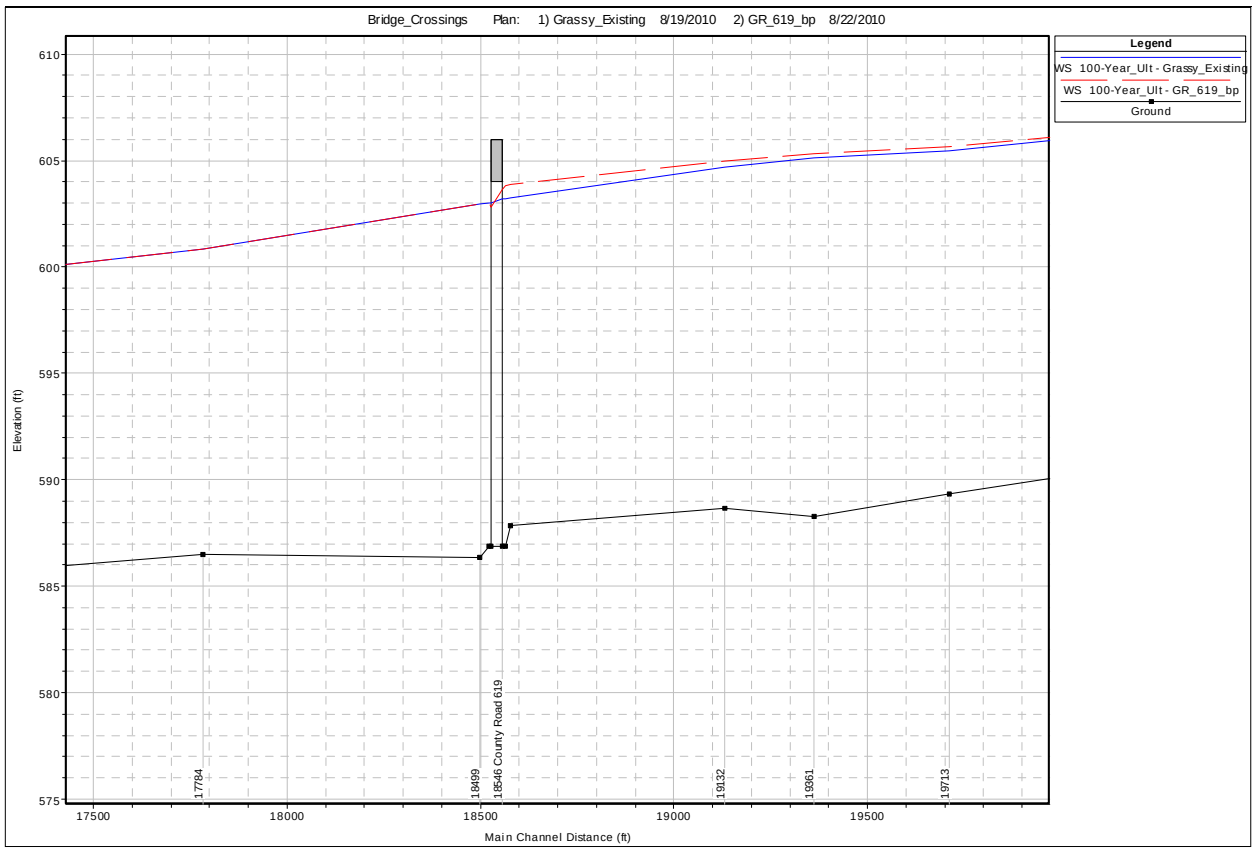
- Elevate minimum Top of Road to 606'
- Construct 400' bridge span opening

STATEMENT OF PROBABLE COST - 2010	
Subtotal	$1,399,500
25% Contingency	$349,900
CONSTRUCTION TOTAL	**$1,749,000**
10% for Engineering and Survey	$174,900
TOTAL	**$1,920,000**

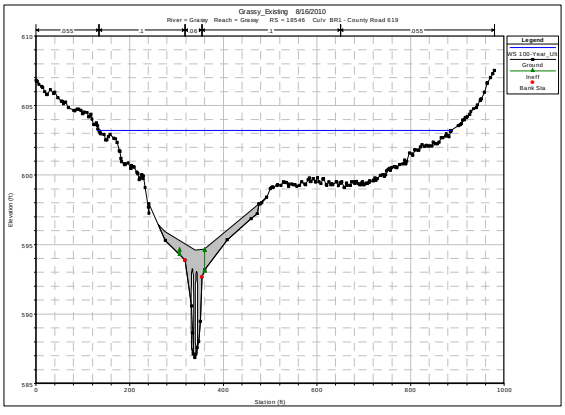
Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. If the Alternative 1 improvements at County Road 619 were implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations increase up to 0.60' upstream of County Road 619 as a result of the proposed improvements; however, no existing structures are adversely affected by the increase in water surface elevations. Valley storage should not be negatively impacted but will need to be checked for the final bridge design and mitigation plan prior to construction. Unless mitigation is implemented, the City may require a CLOMR due to the rise in water surface elevation as a result of construction in the floodway. A LOMR will be necessary after construction of the improvements to incorporate floodplain and floodway mapping revisions into the FEMA mapping. Alternative 1 would require construction

within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

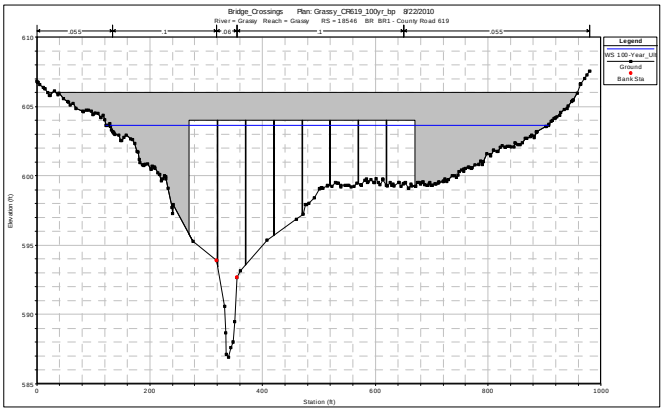
County Road 619 Alternative 1 Profile Comparison



County Road 619 Alternative 1 Bridge Comparison



Existing



Proposed

8. FM 661 AT MOUNTAIN CREEK (STREAM STATION 46+72)

The existing bridge opening at FM 661 is approximately 300' wide and is overtopped by the existing 5-year storm event with the ultimate 100-year storm event overtopping the roadway by more than four feet.

Stream: Mountain Creek									
Model: Mountain_Creek.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
124.	4672	*FM 661*	537.13	No WSEL= 536.38	Yes WSEL= 538.23	Yes WSEL= 538.93	Yes WSEL= 539.98	Yes WSEL= 540.79	Yes WSEL= 541.54

Alternative 1

- Elevate minimum Top of Road to 545'
- Widen bridge span opening to 500'

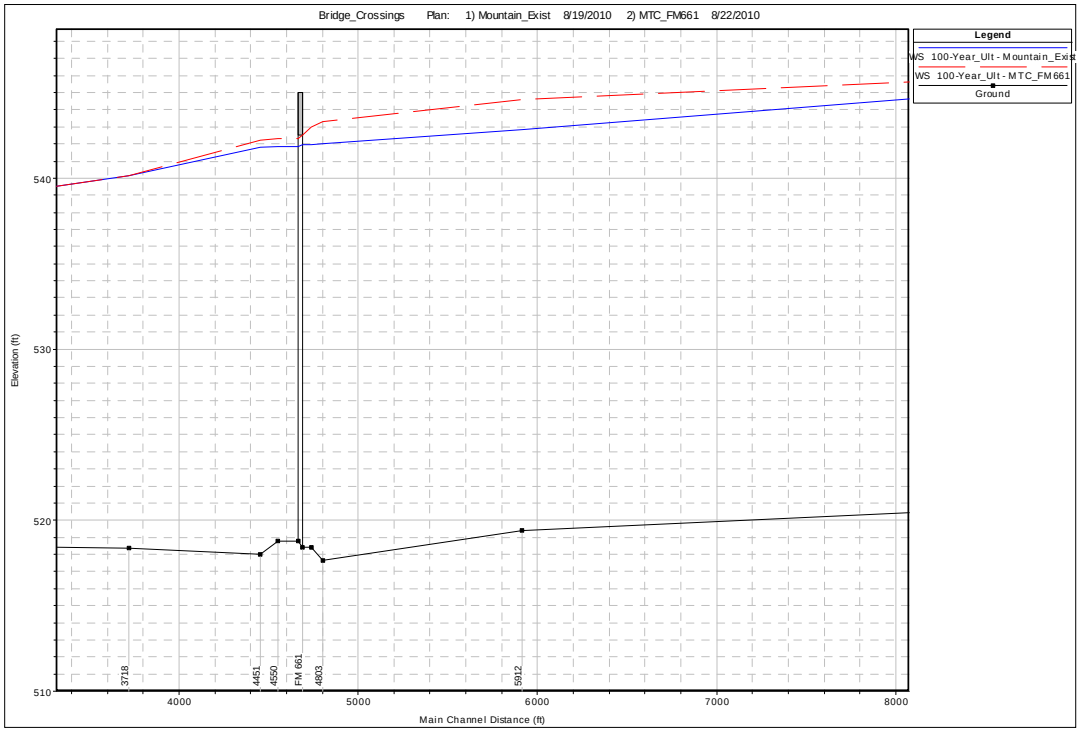
STATEMENT OF PROBABLE COST - 2010	
Subtotal	$1,902,500
25% Contingency	$475,600
CONSTRUCTION TOTAL	**$2,378,000**
10% for Engineering and Survey	$237,800
TOTAL	**$2,620,000**

Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. The Alternative 1 improvements were designed to encroach into the floodway limits. Since the floodway is 1,300 feet wide at FM 661, it seemed economically infeasible to span the entire floodway. The ultimate 100-year water surface elevations increase up to 1.73' upstream of FM 661 as a result of the proposed improvements; however, it does not appear that any structures will be negatively impacted by the increase in water surface elevations at this time. This bridge will not span the entire existing floodway, but the improvements should allow for a revised floodway that will be within the limits of the proposed bridge span. Unless mitigation is implemented, the City may require a CLOMR due to the rise in water surface elevation as a result of construction in the floodway.

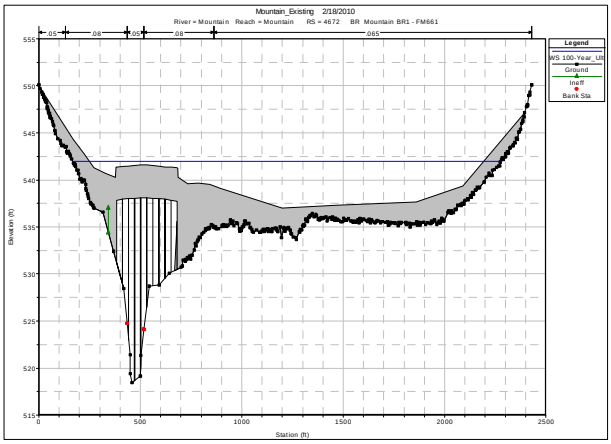
If the Alternative 1 improvements at FM 661 are implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. Valley storage should not be

negatively impacted but will need to be checked for the final bridge design and mitigation plan prior to construction. A LOMR will be necessary after construction of the improvements to incorporate floodplain and floodway mapping revisions into the FEMA mapping. Alternative 1 would require construction within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

FM 661 Alternative 1 Profile Comparison



FM 661 Alternative 1 Bridge Comparison



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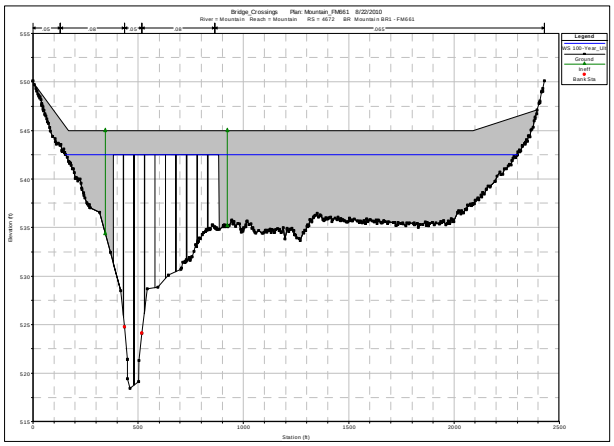


Proposed

9. SEETON ROAD AT TAAFFE CREEK (STREAM STATION 27+03)

The existing bridge crossing at Seeton Road consists of four 8'x 5' box culverts. The existing culverts at Seeton Road only have the capacity to pass the existing 10-year storm event without the roadway being overtopped. Seeton Road is overtopped by the existing 50-year storm event with the ultimate 100-year storm event overtopping the roadway by more than half a foot.

Stream: Taaffe Creek									
Model: TAAFFE_CREEK.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
6.	2703	*Seeton Road*	537.13	No WSEL= 532.80	No WSEL= 534.18	No WSEL= 535.05	No WSEL= 535.85	Yes WSEL= 537.15	Yes WSEL= 537.76

Alternative 1

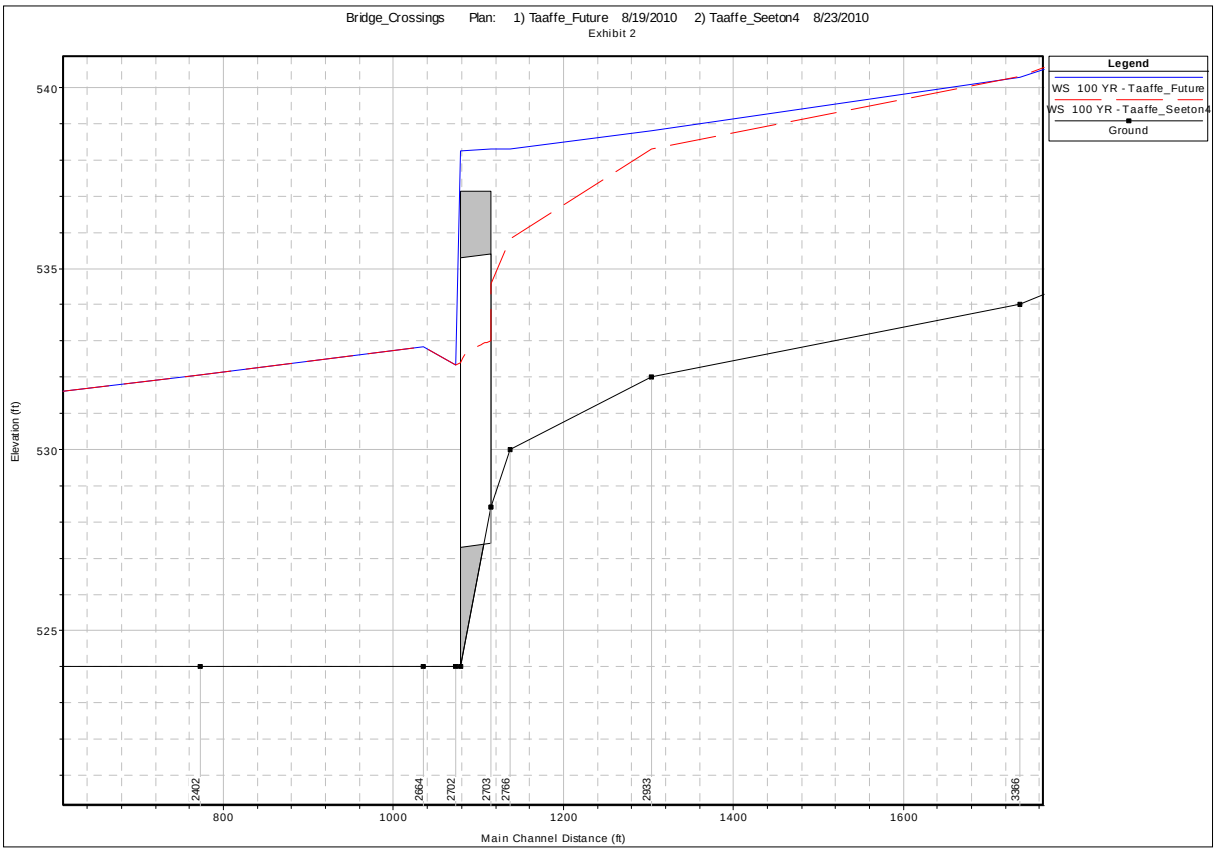
- Construct 4 – 8' x 8' Concrete Box Culverts

STATEMENT OF PROBABLE COST - 2010	
Subtotal	$314,800
25% Contingency	$78,700
CONSTRUCTION TOTAL	**$394,000**
10% for Engineering and Survey	$39,400
TOTAL	**$430,000**

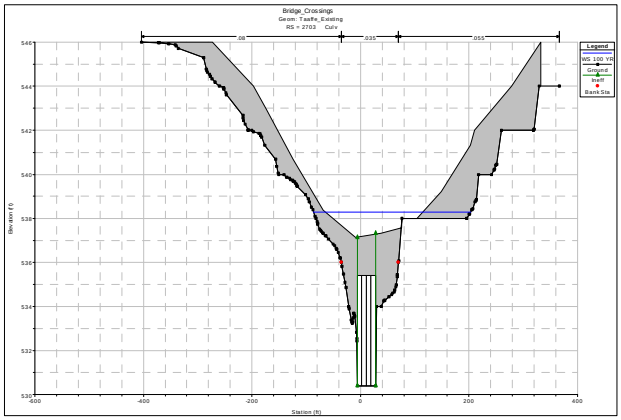
Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. If the Alternative 1 improvements at Seeton Road were implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations decrease up to 2.47' upstream of Seeton Road as a result of the proposed improvements; however, no existing structures benefit from the decrease in water surface elevations. Valley storage will be reduced as a result of this improvement. At the time of this report, no structures downstream appear to be negatively affected. This situation should be re-evaluated prior to the final design and construction. If any possible structures could be affected, a downstream impact assessment should be performed. There is not a mapped floodway along Taaffe Creek so it will be up to the City's discretion whether a CLOMR is required. A LOMR could be necessary after construction of the

improvements to incorporate floodplain mapping revisions into the FEMA mapping. Alternative 1 would require construction within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

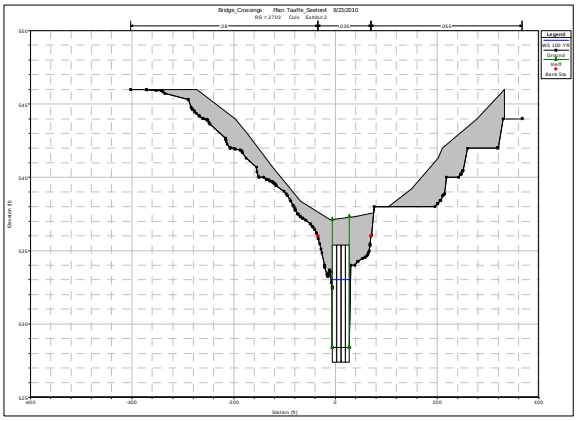
Seeton Road Alternative 1 Profile Comparison



Seeton Road Alternative 1 Bridge Comparison



Existing



Proposed

10. COUNTY ROAD 502 AT WEST SOAP CREEK (STREAM STATION 121+17)

The existing bridge opening at County Road 502 at West Soap Creek is approximately 15' wide and is overtopped by the existing 2-year storm event with the ultimate 100-year storm event overtopping the roadway by more than three feet. There are also multiple relief culverts in the right overbank including two 1.5' diameter culverts, one 2' diameter culvert, one 2.5' diameter culvert, and one 3.0' diameter culvert.

Stream: West Soap Creek									
Model: West_Soap_Creek.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
119.	12117	*County Road 502*	594.46	Yes WSEL= 595.70	Yes WSEL= 596.40	Yes WSEL= 596.78	Yes WSEL= 597.23	Yes WSEL= 597.49	Yes WSEL= 597.66

Alternative 1

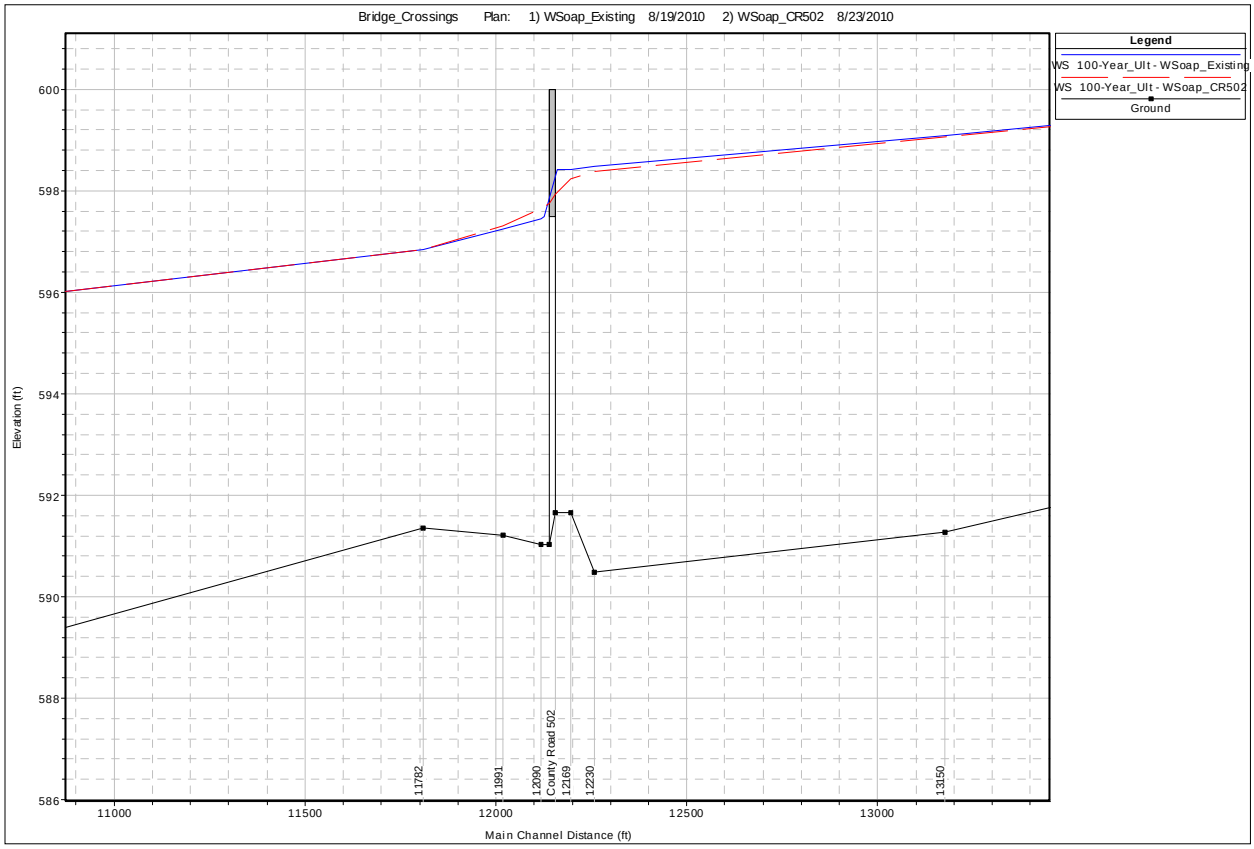
- Elevate minimum Top of Road to 600'
- Construct 450' bridge span opening

STATEMENT OF PROBABLE COST - 2010	
Subtotal	$1,467,100
25% Contingency	$366,800
CONSTRUCTION TOTAL	**$1,834,000**
10% for Engineering and Survey	$183,400
TOTAL	**$2,020,000**

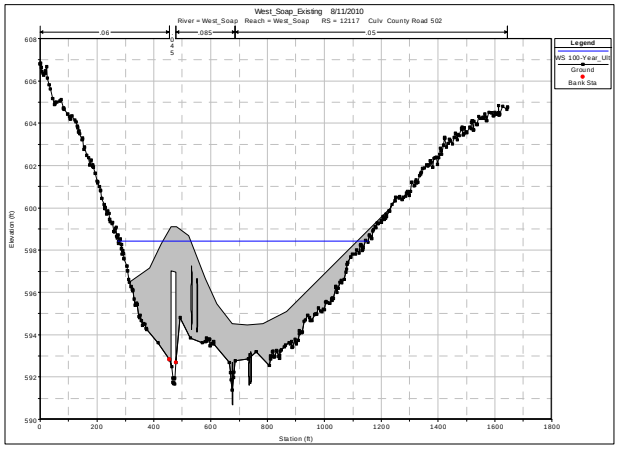
Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. If the Alternative 1 improvements at County Road 502 at West Soap Creek were implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations decrease by 0.32'upstream of County Road 502 as a result of the proposed improvements; however, no existing structures benefit from the decrease in water surface elevations. Valley storage will be reduced as a result of this improvement. At the time of this report, no structures downstream appear to be negatively affected. This situation should be re-evaluated prior to the final design and construction. If any possible structures could be affected, a downstream impact assessment should be performed. Alternative 1 would require construction within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear

Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

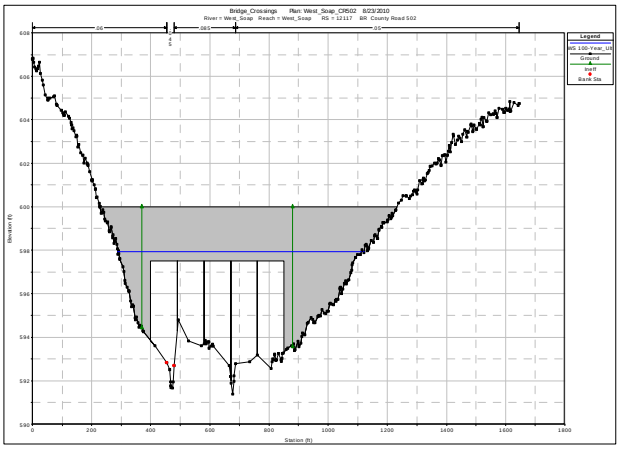
County Road 502 Alternative 1 Profile Comparison



County Road 502 Alternative 1 Bridge Comparison



Existing



Proposed

11. KIMBLE ROAD AT NEWTON BRANCH (STREAM STATION 86+76)

The existing bridge crossing at Kimble Road consists of two 5' corrugated metal pipe culverts. Kimble Road is overtopped by the existing 2-year storm event with the ultimate 100-year storm event overtopping the roadway by almost four feet.

Stream: Newton Branch									
Model: Newton_Branch.prj (HEC-RAS)									
River Station		**Roadway Crossing**	**Min. Top of Road Elev.**	**Ex. 50% Event Overtops Road**	**Ex. 20% Event Overtops Road**	**Ex. 10% Event Overtops Road**	**Ex. 4% Event Overtops Road**	**Ex. 2% Event Overtops Road**	**Ex. 1% Event Overtops Road**
13.	8676	*Kimble Road*	559.80	No WSEL= 557.78	Yes WSEL= 560.66	Yes WSEL= 561.63	Yes WSEL= 562.29	Yes WSEL= 562.71	Yes WSEL= 563.14

Alternative 1

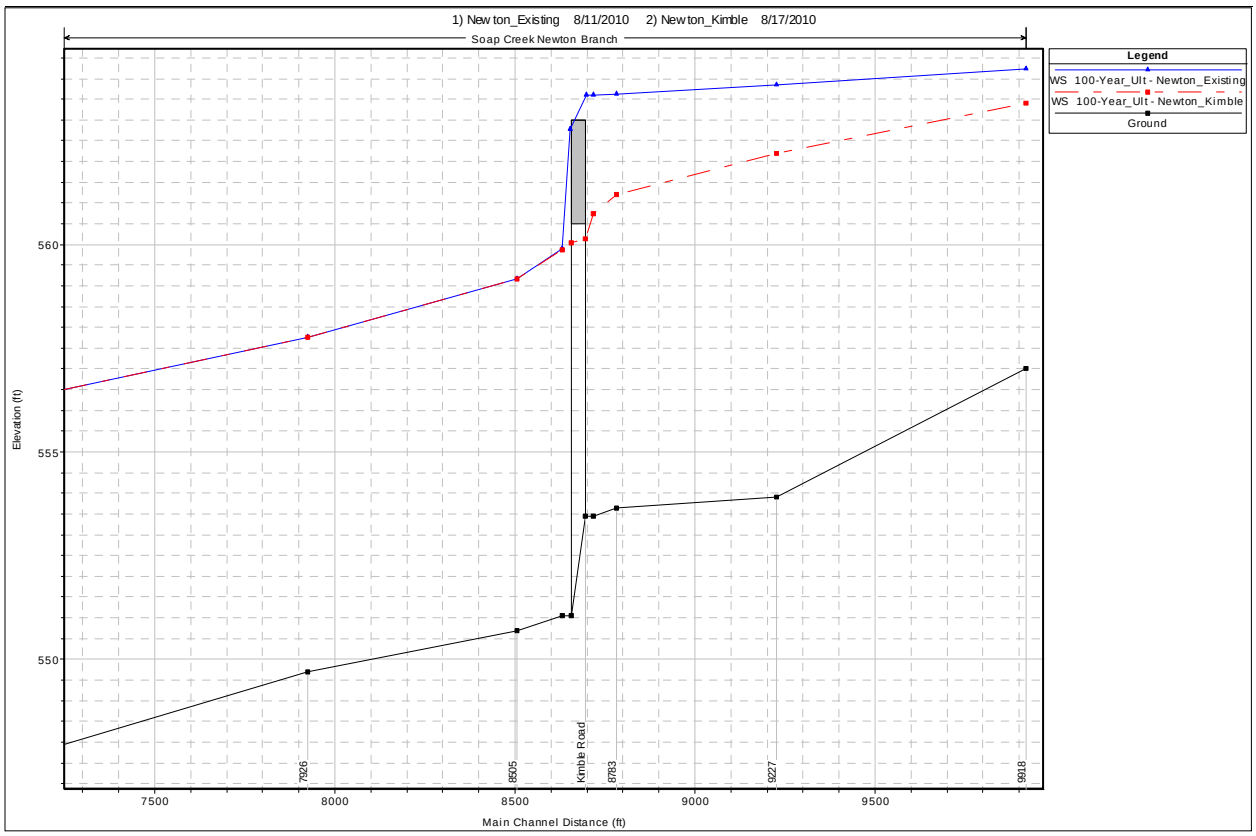
- Elevate minimum Top of Road to 563'
- Construct 375' bridge span opening

STATEMENT OF PROBABLE COST - 2010	
Subtotal	$1,054,000
25% Contingency	$263,500
CONSTRUCTION TOTAL	**$1,318,000**
10% for Engineering and Survey	$131,800
TOTAL	**$1,450,000**

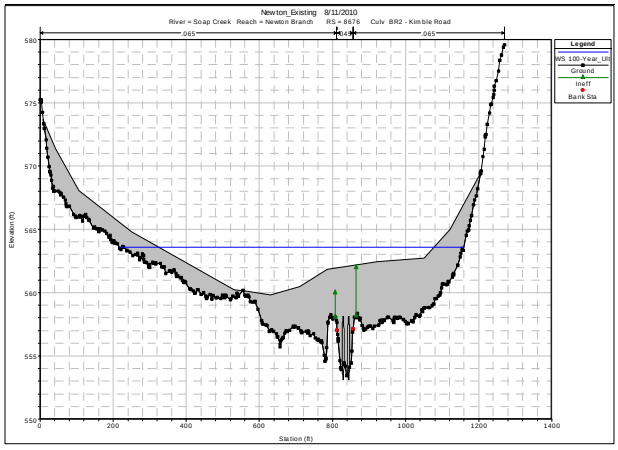
Refer to Section XII of this report for a detailed break down of the preliminary cost estimate. If the Alternative 1 improvements at Kimble Road were implemented the roadway would no longer be overtopped by the ultimate 100-year storm event. The ultimate 100-year water surface elevations decrease up to 2.86' upstream of Kimble Road as a result of the proposed improvements; however, no existing structures benefit from the decrease in water surface elevations. Valley storage loss could be significant, but it appears there are no structures downstream at this time that would be negatively impacted. Before construction of the improvements, a downstream impact assessment will need to be performed based on the final bridge design and any mitigation plan. A zero-rise certificate could potentially be completed to satisfy the requirements for construction within a floodway. A LOMR will be necessary after construction of the improvements to incorporate floodplain and floodway mapping revisions into the FEMA mapping. Alternative 1 would require construction

within the waters of the United States which can be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act.

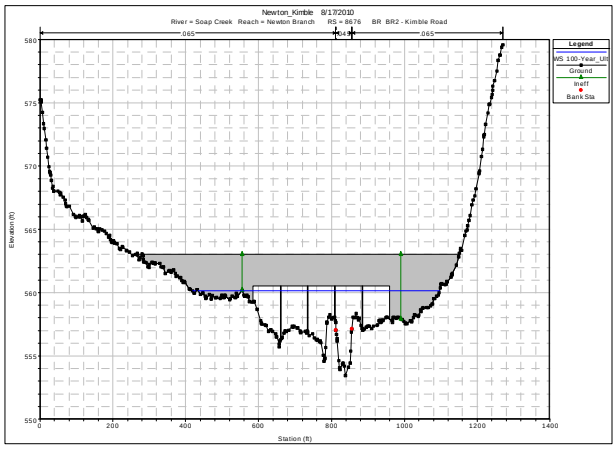
Kimble Road Alternative 1 Profile Comparison



Kimble Road Alternative 1 Bridge Comparison



Existing



Proposed

REGIONAL DETENTION BASIN AT GRASSY CREEK

A relatively large regional storm water detention basin could be located and sized to retain a specified volume of storm water so that the peak of the runoff would be reduced. Such regional basins are typically large enough to require the city to construct and maintain the facilities. Basins could be incorporated into a community or regional park site and function as a major recreational amenity to the park.

One feasible location for a possible regional detention basin in the Joe Pool Lake watershed would be at the confluence of Grassy Creek Tributary with Grassy Creek. This location is currently undeveloped with large open fields and range land.

Alternative 1: Detain 100-year Existing Peak Discharge; Release 10-year Existing Peak Discharge

Grassy Creek - 100yr Existing to 10yr Existing			
Location	Volume (ac-ft)	Detention Area (acres)	Reclaimed Area (acres)
Confluence of Grassy Creek Tributary with Grassy Creek	1,400	240	41

Alternative 1 reclaims 41 acres of developable property along Grassy Creek to its confluence with Mountain Creek. To reduce peak discharges from 100-year existing to 10-year existing conditions the regional detention basin must detain approximately 1,400 ac-ft of storm water. Assuming a depth of 6 feet, this alternative will require approximately 240 acres of land.

Alternative 2: Detain 100-year Ultimate Peak Discharge; Release 100-year Existing Peak Discharge

Grassy Creek - 100yr Ultimate to 100yr Existing			
Location	Volume (ac-ft)	Detention Area (acres)	Reclaimed Area (acres)
Confluence of Grassy Creek Tributary with Grassy Creek	600	100	8

Alternative 2 reclaims 8 acres of developable property along Grassy Creek to its confluence with Mountain Creek. To reduce peak discharges from 100-year ultimate to 100-year

existing conditions the regional detention basin must detain approximately 600 ac-ft of storm water. Assuming a depth of 6 feet, this alternative will require approximately 100 acres of land.

The only justification for regional detention at this time would be to mitigate the effects of future development and provide more developable property. The City would need to consider the long-term benefits based on anticipated future development in the basins with the initial investment and annual maintenance costs of a regional detention facility. At this point, neither alternative 1 nor alternative 2 are considered feasible alternatives.

REGIONAL DETENTION BASIN AT SOAP CREEK

A relatively large regional storm water detention basin could be located and sized to retain a specified volume of storm water so that the peak of the runoff would be reduced. Such regional basins are typically large enough to require the city to construct and maintain the facilities. Basins could be incorporated into a community or regional park site and function as a major recreational amenity to the park.

One feasible location for a possible regional detention basin in the Joe Pool Lake watershed would be at the confluence of West Soap Creek Tributary with Soap Creek. This location is currently undeveloped with large open fields and range land.

Alternative 1: Detain 100-year Existing Peak Discharge; Release 10-year Existing Peak Discharge

Soap Creek - 100yr Existing to 10yr Existing			
Location	Volume (ac-ft)	Detention Area (acres)	Reclaimed Area (acres)
Confluence of West Soap Creek Tributary with Soap Creek	2,500	500	95

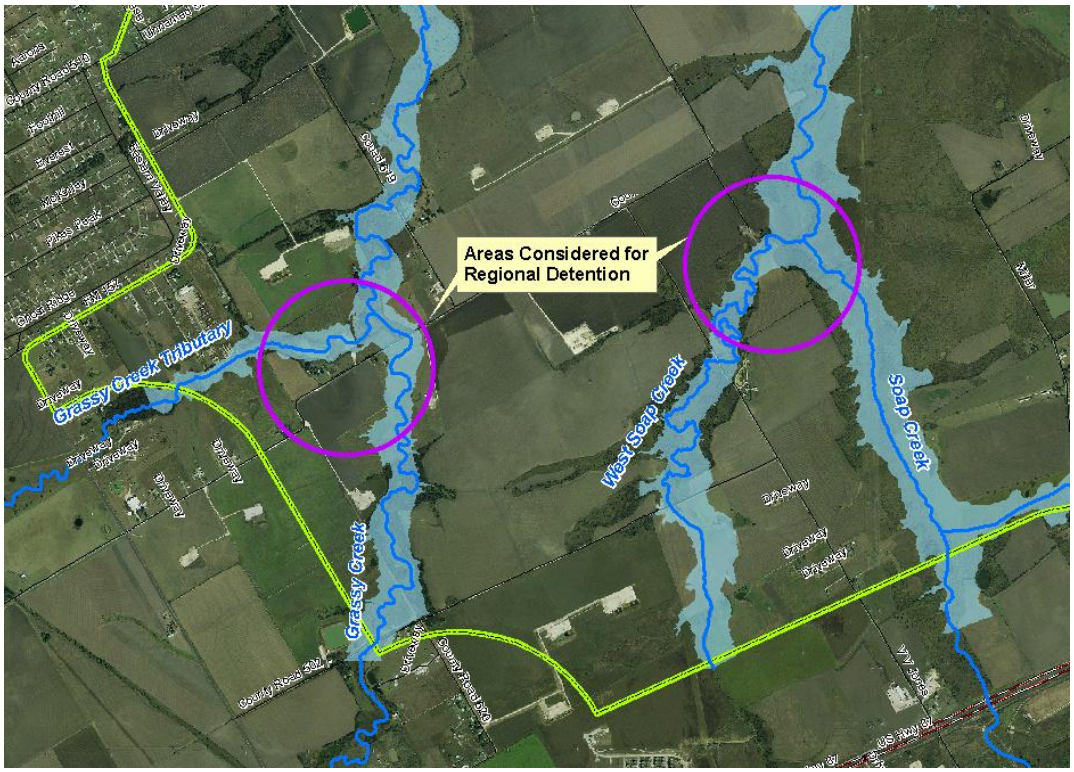
Alternative 1 reclaims 95 acres of developable property along Soap Creek to its confluence with Mountain Creek. To reduce peak discharges from 100-year existing to 10-year existing conditions the regional detention basin must detain approximately 2,500 ac-ft of storm water. Assuming a depth of 6 feet, this alternative will require approximately 500 acres of land.

Alternative 2: 100-Year Ultimate Conditions to 100-year Existing Conditions

Soap Creek - 100yr Ultimate to 100yr Existing			
Location	Volume (ac-ft)	Detention Area (acres)	Reclaimed Area (acres)
Confluence of West Soap Creek Tributary with Soap Creek	1,200	200	12

Alternative 2 reclaims 12 acres of developable property along Soap Creek to its confluence with Mountain Creek. To reduce peak discharges from 100-year ultimate to 100-year existing conditions the regional detention basin must detain 1,200 ac-ft of storm water. Assuming a depth of 6 feet, this alternative will require approximately 200 acres of land.

The only justification for regional detention at this time would be to mitigate the effects of future development and provide more developable property. The City would need to consider the long-term benefits based on anticipated future development in the basins with the initial investment and annual maintenance costs of a regional detention facility. At this point, neither alternative 1 nor alternative 2 are considered feasible alternatives.



VIII. Storm Water Infrastructure Analysis

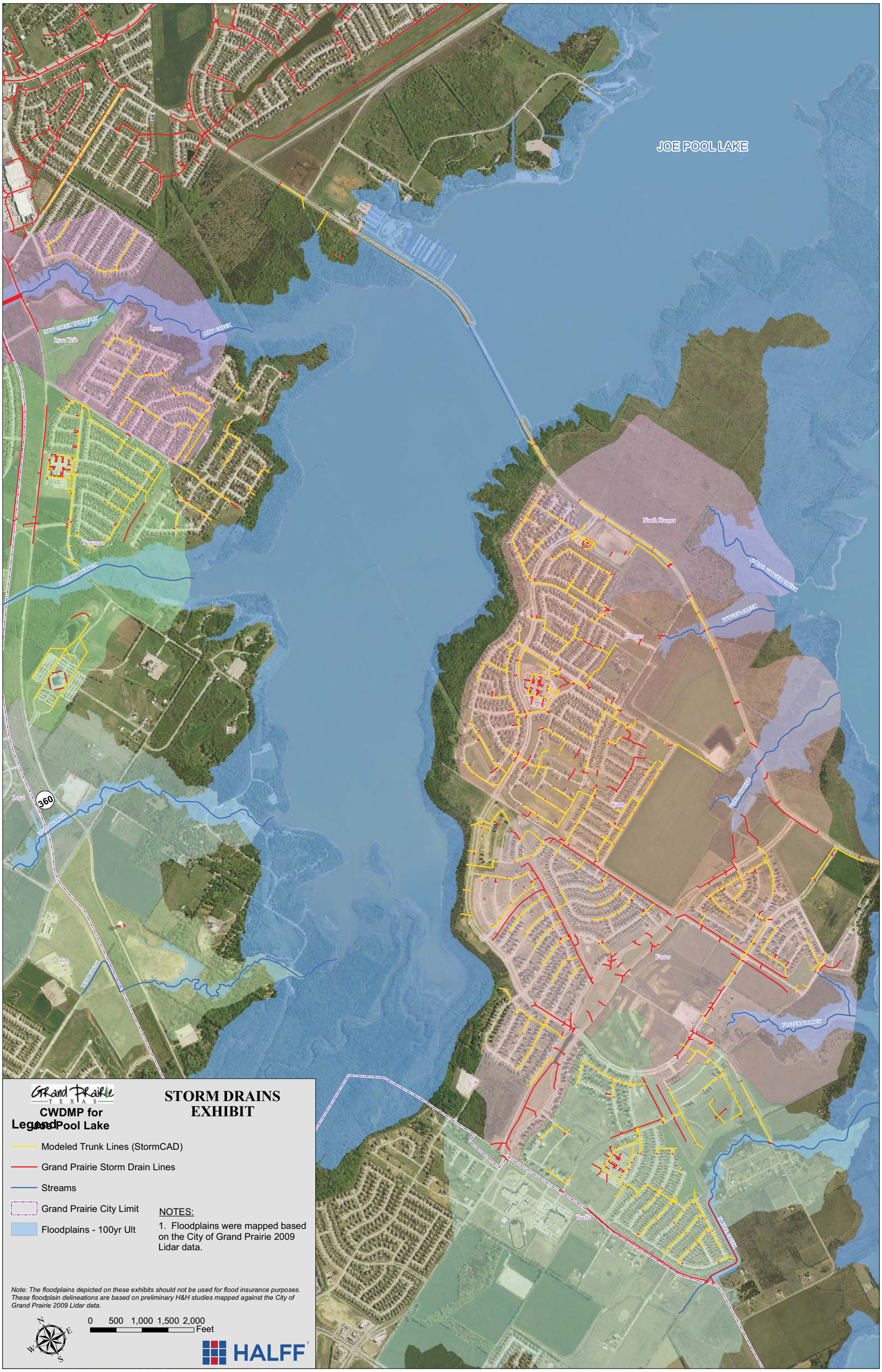


Figure VIII-1 Storm Drains

VIII. STORM WATER INFRASTRUCTURE ANALYSIS

A. OVERVIEW

Storm water drainage network models were prepared utilizing the City-wide Storm Water Infrastructure GIS database and existing record plans. StormCad V8i was utilized to convert plan data into a digital model for the storm sewer trunk lines in the Joe Pool Lake watershed. The age of each system was calculated based on the dates from the GIS database. Most systems within the Joe Pool Lake watershed were designed within the last 10 years using City design standards and criteria. Nearly all of the systems evaluated appear to have been designed for the discharges being carried (i.e. not many areas of new development were found directing runoff into older storm drain systems). There were no hot spot locations identified as part of this storm water infrastructure analysis. The StormCad models indicated sporadic surcharge locations based on EGL calculations, however, none of the surcharge locations corresponded to drainage complaints filed with the City.

The StormCad models were only conversions of existing storm drain plans for trunk lines in the watershed. Models should be checked for inaccuracies in the existing plans and data conversion process prior to utilizing these models for design..

Shapefiles were exported from the StormCad models with all of the input and output data from the storm water infrastructure analysis. Information within these shapefiles can be queried to analyze multiple hydraulic parameters. For example, the shapefiles could be used to identify locations where the EGL calculations were within one foot of the inlet elevation or locations where velocities were greater than 6 ft/s. These locations can quickly be identified and visualized within GIS. The exported shapefiles can be found on the CD-ROM located in Appendix I of this report.

B. EXISTING CAPACITY ANALYSIS

The record plans for each storm drain trunk line in the Joe Pool Lake watershed were converted to StormCad V8i. Discharges were not re-calculated for this analysis. Inlet capacity and laterals were not considered. Record plans were utilized to determine discharges that were input to the model at junction locations. Following is a summary of the methodology used to convert the record plans to StormCad models and compute the existing capacity analysis.

1. Conduit Length

StormCad calculated a length when the City's GIS storm drains were imported into the program. However, this length was approximate and was always overridden with a user specified length determined from the plans.

2. Junction Losses

Junction losses were applied based on the City's Drainage Design Manual Table 8.6. The Generic Headloss Method was always used.

- Inlets – Downstream coefficient = 1.5, Upstream Coefficient = 0
- Degree Bends – Downstream coefficient =1.0, Upstream Coefficient = 1 - K_j (Refer to DDM Table 8.6 for K_j values).
- Other Junctions – Downstream coefficient = 1, Upstream Coefficient = K_j (Refer to DDM Table 8.6 for K_j values).
- Pipe size changes for incoming laterals were not modeled as separate nodes in this study
- The starting branch / lateral K_j was not used for laterals modeled but the mainline K_j was used. This method was chosen to reduce the number of duplicate models that would be necessary to model a separate K_j for each lateral and mainline intersection. In future studies, a separate model may be required to study some laterals.
- A minimum minor loss of 0.1' was used for nodes.

3. Downstream Boundary Condition

The downstream boundary conditions type was always set to user-defined tailwater. The tailwater elevations were entered as the known HGL based on the design plans or the crown of pipe if HGL information was not available.

4. Model Builder

Model Builder was used to import GIS files directly from the City-wide Storm Water Infrastructure GIS database directly into StormCad.

5. Physical Properties

The physical properties of the conduit lines and nodes (including conduit sizes and shapes, invert elevations, ground elevations, etc.) were taken directly from the design plans or record drawings and attributed to the imported GIS files inside StormCad.

6. Manning's N Values

A value of 0.013 was used for all concrete and HDPE pipes.

7. Base Calculation Options

Base Calculation Options were set to be consistent and match the City's Drainage Design Manual to the extent possible.

- General
  - Calculation Type – Analysis selected.
- Hydraulics
  - Flow Profile Method - Capacity Analysis selected
  - Hydraulic Grade Convergence Test – 0.001
  - Average Velocity Method – Full flow velocity selected
  - Minimum Structure Loss – 0.1 selected
  - Structure Loss Mode – Hydraulic Grade selected
- Generic Structure Losses
  - Governing Upstream Pipe Selection Method – Pipe with Max QV selected

C. STORMCAD RESULTS

Some discrepancies were noted between the results of the converted StormCad models and the as-built storm drain plans. Several possible explanations exist:

1. Minor Loss coefficients were updated for inlets based on the current City of Grand Prairie Drainage design manual.

2. StormCad calculates partial flow while most spreadsheets do not. The result is different HGL elevations as pipes transition from partial to pressure flow.

Also, StormCad calculates partial flow velocities that are used in the head loss calculations as pipes transition to pressure flow. Generally speaking, the partial flow velocities were much higher than the full flow velocities and the losses through the junctions (as the flow transitioned to pressure) were sometimes very significant (over 4-feet). This resulted in some discrepancies between the StormCad results and the as-built plans which generally used full flow velocities and started the HGL at the top of pipe for pressure flow calculations.

IX. Channel Stability Assessment

IX. CHANNEL STABILITY ASSESSMENT & EROSION HAZARD ANALYSIS

A. OVERVIEW OF EROSION AND SEDIMENTATION ASSESSMENT

This section of the City-Wide Drainage Master Plan for Joe Pool Lake provides the results of the erosion and sedimentation assessment based on the hydrology and hydraulics analysis for the Joe Pool Lake streams. Selected results from the previous Channel Stability Assessment (2006) and Stream Bank Stability Alternatives Analysis (2006) from the Joe Pool Lake Drainage Master Plan (W.O. 540.26) have been incorporated into this report. Halff Associates utilized local drainage and erosion criteria from the City of Grand Prairie and available stream bank stability measures to come up with solutions to existing and potential erosion problems for Joe Pool Lake studied tributaries.

B. EROSION AND SEDIMENTATION LOCATION DETERMINATION

Erosion and sedimentation locations for the 2006 Joe Pool Lake studied tributaries were determined from onsite visual inspection of each stream and observing hydraulic parameters indicative of erosion/sedimentation from the HEC-RAS hydraulic models. Peter Allen, PhD, professor of geology from Baylor University and his staff developed a Joe Pool Stream Assessment Report (included in Appendix H) detailing their geomorphology analysis of the 2006 Joe Pool Lake studied tributaries. As part of the assessment, Dr. Allen and his staff performed a detailed walk-through of each stream bed, including preparing detailed field notes, taking photographs, and identifying certain definitive characteristics of channel erosion. The HEC-RAS hydraulic models of the nine evaluated tributaries were executed for the 1- and 100-year flood events to represent low flow (1-year), and high-volume flooding conditions (100-year). For the nine evaluated tributaries, stream power was used as an indicator of channel stability. Channels with stream power over 3.4 lb/ft-sec are prone to erosion and instability, while channels with stream power below 1.0 lb/ft-sec are prone to deposition and aggradation. Channels are stable in the 2.5 lb/ft-sec range. Refer to Table IX-1 for the selected streams assessed in 2006 by Dr. Allen and Halff Associates.

Table IX-1 - 2006 Joe Pool Lake Studied Tributaries

Tributary Name	Length (ft)*
Bedford Branch	15,371
Penwell Branch	6,324
Small Branch	7,871
Edge Creek	10,912
Taaffe Creek	6,942
Stuart Branch	4,743
Swadley Creek	6,808
Mills Branch	3,968
Tarrell Creek	4,998
* Note: These lengths were taken from centerline data in GIS and are based on stream lengths within the city limits of Grand Prairie.	

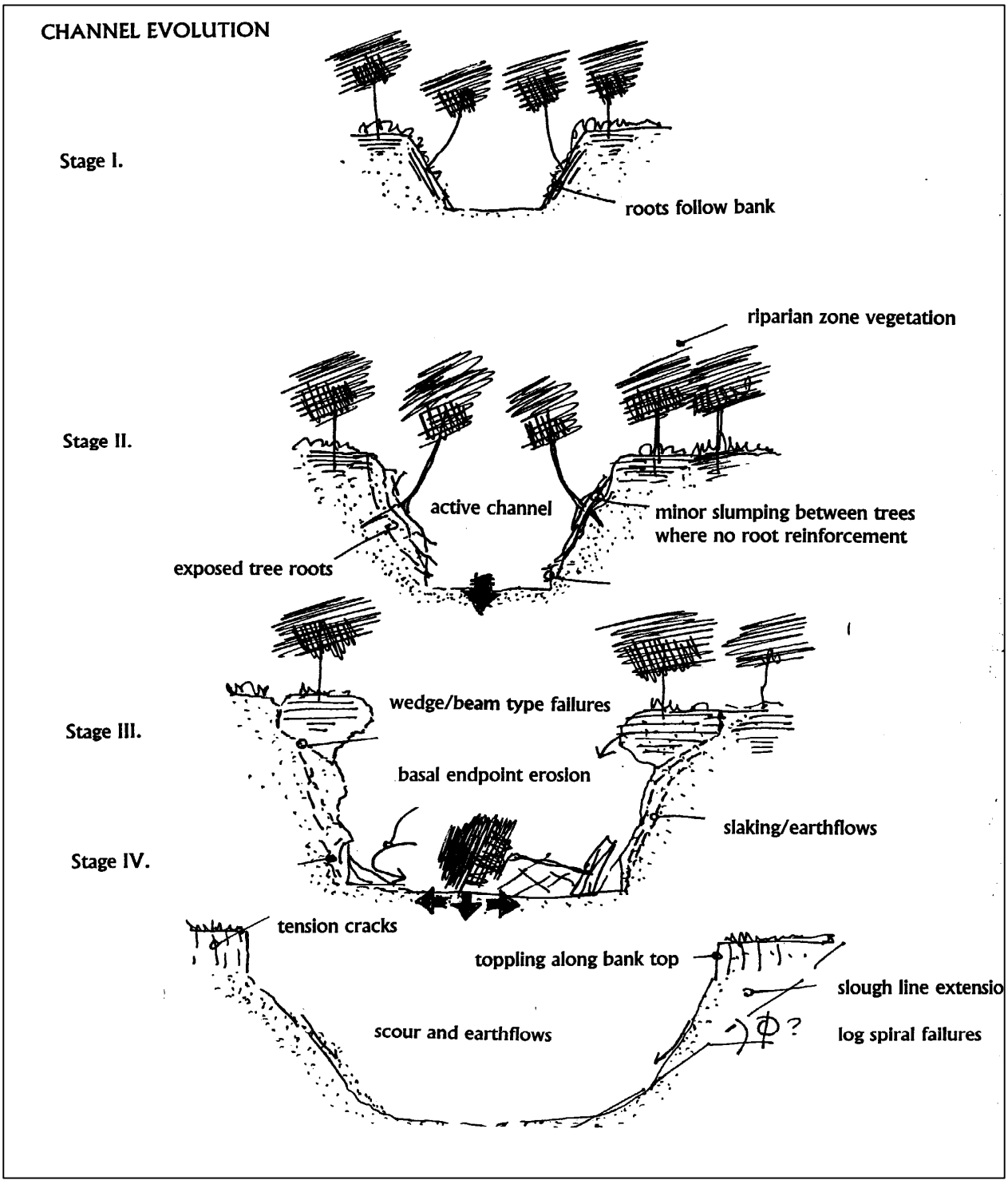
Erosion and sedimentation locations were determined for the remaining Joe Pool Lake streams from visual inspection using aerial photographs in GIS and observing a different set of hydraulic parameters indicative of erosion/sedimentation from the HEC-RAS hydraulic models. Reaches where high channel velocities exist (erosion) and low channel velocities exist (sedimentation) were determined for the 10-year event using conservative values for the upper and lower velocity limits determined from the City of Grand Prairie Drainage Design Manual Table 9.1, *Suggested Maximum Permissible Velocities*. Reaches with channel velocities greater than 6.0 ft/s were identified as prone to erosion and instability, while reaches with channel velocities less than 2.0 ft/s were identified as prone to deposition and aggradation. Steep channel banks on the outside of bends with the potential to meander were identified from aerial photos and the City of Grand Prairie 2009 Lidar data and identified on the Floodplain Workmaps in the Figures section of this report.

C. REVIEW OF CHANNEL STABILITY ASSESSMENT (W.O. 540.26)

In the 2007 Channel Stability Assessment, Halff Associates determined approximate locations of existing identified erosion areas and also provided locations of potential erosion and potential deposition for each studied tributary. The Joe Pool Lake studied tributaries are all dynamic streams in Stage I-II (Refer to Figure IX-1) of the Channel Evolution model. These streams have the ability to further down-cut, widen/enlarge, and meander as they evolve towards Stage III and Stage IV channel reaches.

Although these existing channels are underlain by the Eagle Ford Shale Bedrock, the soils along the channels are erodible. Some channel banks are entrenched or on steep cut banks and downcutting has been evidenced.

Figure IX-1 – Channel Evolution Model



The Joe Pool Lake study streams have the ability to widen up to two times under ultimate condition flows and also have the ability to downcut up to fourteen feet (particularly at Bedford Branch) based on the channel stability analyses conducted for a limited number of streams in 2006. For these reasons, it is important that ultimate land use changes in these watersheds be monitored because greater runoff can re-initiate gully erosion, slumping on steeper side slopes (hillslopes), create bank and bed erosion, and cause further downcutting of channels.

Assessments were made to determine locations along the channel where stream bed material would be subject to movement (incipient motion analysis) and to determine locations of potential erosion and deposition (stream power assessment). The conclusions of the channel stability assessment are that these streams have the ability to change shape and alignment over time, so future development must consider all factors affecting channel stability.

D. CITY OF GRAND PRAIRIE EROSION AND CHANNEL INITIATIVES FOR THE JOE POOL LAKE STUDY TRIBUTARIES

1. City Resolution No. 3919

This resolution (included in Appendix H) states, "Erosion and/or flooding problems on private property will be investigated on a case-by-case basis. The City will focus on improvements to waterways that will result in a general public benefit, such as lowering erosive velocities and increasing flow capacities in proximate streams for the general prevention of erosion and flooding."

Since only limited development has occurred within the majority of the Joe Pool Lake studied watersheds (except for the Peninsula Area), **Halff Associates, Inc. recommends that the City of Grand Prairie view any pre-development stream bank stability improvements as public benefits**. If future development encroaches onto existing or potential erosion areas, then improvements required to benefit these developments should be considered private.

2. 100-Year Floodplain (1% Annual Chance Floodplain)

Floodplain Workmaps illustrating the locations of the 100-year (1% Chance) existing conditions floodplains for each major stream and tributary in the Joe Pool Lake watershed can be found in the Figures section of this report.

City design standards state that all land having an elevation at or below the fully developed 100-year flood elevation shall be contained within an easement dedicated to the public for the purpose of providing drainage (Drainage Design Manual, November 2009, Section 9.0.A – refer to Appendix H). Based on the fact that these streams will be changing more rapidly once flows begin to increase under future conditions, Halff Associates recommends that all future development follow this criteria to not encroach into future 100-year (1% chance) floodplain locations in all study tributaries (i.e. locate development away from and above future 100-year floodplain elevations). Due to additional downcutting and widening that has the potential to occur, the City may desire to make these standards more stringent for the Joe Pool Lake study tributaries at particular locations where floodplains are generally more narrow and closer to existing main channel banks (along outside of meanders). Prior to proposed development occurring in proximity to these channel locations, an individual detailed analysis should be performed based on the information and results studying in this report. The Figures section of this report includes illustrations of the existing and future land use conditions within these watersheds and confirms the fact that these floodplains need to be managed properly as new development occurs.

3. Open Channel Design Guidelines

The City of Grand Prairie Drainage Design Manual provides many valuable tools for consideration of channel velocities and stream bank erosion (Chapter 9.3). If any work is to be done within the limits of the Joe Pool Lake study tributaries, the requirements established in Chapter 9.3 should be followed. This section states that the certifying engineer shall submit a letter report stating that the proposed drainage easement is of sufficient size to take into account any additional width to accommodate future bank erosion as determined by engineering slope stability calculation. The project engineer should be able to utilize the information provided in the CWDMP for Joe Pool Lake as a guideline for his or her analysis and design, but separate individual studies

should be performed for specific future development and channel projects to occur within these streams and tributaries. An end product of future development complying with Chapter 9.3 would be drainage easements that encompass the areas of the future 100-year floodplain and in some locations could be even wider to take into account channel erosion, side slopes erosion, and channel meanders.

Halff Associates, as well as the City Drainage Design Manual guidelines, also recommends that any constructed natural earthen banks within the limits of the Joe Pool Lake study tributaries have engineered slopes of 4:1 or greater (less steep). Also, any design of erosion control measures at meanders and bends should be considered carefully, since there is much evidence of migration of meanders in the study tributaries.

E. EROSION HAZARD SETBACKS (NON-STRUCTURAL)

Erosion setbacks or hazard zones should be determined for each of the Joe Pool Lake study tributaries for the intention of preserving existing natural channel corridors. Setbacks could be determined as described in this section or as described in Section 2.6.F. of the Drainage Design Manual. These setbacks would apply to areas being developed beyond the 100-year ultimate floodplain but where existing channel meanders and potential erosion areas are in proximity to the floodplain limits.

The following is a suggested setback program designed for use in the preservation of natural streams in North Central Texas. It is based on the philosophy of maintainable slopes and allows the natural erosion processes to continue without threatening structures. The stream bank erosion setback zone could be established as follows:

- Locate the toe of the natural stream bank
- From this toe, construct a 4 (horizontal) to 1 (vertical) line away from the stream and intersect the natural ground
- (1) Preferred Option if no grade control structures are implemented - Continue past the intersection an additional 25 feet to the outer edge of the setback (since maximum downcutting could be up to 14 feet in some locations and potential natural channel widening could be on the magnitude of 2 times the current widths, additional distance to the setback lines should be considered for the Joe

Pool Lake tributaries on a case-by-case basis depending on the location of development to a potential erosion zone).

- Or, (2) Preferred Option if grade control structures are implemented - Continue past the intersection an additional 10 feet to the outer edge of the setback (per City standard criteria)

As previously stated, setbacks established for the purposes of stream bank erosion hazard protection may extend beyond the limits of the future 100-year floodplain limits. If the exercise above yields an erosion setback limit within the future 100-year floodplain limits, then Halff recommends utilizing the limits of the 100-year floodplain (as shown in the Figures section) as the outer limits of the erosion setback zone.

Potential situations may occur where stream bank erosion hazard setback lines could be reduced where stream banks consist entirely or partly of rock. In these areas, the interface of the stream bank with the top of the unweathered rock strata should be located with the assistance of a qualified geotechnical engineer. This point on the surface of the slope will be the toe of a 3:1 slope intersecting natural ground. The actual setback line should then be located 25 feet beyond this intersection (City standard criteria is 10 feet beyond this intersection), assuming it is beyond the future 100-year floodplain limits. Once again, setback lines should take into account future widening and downcutting of existing channels.

Also, no building, fence, wall, deck, swimming pool or other structure should be located, constructed, or maintained within the area encompassing the setback.

As an alternative to the setback, the developer or landowner may submit to the City Engineer a plan to stabilize and protect stream banks threatened by erosion. Stabilization shall be of a permanent nature, consistent with the guidelines established in this study and by the City of Grand Prairie, and shall be designed and sealed by a licensed professional engineer. Detailed stream bank erosion protection measures developed for selected 2006 studied streams are discussed in Section IX.K of this report. It is recommended that these limited erosion protection measures be used as a guideline to plan erosion protection alternatives in the Joe Pool Lake watershed.

F. EROSION CONTROL MEASURES (STRUCTURAL)

Halff Associates identified several structural erosion control methods that could be used to help control the effects of erosion on the Joe Pool Lake streams. Typically, grade control structures are used to help prevent channel erosion and the corresponding downstream deposition. Hard and soft surface armor slope protection is used to help prevent bank erosion. Following is a brief description of the different erosion control methods included in this report.

1. Grade Control Structures

i. *Purpose*

Grade control structures are utilized to provide stability to the streambed (refer to Appendix F). The most common method of establishing grade control is the construction of in-channel grade control structures. Two basic types of grade control structures exist. One type is a "bed control" structure as it is designed to provide a hard point in the streambed that is capable of resisting the erosive forces of a degradational zone. The second type is referred to as a "hydraulic control" structure since it functions by reducing the energy slope along the degradational zone to the point that the stream is no longer capable of scouring the bed. Important factors must be considered when siting grade control structures.

ii. *Hydraulic Considerations*

Hydraulic siting of grade control structures is a critical element of the design process, especially determining the anticipated drop at the structure. Procedures for hydraulic siting of these structures are also described in Appendix F. The primary factors affecting the final equilibrium slope upstream of a structure include sediment concentration and load, the channel characteristics (slope, width, depth, roughness, etc.), and the hydraulic effect of the structure. Also important is the time it takes for the equilibrium slope to develop, which could be over a period of a few hydrographs or over many years.

iii. *Other Considerations*

In some cases, traditional bank stabilization measures may not be feasible where system-wide instabilities exist. In these instances, grade

control structures may be more of an appropriate solution. Grade control structures can enhance the bank stability of the bed, can reduce bank heights due to sediment deposition, and can reduce velocities and scouring potential by creating a backwater situation. For flood control, considerations should be made on the potential to cause overbank flooding. Grade control structures are often designed to be hydraulically submerged at flows less than bank-full so the frequency of overbank flooding is not significantly affected. Final siting of grade control structures should also try to minimize adverse environmental impacts to the system and instead provide direct environmental benefits to streams (scour holes and man-made pools provide fish habitat).

iv. *Existing Structures*

Grade control structures can have adverse as well as beneficial effects on existing structures. For structures upstream of hydraulic control measures, the potential exists for increased stages within the structure and also for sediment deposition. Many structures already provide some measure of grade control (usually culverts), however they may not be relied on to provide long-term grade control. Grade control structures can also be implemented during planned improvements to existing structures and as new structures are being built.

v. *Local Site Conditions*

When planning grade control structures, the final siting is often adjusted to accommodate local site conditions or local drainage situations. A stable upstream alignment that provides a straight approach for a grade control structure is critical. In a very sinuous channel, this could require straightening the channel to provide an adequate approach (with considerations for USACE jurisdictional waters). Upstream meanders should also be stabilized prior to implementing a downstream grade control structure.

vi. *Downstream Channel Response*

Since grade control structures affect the sediment delivery to downstream reaches, it is necessary to consider the potential impacts to the downstream channel when grade control structures are planned. Bed control structures reduce the downstream sediment loading by preventing the erosion of the bed and banks, while hydraulic control

structures have the added effect of trapping sediments. The concern is that reduced sediment loads to downstream areas will cause degradational problems downstream. A solution would be to reduce the number of grade control structures upstream or adding additional grade control structures in the downstream reach.

vii. *Typical Grade Control Structures for Joe Pool Tributaries*

Examples of typical grade control structures are included in Appendix F, including hydraulic grade control structures such as Loose Rock Dams and bed control structures such as Rock Chutes and Gabion Check Dams. Various other grade control structure types do exist; however, the typical structures included in this report are the basis for cost estimating purposes. The City of Grand Prairie is not required to solely utilize these typical structures since actual channel/site conditions may require different structure types, and Halff would recommend that other cost-effective solutions be evaluated prior to actual design of the grade control structures.

2. Armored Slope and Channel Protection

i. Soft Armor Slope Protection

Some typical soft armor slope protection solutions include brush mattresses, contour wattling, and/or soil retention blankets/turf reinforcement mats (TRMs). For the purposes of this report, Halff primarily investigated soil retention blankets and turf reinforcement mats as viable solutions for some of the slope protection needs of the studied tributaries. Turf reinforcement mats and soil retention blankets act to supplement the natural ability of vegetation (usually grass) to prevent soil erosion (in comparison to rock riprap). The reinforcement mats do this by providing a permanent net structure that acts as an additional barrier between flowing water and the underlying soil and also acts to reinforce vegetation as it grows through the matting's net structure. However, a turf reinforcement mat cannot provide permanent protection without vegetation. Therefore, design of these solutions must consider three phases: 1 – analyzing the channel in an unvegetated state to determine if the matting alone will handle the needed protection before vegetation establishment, 2 – a partially vegetated state to examine how the matting with immature vegetation

can control soil erosion, and 3 – a permanent state with vegetation fully established and reinforced by the matting's permanent net structure.

Soil retention blankets and TRMs can be used for general slope protection purposes (hill slopes or shoreline) and as a flexible channel liner (stream portions). They can handle shear stresses from 0 pounds per square foot up to approximately 12 pounds per square foot. A list of approved soil retention blanket products from TxDOT is included in Appendix F. Typical examples of installation methods (provided by North American Green) are also included in Appendix F.

Halff recommends that soft armor protection be utilized along steeper slopes, slumps, and bank erosion areas where there are opportunities to lay back slopes to a 3:1 (horizontal to vertical) slope or less steep. Halff also recommends that the soft armor protection be utilized in areas with little or no significant tree growth, root exposure, or rock outcrops along the banks.

ii. Hard Armor Slope and Channel Protection

Hard armor slope and channel protection involves utilizing hard materials such as concrete, rock riprap, or gabions to provide very strong, massive structures to help control the effects of bank and channel erosion. Rock riprap and gabion slope protection were primarily utilized for estimates in this study. Also, hard armor slope protection is not recommended under most current conditions since the majority of stream corridors are currently undeveloped. If development encroaches into areas where slope protection is needed, the City may desire to have additional erosion hazard setbacks to prevent the encroachment or require the developer to design, construct, and implement the hard armor solutions with the development.

The hard armor solutions, including rock riprap, gabion mattress, and gabion basket walls can be used for erosion situations involving high velocities, high shear stresses, and extremely steep slopes (0.5:1 to 2:1).

Recommendations for hard armor solutions are as follows and examples are provided in Appendix F:

1. For 2:1 slopes, utilize 12" gabion mattress slope protection or 18" to 24" thick rock riprap protection,
2. For 1:1 to 1.5:1 slopes, utilize 3' x 1.5' gabion basket staired wall
3. For slopes steeper than 1:1, utilize 3'x3' gabion basket walls (Gravity or Tieback depending on height)

Hard armor solutions are also more expensive and sometimes less aesthetically pleasing solutions than the softer armor, but would have a longer life span and more of an impact on reducing the effects of erosion.

G. FUTURE BRIDGE/CULVERT IMPROVEMENTS – MASTER THOROUGHFARE PLAN

Future stream bank stability improvements would also need to consider existing and future bridge/culvert improvements. Before implementing any structural stability measures, future City Master Thoroughfare planning would need to be evaluated and existing culverts would need to be re-sized to pass the ultimate 100-year flood event (per City criteria).

Future Master Thoroughfare Crossings

According to the City of Grand Prairie's Master Thoroughfare Plan, there are multiple planned major thoroughfares within the Joe Pool Lake studied tributaries' watersheds, including Principal Arterials, Minor Arterials, and Collector streets. Refer to Section VI of this report for information regarding existing and future roadway crossings.

H. POTENTIAL DEPOSITION OF SEDIMENT MATERIAL

To establish stream bank stability measures, it must be determined if the improved reach is susceptible to erosion or to sediment deposition. According to the Channel Stability Assessment, some locations along the studied tributaries were susceptible to sediment deposition (stream power < 1 lb/ft-sec). No sediment transport analysis was performed for this study, however, Halff Associates illustrates locations of potential deposition in the Floodplain Workmaps found in the Figures Section of this report. Refer to Section IX-B for a discussion of Erosion and Sedimentation Location Determination methods.

One location of potential deposition is the improved natural channel along Taaffe Creek from Sta. 49+19 to Sta. 67+45. This portion of the creek is denoted to have a low stream power that could lead to sediment deposition. Photographs and field observations also provide evidence that some sediment is depositing in this area along the channel and upstream of the constructed gabion check dams. Continued sedimentation in this area could reduce existing flow areas and conveyance capacities of this improved channel.

Locations of potential sediment deposition were also determined for the rest of the Joe Pool Lake watershed with the exception of Lynn Creek and Bowman Branch. For Edge Creek, Mills Branch, and Tarrell Creek, some of the sediment locations are at the existing ponds on these creeks. The locations of potential depositions should be monitored over time to ensure that they are not a cause for reduced flood capacity of stream corridors.

Sediment removal practices may be performed, but may be ineffective for flood control purposes for the following reasons:

1. General flooding can re-distribute sediment back into the channel
2. Flooding in the area may be due to the backwater effect of a downstream control, therefore removing sediment in an area may increase flood volume capacity but not flood conveyance
3. Removing sediment may reduce flood attenuation in the modified reach and thus increase flood magnitude for downstream reaches.

I. U.S. ARMY CORPS OF ENGINEERS SECTION 404 PERMITS

For any future channel or slope improvements to the Joe Pool studied tributaries, considerations must be made to impacts to jurisdictional waters of the United States. A wetland investigation and determination should be performed prior to construction of any proposed improvements within the channel. Minor improvements to jurisdictional waters may fall into a Nationwide Permit category, where more extensive modifications of jurisdictional waters would require an extensive Individual Permit process. Refer to Appendix G to locate current Nationwide Permit descriptions and descriptions of and an application for a USACE Individual Permit. Nationwide Permits that could apply to potential channel and development improvements include:

- Nationwide Permit 3 – Maintenance
- Nationwide Permit 13 – Bank Stabilization
- Nationwide Permit 14 – Linear Transportation
- Nationwide Permit 27 – Stream and Wetland Restoration Activities
- Nationwide Permit 29, 39 – Residential, Commercial, and Institutional Activities
- Nationwide Permit 41 – Reshaping of Existing Drainage Ditches

The USACE web-site has more information on the current permits. Please visit http://www.swf.usace.army.mil/ for additional information.

J. GENERAL GUIDELINES FOR FUTURE DEVELOPMENT IN THE JOE POOL LAKE WATERSHED

Each of the Joe Pool Lake streams and tributaries are dynamic stream systems that are constantly changing with time. Currently, the majority of the watersheds contributing to these tributaries are undeveloped. As development grows in these areas, the stream evolution will change, whether it is by more constant low flows, increased flood discharges, new stream crossings, or encroachments into floodplain and channel areas. Following are some general guidelines to consider as new development arises in these watersheds.

1. During Pre–Development Conditions (City of Grand Prairie)

Based on City Resolution 3919, perform pre-development improvements (public) to reduce erosive conditions along a given stream, including:

i. *Grade Control Structures*
ii. *Armored Slope Protection* near existing structures
iii. Recommended *Bridge/Culvert Improvements*

2. As Development is Occurring (Developer/City)

i. *100-Year Floodplain* – The developer shall review Section I through Section V of this report to determine future 100-year floodplain elevations and delineations. Where practical, development shall be located beyond the limits of the 100-year ultimate floodplain and developer shall dedicate a public drainage easement for all land, within

property limits, having an elevation at or below the future 100-year flood elevation.

ii. *Erosion Hazard Setbacks* – Along with the public drainage easement, additional erosion hazard setbacks shall be provided for areas where existing channel meanders and potential erosion areas are in proximity to the floodplain limits.

iii. *Open Channel Guidelines* – New development shall be required to ensure that the public drainage easement is of sufficient size to take into account any additional width beyond future 100-year flood elevation to accommodate future bank erosion

iv. *Armored Slope/Channel Protection* – If development is allowed to encroach into floodplain areas where it is in proximity to existing streams, the developer shall be responsible for implementing channel protection, whether it be a soft armor (TRM) or hard armor (rock riprap or gabion) solution, as necessary.

v. *Bridges/culverts* – Review locations of existing bridge/culverts to determine if new development is in proximity. Review Master Thoroughfare plan to determine proximity of development to the new roadways and future stream crossings. Both City and developer shall consider all existing and proposed roadways to determine potential impacts to proposed developments. If new development requires additional bridges or culverts that are not listed in this report, developer shall provide an engineering study detailing the impacts of the bridge/culvert on future floodplain conditions for the given stream and shall design proposed bridge/culvert systems to contain future 100-year flood events without creating negative floodplain impacts upstream.

vi. *Outfall Design Guidelines* – Storm drain outfalls into existing streams shall be required to adhere to the requirements in Section 8.9 of the Grand Prairie Drainage Design Manual.

vii. *Potential Sedimentation* – The developer shall review the Floodplain Workmap Exhibits in the Figures Section of this report to determine if the new development will need to consider sedimentation for the stream located in the public drainage easement adjacent to or within the development.

viii. *Section 404 permits* – If developer or City is providing either public or private benefits that affect the actual stream corridor, then a determination needs to be made on whether a Section 404 permit is required or not (Nationwide or Individual). The studied Joe Pool Lake

streams and tributaries should be considered as jurisdictional waters of the United States and any improvements to these streams shall obtain the required permits for construction. Refer to Appendix G.

3. Post-Development Conditions (City of Grand Prairie)

City shall inspect public drainage easements periodically for the following scenarios:

i. *Observed erosion – Does erosion within easement have potential to encroach beyond the easement (or setback, if determined)?*
ii. *Observed sediment deposition – Review denoted areas of potential deposition and annotate locations of observed sediment deposition*
iii. *Functionality - Ensure constructed grade control, channel, and/or slope improvements are functioning properly*
iv. *Physical features within easement - Ensure that no building, fence, wall, deck, swimming pool or other structure is located within the area encompassing the public drainage easement (or erosion hazard setback, if determined)*
v. *Bridge/Culvert crossings - Check bridge/culvert crossings for functionality and erosion*

K. REVIEW OF CHANNEL STABILITY ALTERNATIVES (W.O. 540.26)

As part of the Stream Bank Stability Alternatives report for Joe Pool Lake Drainage Master Plan (W.O. #540.26), Halff Associates developed detailed stream stability alternatives for each of the nine studied streams. These alternatives included figures and detailed cost estimates. It is intended that these alternatives and cost estimates be used as a template for future channel stability alternatives that become necessary as development continues throughout the Joe Pool Lake watershed. Included in this section of the CWDMP for Joe Pool Lake is an excerpt from the Stream Bank Stability Alternatives report (W.O. #540.26) for reference. Refer to Section XII of this report for a copy of the Estimates of Probable Cost.

BEDFORD BRANCH

II. JOE POOL LAKE STUDY TRIBUTARIES

A. BEDFORD BRANCH – STREAM BANK STABILITY ALTERNATIVES

1. General Description of Stream Corridor

Bedford Branch is approximately 2.83 miles in length through the study area with an average slope of 0.2%. The lower 6,200 linear feet of Bedford Branch is within the current 1% annual chance floodplain of Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Bedford Branch overbanks consist of open range land with brush and trees.

2. Stream Assessment Results (from Volume II)

Sinuosity - Bedford Branch has a sinuosity of 1.97, which is high compared to the other studied streams.

Channel Survey
Stream Type: Meandering, variable width channel; developed pool/riffle system; Channel Evolution Stage I-II
Channel Bed/Banks: Clay bed with limestone gravels in channel (entire length)
Observations: Moderate bank erosion on near vertical cutbanks; gravel size fines downstream; channel ponded downstream; low woody debris dams evident

Incipient Motion – The results of the incipient motion analysis indicate that the one-year flood frequency flows can move the D50 bed material downstream for almost the entire reach.

Equilibrium Slope – The results indicate an equilibrium slope of **0.0009**. The current average channel slope along the entire study reach is 0.0031.

Projected Channel Enlargement and Degradation – The projected widening ratio (future/existing) for Bedford Branch is 1.77-1.92. Current channel bottom widths are mostly between 10 feet to 20 feet.

Channel Stability - Based on the Bedford Branch hydraulic model, stream power (one-year frequency) exceeds the potential erosion threshold at Stations 60+26, 80+34, 94+88, 113+27, and 144+11. Stream power is below the potential deposition threshold between Stations 105+89 to 111+99.

3. Stream Bank Stability Alternatives

Grade Control Structures

Five locations along Bedford Branch were identified to be areas of potential erosion (see Figure CBD-1 in Volume II). Utilizing these locations, Halff recommends implementation of grade control structures (check dams) along three separate reaches of Bedford Branch (see Figure SBD-1). Refer to Appendix D, Page 2 for formulas utilized for hydraulic siting of grade control structures.

- *Location #1* – Primarily located between Station 54+04 to Station 67+31. Utilizing the existing slope of 0.0030 along this reach, the equilibrium slope of 0.0009, and a proposed grade control structure height of 4 feet, the total number of grade control structures needed for this reach would be one (1), located near the downstream end of the reach.

- *Location #2* – Primarily located between Station 73+47 to Station 98+60. Utilizing the existing slope of 0.0040 along this reach, the equilibrium slope of 0.0009, and a proposed grade control structure height of 2 to 3 feet, the total number of grade control structures needed for this reach would be four (4), with the first being located near the downstream end of the reach and the other three being uniformly distributed for the remainder of the reach.

- *Location #3* – Primarily located between Station 105+89 to Station 120+06. Utilizing the existing slope of 0.0028 along this reach, the equilibrium slope of 0.0009, and a proposed grade control structure height of 4 feet, the total number of grade control structures needed for this reach would be one (1), located near the downstream end of the reach.

Armored Slope and Channel Protection

Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored slope and channel protection at four locations along Bedford Branch (see Figure SBD-1). Halff recommends 18" rock riprap protection for the armored slope protection locations

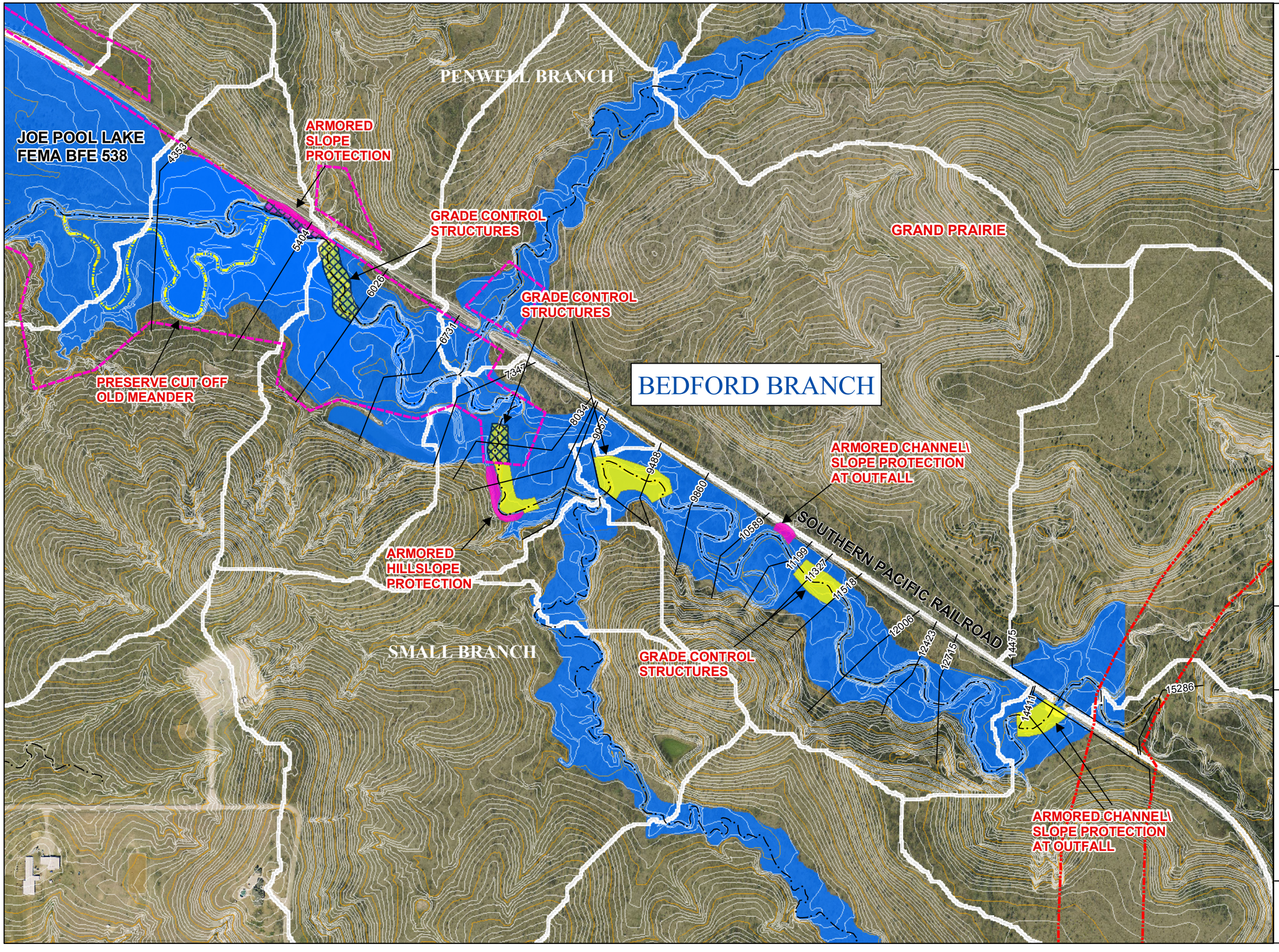
near Station 54+00, 83+00, and 110+50. Please note that locations near Station 54+00 and 110+50 are along the Southern Pacific Railroad, in which Bedford Branch is encroaching into the slope for the railroad. Also, Halff recommends 24" rock riprap protection along the channel and side slopes downstream of the bridge near Station 143+50.

4. Bedford Branch – Prioritized Improvements/Estimates of Probable Cost

As described in Section I (Page 14), the improvements described in this section would be for pre-development conditions. The following table provides a general ranking of proposed pre-development improvements and estimates of probable costs for Bedford Branch.

Bedford Branch – Stream Bank Stability Alternatives

Rank/Description	Estimate of Probable Cost
1) Slope Protection (Sta. 54+00)	$65,000
2) Slope Protection (Sta. 110+50)	$55,000
3) Channel/Slope Protection (Sta. 143+50)	$80,000
4) Grade Control Structure (Sta. 54+04 to 67+31)	$15,000
5) Grade Control Structure (Sta. 73+47 to 98+60)	$45,000
6) Grade Control Structure (Sta. 105+89 to 120+06)	$12,500
7) Slope Protection (Sta. 83+00)	$120,000
Total – Bedford Branch	**$393,000**



City of Grand Prairie

Joe Pool Lake
Stream Bank Stability
Alternatives

FIGURE SBD 1

BEDFORD BRANCH

Legend

- CROSS SECTIONS
- CENTERLINE
- USACE FLOWAGE EASEMENT
- DRAINAGE AREAS
- JOE POOL LAKE 1% FLOOD
- 1 % ANNUAL CHANCE FLOOD
- CITY LIMITS

Notes: 1) Topography provided by the City of Grand Prairie.(1999) NAD 1983 State Plane

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1"=500'

Halff Associates
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BEDFORD BRANCH

Hydraulic Siting of Grade Control Structures

Location #1	XS	Flowline
Downstream	5404	528
Upstream	6731	532

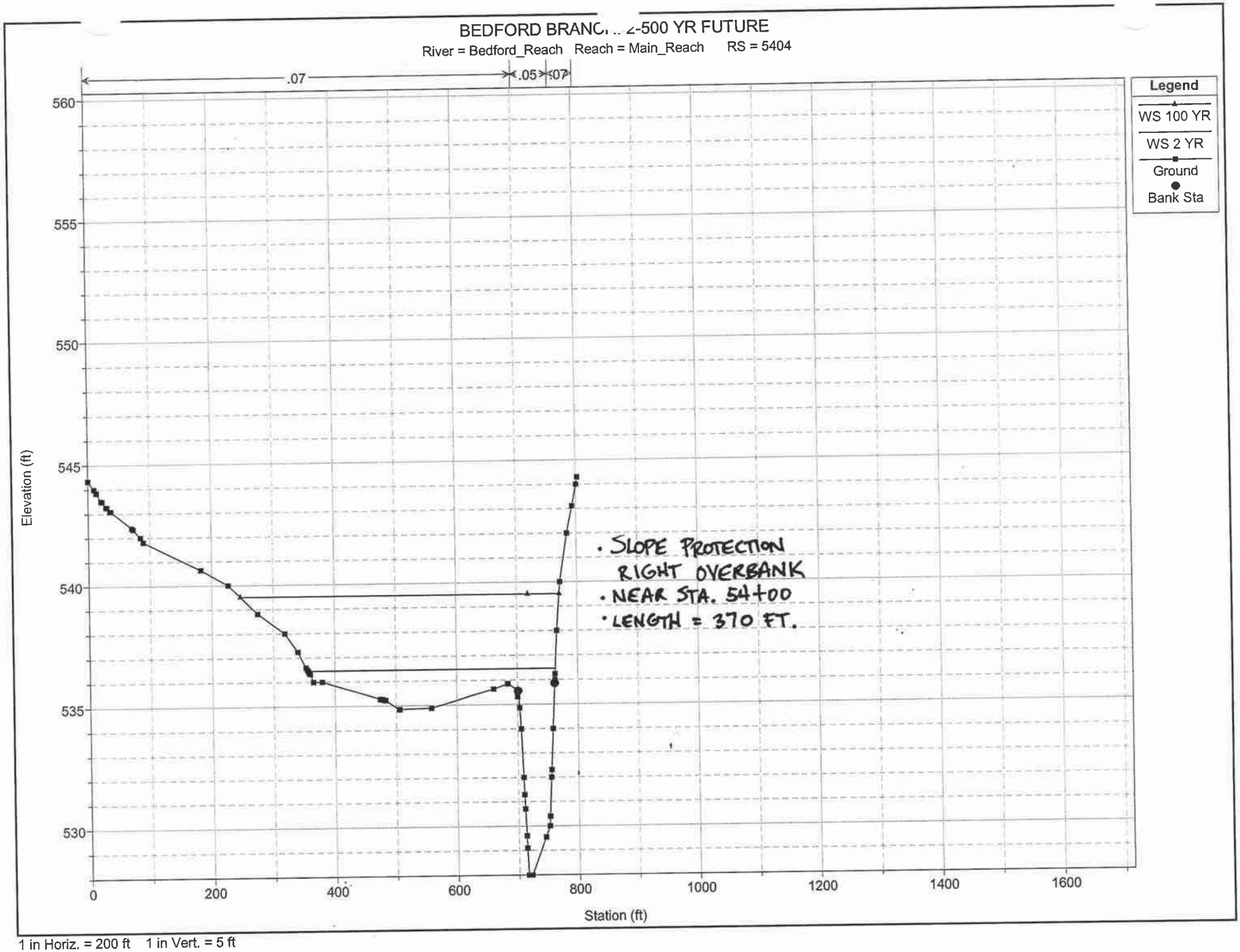
Original Slope=	0.0030
Equilibrium Slope=	0.0009
Height of Drop (ft)=	**4**
Number of structures (calc)=	0.70
Total Grade Control Structures=	**1**

Location #2	XS	Flowline
Downstream	7347	532
Upstream	9860	542

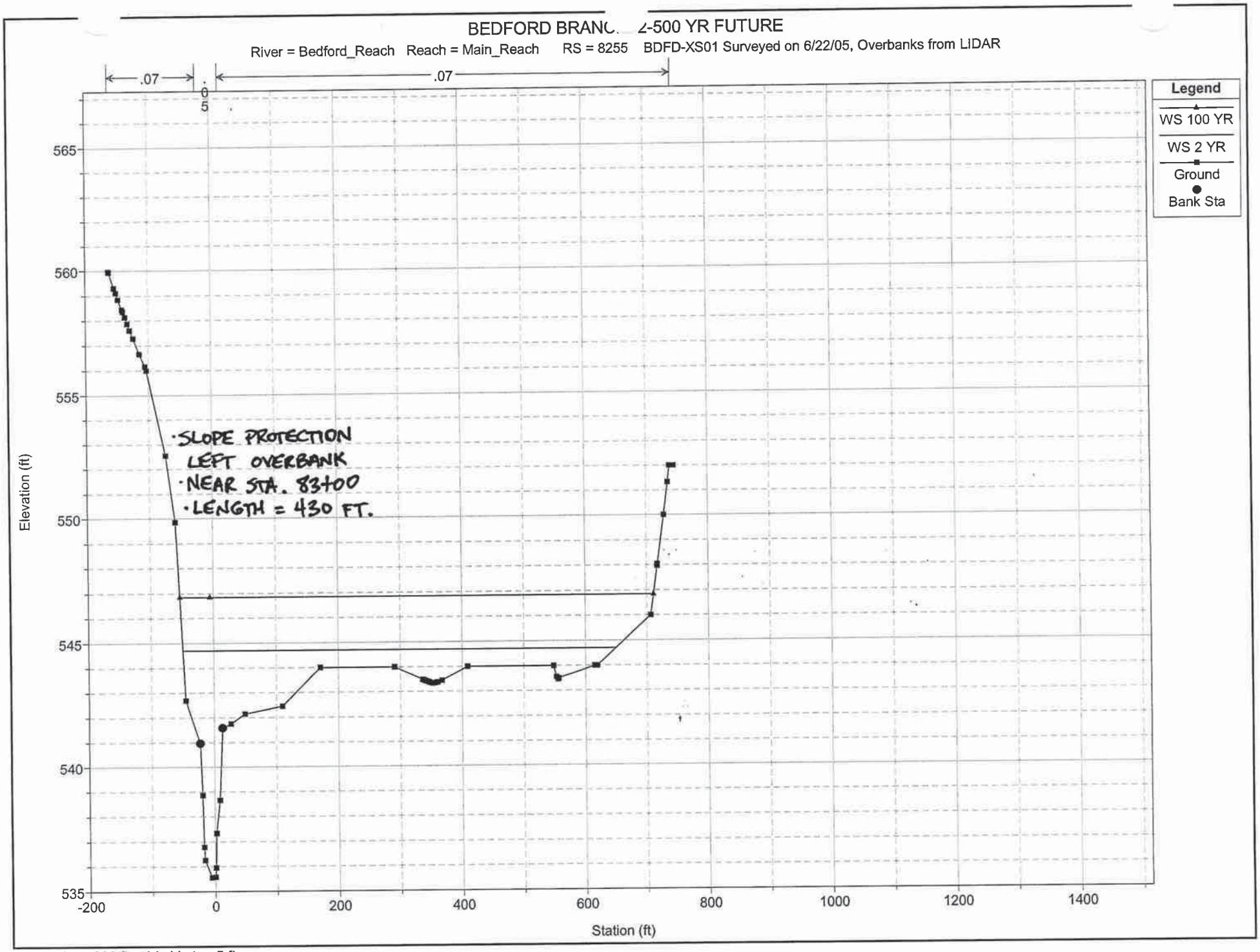
Original Slope=	0.0040
Equilibrium Slope=	0.0009
Height of Drop (ft)=	**2.5**
Number of structures (calc)=	3.10
Total Grade Control Structures=	**4**

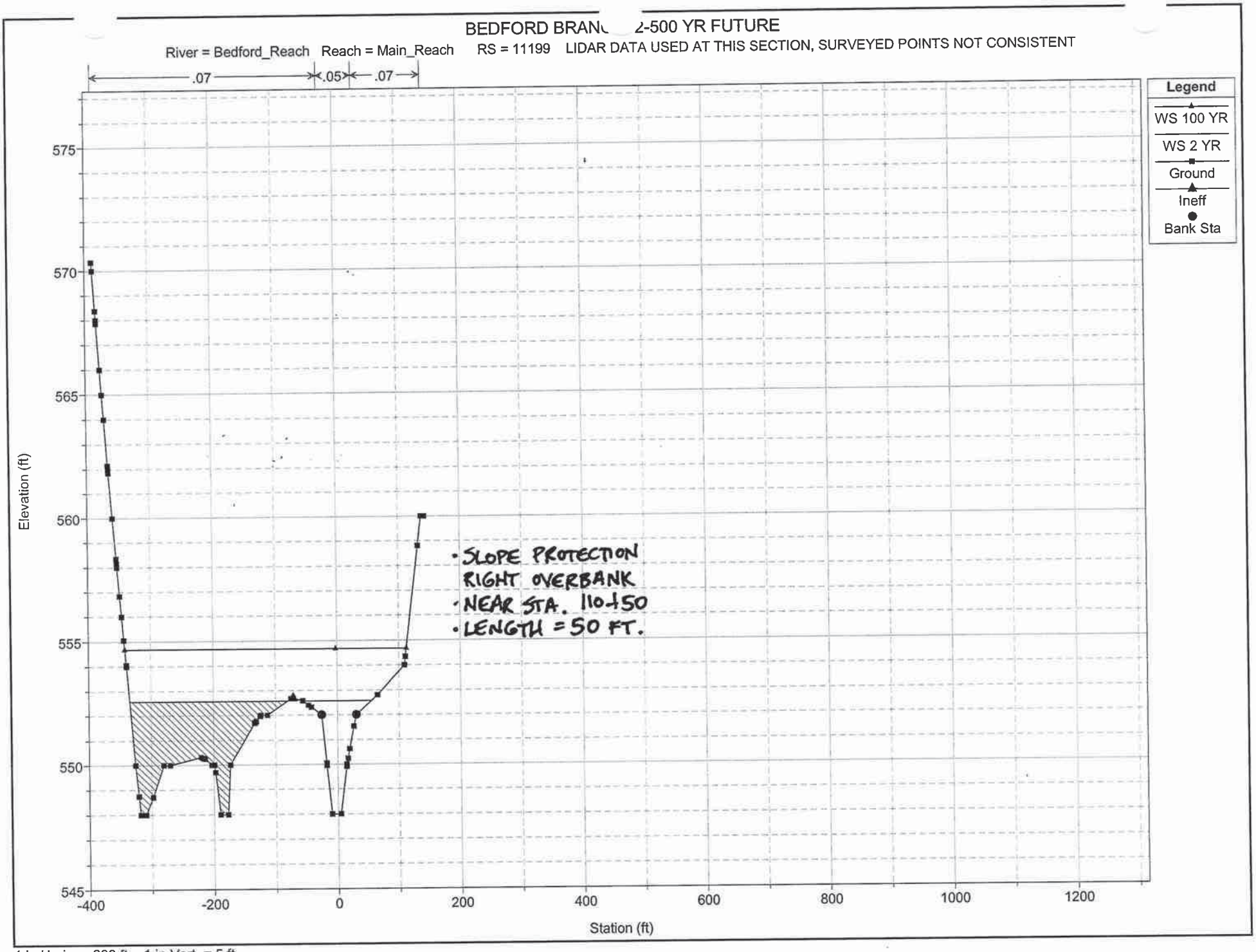
Location #3	XS	Flowline
Downstream	10589	546
Upstream	12006	550.03

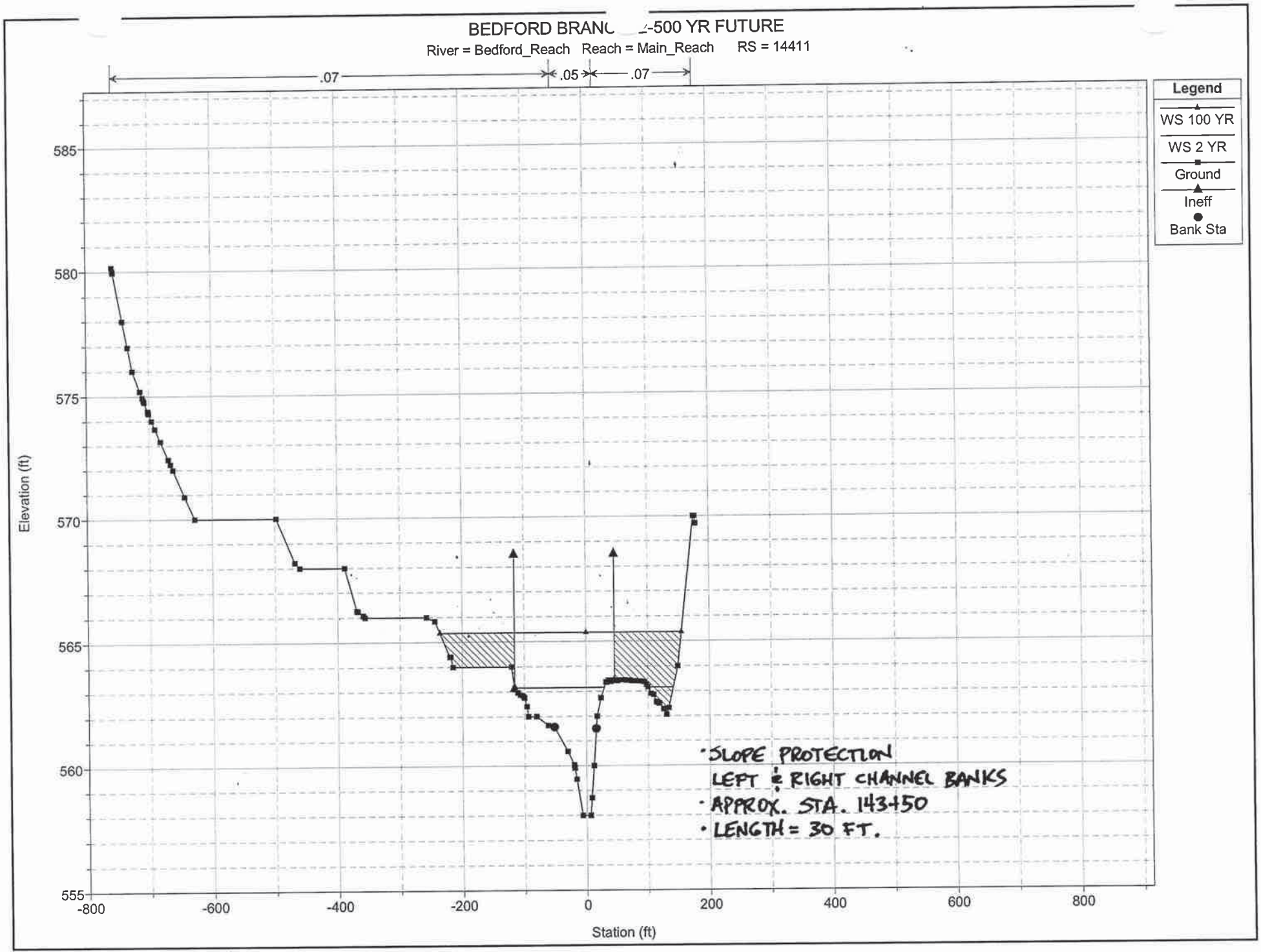
Original Slope=	0.0028
Equilibrium Slope=	0.0009
Height of Drop (ft)=	**3**
Number of structures (calc)=	0.92
Total Grade Control Structures=	**1**



1 in Horiz. = 200 ft 1 in Vert. = 5 ft


BEDFORD BRANC 2-500 YR FUTURE
River = Bedford_Reach Reach = Main_Reach RS = 8255 BDFD-XS01 Surveyed on 6/22/05, Overbanks from LIDAR
.07
.05
.07
Legend
WS 100 YR
WS 2 YR
Ground
Bank Sta
·SLOPE PROTECTION
LEFT OVERBANK
·NEAR STA. 83+00
·LENGTH = 430 FT.
Elevation (ft)
565
560
555
550
545
540
535
-200
0
200
400
600
800
1000
1200
1400
Station (ft)
1 in Horiz. = 200 ft 1 in Vert. = 5 ft


BEDFORD BRAN 2-500 YR FUTURE
River = Bedford_Reach Reach = Main_Reach RS = 11199 LIDAR DATA USED AT THIS SECTION, SURVEYED POINTS NOT CONSISTENT
.07
.05
.07
Legend
WS 100 YR
WS 2 YR
Ground
Ineff
Bank Sta
575
570
565
560
555
550
545
Elevation (ft)
-400
-200
0
200
400
600
800
1000
1200
Station (ft)
• SLOPE PROTECTION RIGHT OVERBANK
• NEAR STA. 110+50
• LENGTH = 50 FT.
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



1 in Horiz. = 200 ft 1 in Vert. = 5 ft

PENWELL BRANCH

B. PENWELL BRANCH – STREAM BANK STABILITY ALTERNATIVES

1. General Description of Stream Corridor

Penwell Branch is a primary tributary to Bedford Branch. Penwell Branch is approximately 1.20 miles in length with an average slope of 1.04%. This branch is located north of Bedford Branch and flows southwest to the confluence with Bedford Branch, approximately 300 feet downstream of the Southern Pacific Railroad. The total contributing watershed of Penwell Branch draining to Bedford Branch is about 0.62 square miles or approximately 400 acres. This stream is a natural earthen channel with some vegetation. Overbanks of Penwell Branch consist of open range land with brush and trees, similar to Bedford Branch.

2. Stream Assessment Results (from Volume II)

Sinuosity - Penwell Branch has a sinuosity range of 1.39 to 1.62, which is slightly higher than most of the other studied streams.

Channel Survey
Stream Type: Swale for first 300 feet; grass, clay meandering channel to 2400 feet downstream of the upstream limits; mixed load meandering channel to confluence; downstream more incised; Channel Evolution Stage I-II
Channel Bed/Banks: Clay bed with limestone gravels in channel (begins 2400 feet downstream of the upstream limits)
Observations: Three (3) knickpoints from 2400 to 3400 feet downstream of the upstream limits; gullies and tighter meanders with some tree loss 4000 feet to confluence

Incipient Motion - The results of the incipient motion analysis indicate that the one-year flood frequency flows can move the D50 bed material downstream for the majority of the reach. Areas between Station 20+00 and 30+00 have velocities lower than those needed to move the D50 grain size.

Equilibrium Slope - The results indicate an equilibrium slope of **0.0014**. The current average channel slope along the entire study reach is 0.0106.

Projected Channel Enlargement and Degradation - The projected widening ratio (future/existing) for Penwell Branch is 1.14-2.14. Current defined channel bottom

widths are mostly between 8 feet to 15 feet. Many parts of the channel are representative of swale conditions, without a clearly defined channel.

Channel Stability - Based on the Penwell Branch hydraulic model, stream power (one-year frequency) exceeds the potential erosion threshold at Stations 13+81, 36+12, 46+00, and 62+87. Stream power is below the potential deposition threshold between Stations 3+30 to 4+53, between Stations 17+08 to 29+56, and at Stations 41+12, 56+00, and 62+57.

3. Stream Bank Stability Alternatives

Grade Control Structures

Four locations along Penwell Branch were identified to be areas of potential erosion (see Figure CPN-1 in Volume II). Utilizing these locations, Halff recommends implementation of grade control structures (check dams) along two separate reaches of Penwell Branch (see Figure SPN-1). Refer to Appendix D, Page 2 for formulas utilized for hydraulic siting of grade control structures.

- *Location #1* – Primarily located between Station 11+25 to Station 24+87. Utilizing the existing slope of 0.0073 along this reach, the equilibrium slope of 0.0014, and a proposed grade control structure height of 2 feet, the total number of grade control structures needed for this reach would be four (4), with the first being located near the downstream end of the reach and the other three being uniformly distributed for the remainder of the reach.

- *Location #2* – Primarily located between Station 36+12 to Station 41+12. Utilizing the existing slope of 0.0053 along this reach, the equilibrium slope of 0.0014, and a proposed grade control structure height of 2 feet, the total number of grade control structures needed for this reach would be one (1), located near the downstream end of the reach.

Armored Slope and Channel Protection

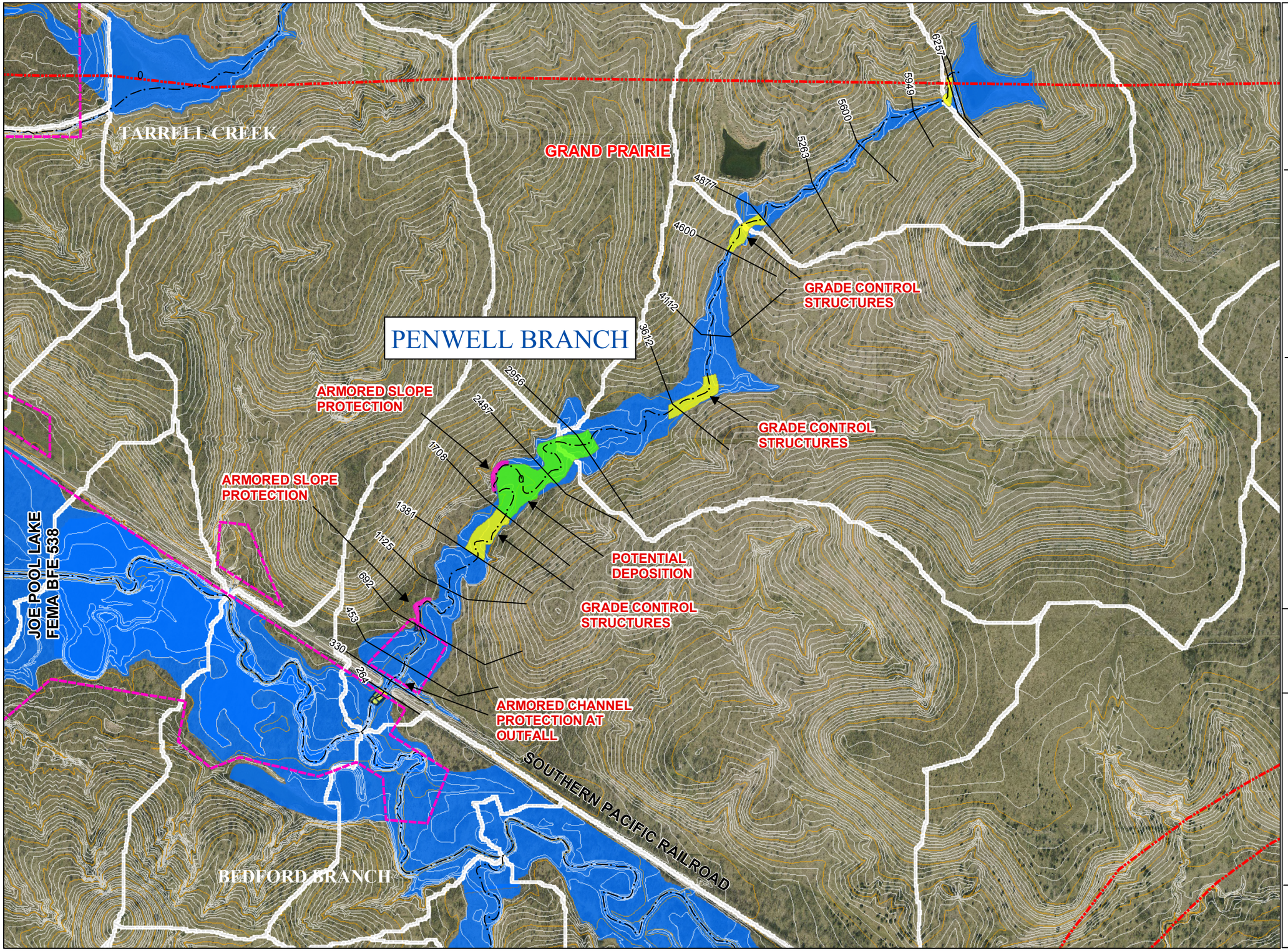
Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored slope and channel protection at three locations along Penwell Branch (see Figure SPN-1). Halff recommends 18" rock riprap protection for the armored slope protection locations near Station 6+92 and 19+00. Also, Halff recommends 24" rock riprap protection along the channel and side slopes downstream of the bridge near Station 2+64.

4. Penwell Branch – Prioritized Improvements/Estimates of Probable Cost

As described in Section I (Page 14), the improvements described in this section would be for pre-development conditions. The following table provides a general ranking of proposed pre-development improvements and estimates of probable costs for Penwell Branch.

Penwell Branch – Stream Bank Stability Alternatives

Rank/Description	Estimate of Probable Cost
1) Channel/Slope Protection (Sta. 2+64)	$50,000
2) Grade Control Structure (Sta. 11+25 to 24+87)	$40,000
3) Grade Control Structure (Sta. 36+12 to 41+12)	$10,000
4) Slope Protection (Sta. 6+92)	$55,000
5) Slope Protection (Sta. 19+00)	$45,000
Total – Penwell Branch	**$200,000**



City of Grand Prairie

Joe Pool Lake
Stream Bank Stability
Alternatives

FIGURE SPN 1

PENWELL BRANCH

Legend

- CROSS SECTIONS
- CENTERLINE
- USACE FLOWAGE EASEMENT
- DRAINAGE AREAS
- JOE POOL LAKE 1% FLOOD
- 1 % ANNUAL CHANCE FLOOD
- CITY LIMITS

Notes: 1) Topography provided by the City of Grand Prairie.(1999)
NAD 1983 State Plane

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1"=500'

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PENWELL BRANCH

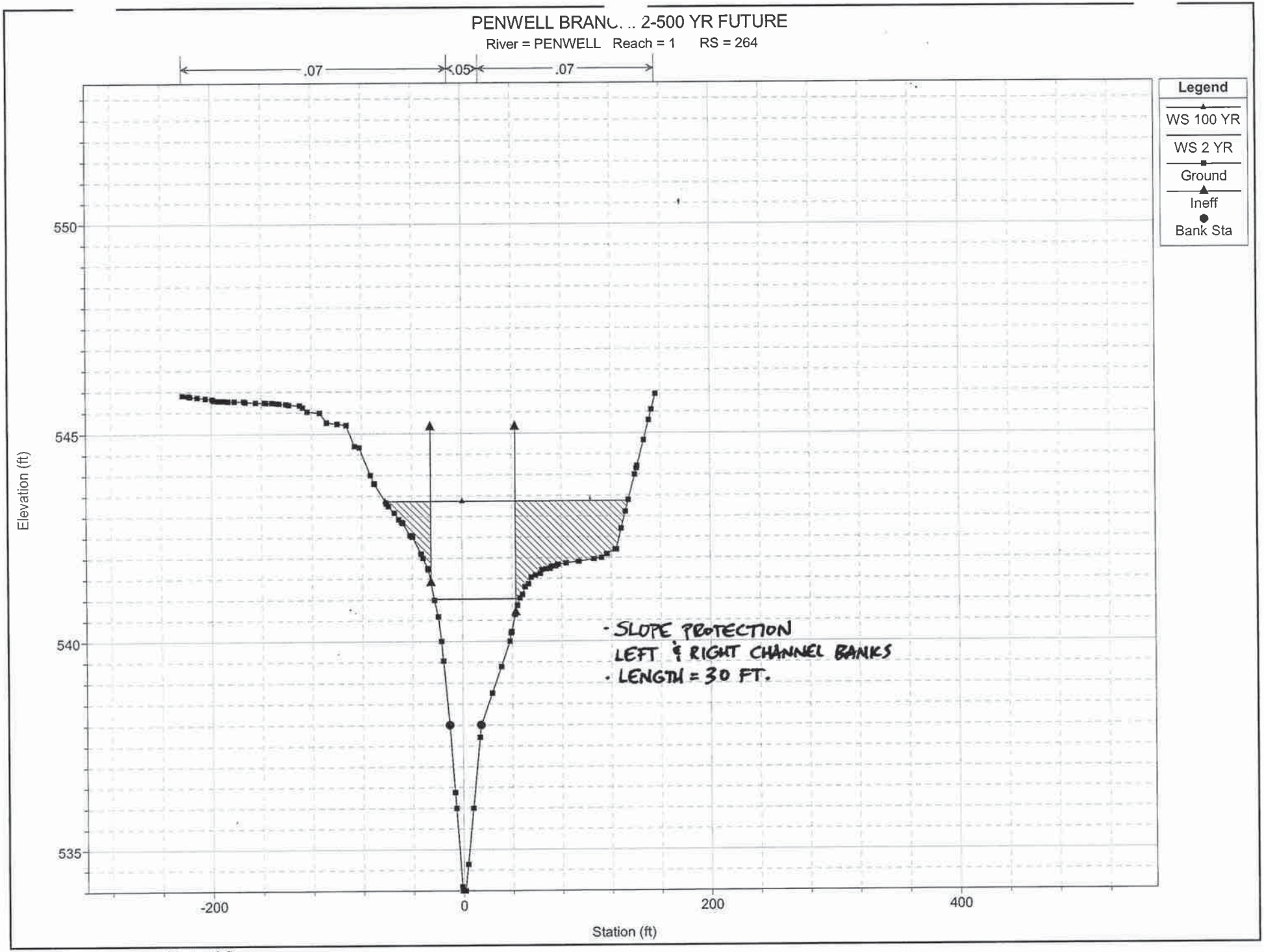
Hydraulic Siting of Grade Control Structures

Location #1	XS	Flowline
Downstream	1125	542
Upstream	2487	552

Original Slope=	0.0073
Equilibrium Slope=	0.0014
Height of Drop (ft)=	**2**
Number of structures (calc)=	4.05
Total Grade Control Structures=	**4**

Location #2	XS	Flowline
Downstream	3612	559.34
Upstream	4112	562

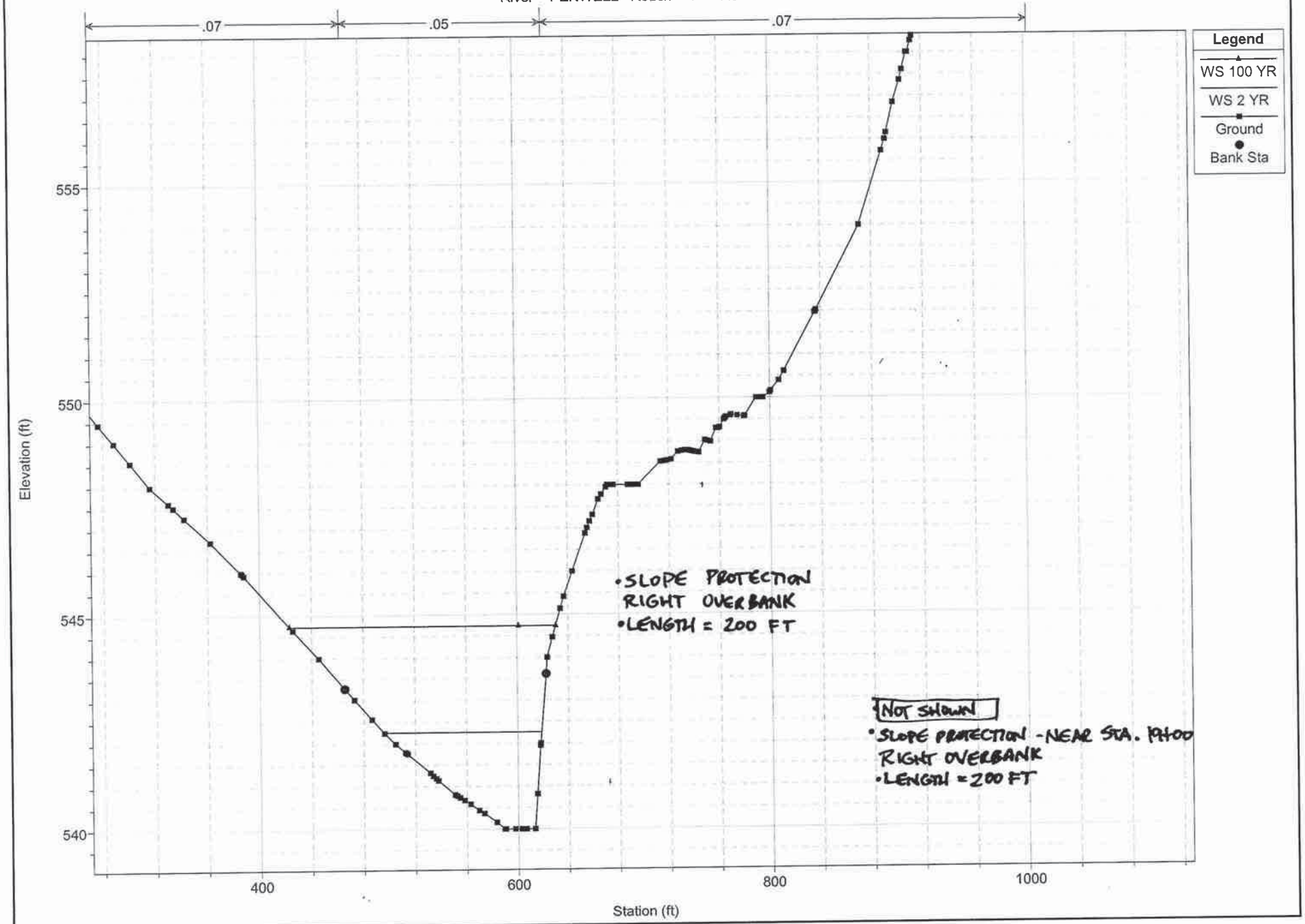
Original Slope=	0.0053
Equilibrium Slope=	0.0014
Height of Drop (ft)=	**2**
Number of structures (calc)=	0.98
Total Grade Control Structures=	**1**



1 in Horiz. = 100 ft 1 in Vert. = 3 ft

PENWELL BRANC. 2-500 YR FUTURE

River = PENWELL Reach = 1 RS = 692



1 in Horiz. = 100 ft 1 in Vert. = 3 ft

SMALL BRANCH

C. SMALL BRANCH– STREAM BANK STABILITY ALTERNATIVES

1. General Description

Small Branch is a primary tributary to Bedford Branch. Small Branch is approximately 1.49 miles in length with an average slope of 1.30%. This branch is located south of Bedford Branch and flows northwest to the confluence with Bedford Branch. The total contributing watershed of Small Branch draining to Bedford Branch is about 0.48 square miles or approximately 310 acres. This stream is a natural earthen channel with some vegetation. Overbanks of Small Branch consist of open range land with brush and trees, similar to Bedford Branch.

2. Stream Assessment Results

Sinuosity- Small Branch has a sinuosity range of 1.34 to 1.72, which is slightly higher than most of the other studied streams.

Channel Survey
Stream Type: Begins shale knickpoint (7 to 8 foot drop); meandering mixed load, pool riffles; Channel Evolution Stage I-II
Channel Bed/Banks: Limestone flags to 1600 feet downstream of the upstream limits, then wide floodplain and clay with limestone bed material
Observations: Large knickpoint near Station 66+10; smaller, 2 to 3 foot knickpoints 1600 feet downstream of the upstream limits; around Station 21+90, large slumps in channel as it cuts into a hill slope

Incipient Motion - The results of the incipient motion analysis indicate that the one-year flood frequency flows can move the D50 bed material downstream for the entire reach.

Equilibrium Slope - The results indicate an equilibrium slope of **0.00096**. The current average channel slope along the entire study reach is 0.0114.

Projected Channel Enlargement and Degradation - The projected widening ratio (future/existing) for Small Branch is 2.5-2.75. Current defined channel bottom widths are mostly between 15 feet to 30 feet.

Channel Stability - Based on the Small Branch hydraulic model, stream power (one-year frequency) exceeds the potential erosion threshold at Stations 4+49, 13+48, 21+90, 49+38, 58+65 to 66+10 and 78+14. Stream power is not below the potential deposition for any Small Branch cross-sections.

3. Stream Bank Stability Alternatives

Grade Control Structures

Two locations along Small Branch were identified to be areas of potential erosion (see Figure CSM-1 in Volume II). Utilizing these locations, Halff recommends implementation of grade control structures (check dams) along two separate reaches of Small Branch (see Figure SSM-1). Refer to Appendix D, Page 2 for formulas utilized for hydraulic siting of grade control structures.

- *Location #1* – Primarily located between Station 16+19 to Station 27+60. Utilizing the existing slope of 0.0070 along this reach, the equilibrium slope of 0.00096, and a proposed grade control structure height of 2 feet, the total number of grade control structures needed for this reach would be four (4), with the first being located near the downstream end of the reach and the other three being uniformly distributed for the remainder of the reach.

- *Location #2* – Primarily located between Station 58+65 to Station 68+40. Utilizing the existing slope of 0.0342 along this reach, the equilibrium slope of 0.00096, and a proposed grade control structure height of 4 feet, the total number of grade control structures needed for this reach would be eight (8), with the first being located near the downstream end of the reach and the other seven being uniformly distributed for the remainder of the reach.

Armored Slope and Channel Protection

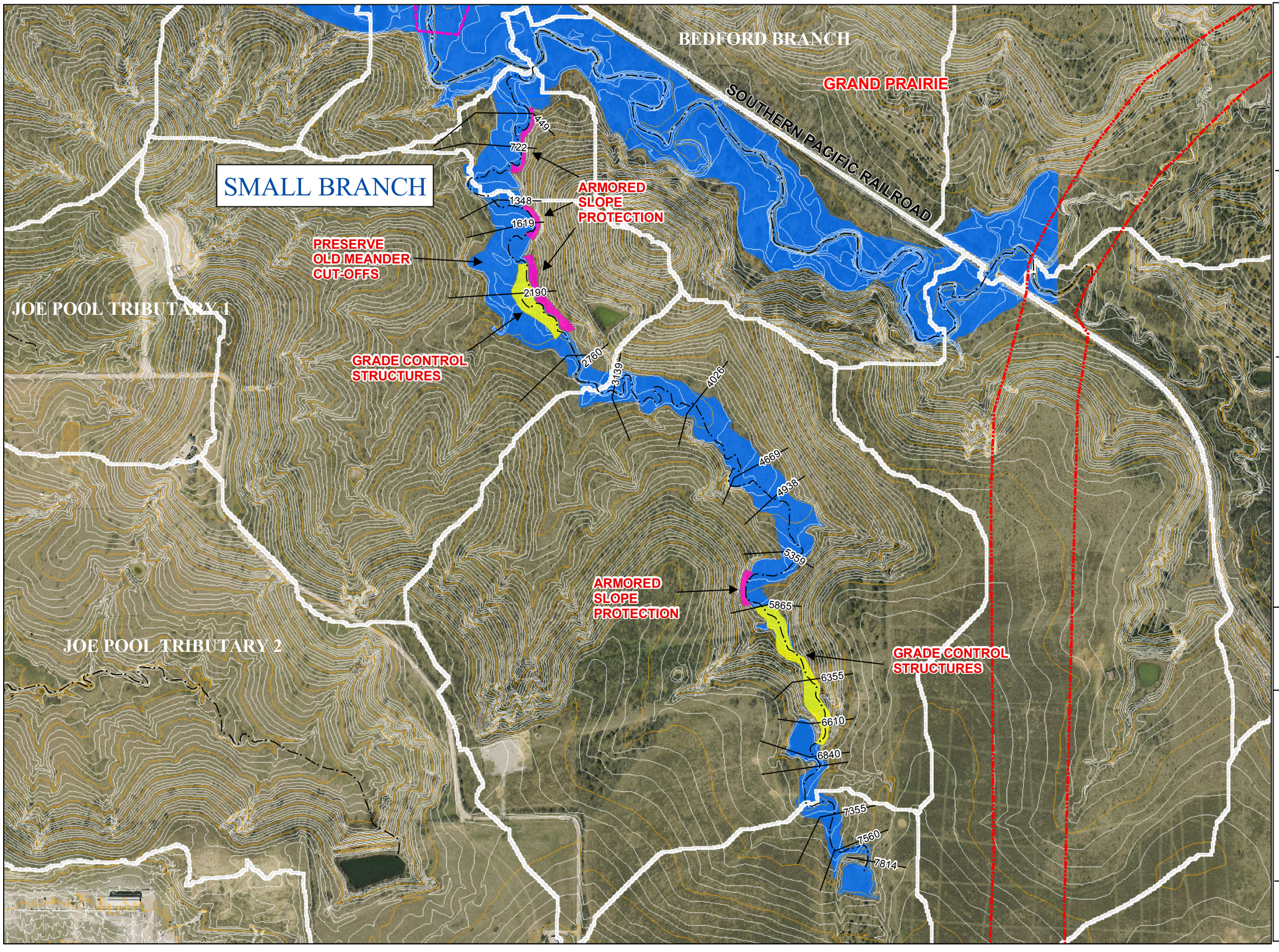
Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored slope and channel protection at four locations along Small Branch (see Figure SSM-1). Halff recommends 18" rock riprap protection for the armored slope protection locations near Station 7+22, 16+19, 21+90, and 57+00.

4. Small Branch – Prioritized Improvements/Estimates of Probable Cost

As described in Section I (Page 14), the improvements described in this section would be for pre-development conditions. The following table provides a general ranking of proposed pre-development improvements and estimates of probable costs for Small Branch.

Small Branch – Stream Bank Stability Alternatives

Rank/Description	Estimate of Probable Cost
1) Grade Control Structure (Sta. 16+19 to 27+60)	$40,000
2) Grade Control Structure (Sta. 58+65 to 68+40)	$120,000
3) Slope Protection (Sta. 7+22)	$70,000
4) Slope Protection (Sta. 16+19)	$40,000
5) Slope Protection (Sta. 21+90)	$75,000
6) Slope Protection (Sta. 57+00)	$40,000
Total – Small Branch	**$385,000**



City of Grand Prairie

Joe Pool Lake
Stream Bank Stability
Alternatives

FIGURE SSM1

SMALL BRANCH

Legend

- CROSS SECTIONS
- CENTERLINE
- USACE FLOWAGE EASEMENT
- DRAINAGE AREAS
- JOE POOL LAKE 1% FLOOD
- 1 % ANNUAL CHANCE FLOOD
- CITY LIMITS

Notes: 1) Topography provided by the City of Grand Prairie.(1999)
NAD 1983 State Plane

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1"=500'

Halff Associates
ENGINEERS ARCHITECTS SCIENTISTS PLANNERS SURVEYORS

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SMALL BRANCH

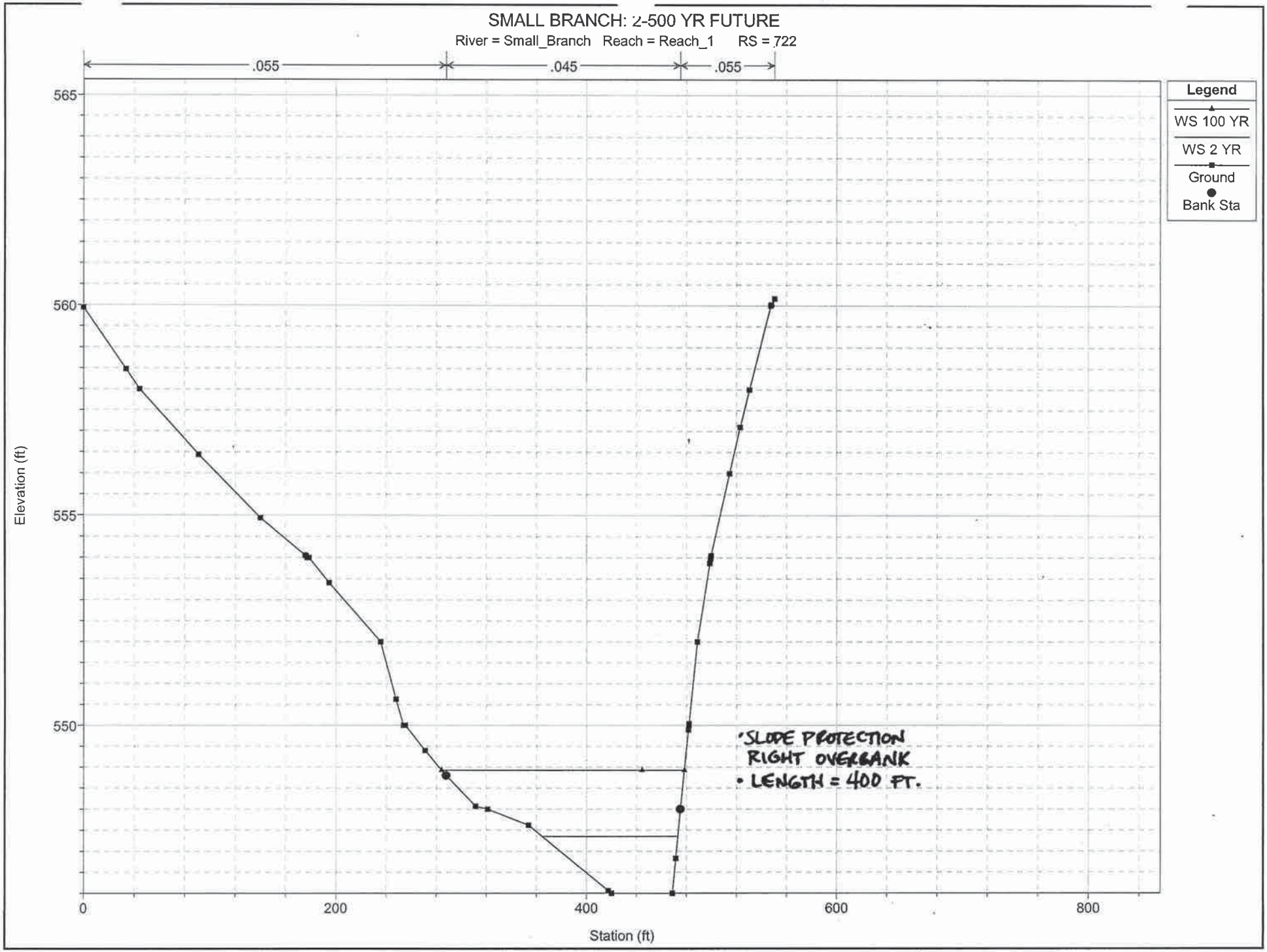
Hydraulic Siting of Grade Control Structures

Location #1	XS	Flowline
Downstream	1619	552
Upstream	2760	560

Original Slope=	0.0070
Equilibrium Slope=	0.00096
Height of Drop (ft)=	**2**
Number of structures (calc)=	3.45
Total Grade Control Structures=	**4**

Location #2	XS	Flowline
Downstream	5865	592.65
Upstream	6840	625.99

Original Slope=	0.0342
Equilibrium Slope=	0.00096
Height of Drop (ft)=	**4**
Number of structures (calc)=	8.10
Total Grade Control Structures=	**8**



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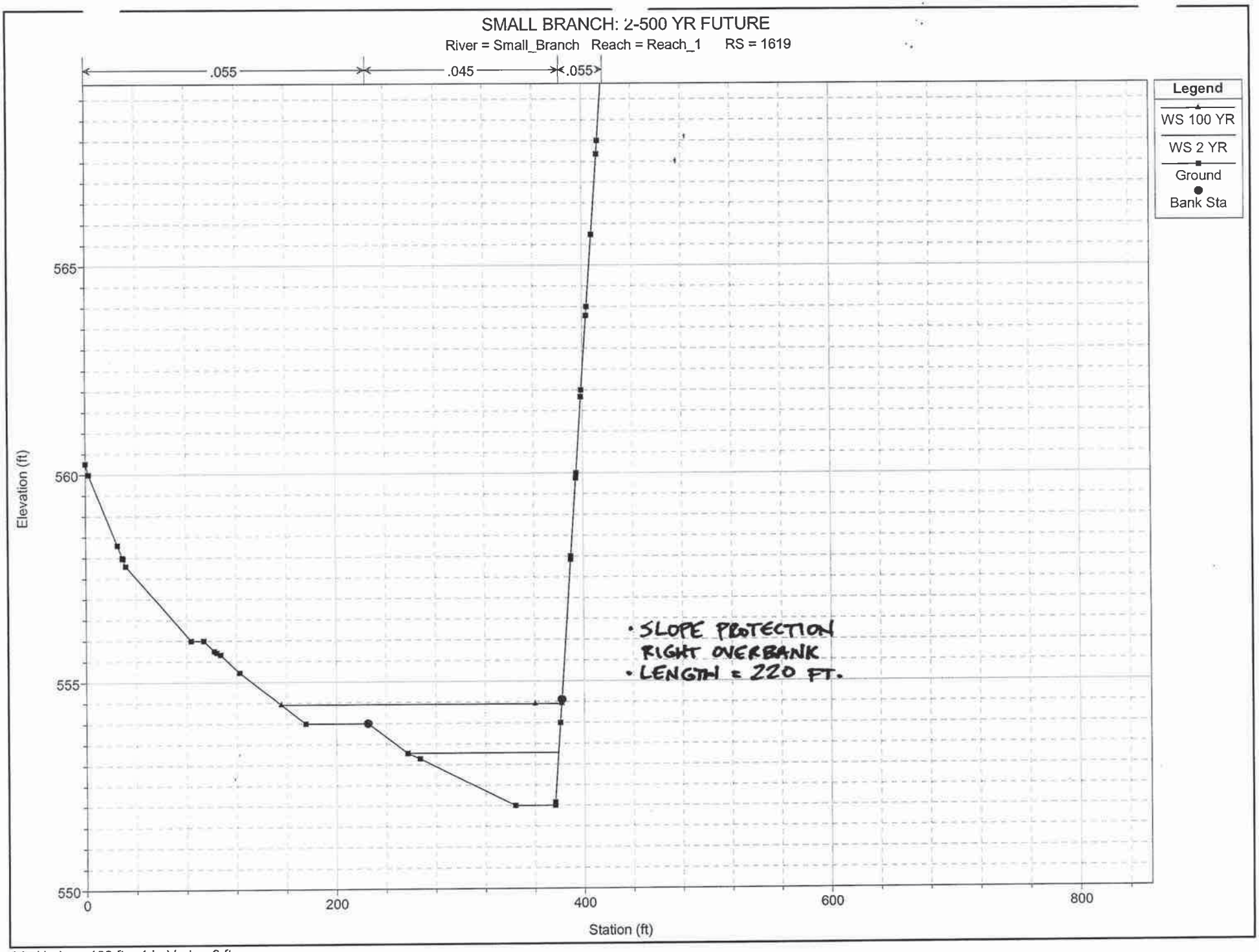

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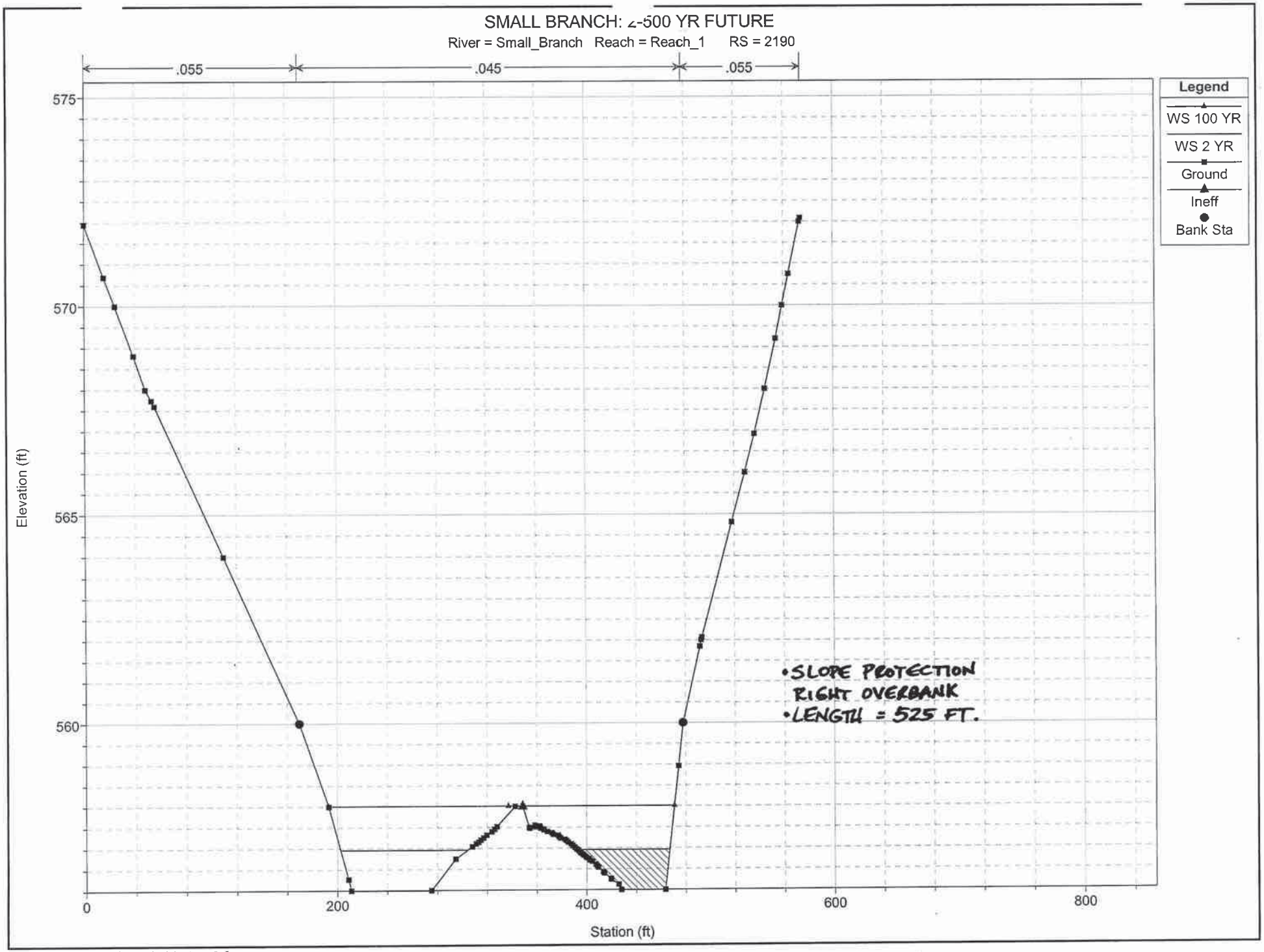
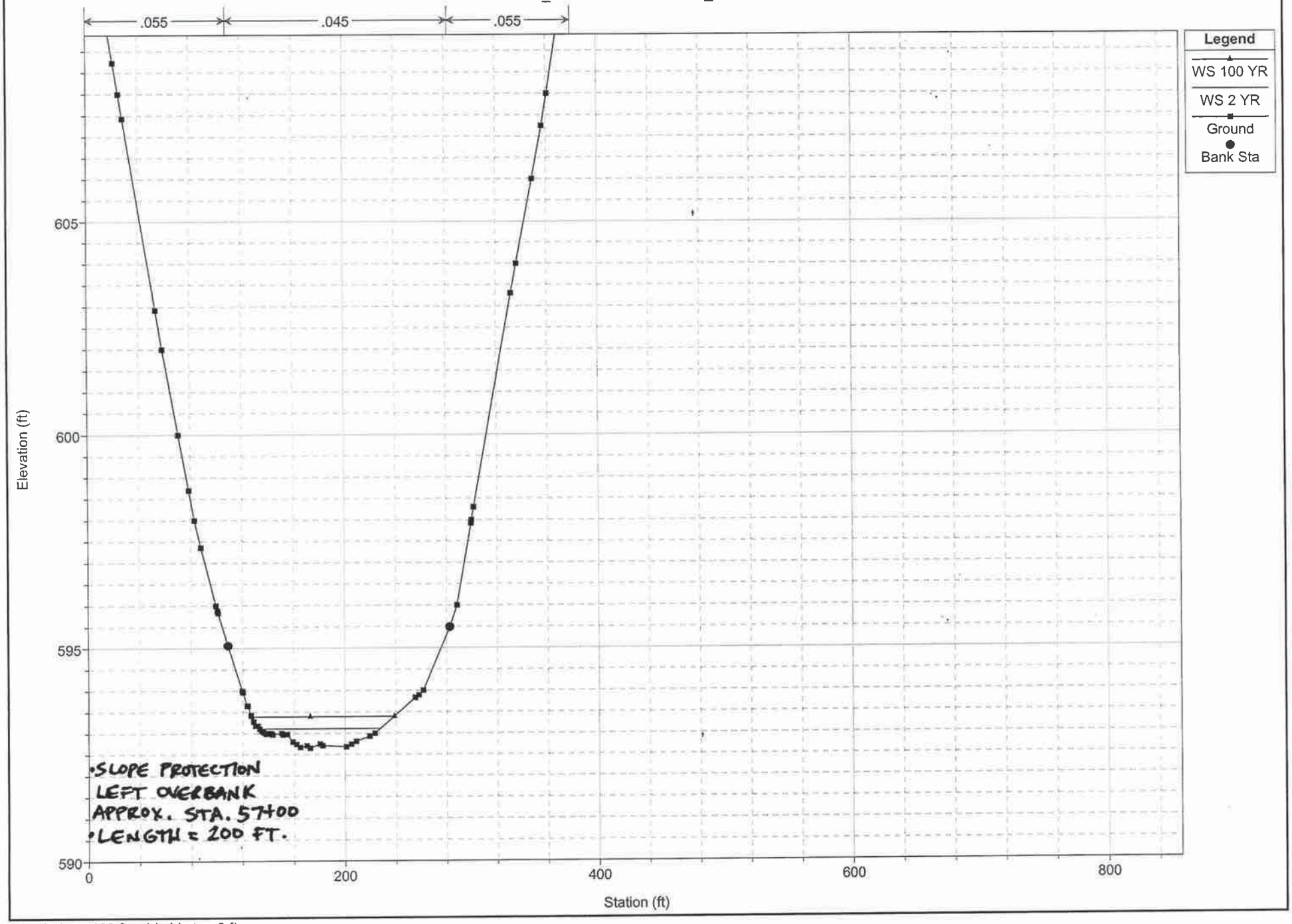


1 in Horiz. = 100 ft 1 in Vert. = 3 ft

SMALL BRANCH: 2-500 YR FUTURE

River = Small_Branch Reach = Reach_1 RS = 5865



1 in Horiz. = 100 ft 1 in Vert. = 3 ft

EDGE CREEK

HALFF ASSOCIATES, INC.
JOE POOL LAKE DRAINAGE MASTER PLAN (W.O. 540.26)
STREAM BANK STABILITY ALTERNATIVES

D. EDGE CREEK– STREAM BANK STABILITY ALTERNATIVES

1. General Description

Edge Creek is approximately 1.93 miles in length through the study area with an average slope of 0.98%. The lower 1,690 linear feet of Edge Creek is within the current 1% annual chance floodplain of Joe Pool Lake. The stream is generally a natural earthen channel with some vegetation. The Edge Creek overbanks consist of open range land with brush and trees.

2. Stream Assessment Results

Sinuosity - Edge Creek has a sinuosity range of 1.39 to 1.91, which is slightly higher than most of the other studied streams.

Channel Survey

Stream Type: Swale, then upstream knickpoint (7 foot drop); grass/clay meandering channel to 2400 feet downstream of the upstream limits, pool riffles; Channel Evolution Stage I

Channel Bed/Banks: Most channel is clay and grass until 2400 feet downstream of the upstream limits; downstream of this more limestone gravels exist in channel; then channel becomes swale with grass and brush to pond

Observations: Slumps and slope failures evident near pond; deposition in lake; abundant backwater tree growth

Incipient Motion - The results of the incipient motion analysis indicate that the one-year flood frequency flows can move the D50 bed material downstream for only a few portions of the reach upstream of the pond location (Station 55+00 to 62+50).

Equilibrium Slope - The results indicate an equilibrium slope of **0.0014**. The current average channel slope along the study reach upstream of the pond is 0.0115.

Projected Channel Enlargement and Degradation - The projected widening ratio (future/existing) for Edge Creek is 0.6-2.36. Current defined channel bottom widths are mostly between 10 feet to 20 feet.

Channel Stability - Based on the Edge Creek hydraulic model, stream power (one-year frequency) exceeds the potential erosion threshold at Stations 55+31, 64+43,

and 106+45. Stream power is below the potential deposition threshold for Stations 19+60 to 50+24, 62+59, 67+73, 78+26 to 83+22, and 95+73.

3. Stream Bank Stability Alternatives

Grade Control Structures

Two locations along Edge Creek were identified to be areas of potential erosion (see Figure CED-1 in Volume II). Utilizing these locations, Halff recommends implementation of grade control structures (check dams) along two separate reaches of Edge Creek (see Figure SED-1). Refer to Appendix D, Page 2 for formulas utilized for hydraulic siting of grade control structures.

- *Location #1* – Primarily located between Station 50+24 to Station 64+43. Utilizing the existing slope of 0.0071 along this reach, the equilibrium slope of 0.0014, and a proposed grade control structure height of 2 feet, the total number of grade control structures needed for this reach would be four (4), with the first being located near the downstream end of the reach and the other three being uniformly distributed for the remainder of the reach.

- *Location #2* – Primarily located between Station 100+09 to Station 108+14. Utilizing the existing slope of 0.0288 along this reach, the equilibrium slope of 0.0014, and a proposed grade control structure height of 4 feet, the total number of grade control structures needed for this reach would be six (6), with the first being located near the downstream end of the reach and the other five being uniformly distributed for the remainder of the reach.

Armored Slope and Channel Protection

Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored slope and channel protection at one location along Edge Creek (see Figure SED-1). Halff recommends 18" rock riprap protection for the armored slope protection location near Station 55+31.

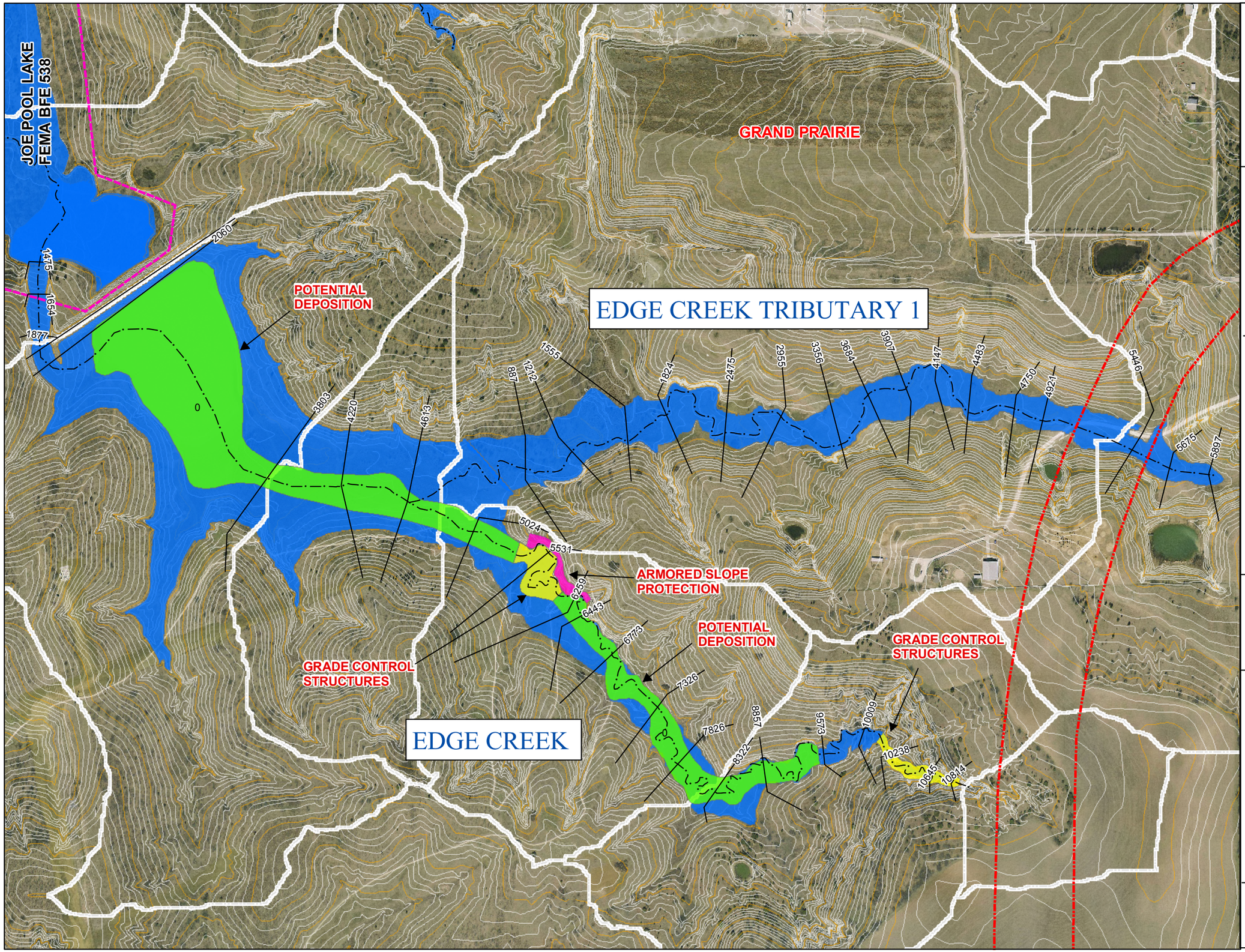
4. Edge Creek – Prioritized Improvements/Estimates of Probable Cost

As described in Section I (Page 14), the improvements described in this section would be for pre-development conditions. The following table provides a general

ranking of proposed pre-development improvements and estimates of probable costs for Edge Creek.

Edge Creek – Stream Bank Stability Alternatives

Rank/Description	Estimate of Probable Cost
1) Grade Control Structure (Sta. 50+24 to 64+43)	$40,000
2) Grade Control Structure (Sta. 100+09 to 108+14)	$90,000
3) Slope Protection (Sta. 55+31)	$65,000
Total – Edge Creek	**$195,000**



City of Grand Prairie

Joe Pool Lake
Stream Bank Stability
Alternatives

FIGURE SED 1

EDGE CREEK

Legend

- CROSS SECTIONS
- CENTERLINE
- USACE FLOWAGE EASEMENT
- DRAINAGE AREAS
- JOE POOL LAKE 1% FLOOD
- 1% ANNUAL CHANCE FLOOD
- CITY LIMITS

Notes: 1) Topography provided by the City of Grand Prairie.(1999)
NAD 1983 State Plane

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EDGE CREEK

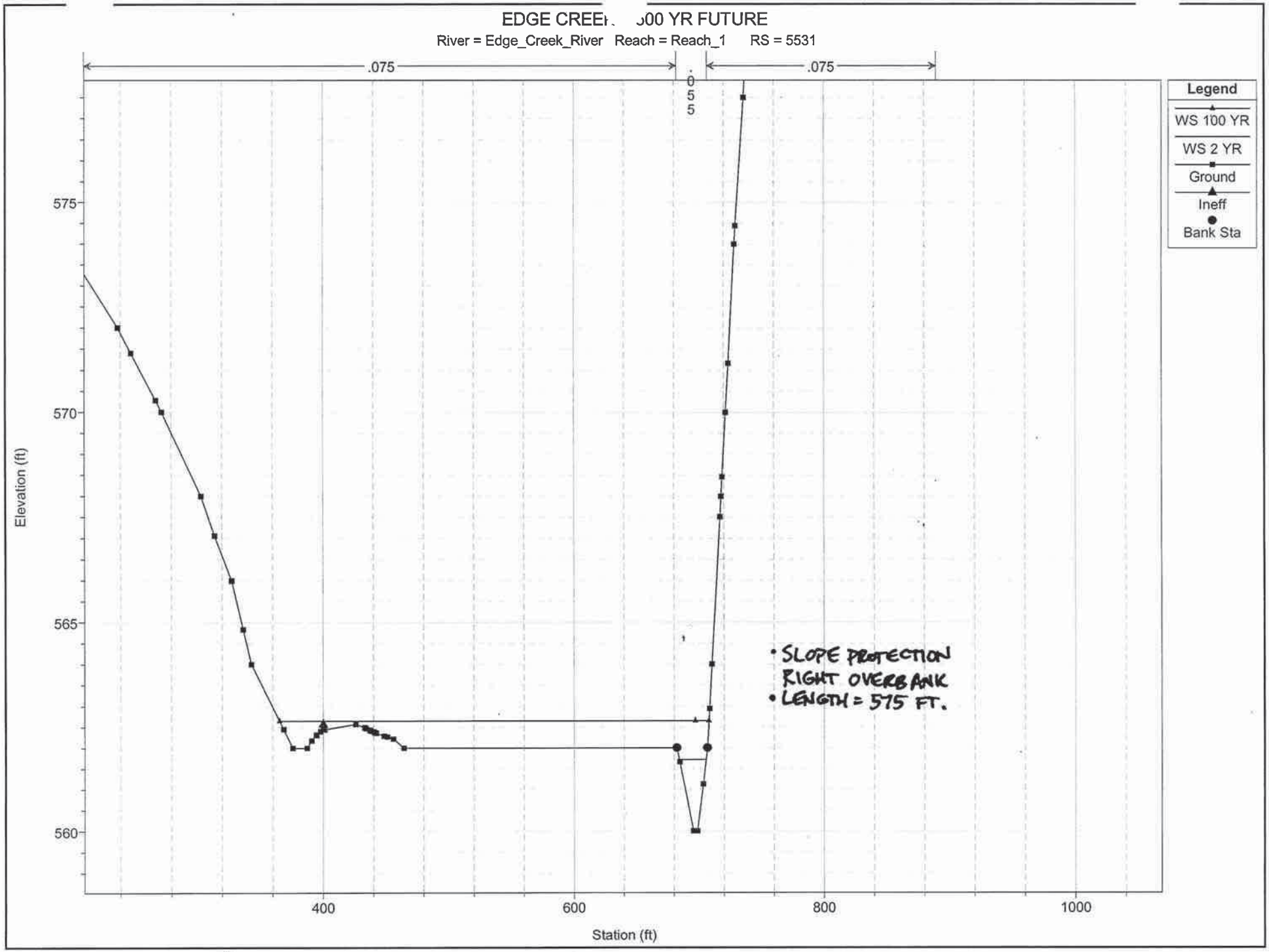
Hydraulic Siting of Grade Control Structures

Location #1	XS	Flowline
Downstream	5024	556
Upstream	6443	566.05

Original Slope=	0.0071
Equilibrium Slope=	0.0014
Height of Drop (ft)=	**2**
Number of structures (calc)=	4.03
Total Grade Control Structures=	**4**

Location #2	XS	Flowline
Downstream	10009	602.83
Upstream	10814	626

Original Slope=	0.0288
Equilibrium Slope=	0.0014
Height of Drop (ft)=	**4**
Number of structures (calc)=	5.51
Total Grade Control Structures=	**6**



1 in Horiz. = 100 ft 1 in Vert. = 3 ft

TAAFFE CREEK

E. TAAFFE CREEK– STREAM BANK STABILITY ALTERNATIVES

1. General Description

Taaffe Creek is approximately 1.31 miles in length through the study area with an average slope of 0.53%. The upstream portion of Taaffe Creek was rerouted around the recent Mira Lagos development (Station 49+19 to 68+88). An improved grass-lined channel is trapezoidal in shape. The upstream overbanks consist of residential structures and some open range land. The downstream portion of the stream is a natural earthen channel with some vegetation. The downstream overbanks consist of open range land with brush and trees and some residential structures.

2. Stream Assessment Results

Sinuosity - Taaffe Creek has a sinuosity range of 1.09, which is lower than most of the other studied streams.

Channel Survey
Stream Type: Improved trapezoidal channel on upstream limits with gabions for grade control and some riprap; pool riffle meandering channel to downstream end
Channel Bed/Banks: Clay bottom to 3300 feet downstream of upstream limits then channel bottom and banks in shale
Observations: Tree falls and small knickpoints in unaltered channel sections downstream of channel improvements; minor erosion of cutbanks; drop structure at Seeton Road

Incipient Motion - The results of the incipient motion analysis indicate that the one-year flood frequency flows can move the D50 bed material along most portions of the channel except along the improved channel upstream and near Station 33+66.

Equilibrium Slope - The results indicate an equilibrium slope of **0.0015**. The current average channel slope along the study reach upstream of Seeton Road is 0.0046.

Projected Channel Enlargement and Degradation - The projected widening ratio (future/existing) for Taaffe Creek is 1.21-1.22. Current defined channel bottom widths, in non-improved channel areas, are mostly between 5 feet to 15 feet.

Channel Stability - Based on the Taaffe Creek hydraulic model, stream power (one-year frequency) exceeds the potential erosion threshold at Stations 27+66 and 37+97.

Stream power is below the potential deposition threshold between Stations 16+29 to 27+02 and 49+19 to 67+45.

3. Stream Bank Stability Alternatives

Grade Control Structures

Three locations along Taaffe Creek were identified to be areas of potential erosion (see Figure CTF-1 in Volume II). Utilizing these locations, Halff recommends implementation of grade control structures (check dams) along one reach and bed control structures (rock chutes) along another reach of Taaffe Creek (see Figure STF-1). Refer to Appendix D, Page 2 for formulas utilized for hydraulic siting of grade control structures.

- *Location #1: Check Dam* – Primarily located between Station 27+15 to Station 36+79. Utilizing the existing slope of 0.022 along this reach, the equilibrium slope of 0.0026, and a proposed grade control structure height of 4 feet, the total number of grade control structures needed for this reach would be one (1), located near the downstream end of the reach.

- *Location #2: Rock Chute* – Primarily located between Station 29+33 to Station 33+66. Since the existing slope is approximately 0.005 along this reach, a rock chute should be utilized instead of a grade control structure to stabilize potential channel downcutting.

Armored Slope and Channel Protection

Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored slope and channel protection at one location along Taaffe Creek (see Figure STF-1) if the recommended rock chute is not implemented at this location. Halff would recommend 18" rock riprap protection, if needed.

Seeton Road Culvert Improvements

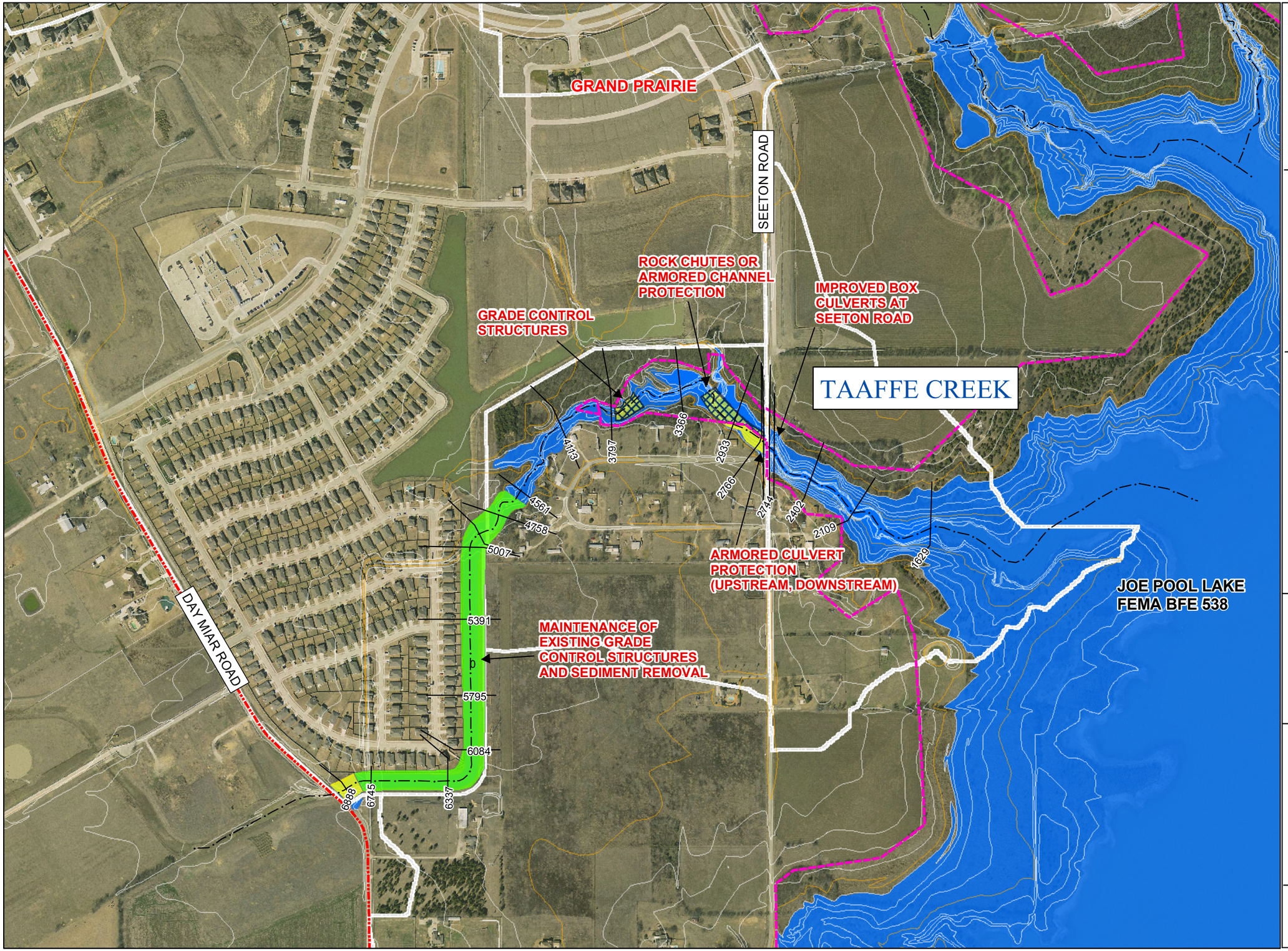
Halff's hydraulic analysis of Taaffe Creek indicated that Seeton Road could only pass the ultimate 25-year flood event. In order for Seeton Road to pass the 100-year flood event, the existing 4-8'x5' box culverts would need to be increased to 4-8'x7' box culverts. HEC-RAS cross-sections of the proposed culvert improvements are included in this section.

4. Taaffe Creek – Prioritized Improvements/Estimates of Probable Cost

As described in Section I (Page 14), the improvements described in this section would be for pre-development conditions. The following table provides a general ranking of proposed pre-development improvements and estimates of probable costs for Taaffe Creek.

Taaffe Creek – Culvert Improvements & Stream Bank Stability Alternatives

Rank/Description	Estimate of Probable Cost
1) Seeton Road Culvert Improvements (Sta. 27+03)	$410,000
2) Grade Control Structure-Check Dam (Sta. 27+15 to 36+79)	$15,000
3) Grade Control Structure-Rock Chute (Sta. 29+33 to 33+66)	$30,000
Total – Taaffe Creek	**$455,000**



City of Grand Prairie

Joe Pool Lake
Stream Bank Stability
Alternatives

FIGURE STF 1

TAAFFE CREEK

Legend

- CROSS SECTIONS
- CENTERLINE
- USACE FLOWAGE EASEMENT
- DRAINAGE AREAS
- JOE POOL LAKE 1% FLOOD
- 1 % ANNUAL CHANCE FLOOD
- CITY LIMITS

Notes: 1) Topography downstream of Cross Section 4758 provided by the City of Grand Prairire (1999) NAD 1983 State Plane
2) Taaffe Creek Floodplain upstream of Cross Section 4758 delineated based upon Mira Lagos Phase F-1B As Built Plans

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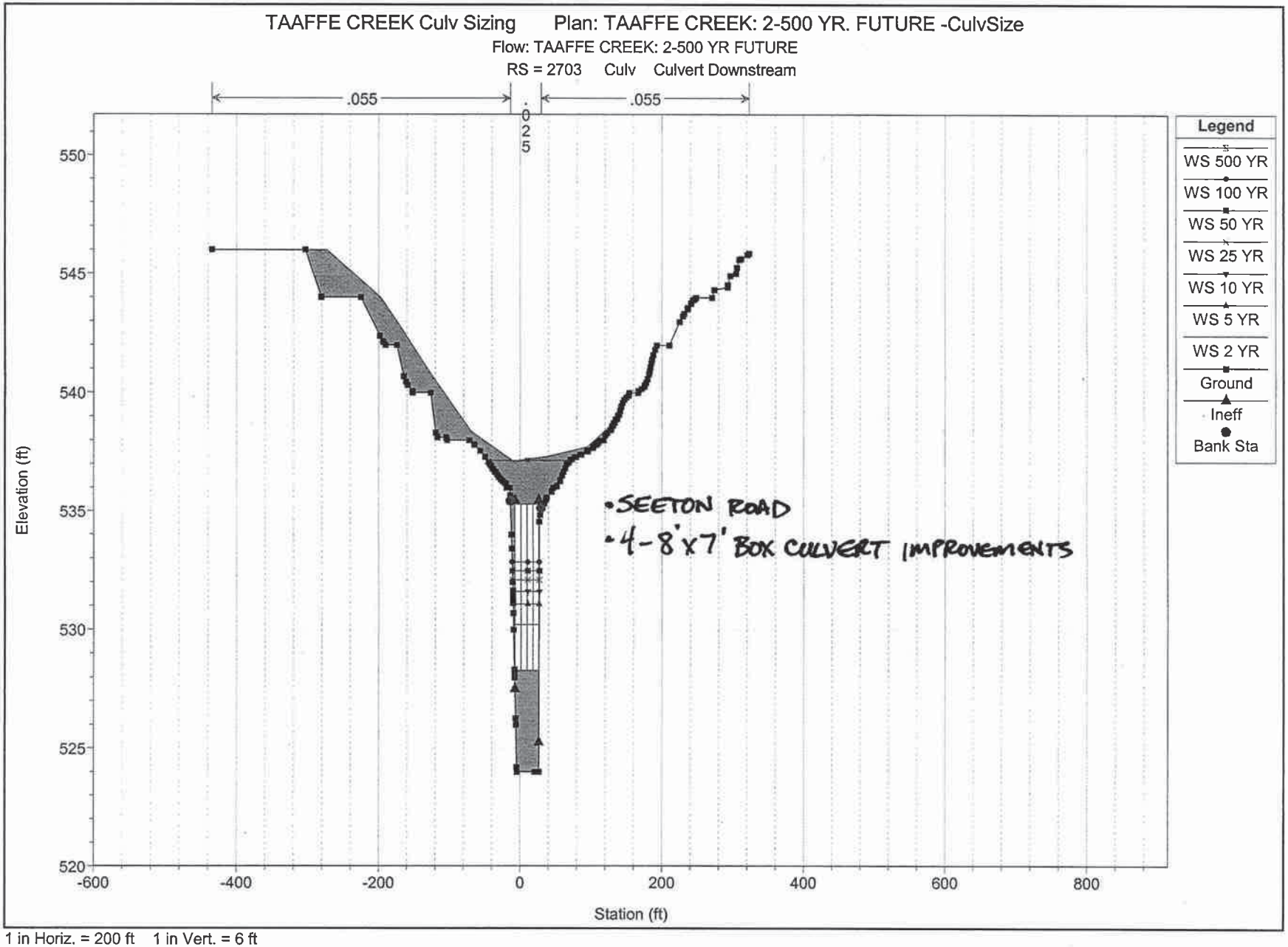
TAAFFE CREEK

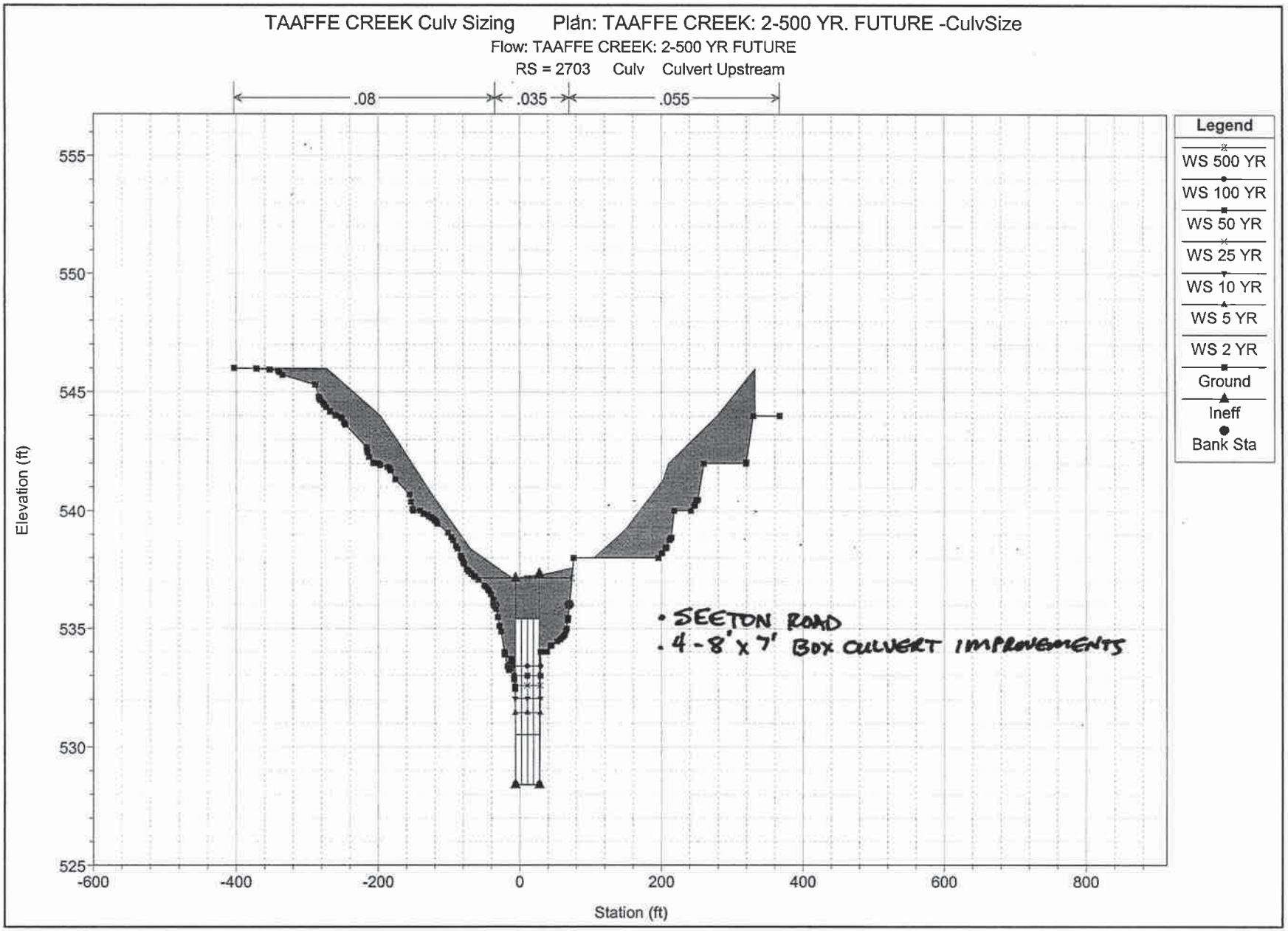
Hydraulic Siting of Grade Control Structures

Location #1	XS	Flowline
Downstream	3366	534
Upstream	3797	538.23

Original Slope=	0.0098
Equilibrium Slope=	0.0015
Height of Drop (ft)=	**4**
Number of structures (calc)=	0.90
Total Grade Control Structures=	**1**



1 in Horiz. = 200 ft 1 in Vert. = 6 ft



1 in Horiz. = 200 ft 1 in Vert. = 6 ft

STUART BRANCH

F. STUART BRANCH– STREAM BANK STABILITY ALTERNATIVES

1. General Description

Stuart Branch is approximately 0.90 miles in length through the study area with an average slope of 1.36%. The stream is generally a natural earthen channel with some vegetation. The Stuart Branch overbanks consist of open range land with brush and trees.

2. Stream Assessment Results

Sinuosity - Stuart Branch has a sinuosity range of 1.19, which is lower than most of the other studied streams.

Channel Survey
Stream Type: Lake to swale channel in grass and brush near upstream end; then meandering channel to downstream end; Channel Evolution Stage I-II
Channel Bed/Banks: Grass and clay near upstream end, then clay and limestone gravel
Observations: Gullies near upstream end and again near 1600 feet from upstream limits

Incipient Motion - The results of the incipient motion analysis indicate that the one-year flood frequency flows can move the D50 bed material at three specific locations along the channel near Station 15+50, Station 25+00, and Station 42+50.

Equilibrium Slope - The results indicate an equilibrium slope of **0.0024**. The current average channel slope along the study reach downstream of Texas Plume Road is 0.0123.

Projected Channel Enlargement and Degradation - The projected widening ratio (future/existing) for Stuart Branch is 1.0-1.21. Current defined channel bottom widths are mostly between 10 feet to 30 feet.

Channel Stability - Based on the Stuart Branch hydraulic model, stream power (one-year frequency) exceeds the potential erosion threshold at Stations 15+69, 25+32, and 43+33. Stream power is below the potential deposition threshold at Stations 12+58, 18+54 to 21+52, 27+95 to 40+20, and 45+60 to 47+16.

3. Stream Bank Stability Alternatives

Grade Control Structures

Three locations along Stuart Branch were identified to be areas of potential erosion (see Figure CST-1 in Volume II). Utilizing these locations, Halff recommends implementation of grade control structures (check dams) along one reach of Stuart Branch and armored pond outfalls for the other two locations (see Figure SST-1). Refer to Appendix D, Page 2 for formulas utilized for hydraulic siting of grade control structures.

- *Location #1* – Primarily located between Station 18+54 to Station 27+95. Utilizing the existing slope of 0.0096 along this reach, the equilibrium slope of 0.0024, and a proposed grade control structure height of 2 feet, the total number of grade control structures needed for this reach would be four (4), with the first being located near the downstream end of the reach and the other three being uniformly distributed for the remainder of the reach.

Armored Pond Outfall Protection/Culvert Protection

Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored pond outfall protection at two locations along Stuart Branch (see Figure SST-1). Halff recommends 24" rock riprap for the armored pond outfall protection locations near Station 15+69 and 42+52.

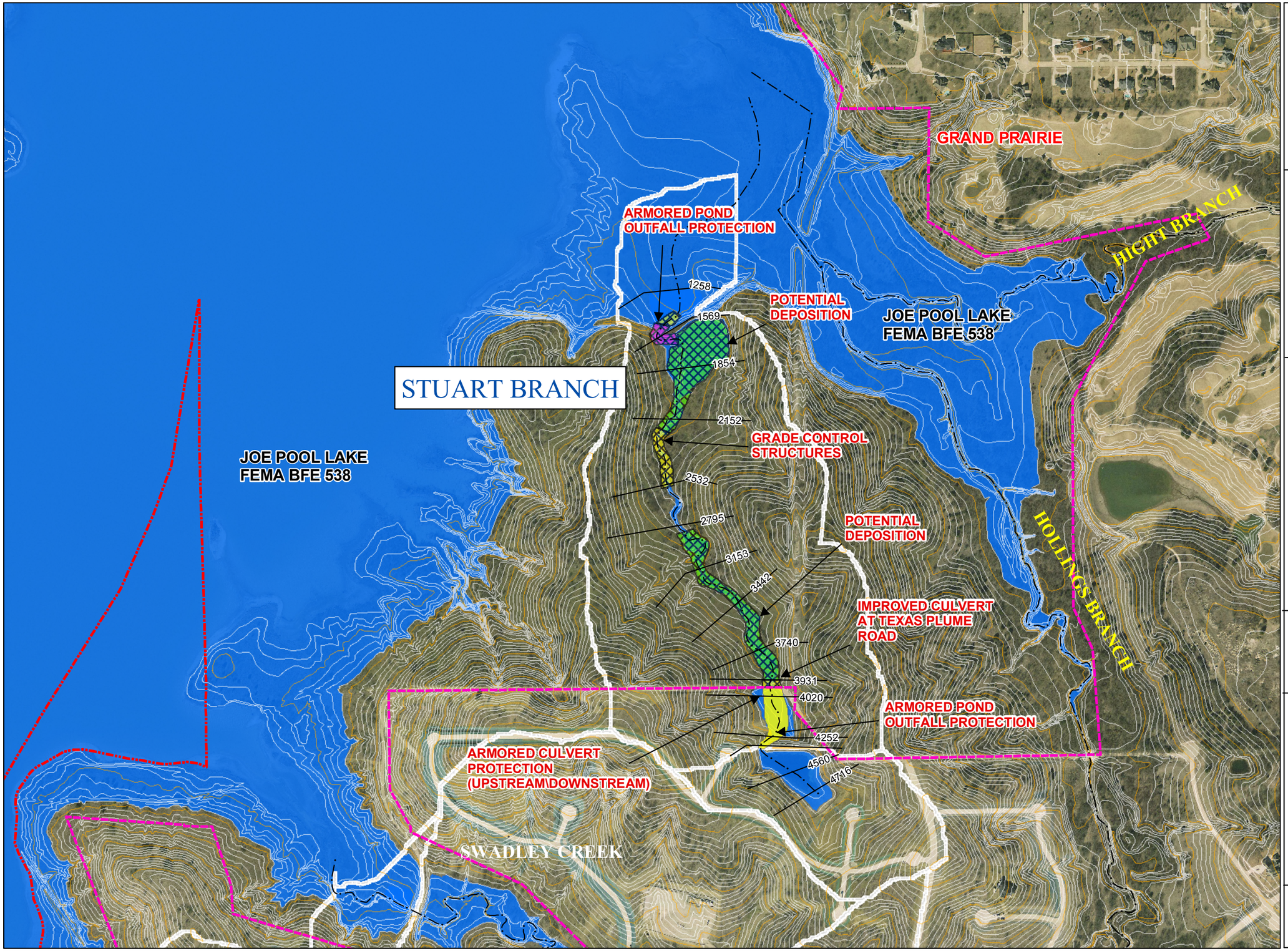
For the existing pipe culvert at Texas Plume Road, Halff would recommend implementation of temporary 24" rock riprap protection that could be re-used when this road is improved from its current state (gravel based). However, based on the current condition of this pipe culvert, the City may want to proceed with rock riprap protection after a new road is constructed. If it is a developer-based road improvement, then the developer would be obligated for construction of the culvert and rock riprap protection.

4. Stuart Branch – Prioritized Improvements/Estimates of Probable Cost

As described in Section I (Page 14), the improvements described in this section would be for pre-development conditions. The following table provides a general ranking of proposed pre-development improvements and estimates of probable costs for Stuart Branch.

Stuart Branch – Stream Bank Stability Alternatives

Rank/Description	Estimate of Probable Cost
1) Armored Pond Outfall Protection (Sta. 15+69)	$125,000
2) Armored Pond Outfall Protection (Sta. 42+52)	$75,000
3) Grade Control Structure (Sta. 18+54 to 27+95)	$40,000
Total – Stuart Branch	**$240,000**



City of Grand Prairie

Joe Pool Lake
Stream Bank Stability
Assessment

FIGURE SST 1

STUART BRANCH

Legend

- CROSS SECTIONS
- CENTERLINE
- USACE FLOWAGE EASEMENT
- DRAINAGE AREAS
- 1 % ANNUAL CHANCE FLOOD
- JOE POOL LAKE 1% FLOOD
- CITY LIMITS

Notes: 1) Topography provided by the City of Grand Prairie.(1999) NAD 1983 State Plane

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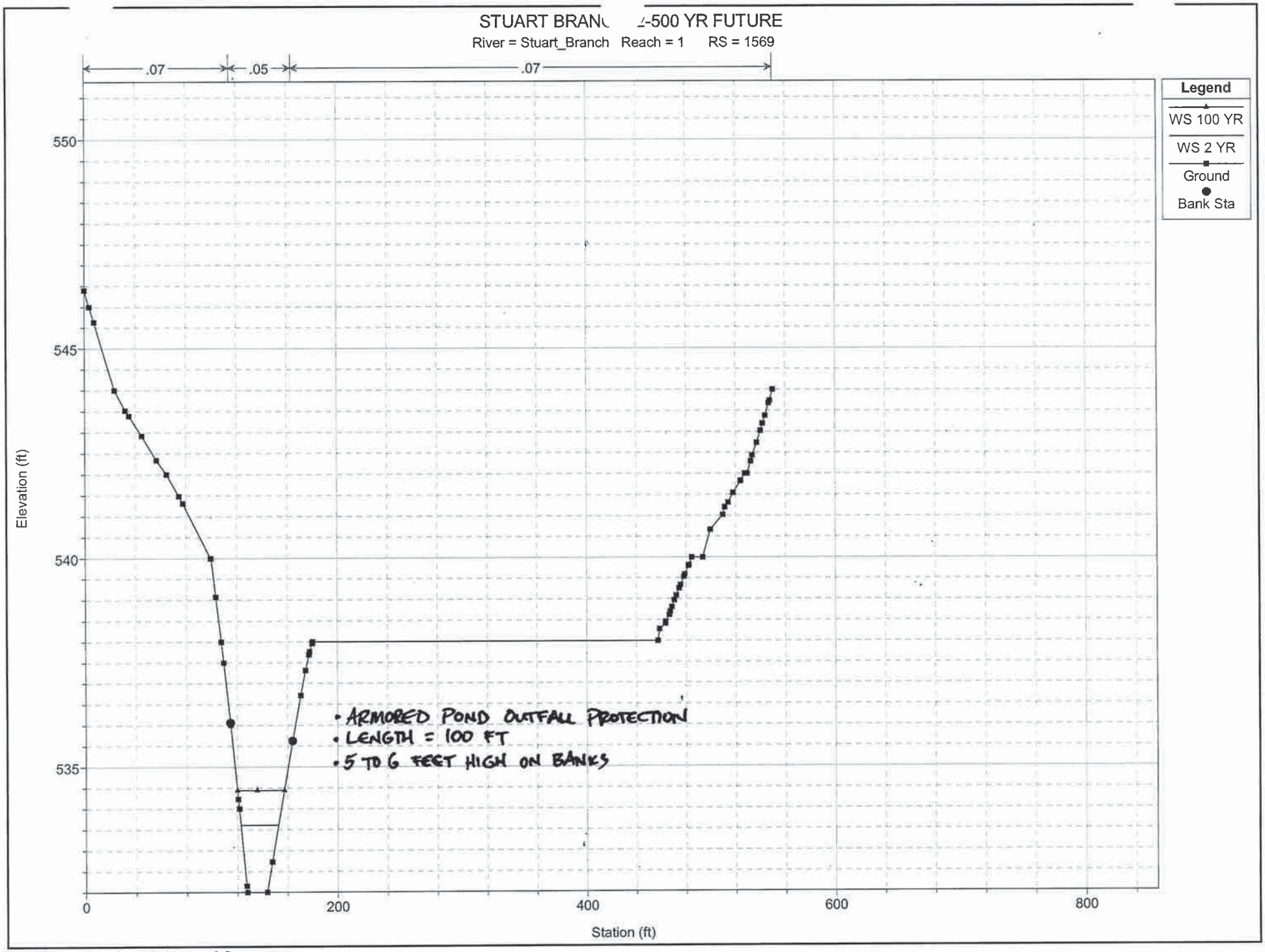
STUART BRANCH

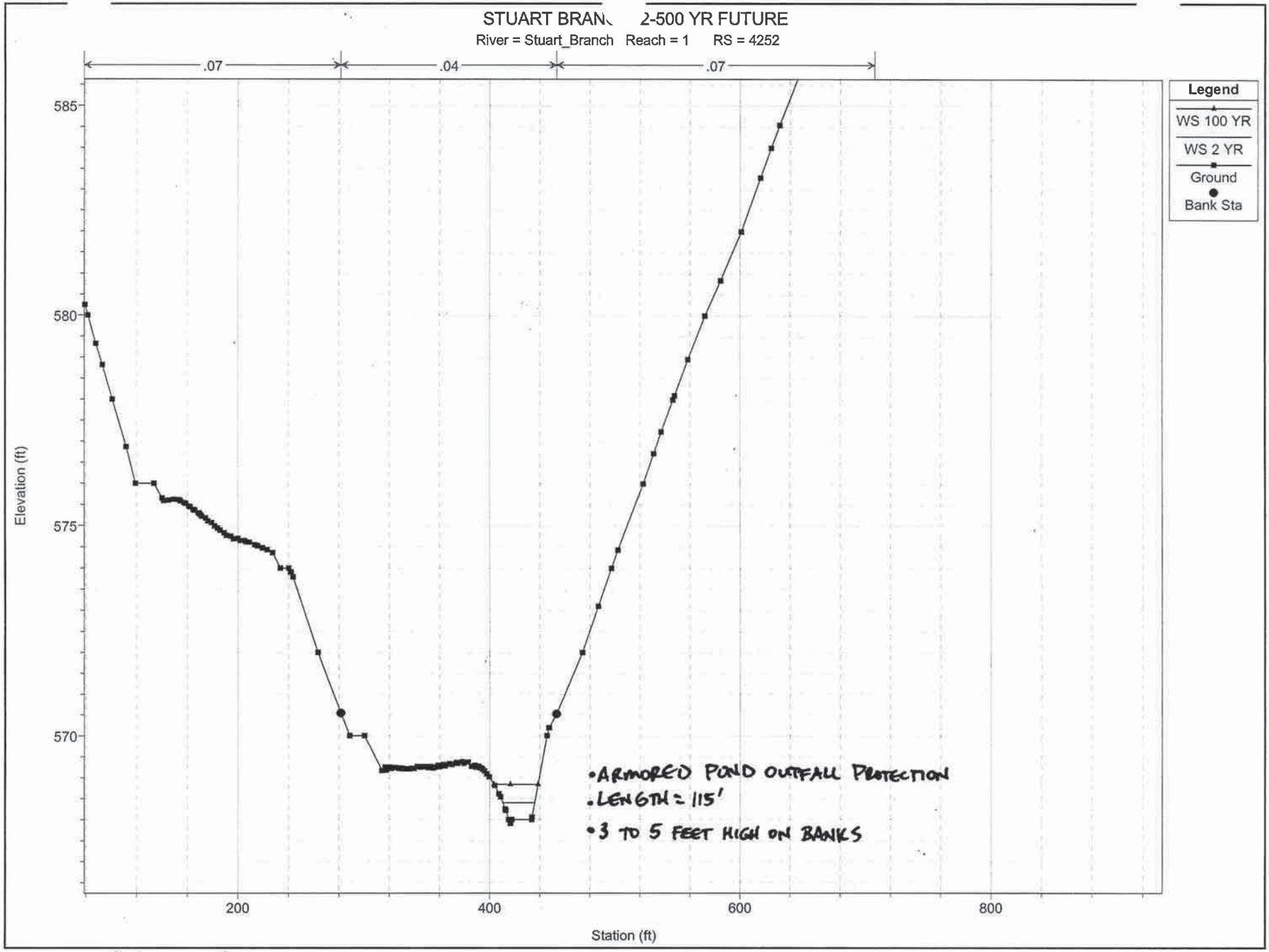
Hydraulic Siting of Grade Control Structures

Location #1	XS	Flowline
Downstream	1854	534
Upstream	2795	543

Original Slope=	0.0096
Equilibrium Slope=	0.0024
Height of Drop (ft)=	**2**
Number of structures (calc)=	3.37
Total Grade Control Structures=	**4**



1 in Horiz. = 100 ft 1 in Vert. = 3 ft



1 in Horiz. = 100 ft 1 in Vert. = 3 ft

SWADLEY CREEK

G. SWADLEY CREEK– STREAM BANK STABILITY ALTERNATIVES

1. General Description

Swadley Creek is approximately 1.27 miles in length through the study area with an average slope of 0.96%. The stream is generally a natural earthen channel with some vegetation. The Swadley Creek overbanks consist of open range land with brush and trees.

2. Stream Assessment Results

Sinuosity - Swadley Creek has a sinuosity range of 1.37-1.81, which is slightly higher than most of the other studied streams.

Channel Survey

Stream Type: Meandering clay and grass channel to about 1600 feet downstream of the upstream limits; transitions to meandering channel to end; Channel Evolution Stage I-II

Channel Bed/Banks: Grass and clay bottom to 1600 feet downstream of the upstream limits, then clay banks and clay/limestone bottom to end

Observations: Knickpoints and gullies near upstream end; bank erosion near downstream end as channel cuts into shale side slopes

Incipient Motion - The results of the incipient motion analysis indicate that the one-year flood frequency flows can move the D50 bed material along most of the studied stream, except for just upstream of Texas Plume Road.

Equilibrium Slope - The results indicate an equilibrium slope of **0.0019**. The current average channel slope along the study reach upstream of Texas Plume Road is 0.0098.

Projected Channel Enlargement and Degradation - The projected widening ratio (future/existing) for Swadley Creek is 1.28-1.39. Current defined channel bottom widths are mostly between 10 feet to 30 feet.

Channel Stability - Based on the Swadley Creek hydraulic model, stream power (one-year frequency) exceeds the potential erosion threshold at Stations 4+92 to 6+36, 44+34, and 53+63. Stream power is below the potential deposition threshold at Stations 7+69, 16+71, 36+70, 49+14, 56+41, and 63+06.

3. Stream Bank Stability Alternatives

Grade Control Structures

Three locations along Swadley Creek were identified to be areas of potential erosion (see Figure CSW-1 in Volume II). Utilizing these locations, Halff recommends implementation of grade control structures (check dams) along one reach and bed control structures (rock chutes) at three other locations along Swadley Creek (see Figure SSW-1). Refer to Appendix D, Page 2 for formulas utilized for hydraulic siting of grade control structures.

- *Location #1: Check Dam* – Primarily located between Station 36+70 to Station 56+41. Utilizing the existing slope of 0.0098 along this reach, the equilibrium slope of 0.0019, and a proposed grade control structure height of 3 feet, the total number of grade control structures needed for this reach would be six (6), with the first being located near the downstream end of the reach and the other five being uniformly distributed for the remainder of the reach.

- *Location #2: Rock Chutes* – Three rock chutes primarily located between Station 60+41 to Station 67+39 to stabilize potential downcutting of Swadley Creek at its headwaters, where the existing channel slope is approximately 0.02.

Armored Pond Outfall Protection/Culvert Protection

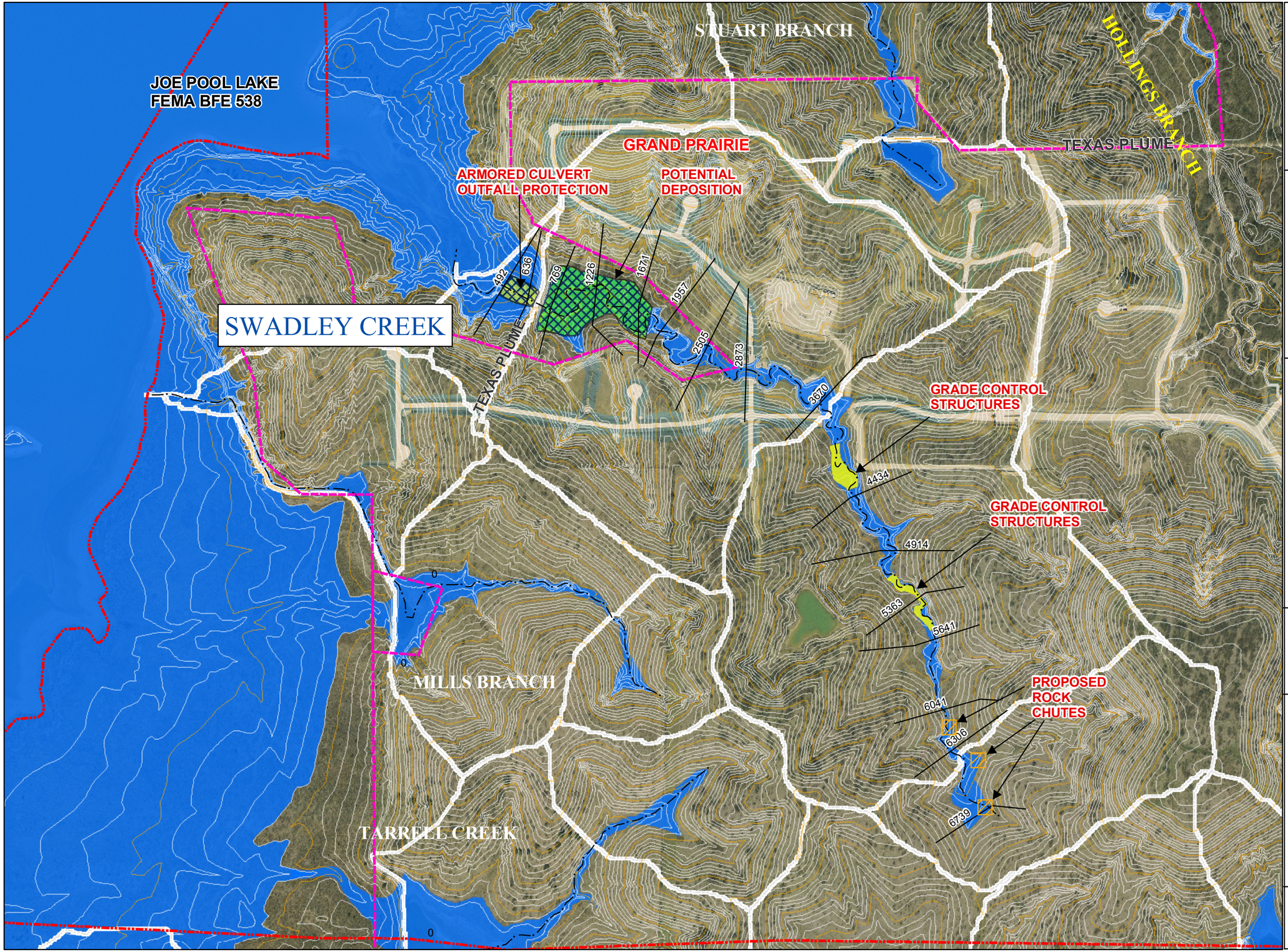
Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored pond outfall protection at one location along Swadley Creek (see Figure SSW-1). Halff recommends 24" rock riprap for the armored pond outfall protection location near Station 6+36.

4. Swadley Creek – Prioritized Improvements/Estimates of Probable Cost

As described in Section I (Page 14), the improvements described in this section would be for pre-development conditions. The following table provides a general ranking of proposed pre-development improvements and estimates of probable costs for Swadley Creek.

Swadley Creek –Stream Bank Stability Alternatives

Rank/Description	Estimate of Probable Cost
1) Armored Outfall Protection (Sta. 6+36)	$50,000
2) Grade Control Structure-Check Dam (Sta. 36+70 to 56+41)	$65,000
3) Grade Control Structure-Rock Chutes (Sta. 60+41 to 67+39)	$80,000
Total – Swadley Creek	**$195,000**



City of Grand Prairie

Joe Pool Lake
Stream Bank Stability
Alternatives

FIGURE SSW1

SWADLEY CREEK

Legend

- CROSS SECTIONS
- CENTERLINE
- USACE FLOWAGE EASEMENT
- DRAINAGE AREAS
- 1 % ANNUAL CHANCE FLOOD
- JOE POOL LAKE 1% FLOOD
- CITY LIMITS

Notes: 1) Topography provided by the City of Grand Prairie.(1999)
NAD 1983 State Plane

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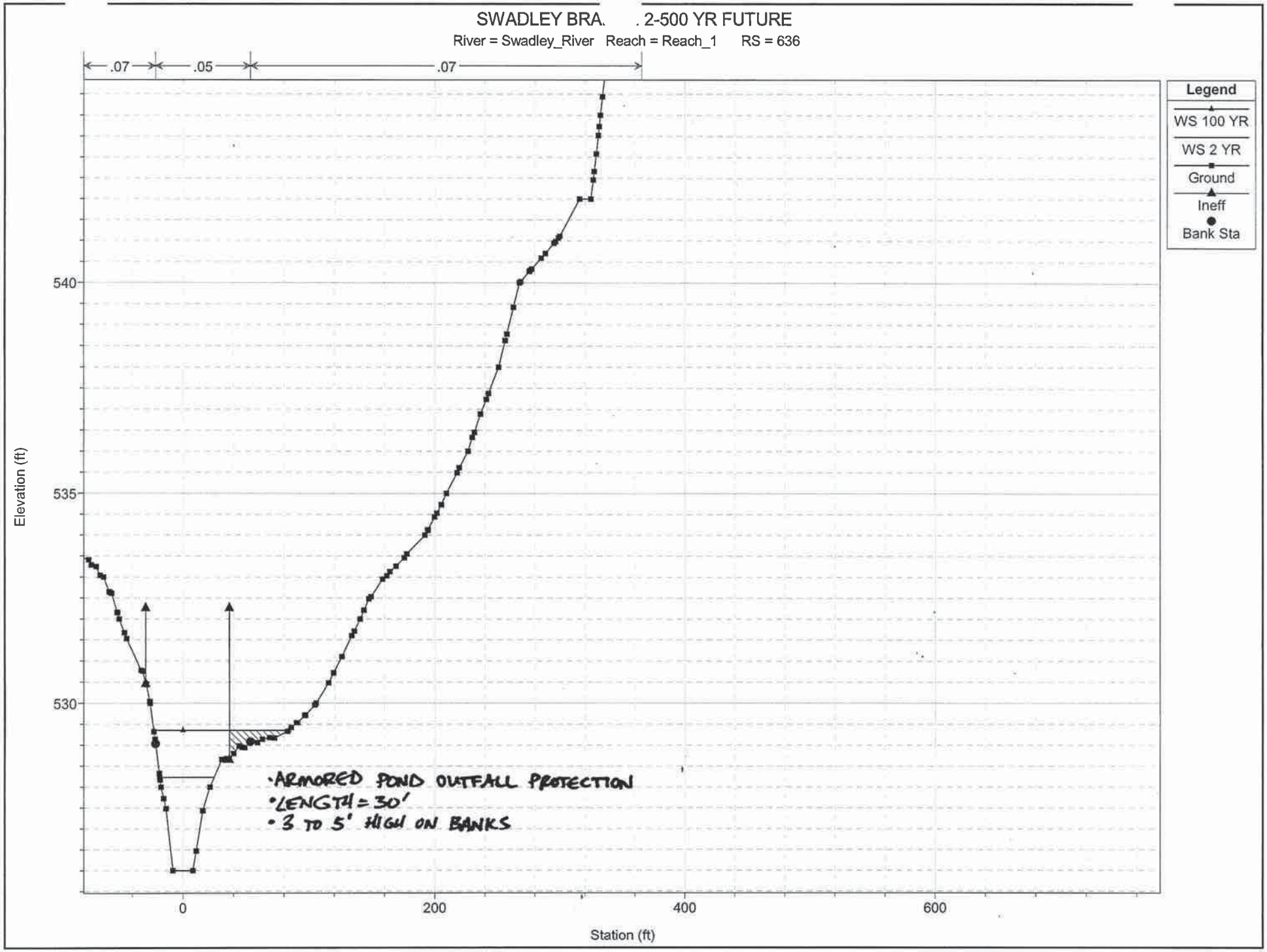
SWADLEY CREEK

Hydraulic Siting of Grade Control Structures

Location #1	XS	Flowline
Downstream	3670	544.77
Upstream	5641	564

Original Slope=	0.0098
Equilibrium Slope=	0.0019
Height of Drop (ft)=	**3**
Number of structures (calc)=	5.16
Total Grade Control Structures=	**6**



1 in Horiz. = 100 ft 1 in Vert. = 3 ft

MILLS BRANCH

H. MILLS BRANCH– STREAM BANK STABILITY ALTERNATIVES

1. General Description

Mills Branch is approximately 0.75 miles in length through the study area with an average slope of 1.40%. The stream is generally a natural earthen channel with some vegetation. The Mills Branch overbanks consist of open range land with brush and trees.

2. Stream Assessment Results

Sinuosity - Mills Branch has a sinuosity 1.2, which is lower than most of the other studied streams.

Channel Survey

Stream Type: Swale to pool/riffle channel with grass and clay bed and banks; slightly incised near downstream end in altered channel; Channel Evolution Stage I-II

Channel Bed/Banks: Grass and clay bed and banks; shale in bottom along altered channel

Observations: Abundant knickpoints first 800 feet of channel; slumps in channel bank as channel cuts into hillside near altered channel (dangerous area for future slumps); channel appears altered and rerouted here

Incipient Motion - The anticipated incipient motion would indicate that the one-year flood frequency flows can move the D50 bed material along some portions of the study stream downstream and upstream of the ponded area (near Station 18+07).

Equilibrium Slope - The results indicate an equilibrium slope of **0.0026**. The current average channel slope along the study reach upstream of the ponded area (near Station 18+07) is 0.022.

Projected Channel Enlargement and Degradation - The projected widening ratio (future/existing) for Mills Branch is 1.0-1.28. Current defined channel bottom widths are mostly between 10 feet to 20 feet.

Channel Stability - Based on the Mills Branch hydraulic model, stream power (one-year frequency) exceeds the potential erosion threshold at Stations 10+85 to 12+32,

27+15, 34+80, and 39+12. Stream power is below the potential deposition threshold at Stations 15+79 to 23+54 and Station 31+99.

3. Stream Bank Stability Alternatives

Grade Control Structures

Three locations along Mills Branch were identified to be areas of potential erosion (see Figure CML-1 in Volume II). Utilizing these locations, Halff recommends implementation of grade control structures (check dams) along one reach and bed control structures (rock chutes) at one other location along Mills Branch (see Figure SML-1). Refer to Appendix D, Page 2 for formulas utilized for hydraulic siting of grade control structures.

- *Location #1: Check Dam* – Primarily located between Station 27+15 to Station 36+79. Utilizing the existing slope of 0.022 along this reach, the equilibrium slope of 0.0026, and a proposed grade control structure height of 3 feet, the total number of grade control structures needed for this reach would be seven (7), with the first being located near the downstream end of the reach and the other six being uniformly distributed for the remainder of the reach.

- *Location #2: Rock Chutes* – One rock chute primarily located upstream of Station 36+79 to stabilize potential downcutting of Mills Branch at its headwaters, where the existing channel slope is approximately 0.04.

Armored Pond Outfall Protection

Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored pond outfall protection at one location along Mills Branch (see Figure SML-1). Halff recommends 18" rock riprap for the armored pond outfall protection location near Station 19+54.

Armored Slope and Channel Protection

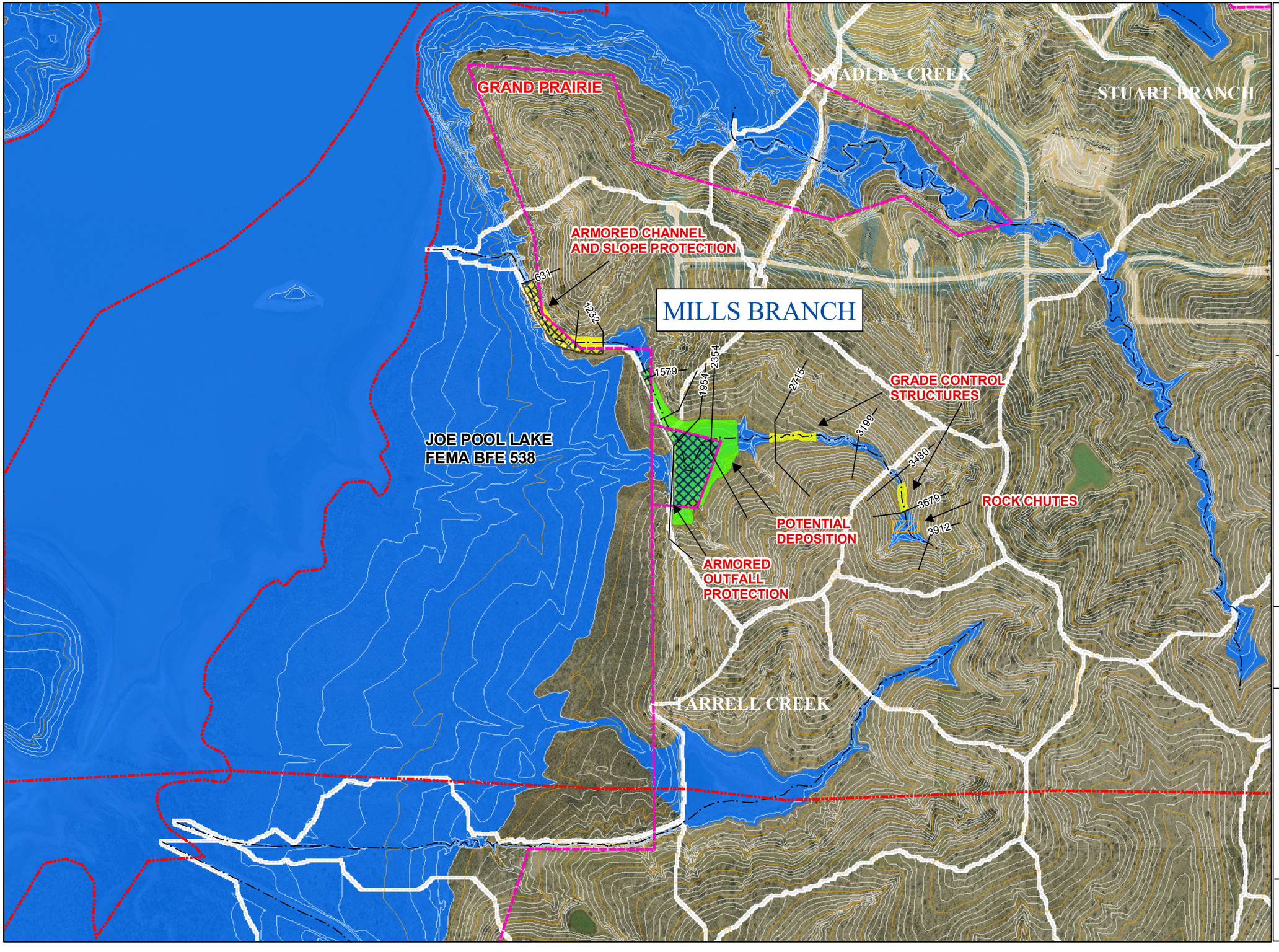
Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored slope and channel protection at one location along Mills Branch (see Figure SML-1). Halff recommends 18" rock riprap protection along the channel and side slopes from downstream of Station 6+31 to upstream of Station 12+32, approximately 850 linear feet.

4. Mills Branch – Prioritized Improvements/Estimates of Probable Cost

As described in Section I (Page 14), the improvements described in this section would be for pre-development conditions. The following table provides a general ranking of proposed pre-development improvements and estimates of probable costs for Mills Branch.

Mills Branch –Stream Bank Stability Alternatives

Rank/Description	Estimate of Probable Cost
1) Grade Control Structure-Check Dam (Sta. 27+15 to 36+79)	$100,000
2) Grade Control Structure-Rock Chute (Upstream of Sta. 36+79)	$50,000
3) Armored Outfall Protection (Sta. 19+54)	$140,000
4) Armored Slope/Channel Protection (Sta. 6+31 to Sta. 12+32)	$130,000
Total – Mills Branch	**$420,000**



City of Grand Prairie

Joe Pool Lake
Stream Bank Stability
Alternatives

FIGURE SML 1

MILLS BRANCH

Legend

- CROSS SECTIONS
- CENTERLINE
- USACE FLOWAGE EASEMENT
- DRAINAGE AREAS
- 1 % ANNUAL CHANCE FLOOD
- JOE POOL LAKE 1% FLOOD
- CITY LIMITS

Notes: 1) Topography provided by the City of Grand Prairie.(1999)
NAD 1983 State Plane

N
W E
S

500 250 0 500 Feet

1"=500'

Halff Associates
ENGINEERS ARCHITECTS SCIENTISTS PLANNERS SURVEYORS

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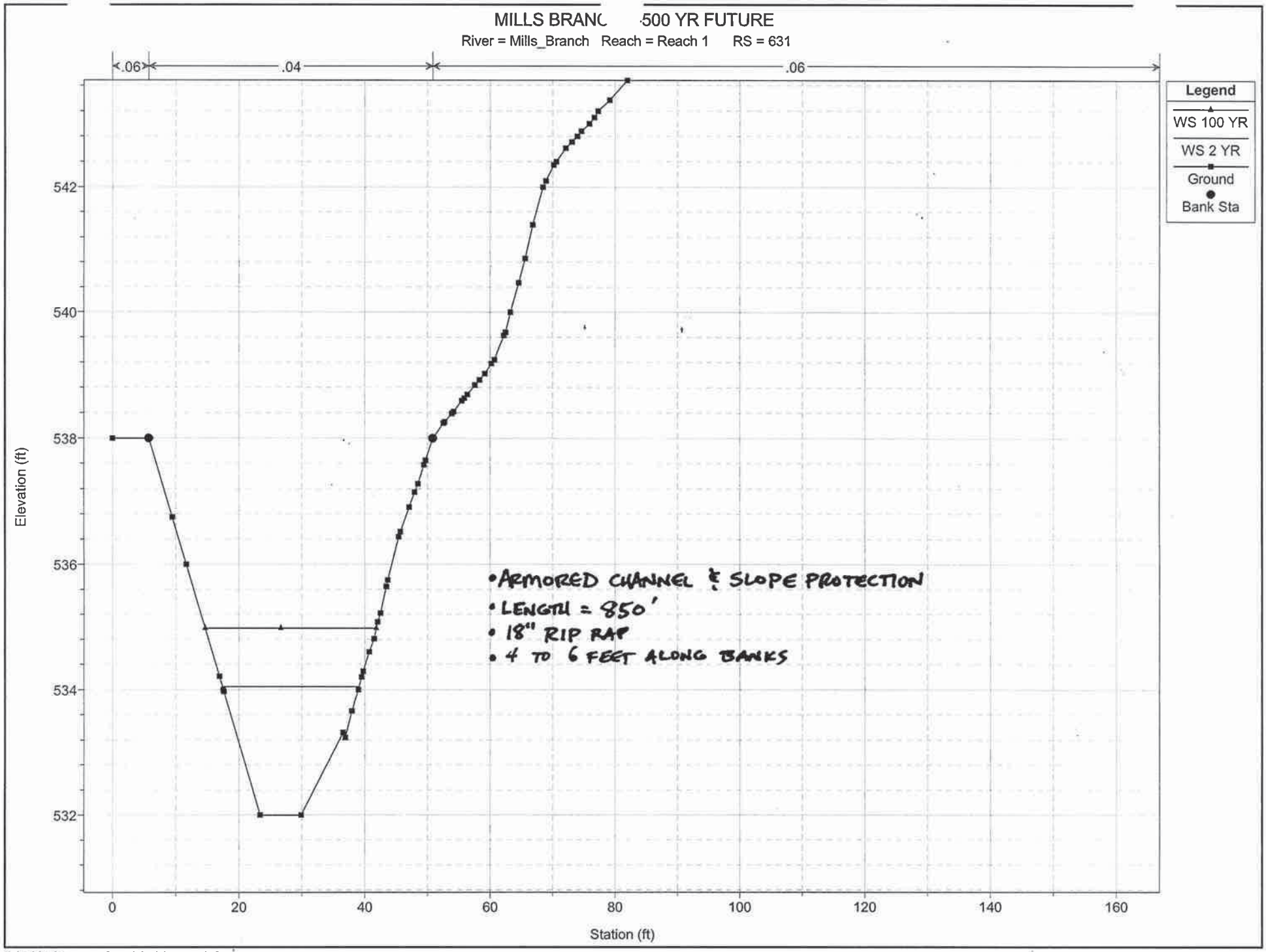
MILLS BRANCH

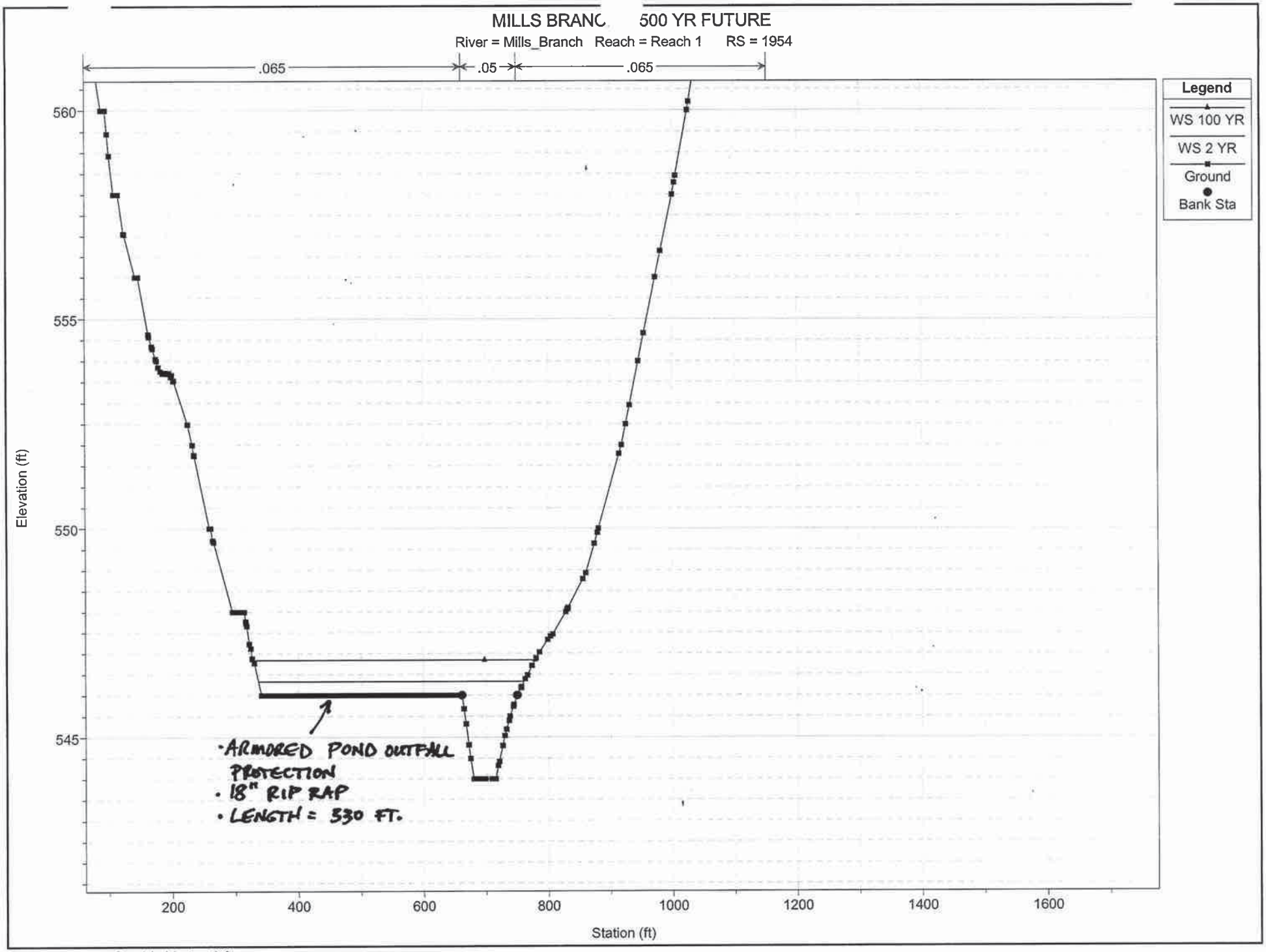
Hydraulic Siting of Grade Control Structures

Location #1	XS	Flowline
Downstream	2715	548
Upstream	3679	569.53

Original Slope=	0.0223
Equilibrium Slope=	0.0026
Height of Drop (ft)=	**3**
Number of structures (calc)=	6.34
Total Grade Control Structures=	**7**



1 in Horiz. = 20 ft 1 in Vert. = 2 ft



1 in Horiz. = 200 ft 1 in Vert. = 3 ft

TARRELL CREEK

I. TARRELL CREEK– STREAM BANK STABILITY ALTERNATIVES

1. General Description

Tarrell Creek is approximately 0.96 miles in length through the study area with an average slope of 1.50%. The stream is generally a natural earthen channel with some vegetation. The Tarrell Creek overbanks consist of open range land with brush and trees.

2. Stream Assessment Results

Sinuosity - Tarrell Creek has a sinuosity 1.05, which is lower than all of the other studied streams.

Channel Survey
Stream Type: Swale to about 600 feet downstream of upstream limits; then meandering clay/gravel pool riffle channel to ponded area; below pond, an incised Stage II channel exists for 800 feet then channel moves into heavy brush and mesquite as floodplain widens
Channel Bed/Banks: Clay to clay and limestone bed and also clay to shale banks; shale occurs in banks just downstream of ponded area
Observations: Erosion and slumping downstream of ponded area before floodplain widens

Incipient Motion - The anticipated incipient motion would indicate that the one-year flood frequency flows can move the D50 bed material along for only a few short reaches of the stream.

Equilibrium Slope - The results indicate an equilibrium slope of **0.0014**. The current average channel slope along the study reach upstream of the ponded area (near Station 28+97) is 0.014.

Projected Channel Enlargement and Degradation - The projected widening ratio (future/existing) for Tarrell Creek is 2.09-3.19. Current defined channel bottom widths are mostly between 10 feet to 20 feet.

Channel Stability - Based on the Tarrell Creek hydraulic model, stream power (one-year frequency) exceeds the potential erosion threshold at Stations 39+13 and 49+70.

Stream power is below the potential deposition threshold at Stations 25+03 to 35+95 and Station 41+32.

3. Stream Bank Stability Alternatives

Grade Control Structures

Two locations along Tarrell Creek were identified to be areas of potential erosion (see Figure CTR-1 in Volume II). Utilizing these locations, Halff recommends implementation of grade control structures (check dams) along one reach of Tarrell Creek (see Figure STR-1). Refer to Appendix D, Page 2 for formulas utilized for hydraulic siting of grade control structures.

- *Location #1: Check Dam* – Primarily located between Station 35+95 to Station 49+70. Utilizing the existing slope of 0.020 along this reach, the equilibrium slope of 0.0014, and a proposed grade control structure height of 3 feet, the total number of grade control structures needed for this reach would be nine (9), with the first being located near the downstream end of the reach and the other eight being uniformly distributed for the remainder of the reach.

Armored Pond Outfall Protection

Based on the identified areas of potential erosion in the Channel Stability Assessment, Halff recommends implementation of armored pond outfall protection at one location along Tarrell Creek (see Figure STR-1). Halff recommends 18" rock riprap for the armored pond outfall protection location near Station 28+97.

Armored Slope and Channel Protection

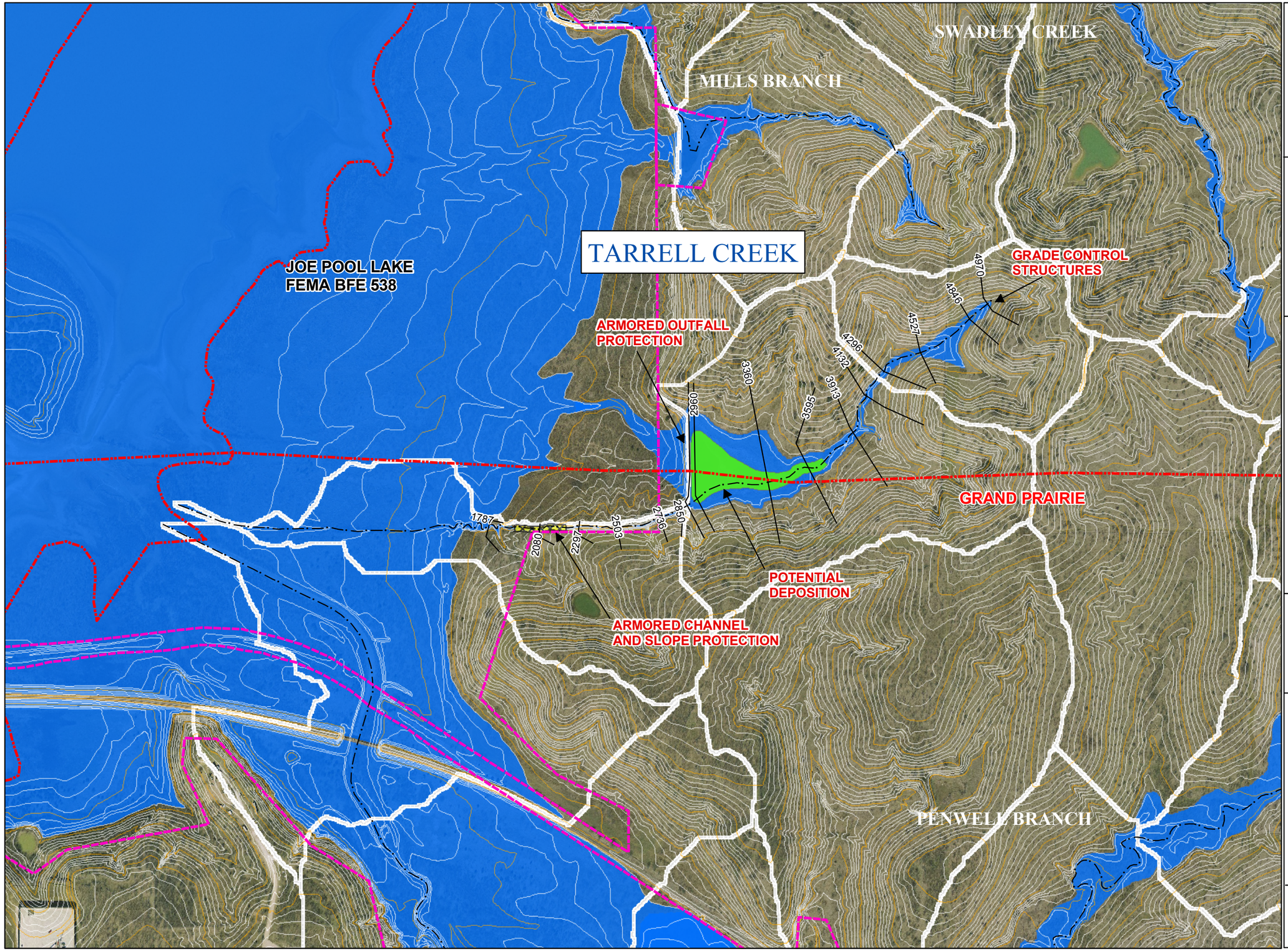
Halff recommends implementation of armored slope and channel protection at one location along Tarrell Creek (see Figure STR-1). Halff recommends 18" rock riprap protection along the channel and side slopes from downstream of Station 17+87 to upstream of Station 28+50, approximately 1,150 linear feet. Although this location is not identified as a potential erosion area in Volume II, it is an entrenched channel from the outfall of the pond along Tarrell Creek. Future development in this area would need to consider potential erosion problems along this reach.

4. Tarrell Creek – Prioritized Improvements/Estimates of Probable Cost

As described in Section I (Page 14), the improvements described in this section would be for pre-development conditions. The following table provides a general ranking of proposed pre-development improvements and estimates of probable costs for Tarrell Creek.

Tarrell Creek –Stream Bank Stability Alternatives

Rank/Description	Estimate of Probable Cost
1) Grade Control Structure-Check Dam (Sta. 35+95 to 49+70)	$130,000
2) Armored Outfall Protection (Sta. 28+97)	$175,000
3) Armored Slope/Channel Protection (Sta. 17+87 to Sta. 28+50)	$235,000
Total – Tarrell Creek	**$540,000**



City of Grand Prairie

Joe Pool Lake
Stream Bank Stability
Alternatives

FIGURE STR 1

TARRELL CREEK

Legend

- CROSS SECTIONS
- CENTERLINE
- USACE FLOWAGE EASEMENT
- DRAINAGE AREAS
- 1 % ANNUAL CHANCE FLOOD
- JOE POOL LAKE 1% FLOOD
- CITY LIMITS

Notes: 1) Topography provided by the City of Grand Prairie.(1999) NAD 1983 State Plane

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500 250 0 500 Feet

1"=500'

Halff Associates
ENGINEERS ARCHITECTS SCIENTISTS PLANNERS SURVEYORS

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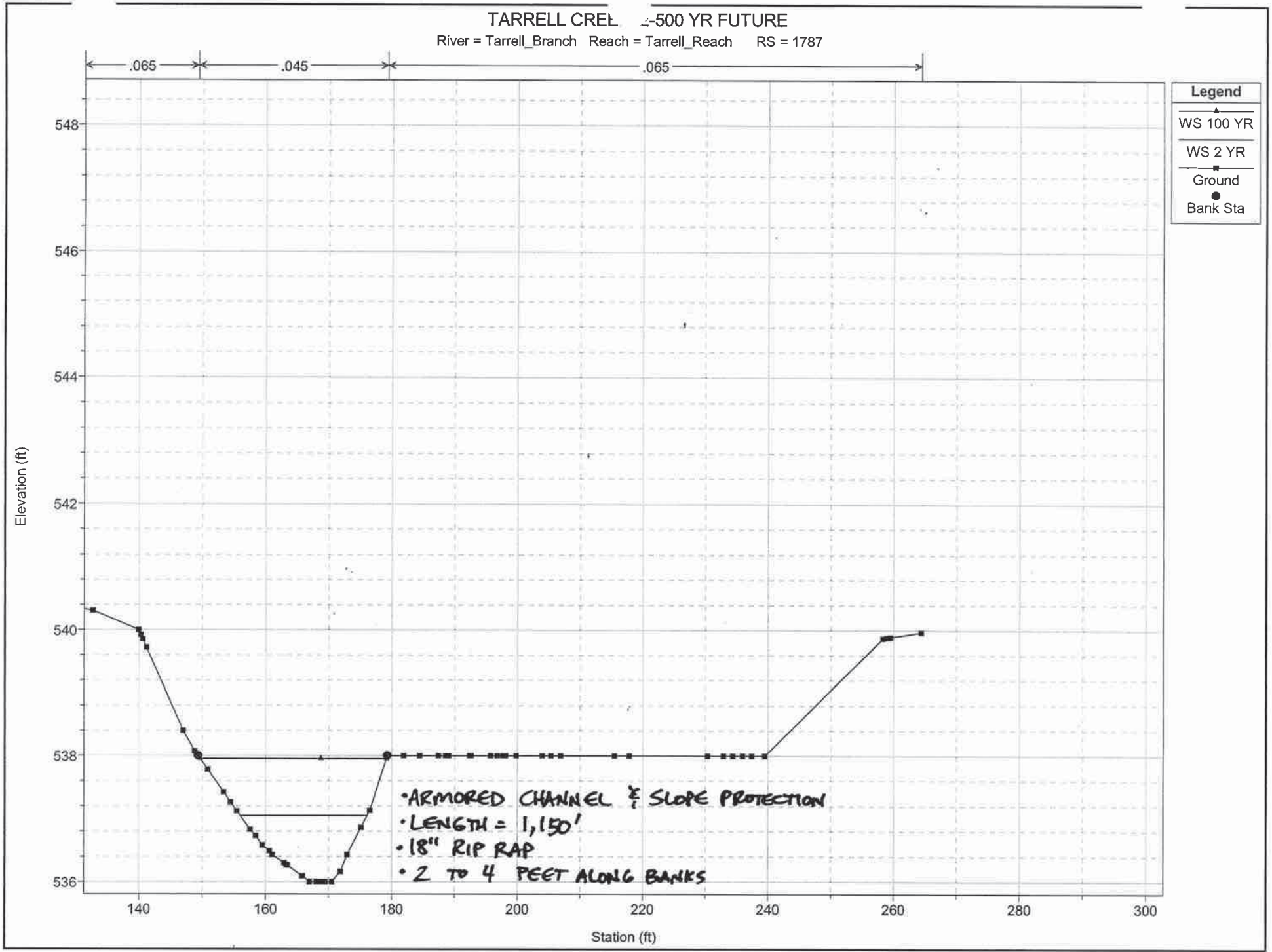
TARRELL CREEK

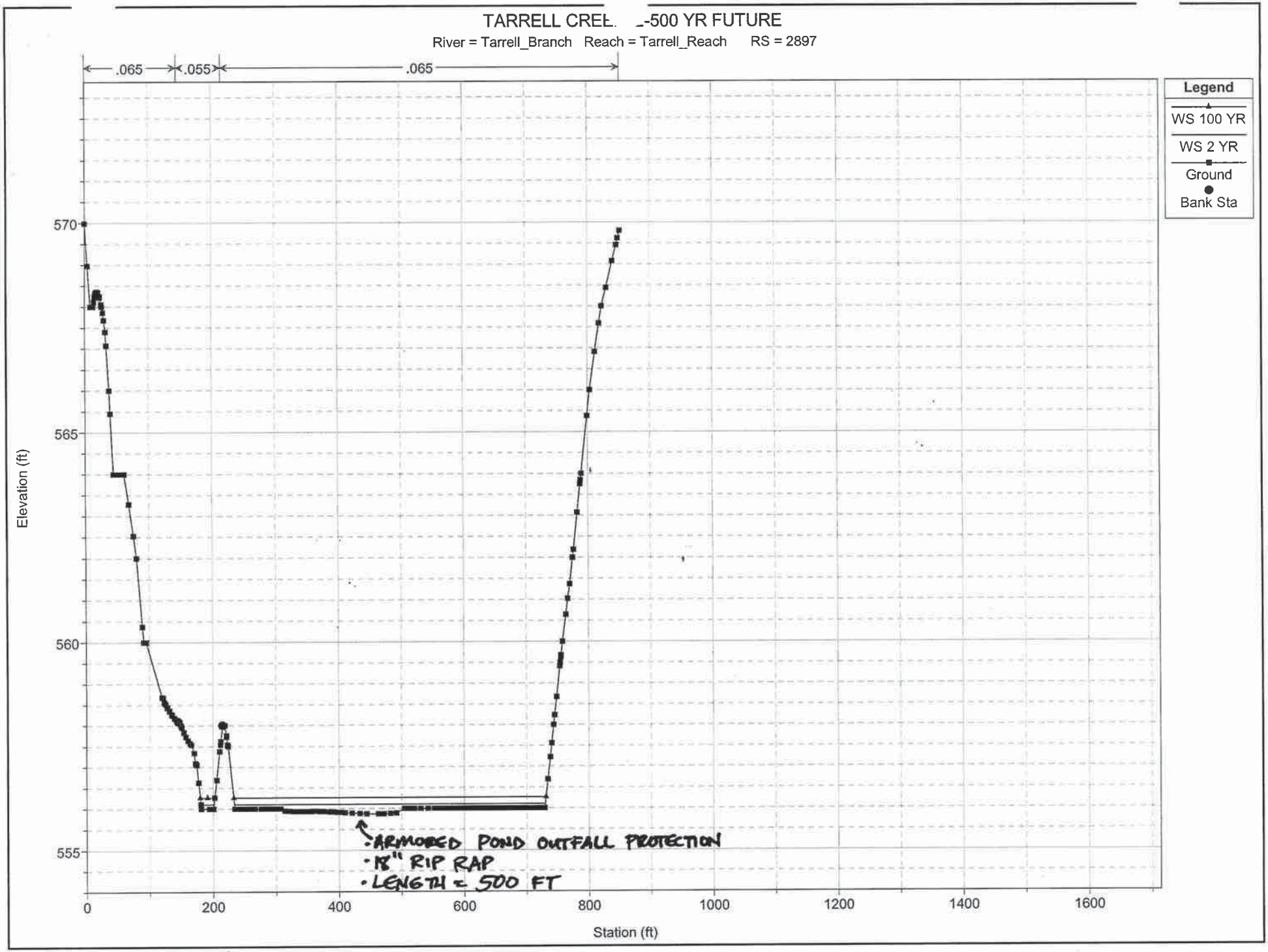
Hydraulic Siting of Grade Control Structures

Location #1	XS	Flowline
Downstream	3595	556
Upstream	4970	584

Original Slope=	0.0204
Equilibrium Slope=	0.0014
Height of Drop (ft)=	**3**
Number of structures (calc)=	8.69
Total Grade Control Structures=	**9**



1 in Horiz. = 20 ft 1 in Vert. = 2 ft



1 in Horiz. = 200 ft 1 in Vert. = 3 ft

X. Dams/Levees/Detention/Drainage Reviews

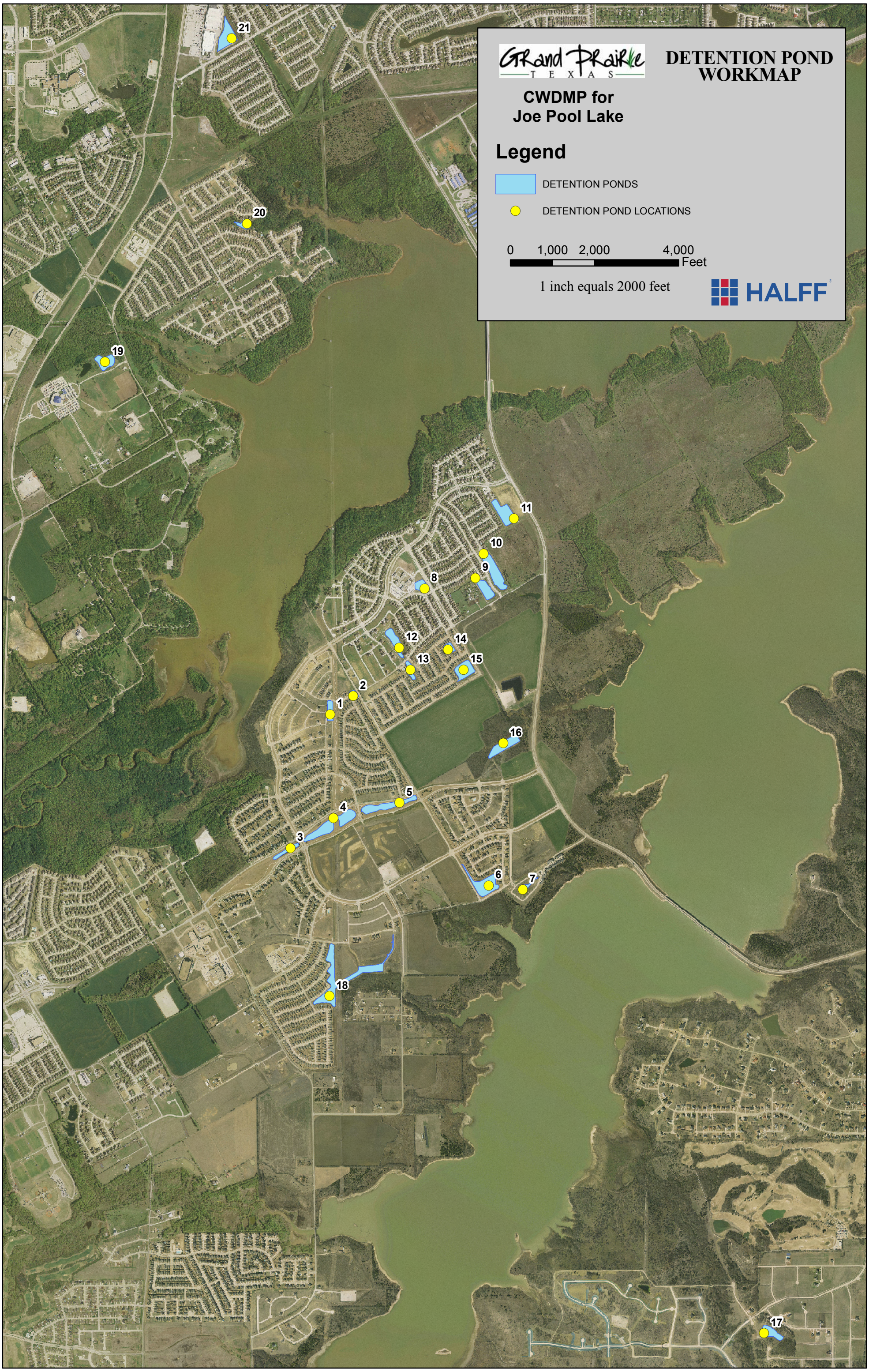


Figure X-1 Detention Pond Workmap

X. DAMS / LEVEES / DETENTION / DRAINAGE REVIEWS

A. DAMS/LEVEES

Joe Pool Dam is the primary dam or levee recognized as providing flood control benefits in the watershed. Joe Pool Dam and Lake are owned by the U.S. Army Corp of Engineers (USACE). The USACE is also the regulating agency of Joe Pool Lake. Joe Pool Dam is located at river mile 11.2 on Mountain Creek, a tributary of the West Fork of the Trinity River. The dam consists of a rolled earthfill embankment which is approximately 24,340 feet long. The outlet works consists of a 10.5 foot diameter conduit located under the dam that is controlled by slide gates. The dam also has an uncontrolled broad-crested weir spillway with a stilling basin acting as an energy dissipater. Information concerning Joe Pool Dam and Lake was taken from the Joe Pool Lake Water Control Manual from the USACE, January 2000, which can be found in digital format on the CD-Rom in Appendix I of this report.

Figure X-2 – Joe Pool Lake Dam (USACE Water Control Manual)

B. DETENTION PONDS

Twenty-one (21) detention ponds were identified in the City of Grand Prairie drainage plans for the Joe Pool Lake watershed. A mobile GIS device was utilized to field verify detention pond locations and potential problems associated with these features. The following photos were taken in March 2009 to document the condition of each pond and any maintenance, outfall, or erosion issues associated with the ponds.

Figure X-3 - Detention Pond # 1: The Villas at Mira Lagos

Figure X-4 - Detention Pond # 2: The Villas at Mira Lagos

Figure X-5 - Detention Pond # 3: Estates at Mira Lagos

Figure X-6 - Detention Pond # 4: Mira Lagos

Figure X-7 - Detention Pond # 4: Mira Lagos

Figure X-8 - Detention Pond # 5: Mira Lagos

Figure X-9 - Detention Pond # 6: Mira Lagos East

Figure X-10 - Detention Pond # 7: Lakeshore Village

Figure X-11 - Detention Pond # 8: The Bluffs

Figure X-12 - Detention Pond # 9: Grand Peninsula

Figure X-13 - Detention Pond # 10: Grand Peninsula

Figure X-14 - Detention Pond # 11: Grand Peninsula Retail

Figure X-15 - Detention Pond # 12: The Bluffs

Figure X-16 - Detention Pond # 13: The Bluffs

Figure X-17 - Detention Pond # 14: The Bluffs

Figure X-18 - Detention Pond # 15: The Bluffs

Figure X-19 - Detention Pond # 16

Figure X-20 - Detention Pond # 17

Figure X-21 - Detention Pond # 18: Mira Lagos Phase F-2

Figure X-22 - Detention Pond # 19: Crossroads Christian Church

Figure X-23 - Detention Pond # 20: Southgate

Figure X-24 - Detention Pond # 21: Doryn Drive

Halff Associates evaluated whether detention ponds were constructed according to as-built plans obtained from the City of Grand Prairie. Proposed grading plans were compared to aerial photos to visually confirm the pond was constructed as proposed. Elevation-area tables were developed by Halff Associates using the City of Grand Prairie 2009 Lidar Data to determine the storage capacity for the constructed ponds. The 100-year water surface elevations specified in the as-built plan sets were used to determined the constructed 100-year storage capacities and make a comparison to the plan data. Refer to Table X-1 for a comparison between constructed ponds and the as-built plan pond data.

1. Detention Pond Evaluation Results

Visual evaluation of the as-built plans compared to the April 2009 Landiscor Aerial Orthophotography revealed that nearly all of the 21 detention ponds in the Joe Pool Lake watershed appear to be constructed as shown in the plans. The only exception was Pond No. 10, Grand Peninsula, which was constructed larger than the as-built plans showed. This appears to be the result of a revision that was made after the date of the as-built plans. As

shown in Table X-1, most of the ponds appear to provide 100-year storage equal to or greater than the as-built plans. The computed 100-year storage was significantly less than the plans for Detention Ponds No. 1, 2, and 20 (Mira Lagos, The Villas at Mira Lagos, and Southgate, respectively). The calculated storage volumes were only approximate but several explanations for this discrepancy are possible. The City of Grand Prairie 2009 Lidar data was used with the assumption that the lowest elevation in the Lidar represented the elevation of the water in the pond which would correspond to the flowline elevation of the outlet structure. If the pond was detaining water at the time of the Lidar data acquisition flight then it is possible that the volume has been underestimated for this report. Second, it is possible that the pond has adequate storage but the 100-year water surface elevation was incorrect. For the sake of comparison, the volume was calculated using the 100-year water surface elevation from the plans. For these 3 ponds that were significantly below the storage volume from the plans, the total storage volume was calculated from the 2009 Lidar data up to the elevation where it appears water would begin to spill out of the pond. These storage volumes are also shown in Table X-1.

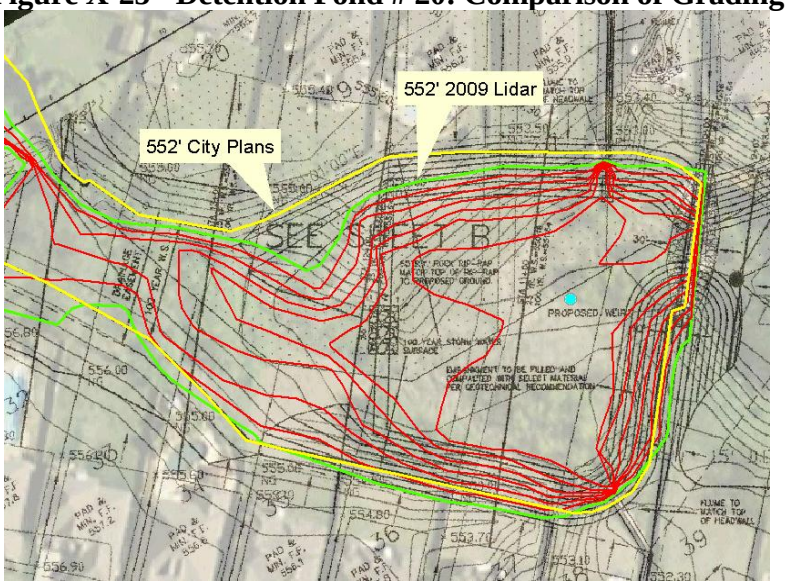
The maximum storage volume for Pond No. 20 is still below the 100-year storage volume from the plans. During construction, most of this pond was designed to remain natural with some grading along the dam and spillway. It appears that the proposed grading was completed as intended according to the 2009 Lidar. Therefore, it seems that the discrepancy is between the design topography and the 2009 Lidar topography in the non-graded pond area. Refer to Figure X.25 for a visual comparison. This pond will be recommended for further investigation to determine whether the storage discrepancy is an issue that needs attention or if it is a matter of topography inaccuracies. The cost to investigate the discrepancy should be minimal.

Table X-1 - Detention Pond Comparison

Pond No.	City Plan ID	HEC-HMS Pond ID	100 YR WSEL City Plans (ft)	Volume at Plan Set 100YR WSEL (ac-ft)		Maximum Storage Volume (ac-ft)
				City Plans *	Halff (Lidar)	Halff (Lidar)
1	P-1179	DET_FST1	558.04	4.51	3.2	4.6
2	P-1098	DET_FST2	556.48	1.62	1.12	2.1
3	P-1091	DET_FST3	554.64	--------	6.7	
4	P-935-4	DET_FST4	551.60	--------	36.8	
5	P-935-4	DET_FST5	549.40	--------	20.8	
6	P-935E	DET_FST6	544.00	29.66	29.6	
7	P-1061	DET_FST7	543.50	--------	1.0	
8	P-987	DET_HC1	550.99	--------	8.5	
9	P-968	DET_HC2	542.50	25.61	37.7	
10	P-838B	DET_HC2	542.50	25.61	37.7	
11	P-1198	DET_NHC1	546.23	13.30	13.1	
12	P-987	DET_WB1	546.97	--------	20.2	
13	P-987	DET_WB2	546.11	--------	10.2	
14	P-987	DET_WB3	545.45	--------	6.8	
15	P-987	DET_WB4	543.68	--------	25.8	
16	P-1036	DET_WB5	538.20	12.21	17.9	
17	P-1168	--------	N/A	--------	--------	
18	P-1014	--------	545.85	--------	29.5	
19	P-920	--------	553.89	--------	2.1	
20	P-844	--------	551.56	7.5	5.4	5.6
21	P-1134	--------	N/A	--------	--------	

* As-built plans did not provide the 100-year storage capacity for all ponds.

Figure X-25 - Detention Pond # 20: Comparison of Grading



C. DETENTION POND MAINTENANCE

Soil erosion can be particularly detrimental to detention ponds as it can reduce storage volumes and have a negative impact on water quality and wildlife habitat. Eight detention ponds were found to be experiencing some form of moderate erosion whether it be gullies/rills or symptoms of slope failure. Most of the erosion was relatively minor with the exception of Pond No. 18 (Mira Lagos Phase F-2), along Taaffe Creek. This pond appeared to be experiencing significant erosion and resulting sedimentation. The main cause is the large area of undeveloped land (See to the north that does not have significantly established vegetation to adequately prevent the erosion. Silt fence and rock berms are in place but have been overwhelmed and are in need of maintenance in order to function as intended. Halff recommends that immediate action be taken to establish vegetation in the undeveloped area, maintain silt fence and berms, and evaluate whether dredging is needed in the pond to recover lost conveyance/storage. The cost to maintain and restore this detention pond is dependent upon the amount of sedimentation accumulated around the silt fence and berms and within the detention pond itself. A GIS shapefile is included on the CD-ROM in Appendix I of this report that shows location of other erosion areas along detention ponds.

Figure X-26 – Erosion at Detention Pond #18

Detention ponds were assigned one of the four following maintenance conditions: **1) Good** (requires no remedial maintenance- continued normal inspections), **2) Fair** (may require some remedial maintenance – not immediate), **3) Poor** (requires immediate remedial maintenance), **4) Failure** (requires immediate assistance beyond remedial maintenance). Table X-2 shows the condition assigned to each detention pond.

Table X-2 - Detention Pond Maintenance Condition

Pond No.	City Plan ID	HEC-HMS Pond ID	Condition
1	P-1179	DET_FST1	Good
2	P-1098	DET_FST2	Good
3	P-1091	DET_FST3	Good
4	P-935-4	DET_FST4	Good
5	P-935-4	DET_FST5	Good
6	P-935E	DET_FST6	Fair
7	P-1061	DET_FST7	Good
8	P-987	DET_HC1	Good
9	P-968	DET_HC2	Fair
10	P-838B	DET_HC2	Fair
11	P-1198	DET_NHC1	Fair
12	P-987	DET_WB1	Fair
13	P-987	DET_WB2	Fair
14	P-987	DET_WB3	Good
15	P-987	DET_WB4	Fair
16	P-1036	DET_WB5	Good
17	P-1168	--------	Good
18	P-1014	--------	**Poor**
19	P-920	--------	Good
20	P-844	--------	**Poor***
21	P-1134	--------	Good
* Pond No. 20 is recommended for further investigation to confirm storage volume is consistent with plans.			

Detention pond maintenance should be conducted as staff and funding is available, with the highest priority given to the ponds receiving a rating of poor. Continued field inspection and remedial maintenance should be performed for the good and fair ponds in a regularly scheduled cycle, as determined by City.

D. DRAINAGE REVIEWS

There are approximately 200 total drainage reviews to date in the City of Grand Prairie. Approximately 50 drainage reviews are from the Joe Pool Lake Watershed. Halff Associates compiled the completed drainage reviews for the Joe Pool Lake Watershed into one single spreadsheet. This spreadsheet provides a detailed summary of the drainage reviews including the project name, City project number, description of review, and indicates if detention was included in the project. The spreadsheet is included in Table X-3.

City Project No.	Project Name	Design Engineer	Date Approved	Project Location	County	Mapsco	Creek Basin	Project Type	Downstream Constraint	Flood-plain	De-tention	Comments	Watershed
Drainage Reviews Performed Under AVO 20716													
Y #0218	Arlington Christian Church	JE & Associates	17-Dec-02	Webb-Lynn Road at Ragland Road	Tarrant	112P	Joe Pool Lake	Church	no	no	yes	no issues	Joe Pool Lake
Y #0270	Bluegreen Southwest Sanitary Sewer/Dam	Baird Hamptom and Brown	11-Jul-03	Hollings Branch	Dallas	81X	Hollings Branch	Dam	no	no	no	reviewed spillway design plans	Joe Pool Lake
Y #0278	Grand Peninsula Ph 2 - Village 4B and 4C	Huitt-Zollars	6-Aug-03	near Grand Peninsula Drive and Coastal Blvd	Tarrant	98Z	Joe Pool Lake	Residential	yes	no	yes	The original pond design was by Nathan D. Maier. O'Brien Engineering modified the ponds to add storage for future phases. An erosion issue downstream of an existing pond was also noted in review.	Joe Pool Lake
Y #0292	Grand Peninsula - Villages 5A, 6A, and 7A	Huitt-Zollars	8-Dec-03	near Grand Peninsula Drive and Coastal Blvd	Tarrant	98Z	Joe Pool Lake	Residential	yes	no	yes	O'Brien Engineering did the pond hydraulics - reports are on file	Joe Pool Lake
Y #0281	Villages at Grand Peninsula Southwest of Coastal Boulevard Drainage Study	Huitt-Zollars	13-Oct-03	near Grand Peninsula Drive and Coastal Blvd	Tarrant	98Z	Joe Pool Lake	Residential	yes	no	yes	Reviewed O'Brien Engineering detention pond H&H - reports are in the file	Joe Pool Lake
Y #0215	Heather Glen	Wilbur N. Smith & Associates	9-Dec-02	Heather Drive and Webb-Lynn Road	Tarrant	112P	Joe Pool Lake	Residential	no	no	no	no issues	Joe Pool Lake
Y #0318	Engineering Study of Hollings and Hight Branch	Grantham and Associates	11-Mar-04	on Hollings Branch south of Tanglewood GC	Dallas	81X	Hollings Branch	Channel Study	no	yes	no	dispute over flood elevations based on topo differences	Joe Pool Lake
Y #0252	Ivy Glen	Welch Engineering	13-Jan-04	Near Webb Lynn Road and Joe Pool Lake?	Tarrant?	112P?	Joe Pool Lake	Residential	no	no	no	drains to Joe Pool Lake - Corps property	Joe Pool Lake
Y #0324	Lakeridge Section 18 Pond Review	Baird Hampton and Brown	10-Oct-04	near Hollings Branc S. of Tangleridge GC	Dallas	81X	Hollings Branch	Dam Study	no	no	no	verified spillway design	Joe Pool Lake
Y #0253	Lake Ridge Section 18-A Ph 2	Grantham and Associates	30-Jul-04	on Hollings Branch south of Tanglewood GC	Dallas	81X	Hollings Branch	Rural Residential	no	no	no	associated with Hollings Branch Channel study	Joe Pool Lake
Y #0299	Lake Ridge Section 18-A Ph 3	Grantham and Associates	31-Jul-04	on Hollings Branch south of Tanglewood GC	Dallas	81X	Hollings Branch	Rural Residential	no	no	no	supplemental agreement to Y #0253	Joe Pool Lake
Y #0306	Lake Ridge Section 18-A Ph 3	Grantham and Associates	2-Aug-04	on Hollings Branch south of Tanglewood GC	Dallas	81X	Hollings Branch	Rural Residential	no	no	no	associated with Hollings Branch Channel study	Joe Pool Lake
Y #0321	Lynn Creek Hills Phase III	Teague Nall and Perkins	2-Aug-04	SE Quad of Webb-Lynn Road and Magna Carta	Tarrant	112F	Lake Joe Pool	Residential	no	no	no	drains to Joe Pool Lake - Corps property	Joe Pool Lake
Y #0263	Lynn Creek Hills Phase II	Teague Nall and Perkins	9-Jun-03	SE Quad of Webb-Lynn Road and Magna Carta	Tarrant	112F	Lake Joe Pool	Residential	no	no	no	drains to Joe Pool Lake - Corps property	Joe Pool Lake
Y #0364	Lakeshore Village	Grantham and Associates	28-Jan-05	SW Quad of Seeton Road and Lakeridge Pkwy	Dallas	81E	Lake Joe Pool	Residential	no	no	no	drains to Joe Pool Lake - Corps property	Joe Pool Lake
Y #0219	Mira Lagos Paving and Drainage Plans (Broad Street and Grand Peninsula Drive)	Jones and Boyd, Inc.	18-Dec-03	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	yes	This was the first of many phases of Mira Lagos - the overall preliminary drainage plan for the entire project as well as detention in Broad Street was approved	Joe Pool Lake
Y #0271	Mira Lagos Phase A-1	Jones and Boyd, Inc.	5-Aug-04	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	review included Channels "A" and "E"	Joe Pool Lake
Y #0272	Mira Lagos Phase B	Jones and Boyd, Inc.	25-Nov-03	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	review included Channel "B"	Joe Pool Lake
Y #0273	Mira Lagos Phase F-1-A	Jones and Boyd, Inc.	5-Aug-03	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	Drainage along Day-Miar Road (boundary with Irving was an issue	Joe Pool Lake
Y #0286	Mira Lagos Phases C-1 and E-3	Jones and Boyd, Inc.	23-Oct-03	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	no issues	Joe Pool Lake
Y #0293	Mira Lagos Phase F-1B	Jones and Boyd, Inc.	6-Oct-04	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	This included the Mansfield Channel (Taafee Creek?) that drains across Day-Miar Road and into the site	Joe Pool Lake
Y #0350	Mira Lagos East Ph I and II Detention Pond #4	Jones and Boyd, Inc.	29-Oct-05	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	yes	no issues	Joe Pool Lake
Y #0311	Mira Lagos Phase F-2	Jones and Boyd, Inc.	8-Mar-04	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	no issues	Joe Pool Lake
Y #0344	Mira Lagos East Infrastructure	Jones and Boyd, Inc.	11-Nov-04	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	yes	includes South Detention Pond at Seeton Road and Arlington Webb-Brittan Road (aka Pond 6)	Joe Pool Lake
Y #0350	Mira Lagos East Phases A and B	Jones and Boyd, Inc.	29-Mar-05	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	yes	includes Detention Pond No. 7	Joe Pool Lake
Y #0372	Mira Lagos Phase A2a	Jones and Boyd, Inc.	26-Mar-05	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	no issues	Joe Pool Lake
Y #0401	Mansfield Independent School District #17	Huitt-Zollars	19-Jan-05	SE Quad of Grand Peninsula Drive and Coastal Boulevard in the Grand Peninsula development	Tarrant	112Z	Lake Joe Pool	School	no	no	no	Exist.Detention Pond located adjacent to site	Joe Pool Lake
Y #0402	Mansfield Independent School District #18	Dunaway and Associates	28-Jan-05	at intersection of South Camino Lagos and Salor Street in the Mira Lagos development	Tarrant	126L	Lake Joe Pool	School	no	no	no	into Mira Lagos 100-year system	Joe Pool Lake

City Project No.	Project Name	Design Engineer	Date Approved	Project Location	County	Mapsco	Creek Basin	Project Type	Downstream Constraint	Flood-plain	De-tention	Comments	Watershed
Y #0408	Southgate Addition Phase II	GSWW, Inc	23-May-05	between Southgate and Heather Glen Additions on west Shore of Lake Joe Pool	Tarrant	112Q	Lake Joe Pool	Residential	no	no	no	drains to Lake Joe Pool	Joe Pool Lake
Y #0307	West Shore at Joe Pool Lake	Cheatham and Associates		near Webb Lynn Road on Lake Joe Pool - near Ivey Glen Addition	Tarrant	112P?	Lake Joe Pool	Residential	no	no	no	drains to Lake Joe Pool	Joe Pool Lake
Drainage Reviews Performed Under AVO 22958													
Y #0450-14A	Bella Vista at Mira Lagos	Jones and Boyd, Inc.	3-Oct-05	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	no issues	Joe Pool Lake
Y #0418-4A	The Bluff's Phase II & The Cove Ph II at Peninsula Study	Huitt-Zollars	27-Apr-05	near Grand Peninsula Drive and Coastal Blvd	Tarrant	98Z	Joe Pool Lake	Residential	no	no	no	This phase drains to previously approved detention ponds	Joe Pool Lake
Y #0417-3A	The Cove Ph III at Peninsula	Huitt-Zollars	27-Apr-05	near Grand Peninsula Drive and Coastal Blvd	Tarrant	98Z	Joe Pool Lake	Residential	no	no	no	This phase drains to previously approved detention ponds	Joe Pool Lake
Y #0431-8A	England Parkway and Estates at Mira Lagos	Jones and Boyd, Inc.	29-Aug-05	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	no issues	Joe Pool Lake
Y #0412-1A	Lynn Creek Hills Phase III	Teague Nall and Perkins	2-Aug-04	SE Quad of Webb-Lynn Road and Magna Carta	Tarrant	112F	Lake Joe Pool	Residential	no	no	no	This is a revision to previously approved plans to eliminate Magna Carta Drive	Joe Pool Lake
Y #0442-11A	Villas at Mira Lagos - Ph 1	Jones and Boyd, Inc.	11-Oct-05	SW Quad of Grand Peninsula Drive and Arlington Webb-Britton Road	Tarrant	126C	Joe Pool Lake	Residential	yes	no	yes	Included Detention Ponds 1 and 2, not to be confused with original Mira Lagos Ponds 1 and 2 in England Parkway	Joe Pool Lake
Drainage Reviews Performed Under AVO 23359													
Y #0546-29C	Lakeridge Section 19	Engineering Concepts and Design. LP	3-Jan-07	on Hollings Branch south of Tanglewood GC	Dallas	81X	Hollings Branch	Rural Residential	no	no	no	associated with Hollings Branch Channel study - LOMR required for lot fill in Hollings Branch	Joe Pool Lake
Y #0548-31C	Grand Peninsula - Village 5C, Village 6B, and Village 6C (Bluffs and Coast)	Huitt and Zollars	26-Aug-06	near Grand Peninsula Drive and Coastal Blvd	Tarrant	98Z	Joe Pool Lake	Residential	no	no	no	This phase drains to previously approved detention ponds	Joe Pool Lake
Y #0657-40C	The Villas at Mira Lagos Ph 2	Jones and Boyd, Inc	20-Sep-06	SW Quad of Grand Peninsula Drive and Arlington Webb-Britton Road	Tarrant	126C	Joe Pool Lake	Residential	no	no	no	drains to detention approved in Ph 2	Joe Pool Lake
Y #0492-8C	Crossroads Christian Church	JE & Associates	?	NW Quad of Arlington Webb-Britton Road and Ragland Road	Tarrant	112S	Lake Joe Pool	Church	yes	no	yes	no issues - Brian Haynes review	Joe Pool Lake
Y #508-17C	Mira Lagos Ph E-1a	Jones and Boyd, Inc	31-Mar-06	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	drains to previously approved ponds	Joe Pool Lake
Y #0545-28C	Mira Lagos Ph G-1	Jones and Boyd, Inc	26-Jul-06	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	drains to previously approved ponds	Joe Pool Lake
Y #0515-20C	Mira Lagos Ph A-2b	Jones and Boyd, Inc	3-Apr-06	North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	drains to previously approved ponds	Joe Pool Lake
Y #0527-24C	Southgate Ph 3	GSWW, Inc	none	between Southgate and Heather Glen Additions on west Shore of Lake Joe Pool	Tarrant	112Q	Lake Joe Pool	Residential	no	no	no	drains to Heather Glen	Joe Pool Lake
Y #0543-27C	Prairie Ridge Phase I Offsites	Jones and Carter	no	Ellis County S. of US 287	Ellis		Soap Creek	Roadway/Bridge	no	yes	no	Flood study - avoid CLOMR by making no changes to the floodway - still in review	Joe Pool Lake
Drainage Reviews Performed Under AVO 24991													
not authorized	Grand Peninsula Drive and Seeton Road	Jones and Boyd, Inc		North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Roadway	no	no	no	drains to previously approved ponds - project not yet authorized	Joe Pool Lake
Y #0598-5D	Grand Peninsula Retail	Huitt Zollars		SW Quad of Grand Pensinsula Drive and Lakeridge Parkway	Dallas/Tarrant	98V	Lake Joe Pool	Commercial	yes	no	yes	culvert under Lakeridge Parkway is a constraint	Joe Pool Lake
not authorized	Greenway Trails Ph I Addition	Mycoskie McInnis Associates		N. of US 287 and E. of SH 360	Ellis		Lake Joe Pool	Residential	yes	no	yes	project not yet approved	Joe Pool Lake
Y #0600-6D	Lakeridge Section 20	Engineering Concepts and Design. LP		on Hollings Branch south of Tanglewood GC	Dallas	81X	Hollings Branch	Rural Residential	no	no	no	upstream of Section 19	Joe Pool Lake
Y #0587-4D	Lakeview West	Jones and Boyd, Inc		E. of Day Miar and S. of Seeton Road	Tarrant	126Q	Lake Joe Pool	Residential	no	no	no	no issues	Joe Pool Lake
not authorized	Mira Lagos Ph G-2	Jones and Boyd, Inc		North and south of Broad Street (England Parkway) from Day Miar to Lakeridge Parkway	Dallas/Tarrant	81, 112	Lake Joe Pool	Residential	no	no	no	drains to previously approved ponds - project not yet authorized	Joe Pool Lake
not authorized	Primrose School at Grand Prairie	Roland Foerster Civil Engineers		near SW Quad of Grand Pensinsula Drive and Lakeridge Parkway	Tarrant	112V	Lake Joe Pool	School	no	no	no	adjacent and drains to detention pond in Grand Prairie Retail - project not authorized - to be reviewed in-house by City of GP	Joe Pool Lake

XI. Maintenance

XI. STORM DRAIN OUTFALL ASSESSMENT

This section of the CWDMP for Joe Pool Lake report covers the assessment and prioritization rankings of storm drain outfalls in need of repair in the Joe Pool Lake watershed (Refer to Section X.C for detention ponds maintenance). Halff Associates utilized resources from the City of Grand Prairie, including recent photos and field reports, to determine the condition of each outfall and to rank each outfall based on need of repair using criteria established for this assessment. The high priority outfalls were field checked by Halff Associates to finalize their ranking. The results showing the condition, criteria category, and ranking of each outfall can be seen in Table XI-1 at the end of this section.

A. ASSESSMENT RESOURCES

Halff Associates determined the initial ranking of each outfall based on three resources; the City of Grand Prairie Drainage Design Manual criteria, the City of Grand Prairie database of field-checked storm drain outfalls, and photos of the Joe Pool Lake outfalls obtained from the City of Grand Prairie. From the Drainage Design Manual Halff Associates noted city requirements for storm drain outfalls and identified outfalls not meeting this criterion. The database of field-checked storm drain outfalls provided information on the condition of each outfall and gave a description of the issues needing repair/maintenance. The storm drain outfall photos helped reveal the severity of the condition of each outfall. These three resources provided the information needed to assess conditions and establish criteria to prioritize the outfalls based on necessity to repair.

B. CONDITION AND CRITERIA

Each storm drain outfall was assigned a condition and a criteria category. The four possible conditions included: **1) Good** (requires no remedial maintenance-continued normal inspections), **2) Fair** (may require some remedial maintenance – not immediate), **3) Poor** (requires immediate remedial maintenance), **4) Failure** (requires immediate assistance beyond remedial maintenance).

Next, the outfalls were assigned a criteria category: Structural, No Headwall, RipRap/Scour, Siltation, or Aesthetics. Criteria were assigned by answering the following criteria questions: "Is there a threat to the structural integrity of the outfall?"; "Does the outfall have a headwall?"; "Is erosion control needed at the outfall?"; "Is there siltation at the outfall limiting its conveyance?"; "Is the outlet

structure of concern aesthetically?"; After each storm drain outfall was assessed based on condition and criteria, a number ranking was given based on need of repair (number 1 being of highest priority). The following paragraphs give a brief description of each criteria category. The photos show examples of outfalls from each criteria category that are in poor condition.

1. **Structural Criteria Category**

   Outfalls were placed under the structural criteria category if there was a threat to the structural integrity of the outfall or if there was already a structural failure of the outfall. This threat was typically due to erosion around the outfall structure, wingwalls, or toewalls.

Figure XI-1 – Example of Structural Criteria (Photo ID 1613)

2. **RipRap/Scour Criteria Category**

   Outfalls where there was a threat to the structure due to erosion or where erosion/scour was occurring downstream were placed under the RipRap/Scour criteria category. Most of the erosion/scour at these outfalls could be reduced or eliminated with the placement of rock riprap or other outfall protection.

Figure XI-2 – Example of RipRap/Scour Criteria (Photo ID 1471)

3. Siltation Criteria Category

Outfalls where the conveyance of the drainage pipe/culvert could be hindered due to silt deposition were placed under the siltation criteria category. Decreased capacity at the outfall structure due to silt deposition could cause flooding concerns upstream if the silt is not removed.

Figure XI-3 – Example of Siltation Criteria (Photo ID 622)

4. No Headwall Criteria Category

Outfalls where there was no headwall to protect the structural integrity of the pipe/culvert were placed under the no headwall criteria category. The City of Grand Prairie Drainage Design Manual requires City standard or TxDOT standard headwalls for all inlets and outfalls on closed conduits.

Figure XI-4 – Example of No Headwall Criteria (Photo ID 949)

5. Aesthetics Criteria Category

Outfalls where the aesthetic appearance of the structure requires maintenance were placed under the aesthetics criteria category. Some examples of poor aesthetic appearance would be a downed tree near the outfall structure, loose rock around the outfall structure, or signs of vandalism.

Figure XI-5 – Example of Aesthetics Criteria (Photo ID 153)

C. FIELD CHECK

Halff Associates field checked many of the high priority outfalls to verify their necessity to repair. This exercise was necessary for two reasons. The first reason was to re-prioritize the outfall rankings based on their most current condition. The second was to confirm the final rankings of each high priority outfall. Some questions concerning the risk of an outfall were not able to be answered from the resources mentioned above, such as does the outfall drain an entire subdivision or does the outfall convey flow at a minor road crossing? After the field visit, the rankings were adjusted and finalized based on the need of repair for each outfall.

D. USACE FLOWAGE EASEMENT OUTFALL DESIGNS

The U.S. Army Corps of Engineers (USACE) requires development adjacent to Joe Pool Lake to discharge storm water in sheet flow conditions across the USACE flowage easement boundary (541' contour). The USACE has defined sheet flow conditions across the flowage easement boundary as one foot per second per foot

(1 cfs/foot). The purpose of the USACE storm water outfall requirements is to protect USACE property from overland flow erosion and to minimize sedimentation in Joe Pool Lake.

The April 2007 report entitled "Stream Bank Stability Alternatives and Storm Water Outfalls," was prepared for the Joe Pool Lake Watershed and included examples of 5 outfall designs that could be used independently or in combinations to return collected storm water runoff to sheet flow conditions at the USACE boundary. Other options are possible, but the example outfall designs provided were as follows:

- Riprap Apron
- Riprap Outlet Basin (Stilling Basin)
- Baffled Outlet
- Weirs
- Energy Dissipation Blocks

Each of these designs is adequate to meet the USACE requirements for sheet flow discharge at the USACE flowage easements, depending on the site conditions and culvert discharge. Site conditions sometimes dictate that one design may be more appropriate than another for certain tailwater constraints or downstream slopes. Certain outfalls are not effective at dissipating energy for high velocity discharges. For this CWDMP for Joe Pool Lake report, Halff Associates, Inc. evaluated the performance of several outfall designs that have been constructed in the Joe Pool Lake watershed. It should be noted that most of these outfalls were constructed relatively recently and we were unable to judge in the field the long-term performance of these outfalls.

Figure XI-6 - Riprap Apron

1. Riprap Apron

The riprap lined apron is a common design for energy dissipation due to the low cost and ease of installation. To be effective, the apron needs to have sufficient length and width to dissipate the outfall energy along a mild slope, as is the case for the Joe Pool Lake outfall shown above in Figure XI-6. This design is not adequate for all outlets, but when the proper site conditions exist, the riprap apron can perform very well. The riprap apron is not recommended for culvert outlets when the Froude Number increases above 2.5. Grouted riprap allows for higher discharge velocities and helps prevent vandalism but it often provides less aesthetic appeal than other options.

2. Riprap Outlet Basin

The Riprap Outlet Basin is designed to mimic the characteristics of a scour hole. The outlet dissipates energy by initiating a hydraulic jump within the confines of the riprap protected basin. Since the effectiveness of the dissipation is dependent upon this hydraulic jump, the performance of the design can be negatively impacted by high tailwater conditions. When high tailwater exists, the culvert outflow can retain its energy and scour bed

material beyond the limits of the outlet basin. Even in low tailwater conditions there is typically some superficial degradation to the floor of the basin. Like the riprap apron, this outlet design is also dependent upon site conditions allowing adequate space of mild sloping terrain downstream of the outfall to construct the basin. The riprap basin encountered in the Joe Pool Lake Watershed can be seen in Figure XI-7. The design appeared to be fairly new and was performing well up to this point. There is no sign of scour beyond the basin and very little sign of degradation within the basin. Tailwater is not expected to be an issue since the outlet is significantly above the Joe Pool Lake 100 year water surface elevation.

Figure XI-7 - Riprap Outlet Basin (Photo ID 1327)

3. Baffled Outlet

The baffled outlet is a boxlike structure with a vertical baffle and end sill. Energy is dissipated primarily as a result of the water impacting the baffle.

This outfall design can be used with very high outlet velocities. The Joe Pool Lake baffled outlet shown below in Figure XI-8 also incorporates small weirs to control the release of water and further dissipate the energy. When the entrance pipe slopes steeply, this outfall design can be turned horizontally as shown below to provide even more dissipation. This design appears to be particularly effective due to its ability to divide the flow and increase the spread of water being discharges by the outlet.

Figure XI-8 - Baffled Outlet (Photo ID 152)

4. Weirs

Weirs are typically used to control the discharge rate of water and to spread out the discharge length so that energy is effectively dispersed along a larger area. We did not discover any outlet structure in the Joe Pool Lake watershed that relied solely upon weirs to dissipate the energy of the outlet discharge, but weirs were often used in combination with other outlet designs. For instance, the baffled outlet in Figure XI-8 and the energy dissipation blocks in Figure XI-9 both incorporate a weir to enhance the effectiveness of the outlet design.

5. Energy Dissipation Blocks

Energy dissipation blocks are designed to operate at the streambed layer and return flow to natural conditions downstream of the outlet. The design does require adequate area downstream of the outlet and there is some risk of the flow splashing over the initial row if the blocks are too large and the velocity is high. Other than these concerns, the design has proved to work efficiently. In Figure XI-9, the energy dissipation blocks were combined with a weir to handle substantial runoff from a residential area and disperse the flow according to the USACE flowage easement requirements.

Figure XI-9 - Energy Dissipation Blocks (Photo ID 149)

Each of the unique outfall designs currently constructed in the Joe Pool Lake watershed (see Figure XI-6 through Figure XI-9, this section) appear to be functioning adequately to meet the USACE requirements for sheet flow given the site constraints and outfall discharges. For additional information on energy dissipation features, refer to the North Central Texas Council of Governments (NCTCOG) *integrated Storm Water Management (iSWM) Technical Manual for Hydraulics* (January 2010).

E. OUTFALL CONCLUSIONS/RECOMMENDATIONS

It is the recommendation of this study that the City of Grand Prairie proceed immediately with maintenance for the 50 outfall structures identified as being in poor condition in Table XI-1 (included at the end of this section). The maintenance schedule may need to be adjusted based on budget availability but it is advised that the City proceed with maintenance for at least the 20 highest priority outfalls as soon as possible. These structures appear to be at risk of either structural damage that would render the structures irreparable or of siltation that would compromise the ability of the outfall to adequately convey the design discharge. The additional 30 outfalls receiving a poor rating condition should be addressed, as budget becomes available, to prevent future negative impacts to the storm drain system and avoid unnecessary costs. Remedial maintenance of the fair outfalls and continued field inspection for the good outfalls should be conducted in a regularly scheduled cycle determined by the City. Recommended maintenance activities are as follows.

1. Recommended Maintenance Activities

i. *Structural*

Evaluate necessary structural repairs and determine whether replacement of outfall structure is necessary. Restore outfall to adequate operating condition and install erosion protection to prevent future structural undermining. Design of any outfalls or structural repairs shall be according to the City of Grand Prairie standards.

Estimated Cost: $5,000 - $25,000 per outfall

ii. *Siltation/Scour/Riprap*

Refer to the City of Grand Prairie Drainage Design Manual Section 8.9 – Outfall Design Guidelines for acceptable design applications for outfall protection. Additional information is available in the North Central Texas Council of Governments iSWM Technical Manual Section 4.0 and Section XI.D of this report. Scour protection should be designed to adequately protect structural integrity of the outfall and to prevent erosion and siltation downstream. Siltation blocking the outfall should be removed.

Estimated Cost: $1,000 - $5,000 per outfall

iii. *No Headwall*

All outfall and inlets shall have reinforced concrete headwall. Headwalls shall be City of Grand Prairie or TxDOT standard. Refer to current City of Grand Prairie Drainage Design Manual.

Estimated Cost: $1,000 - $5,000 per outfall

iv. *Aesthetics*

Remove accumulated debris including trees, vegetation, and garbage from the outfall structure. Repair superficial defects to the outfall structure. These defects could include displaced riprap, vandalization in the form of graffiti or disturbance to erosion protection, and overgrown vegetation.

Estimated Cost: $500 - $1,500 per outfall

v. *Continued Monitoring*

All repaired outfalls and those categorized as "good" in this report should continue to be monitored in a regularly scheduled cycle (determined by the City) to ensure that repairs are adequate and to determine where additional maintenance is needed.

Table XI-1 - Storm Drain Outfall Assessment

Condition, Criteria, & Overall Prioritization Ranking					
Overall Ranking	**Photo ID**	**Photo Date**	**Condition**	**Criteria**	**Comments**
1	1613	5/21/2009	Failure	Structural	Structural damage; immediate repair needed
2	948	4/21/2009	Failure	Structural	Severe erosion on west side of structure
3	1035	1/2/2008	Failure	No Headwall	No headwall; pipe broken; close to lake
4	949	1/2/2008	Failure	No Headwall	No headwall; pipe broken; Heavy siltation
5	931	12/11/2007	Failure	No Headwall	No headwall
6	1475	1/17/2008	Poor	Structural	Crack in headwall
7	1037	1/8/2008	Poor	Structural	This area needs attention soon
8	1467	1/24/2008	Poor	RipRap/Scour	Needs rip rap
9	1367	1/11/2008	Poor	Structural	Looks like area around rip rap and headwall is eroding
10	1639	6/5/2009	Poor	Structural	Erosion along sides of structure
11	1480	4/13/2009	Poor	Structural	Some erosion east side of structure; outfall will be relocated
12	1596	5/18/2009	Poor	Structural	Ground on sides of structure eroding
13	1038	4/2/2009	Poor	Siltation	Pipe full of siltation
14	616	1/18/2008	Poor	Siltation	Pipe almost full of siltation
15	930	12/11/2007	Poor	Siltation	Heavy Siltation
16	622	1/22/2008	Poor	Siltation	Heavy Siltation
17	1471	12/18/2007	Poor	RipRap/Scour	Erosion downstream; no rip rap
18	1631	5/26/2009	Poor	Structural	Eroding along sides of headwall
19	621	1/10/2008	Poor	Structural	Eroding along east wing wall
20	1468	1/24/2008	Poor	Siltation/RipRap	Siltation; needs rip rap
21	1630	5/26/2009	Poor	Structural	Tree roots exposed
22	1551	4/22/2009	Poor	Aesthetics	Large downed tree on structure
23	153	12/20/2007	Poor	Aesthetics	Gabions; Pic shows large downded tree
24	1036	4/2/2009	Poor	Siltation	Heavy siltation; rip rap almost falling into flowline
25	1518	4/23/2009	Poor	Siltation/RipRap	Siltation and Vegetation
26	624	12/11/2007	Poor	Structural	Crack in headwall
27	1488	3/24/2008	Poor	Structural	Crack in headwall
28	243	12/20/2007	Poor	Aesthetics	Downstream Erosion
29	1532	4/10/2009	Poor	RipRap/Scour	Erosion control needed
30	1533	4/10/2009	Poor	RipRap/Scour	Erosion control needed
31	619	1/18/2008	Poor	Siltation	Pipe is full and the function is failing
32	1444	12/11/2007	Poor	RipRap/Scour	Possible rip rap needed
33	1520	4/21/2009	Poor	RipRap/Scour	Erosion control needed
34	1521	4/21/2009	Poor	RipRap/Scour	Erosion control needed
35	1633	6/5/2009	Poor	RipRap/Scour	Structure looks good; some erosion along banks just downstream
36	1466	1/24/2008	Poor	Siltation/RipRap	Siltation; needs rip rap
37	1491	4/16/2009	Poor	Siltation/RipRap	Siltation; erosion control needed
38	1597	5/21/2009	Poor	Siltation/RipRap	Siltation; rip rap needed
39	142	1/9/2008	Poor	Siltation	Heavy Siltation
40	1545	4/21/2009	Poor	Siltation/RipRap	Siltation; Re-establish rip rap
41	1493	12/18/2007	Poor	RipRap/Scour	Some erosion occuring
42	1547	4/21/2009	Poor	Siltation/RipRap	Siltation; Re-establish rip rap
43	1160	1/10/2008	Poor	Siltation	Heavy Siltation
44	620	1/22/2008	Poor	Siltation	Heavy Siltation
45	1284	12/18/2007	Poor	Siltation	Heavy Siltation
46	1549	4/21/2009	Poor	Siltation	Heavy Siltation
47	1548	4/21/2009	Poor	Siltation	Heavy Siltation
48	1550	4/21/2009	Poor	Siltation	Heavy Siltation
49	1335	1/9/2008	Poor	Siltation	Siltation
50	932	12/11/2007	Poor	Siltation	Siltation; Wingwall looks damaged
51	110	12/11/2007	Fair	Structural	Slight cracking
52	1344	1/8/2008	Fair	Structural	Slight cracking in headwall
53	224	1/22/2008	Fair	Aesthetics	Loose rock around structure
54	1175	1/22/2008	Fair	Aesthetics	Small trees in outfall flowline
55	915	1/2/2008	Fair	Aesthetics	Dirt falling into flowline; possible siltation as well
56	950	1/2/2008	Fair	RipRap/Scour	Scour Pond
57	1490	4/16/2009	Fair	RipRap/Scour	Erosion control needed
58	241	1/17/2008	Fair	RipRap/Scour	Some Erosion
59	1368	1/11/2008	Fair	RipRap/Scour	Looks like area around rip rap is eroding
60	615	1/18/2008	Fair	RipRap/Scour	Slight erosion; falling rip rap may need grouting
61	1562	4/21/2009	Fair	RipRap/Scour	Some erosion; erosion control needed
62	136	12/18/2007	Fair	RipRap/Scour	Possible Erosion
63	1542	4/10/2009	Fair	RipRap/Scour	Erosion control needed
64	1162	1/10/2008	Fair	RipRap/Scour	Possible Erosion Downstream
65	1537	4/21/2009	Fair	RipRap/Scour	Erosion control needed
66	135	12/18/2007	Fair	RipRap/Scour	Possible Erosion
67	140	12/18/2007	Fair	RipRap/Scour	Some Erosion at outfall
68	1159	1/10/2008	Fair	RipRap/Scour	Possible Erosion
69	1285	4/21/2009	Fair	RipRap/Scour	Possible re-establishment of rip rap
70	1163	1/22/2008	Fair	Siltation	Siltation
71	1619	5/21/2009	Fair	Siltation	Siltation
72	223	1/22/2008	Fair	Siltation	Some Siltation
73	242	1/17/2008	Fair	Siltation	Some Siltation and Vegetation
74	1628	5/26/2009	Fair	Siltation	Siltation
75	1198	12/20/2007	Fair	Siltation	Siltation
76	1165	1/10/2008	Fair	Siltation	Siltation
77	1340	12/20/2007	Fair	Siltation	Baffle Blocks; siltation
78	1598	5/21/2009	Fair	Siltation	Siltation
79	1430	12/18/2007	Fair	Siltation	Some Siltation and Vegetation
80	640	12/18/2007	Fair	Siltation	Some Siltation and Vegetation
81	1617	5/21/2009	Fair	Siltation	Siltation
82	1641	6/5/2009	Fair	Siltation	Siltation
83	141	1/9/2008	Fair	Siltation	Some Siltation

Condition, Criteria, & Overall Prioritization Ranking					
Overall Ranking	**Photo ID**	**Photo Date**	**Condition**	**Criteria**	**Comments**
84	1622	5/26/2009	Fair	Siltation	Some siltation
85	1610	5/21/2009	Fair	Siltation	Some siltation; possible rip rap needed
86	1611	5/21/2009	Fair	Siltation	Some Siltation
87	1449	1/2/2008	Fair	Siltation	Some Siltation
88	1618	5/21/2009	Fair	Siltation	Some Siltation
89	1626	5/26/2009	Fair	Siltation	Some Siltation
90	1629	5/26/2009	Fair	Siltation	Some Siltation
91	1523	4/21/2009	Fair	Siltation	Some siltation
92	1554	4/21/2009	Fair	Siltation	Siltation
93	1477	4/13/2009	Fair	Siltation	Siltation; outfall will be relocated according to P-1167
94	1602	5/21/2009	Fair	Siltation/RipRap	Siltaton and Vegetation; possible rip rap needed
95	1616	5/21/2009	Fair	Siltation/RipRap	Siltation; Re-establish rip rap
96	1640	6/5/2009	Fair	Siltation/RipRap	Possible rip rap needed
97	1600	5/21/2009	Fair	Siltation/RipRap	Siltation; Re-establish rip rap
98	1601	5/21/2009	Fair	Siltation/RipRap	Siltation; Re-establish rip rap
99	1528	4/21/2009	Fair	Siltation/RipRap	Siltation; Re-establish rip rap
100	1529	4/21/2009	Fair	Siltation/RipRap	Siltation; Re-establish rip rap
101	1530	4/21/2009	Fair	Siltation/RipRap	Siltation; Re-establish rip rap
102	449	1/2/2008	Good		36" Pipe looks good
103	1536	4/21/2009	Good		Possible additional erosion control needed
104	1325	1/29/2008	Good		Possible future erosion
105	1326	1/29/2008	Good		Possible future erosion
106	1327	1/29/2008	Good		Possible future erosion
107	1324	4/10/2009	Good		Possible future erosion; hard to see
108	1345	4/13/2009	Good		Possible future siltation
109	1627	5/26/2009	Good		some siltation
110	150	12/20/2007	Good		Some Vegetation
111	1161	1/10/2008	Good		Some Vegetation
112	1333	4/21/2009	Good		Some Vegetation
113	134	12/18/2007	Good		Light vegetation at outfall
114	144	4/2/2009	Good		Looks good but photo is far away
115	1559	4/21/2009	Good		Minor siltation
116	1609	5/21/2009	Good		remove rip rap stones in culvert
117	149	12/20/2007	Good		Baffle Blocks
118	517	12/18/2007	Good		Baffle Blocks
119	154	12/20/2007	Good		Baffle Blocks; some debris
120	152	1/11/2008	Good		Box Outlet Structure
121	472	1/2/2008	Good		Box Outlet Structure
122	641	1/11/2008	Good		Box Outlet Structure
123	151	12/20/2007	Good		Grouted Rip Rap
124	1489	4/16/2009	Good		Grouted Rip Rap
125	225	1/29/2008	Good		
126	226	4/10/2009	Good		
127	227	1/8/2008	Good		
128	233	1/8/2008	Good		
129	234	1/8/2008	Good		
130	235	4/13/2009	Good		
131	236	1/8/2008	Good		
132	237	1/17/2008	Good		
133	240	1/11/2008	Good		
134	244	12/20/2007	Good		
135	245	12/20/2007	Good		
136	246	1/10/2008	Good		
137	248	4/10/2009	Good		
138	249	4/10/2009	Good		
139	452	1/17/2008	Good		
140	469	1/8/2008	Good		
141	470	1/8/2008	Good		
142	513	1/11/2008	Good		
143	514	1/11/2008	Good		
144	516	12/11/2007	Good		
145	617	1/18/2008	Good		
146	618	1/18/2008	Good		
147	636	4/13/2009	Good		
148	637	4/13/2009	Good		
149	933	4/21/2009	Good		
150	951	1/8/2008	Good		
151	1164	1/10/2008	Good		
152	1199	1/14/2008	Good		
153	1283	12/18/2007	Good		
154	1286	4/10/2009	Good		
155	1287	1/8/2008	Good		
156	1288	1/11/2008	Good		
157	1304	12/11/2007	Good		
158	1323	1/29/2008	Good		
159	1328	1/17/2008	Good		
160	1329	1/17/2009	Good		
161	1330	1/17/2008	Good		
162	1331	12/18/2007	Good		
163	1342	1/2/2008	Good		
164	1343	1/8/2008	Good		
165	1369	1/17/2008	Good		
166	1427	1/17/2008	Good		
167	1428	1/17/2008	Good		
168	1442	12/11/2007	Good		

Condition, Criteria, & Overall Prioritization Ranking					
Overall Ranking	**Photo ID**	**Photo Date**	**Condition**	**Criteria**	**Comments**
169	1470	12/11/2007	Good		
170	1517	4/21/2009	Good		
171	1519	4/21/2009	Good		
172	1522	4/21/2009	Good		
173	1524	4/23/2009	Good		
174	1525	4/13/2009	Good		
175	1526	4/13/2009	Good		
176	1527	4/13/2009	Good		
177	1531	4/13/2009	Good		
178	1534	4/10/2009	Good		
179	1535	4/13/2009	Good		
180	1539	4/21/2009	Good		
181	1540	4/21/2009	Good		
182	1541	4/21/2009	Good		
183	1543	4/14/2009	Good		
184	1544	4/14/2009	Good		
185	1546	4/21/2009	Good		
186	1552	4/21/2009	Good		
187	1553	4/21/2009	Good		
188	1555	4/21/2009	Good		
189	1556	4/21/2009	Good		
190	1557	4/22/2009	Good		
191	1560	4/21/2009	Good		
192	1561	4/21/2009	Good		
193	1578	4/21/2009	Good		
194	1599	5/21/2009	Good		
195	1603	5/21/2009	Good		
196	1604	5/21/2009	Good		
197	1605	5/21/2009	Good		
198	1606	5/21/2009	Good		
199	1607	5/21/2009	Good		
200	1608	5/21/2009	Good		
201	1612	5/21/2009	Good		
202	1614	5/21/2009	Good		
203	1615	5/21/2009	Good		
204	1620	5/21/2009	Good		
205	1621	5/26/2009	Good		
206	1623	5/26/2009	Good		
207	1625	5/26/2009	Good		
208	1632	5/26/2009	Good		
209	1637	6/5/2009	Good		
210	1638	6/5/2009	Good		
211	1642	6/5/2009	Good		
212	631	12/11/2007	Good		Pond
213	632	12/11/2007	Good		Pond
214	639	12/18/2007	Good		Pond
215	155	12/11/2007	Good		Pond inflow
216	158	12/11/2007	Good		Pond inflow
217	143	4/2/2009	Submerged		Possible Pond
218	228	4/13/2009	Submerged		Pond
219	229	4/13/2009	Submerged		Pond
220	230	4/13/2009	Submerged		Pond
221	231	4/13/2009	Submerged		Pond
222	232	4/13/2009	Submerged		Pond
223	446	4/13/2009	Submerged		Pond
224	471	1/8/2008	Submerged		Pond
225	512	4/13/2009	Submerged		Pond
226	625	4/13/2009	Submerged		Pond
227	626	4/13/2009	Submerged		Pond
228	627	4/13/2009	Submerged		Pond
229	633	4/13/2009	Submerged		Pond
230	634	4/13/2009	Submerged		Pond
231	635	4/13/2009	Submerged		Pond
232	638	4/13/2009	Submerged		Pond
233	645	4/13/2009	Submerged		Pond
234	1309	4/10/2009	Submerged		Pond
235	1310	4/10/2009	Submerged		Pond
236	1311	4/10/2009	Submerged		Pond
237	1346	4/10/2009	Submerged		Pond
238	1347	4/10/2009	Submerged		Pond
239	1349	4/10/2009	Submerged		Pond
240	1350	4/10/2009	Submerged		Pond
241	1351	4/10/2009	Submerged		Pond
242	1352	4/10/2009	Submerged		Pond
243	1353	4/10/2009	Submerged		Pond
244	1354	4/10/2009	Submerged		Pond
245	1355	4/10/2009	Submerged		Pond
246	1356	4/10/2009	Submerged		Pond
247	1357	4/10/2009	Submerged		Pond
248	1358	4/10/2009	Submerged		Pond

XII. Preliminary Quantities/ Estimates of Probable Cost

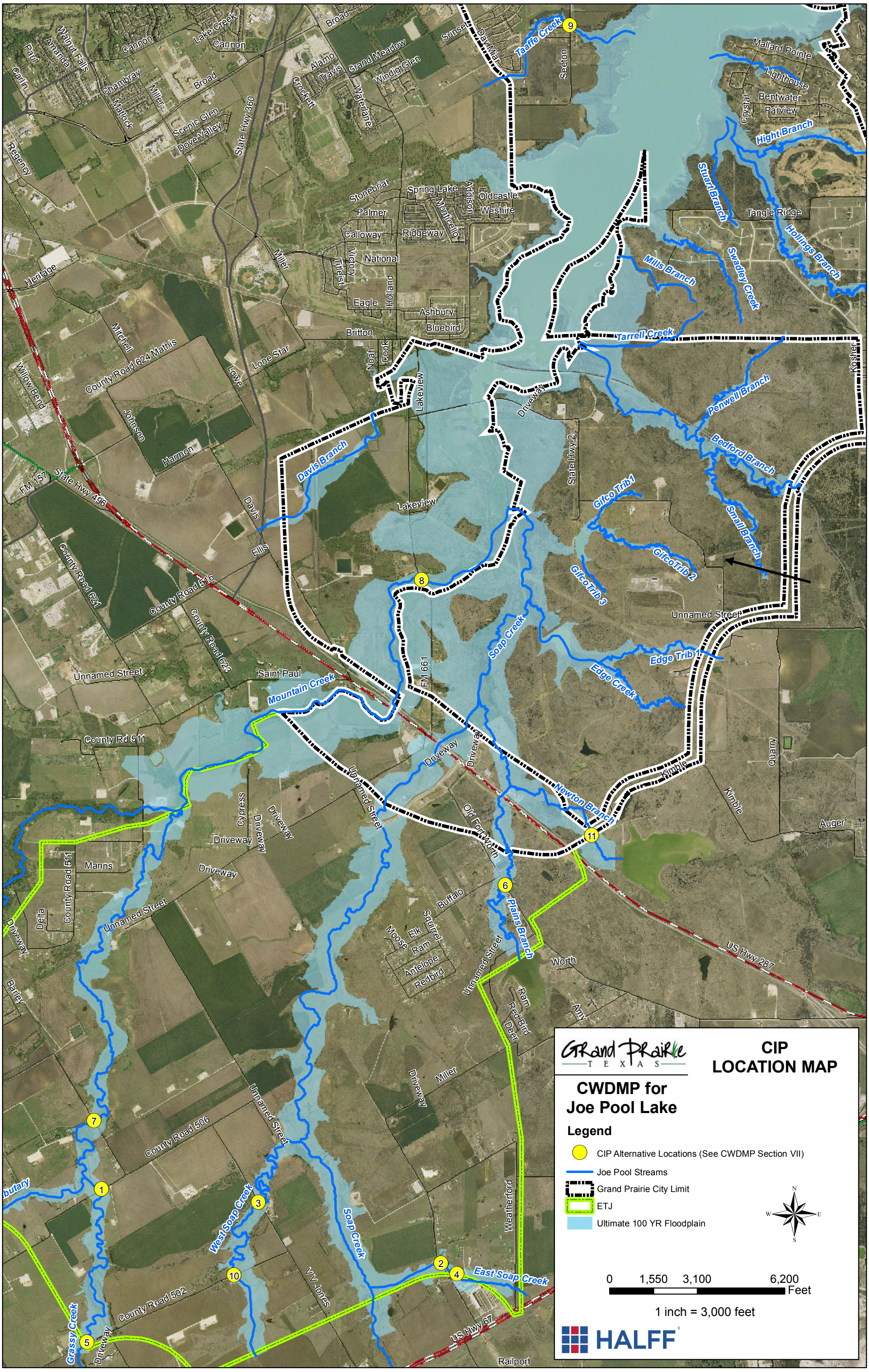


Figure XII-1 CIP Location Map

Table XII-1 Preliminary Short-Term & Long-Term Implementation Plan

Joe Pool Lake Watershed

	Capital Improvement Project	Project Size & Short-Term/Long-Term	Step 1 - Initial Ranking Factor - Estimate of Probable Cost vs. # Structures Benefited [1]			Step 2 - Second Ranking Factor - Cost to Benefit of Roadway Number of Citizens Impacted [2]							Step 3 - Tax Value of Benefited Property Structures [7]		Sum of 1st, 2nd, and 3rd Factors - Step 4	Initial Rank - Step 4	100-Year Ultimate Discharge at CIP Location - Step 5		Final Rank - Step 6
			# Structures	Cost	1st Factor [1]	Type	Roadway Flood Event Protection	Roadway % Citizens Protected [3]	Roadway % Citizens Impacted [4]	Roadway # Citizens Impacted [5]	Cost to Benefit Roadway # Citizens Impacted [6]	2nd Factor	Tax Value of Property Structures Benefited	3rd Factor	Total	Rank [8]	Ultimate Q_{100}	Sorting [9]	Rank [10]
1	**Alt. 1 -** CR 506 at Grassy Creek	Medium/Long-Term	0	$1,183,000	4	P4D	1	0%	100%	7800	$151.67	2	$0	20	26	2	7,730		1
2	**Alt. 2 -** Miller Road at East Soap Creek	Medium/Long-Term	0	$675,000	4	P4D	10	50%	50%	3900	$173.08	3	$0	20	27	3	6,100		2
3	**Alt. 3 -** Jones Road at West Soap Creek	Medium/Long-Term	0	$1,327,000	4	M3U	1	0%	100%	5070	$261.74	4	$0	20	28	4	7,500		3
4	**Alt. 4 -**Turner Road at East Soap Creek	Medium/Long-Term	0	$659,000	4	C2U	2	15%	85%	2320.5	$283.99	5	$0	20	29	5	5,500		4
5	**Alt. 5 -** CR 502 at Grassy Creek	Large/Long-Term	0	$1,685,000	5	M3U	1	0%	100%	5070	$332.35	6	$0	20	31	6	7,000	5	5
6	**Alt. 6 -** Old Fort Worth Road at Plains Branch	Large/Long-Term	0	$1,685,000	5	M3U	1	0%	100%	5070	$332.35	6	$0	20	31	6	4,800	6	6
7	**Alt. 7 -** CR 619 at Grassy Creek	Large/Long-Term	0	$1,924,000	5	M3U	1	0%	100%	5070	$379.49	8	$0	20	33	8	10,740		7
8	**Alt. 8 -** FM 661 at Mountain Creek	Large/Long-Term	0	$2,616,000	5	P4D	2	15%	85%	6630	$394.57	9	$0	20	34	9	39,320	8	8
9	**Alt. 9 -** Seeton Road at Taaffe Creek	Small/Long-Term	0	$433,000	3	C2U	25	70%	30%	819	$528.69	11	$0	20	34	9	2,090	9	9
10	**Alt. 10 -** CR 502 at West Soap Creek	Large/Long-Term	0	$2,017,000	5	M3U	1	0%	100%	5070	$397.83	10	$0	20	35	11	7,500		10
11	**Alt. 11 -** Kimble Road at Newton Branch	Medium/Long-Term	0	$1,449,000	4	C2U	2	15%	85%	2320.5	$624.43	12	$0	20	36	12	6,600		11

1 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 1
2 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 2
3 Based on approximation, using logarithmic chart, with 1-Year Event coverage protecting 0% of traffic volume and 100-Year Event coverage protecting 100% of traffic volume
4 Percent Impacted = 100% minus % of Roadway Citizens Protected (approximate)
5 Number Impacted = % Impacted multiplied by [No. Lanes * 4 Hours Impacted * Hourly Volume Per Lane * Level of Service "C" Traffic Volume]
6 Cost of CIP divided by Roadway # Citizens Impacted
7 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 3
8 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 4
9 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 5
10 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 6

Additional Notes:

a. Phased projects shall be ranked in order of Phasing (i.e. Phase 1 shall be ranked higher than Phase 2, etc.)

b. In Step 5, when comparing projects between two different watersheds: If two projects have same rank in Step 4 and need to be sorted, but have similar 100-Year Ultimate Discharges, then projects should be ranked in order of lowest cost estimate

XII. PRELIMINARY QUANTITIES/ESTIMATES OF PROBABLE COST

Preliminary quantities and estimates of probable cost were calculated for stream and open channel alternatives from Section VII of this report.

The roadway improvement cost estimates were based on the existing roadway sizes, which typically consisted of two lane roadways in the rural areas. Any future expansion of these roadways will need to be accounted for with an update to the included cost estimates.

The following estimates of probable cost were prepared using standard cost estimate practices and it is understood and agreed that these statements are estimates only.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
Grassy Creek at County Road 506 Improvements - Alt. 1
Total Replacement (stream station 232+44)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	Grassy Creek at County Road 506 Improvements				
1	Mobilization	LS	1	$20,000	$20,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	1,500	$15	$22,500
4	New Bridge Construction	SF	8,300	$70	$581,000
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	10,000	$7	$70,000
7	Select Fill	CY	6,000	$15	$90,000
8	Furnish and Install 24-inch Rock Rip Rap	CY	150	$100	$15,000
9	Furnish and Install Turf Reinforcing Mat	SY	3,000	$10	$30,000
10	Furnish and Install Seeding	SY	3,000	$2	$6,000
				Subtotal	$860,000
				25% Contingency	$215,000
				CONSTRUCTION TOTAL	**$1,075,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$107,500
				TOTAL	**$1,180,000**
				TOTAL ANNUAL	**$86,000**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
East Soap Creek at Miller Road Improvements - Alt. 2
Total Replacement (stream station 27+40)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	East Soap Creek at Miller Road Improvements				
1	Mobilization	LS	1	$15,000	$15,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	1,400	$15	$21,000
4	New Bridge Construction	SF	3,000	$70	$210,000
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	12,500	$7	$87,500
7	Select Fill	CY	5,000	$15	$75,000
8	Furnish and Install 24-inch Rock Rip Rap	CY	90	$100	$9,000
9	Furnish and Install Turf Reinforcing Mat	SY	4,000	$10	$40,000
10	Furnish and Install Seeding	SY	4,000	$2	$8,000
				Subtotal	$491,000
				25% Contingency	$122,800
				CONSTRUCTION TOTAL	**$614,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$61,400
				TOTAL	**$680,000**
				TOTAL ANNUAL	**$49,000**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
West Soap Creek at VV Jones Road Improvements - Alt. 3
Total Replacement (stream station 67+27)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	West Soap Creek at VV Jones Road Improvements				
1	Mobilization	LS	1	$20,000	$20,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	800	$15	$12,000
4	New Bridge Construction	SF	10,500	$70	$735,000
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	8,800	$7	$61,600
7	Select Fill	CY	5,000	$15	$75,000
8	Furnish and Install 24-inch Rock Rip Rap	CY	120	$100	$12,000
9	Furnish and Install Turf Reinforcing Mat	SY	2,000	$10	$20,000
10	Furnish and Install Seeding	SY	2,000	$2	$4,000
				Subtotal	$965,100
				25% Contingency	$241,300
				CONSTRUCTION TOTAL	**$1,206,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$120,600
				TOTAL	**$1,330,000**
				TOTAL ANNUAL	**$96,000**

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HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
East Soap Creek at Turner Road Improvements - Alt. 4
Total Replacement (stream station 38+16)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	East Soap Creek at Turner Road Improvements				
1	Mobilization	LS	1	$15,000	$15,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	1,200	$15	$18,000
4	New Bridge Construction	SF	3,800	$70	$266,000
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	12,500	$7	$87,500
7	Select Fill	CY	1,300	$15	$19,500
8	Furnish and Install 24-inch Rock Rip Rap	CY	120	$100	$12,000
9	Furnish and Install Turf Reinforcing Mat	SY	3,000	$10	$30,000
10	Furnish and Install Seeding	SY	3,000	$2	$6,000
				Subtotal	$479,500
				25% Contingency	$119,900
				CONSTRUCTION TOTAL	**$599,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$59,900
				TOTAL	**$660,000**
				TOTAL ANNUAL	**$48,000**

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HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
Grassy Creek at County Road 502 Improvements - Alt. 5
Total Replacement (stream station 317+37)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	Grassy Creek at County Road 502 Improvements				
1	Mobilization	LS	1	$20,000	$20,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	1,750	$15	$26,250
4	New Bridge Construction	SF	10,500	$70	$735,000
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	22,500	$7	$157,500
7	Select Fill	CY	10,000	$15	$150,000
8	Furnish and Install 24-inch Rock Rip Rap	CY	150	$100	$15,000
9	Furnish and Install Turf Reinforcing Mat	SY	8,000	$10	$80,000
10	Furnish and Install Seeding	SY	8,000	$2	$16,000
				Subtotal	$1,225,250
				25% Contingency	$306,300
				CONSTRUCTION TOTAL	**$1,532,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$153,200
				TOTAL	**$1,690,000**
				TOTAL ANNUAL	**$122,000**

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HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
Plains Branch at Old Fort Worth Road Improvements - Alt. 6
Total Replacement (stream station 50+78)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	Plains Branch at Old Fort Worth Road Improvements				
1	Mobilization	LS	1	$20,000	$20,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	1,225	$15	$18,375
4	New Bridge Construction	SF	10,500	$70	$735,000
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	22,500	$7	$157,500
7	Select Fill	CY	12,000	$15	$180,000
8	Furnish and Install 24-inch Rock Rip Rap	CY	290	$100	$29,000
9	Furnish and Install Turf Reinforcing Mat	SY	5,000	$10	$50,000
10	Furnish and Install Seeding	SY	5,000	$2	$10,000
				Subtotal	$1,225,375
				25% Contingency	$306,300
				CONSTRUCTION TOTAL	**$1,532,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$153,200
				TOTAL	**$1,690,000**
				TOTAL ANNUAL	**$122,000**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
Grassy Creek at County Road 619 Improvements - Alt. 7
Total Replacement (stream station 185+46)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	Grassy Creek at County Road 619 Improvements				
1	Mobilization	LS	1	$25,000	$25,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	900	$15	$13,500
4	New Bridge Construction	SF	15,000	$70	$1,050,000
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	12,500	$7	$87,500
7	Select Fill	CY	8,000	$15	$120,000
8	Furnish and Install 24-inch Rock Rip Rap	CY	300	$100	$30,000
9	Furnish and Install Turf Reinforcing Mat	SY	4,000	$10	$40,000
10	Furnish and Install Seeding	SY	4,000	$2	$8,000
				Subtotal	$1,399,500
				25% Contingency	$349,900
				CONSTRUCTION TOTAL	**$1,749,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$174,900
				TOTAL	**$1,920,000**
				TOTAL ANNUAL	**$139,000**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
Mountain Creek at FM 661 Improvements - Alt. 8
Total Replacement (stream station 46+72)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	Mountain Creek at FM 661 Improvements				
1	Mobilization	LS	1	$25,000	$25,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	7,500	$15	$112,500
4	New Bridge Construction	SF	15,000	$70	$1,050,000
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	37,500	$7	$262,500
7	Select Fill	CY	17,000	$15	$255,000
8	Furnish and Install 24-inch Rock Rip Rap	CY	400	$100	$40,000
9	Furnish and Install Turf Reinforcing Mat	SY	11,000	$10	$110,000
10	Furnish and Install Seeding	SY	11,000	$2	$22,000
				Subtotal	$1,902,500
				25% Contingency	$475,600
				CONSTRUCTION TOTAL	**$2,378,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$237,800
				TOTAL	**$2,620,000**
				TOTAL ANNUAL	**$190,000**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
Taaffe Creek at Seeton Road Improvements - Alt. 9
Total Replacement (stream station 27+03)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	Taaffe Creek at Seeton Road Improvements				
1	Mobilization & Demolition	LS	1	$30,000	$30,000
2	Excavation (Channel)	CY	200	$12	$2,400
3	4 - 8' x 8' Precast Concrete Box	LF	150	$650	$97,500
4	Wingwalls & Toewall	EA	2	$25,000	$50,000
5	Furnish and Install 24-inch Rock Rip Rap	CY	400	$100	$40,000
6	Pavement Repair	SF	2,500	$7	$17,500
7	Traffic Control	LS	1	$25,000	$25,000
8	Connect to Existing Concrete	LS	1	$30,000	$30,000
9	Furnish and Install 24-inch Rock Rip Rap	CY	200	$100	$20,000
10	Furnish and Install Turf Reinforcing Mat	SY	200	$10	$2,000
11	Furnish and Install Seeding	SY	200	$2	$400
				Subtotal	$314,800
				25% Contingency	$78,700
				CONSTRUCTION TOTAL	**$394,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$39,400
				TOTAL	**$430,000**
				TOTAL ANNUAL	**$31,000**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
West Soap Creek at County Road 502 Improvements - Alt. 10
Total Replacement (stream station 121+17)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	West Soap Creek at County Road 502 Improvements				
1	Mobilization	LS	1	$25,000	$25,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	1,000	$15	$15,000
4	New Bridge Construction	SF	16,500	$70	$1,155,000
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	13,800	$7	$96,600
7	Select Fill	CY	6,000	$15	$90,000
8	Furnish and Install 24-inch Rock Rip Rap	CY	120	$100	$12,000
9	Furnish and Install Turf Reinforcing Mat	SY	4,000	$10	$40,000
10	Furnish and Install Seeding	SY	4,000	$2	$8,000
				Subtotal	$1,467,100
				25% Contingency	$366,800
				CONSTRUCTION TOTAL	**$1,834,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$183,400
				TOTAL	**$2,020,000**
				TOTAL ANNUAL	**$146,000**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

HALFF ASSOCIATES, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137
(817) 847-1422

CLIENT: City of Grand Prairie
PROJECT CWDMP for Joe Pool Lake
Newton Branch at Kimble Road Improvements - Alt. 11
Total Replacement (stream station 86+76)

FILE NAME: Cost_Estimate
DATE: 8/23/2010
PREPARED BY: bp/sr
AVO: 26418

ESTIMATE OF PROBABLE COST

Item No.	Description	Unit	Total Quantity	Unit Cost	Total Amount
	Newton Branch at Kimble Road Improvements				
1	Mobilization	LS	1	$20,000	$20,000
2	Traffic Control	LS	1	$25,000	$25,000
3	Remove and Dispose Existing Bridge	SF	1,500	$15	$22,500
4	New Bridge Construction	SF	11,250	$70	$787,500
5	Sawcut for Removal of Pavement	FT	100	$5	$500
6	Pavement Repair	SF	12,500	$7	$87,500
7	Select Fill	CY	4,000	$15	$60,000
8	Furnish and Install 24-inch Rock Rip Rap	CY	150	$100	$15,000
9	Furnish and Install Turf Reinforcing Mat	SY	3,000	$10	$30,000
10	Furnish and Install Seeding	SY	3,000	$2	$6,000
				Subtotal	$1,054,000
				25% Contingency	$263,500
				CONSTRUCTION TOTAL	**$1,318,000**
	Engineering, Surveying, and Environmental for Design			10% of Construction	$131,800
				TOTAL	**$1,450,000**
				TOTAL ANNUAL	**$105,000**

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and that Engineer shall not be liable to Owner or to a third party for any failure to accurately estimate the cost of the project, or any part thereof.

XIII. Evaluation & Prioritization/ Phasing & Implementation

XIII. EVALUATION & PRIORITIZATION/PHASING & IMPLEMENTATION

A. EVALUATION & PRIORITIZATION

Halff Associates developed thirteen (13) stream and open channel alternatives that are described in detail in Section VII of this report. Two of these alternatives involved regional detention facilities that are not considered feasible at this time. Regional Detention will need to be evaluated by City staff based on expected future development and floodplain management planning. Halff Associates evaluated and prioritized the remaining eleven (11) alternatives within the Joe Pool Lake watershed which consisted entirely of proposed roadway improvements for existing roadways overtopped by the ultimate 100-year flood event. A process of assigning ranking factors was utilized to rank short-term and long-term priority projects based on criteria from Section II.G of the City of Grand Prairie City-Wide Drainage Master Plan Road Map. Refer to Table XIII-1 for the final proposed CIP alternative rankings. The following is a brief summary of the criteria and methodology utilized to rank short-term and long-term priority projects to be incorporated into the overall City-wide implementation plan.

1. Ranking Criteria:

i. Number of properties/structures benefited – The number of structures benefited by the reduction in flood damage was determined for each proposed CIP alternative. Due to the lack of development at the majority of proposed CIP alternative locations, there were no structures benefited by the reduction in flood damage.

ii. Estimates of probable cost – A preliminary cost-estimate was determined for each proposed CIP alternative and then categorized as follows:

- **Small Projects** – Less than $500,000
- **Medium Projects** - $500,000 to $1,500,000
- **Large Projects** – $1,500,000 to $5,000,000
- **Extra-Large Projects** – $5,000,000 to $10,000,000
- **Super Size Projects** – Greater than $10,000,000

iii. Roadway Type Benefited – Each proposed CIP alternative roadway was categorized based on existing roadway type. Categories include **HWY,**

P7U, P6D, P4D, P3U, M5U, M4U, M3U, C2U, and **No Roadway** (if no roadway benefits are included with project).

iv. *Roadway Flood Event Protection* – The level of flood protection, if no improvements were made, was determined for each proposed CIP alternative roadway crossing. Halff Associates described existing roadway crossing protection based on the following storm events: 2-year, 5-year, 10-year, 25-year, 50-year, or 100-year (existing).

v. *Roadway Citizens Protected/Impacted* – Per Ranking Factor #3 below, an approximate percentage of total roadway citizens impacted was determined for each proposed CIP alternative if no improvements were made.

vi. *Ultimate 100-Year Discharge* – The ultimate 100-year discharge was determined for each proposed CIP alternative location.

2. Ranking Methodology:

i. *Ranking Factor #1*- The initial ranking factor was based on the estimate of probable cost versus the number of properties/structures benefited:

Determine Initial Ranking Factor		**No. of Properties/Structures Benefited**		
		High > 10	**Medium 5 to 10**	**Small < 5**
Estimate of Probable Cost ($)	**Small < $500k**	**1**	**2**	**3**
	Medium $500k - $1.5Mil	**2**	**3**	**4**
	Large > $1.5Mil	**3**	**4**	**5**
	X-Large (> $5M)	**6**	**7**	**8**
	Super-Size (>$10M)	**9**	**10**	**11**

ii. *Ranking Factor #2* - A second ranking factor was determined based on the number of citizens impacted, by potential for roadway shutdowns if no improvements were made on existing roadways, and by a cost to benefit ratio of proposed improvements per roadway citizens impacted.

Step 1 – Determine Existing Roadway Type

Roadway Type
HWY
P7U
P6D
P4D
P3U
M5U
M4U
M3U
C2U

Step 2 – Determine Existing Conditions Roadway Flood Event Protection and Percentage of Roadway Citizens Protected

Roadway Flood Event Protection	Percentage of Citizens Protected [1]
1-Year	0%
2-Year	15%
5-Year	35%
10-Year	50%
25-Year	70%
50-Year	85%
100-Year	100%

[1]Based on approximation, using logarithmic chart, with 1-Year Event coverage protecting 0% and with 100-Year Event protecting 100%

Step 3 – Determine Percentage of Roadway Citizens Impacted

100% minus percentage of citizens protected

Step 4 – Determine Number of Roadway Citizens Impacted

Roadway Type Benefited	Percentage of Citizens Protected [1]
HWY	20800
P7U	12740
P6D	11700
P4D	7800
P3U	5460
M5U	8450
M4U	6760
M3U	5070
C2U	2730

[1]Based on percentage of citizens impacted multiplied by [No. Lanes * 4 hours impacted *hourly volume per lane * Level of Service C Traffic Volume (see table below)]

Grand Prairie Classification	NCTCOG Classification	Lanes	Hourly Service Vol./lane	NCTCOG LOS*			Current UDC "LOS C" Traffic Volume
				Roadway Capacity LOS E	LOS D	LOS C	
P7U	Principal Arterial-Undiv.	7	700	49,000	39,200	31,850	42,000
P6D	Principal Arterial-Divided	6	750	45,000	36,000	29,250	42,000
P4D	Principal Arterial-Divided	4	750	30,000	24,000	19,500	28,000
P3U	Principal Arterial-Undiv.	3	700	21,000	16,800	13,650	18,000
M5U	Minor Arterial	5	650	32,500	26,000	21,125	28,000
M4U	Minor Arterial	4	650	26,000	20,800	16,900	22,000
M3U	Minor Arterial	3	650	19,500	15,600	12,675	18,000
C2U	Collector	2	525	10,500	8,400	6,825	10,000
L2U	Local Street	2	525	10,500	8,400	6,825	8,000
LU	Local Street	1	525	5,250	4,200	3,413	8,000
R2U	Rural Street	2	525	10,500	8,400	6,825	8,000

* = from the Dallas-Fort Worth Regional Travel Model Manual, Exhibits 23 and 24
NCTCOG capacity: LOS E = (# lanes) * 10 * (NCTCOG Hourly Service Volume per Lane)
NCTCOG capacity: LOS D = (LOS E) * .8
NCTCOG capacity: LOS C = (LOS E) * .65

Step 5 – Divide Cost to Benefit of Roadway Number of Citizens Impacted

Divide the estimate of probable cost by the results from Step 4 to determine the cost to benefit ratio (in dollars)

Step 6 – Develop Second Ranking Factor with highest rank being the lowest cost to benefit ratio

iii. *Ranking Factor #3* – A third ranking factor was determined based on the total tax value of all the properties with structures that are benefited by the project from Ranking Factor #1. The Third Ranking Factor was based on the table below.

Total Tax Value of Properties with Structures Benefited	Third Ranking Factor
$2,000,000 +	1
≥ $1,900,000	2
≥ $1,800,000	3
≥ $1,700,000	4
≥ $1,600,000	5
≥ $1,500,000	6
≥ $1,400,000	7
≥ $1,300,000	8
≥ $1,200,000	9
≥ $1,100,000	10
≥ $1,000,000	11
≥ $900,000	12
≥ $800,000	13
≥ $700,000	14
≥ $600,000	15
≥ $500,000	16
≥ $400,000	17
≥ $300,000	18
≥ $200,000	19
$0 to $199,999	20

iv. *Initial Ranking* - A total ranking factor was determined using the summation of Ranking Factors #1, #2, and #3. The initial ranking of proposed CIP alternatives was determined with the top ranked (#1) project having the lowest total ranking factor.

v. *Final Ranking* - If two or more projects had the same initial ranking, the projects were sorted further using the ultimate 100-year discharge at each project location. The higher ranked of these projects was the one with the greatest ultimate 100-year discharge at the project location. If two projects in different watersheds had the same initial ranking and similar ultimate 100-year discharges (within 500 cfs) then the projects were ranked in order of the lowest estimate of probable cost.

B. PHASING & IMPLEMENTATION

1. Final Short-term Priorities Implementation

Short-term Priority CIPs could generally be described as those projects with an initial ranking factor of 1, 2, or 3 from the matrix under Ranking Factor #1 above. The Short-term Priority projects would become the City's key Capital Improvement Projects for immediate implementation, contingent upon City Council approval and allocated funding. Prior to beginning the construction process on these projects, the following key issues may need to be examined:

- Public or private participation in funding and implementation
- Drainage right-of-way or easement needs
- Permitting – FEMA, NCTCOG, U.S. Army Corps of Engineers, TCEQ, or EPA
- Public or neighborhood meetings to describe project and receive citizen feedback
- Adherence of project to City's ordinances and standards for construction

2. Final Long-term Plan Implementation

All other CIPs not classified as Short-term priorities will be considered **Long-term CIPs**. These need to be planned properly with funding allocated for future construction, contingent on City Council approval. Projects that could be constructed by phasing (i.e., will phasing provide immediate benefits or does the whole project need to be constructed for benefits to occur) would need to be re-evaluated by each Phase and re-ranked accordingly with the other CIP alternatives.

For the Long-term projects, the following key issues may need to be examined:

- All the Short-term issues listed above
- Longer range funding plans for larger projects, including phasing (look into State and Federal grants and construction loans)
- More global view, watershed-wide or regional type projects (look into cooperative efforts with U.S. Army Corps of Engineers, NCTCOG, or adjacent communities)
- Examine how increased development of the City's flood warning system could provide further benefits to these areas until funding is allocated for project implementation

- Non-structural measures including:
  - **Buy-out program** – City would need to decide on perpetual maintenance of property or re-selling property after measures are taken to remove lot from flood hazard. Recommend pursuit of City funding, if available, or associated grants (see CWDMP Roadmap Section II.D – Funding Opportunities), if applicable
  - Enforce **new and/or improved development standards** to restrict future development in flood hazard areas

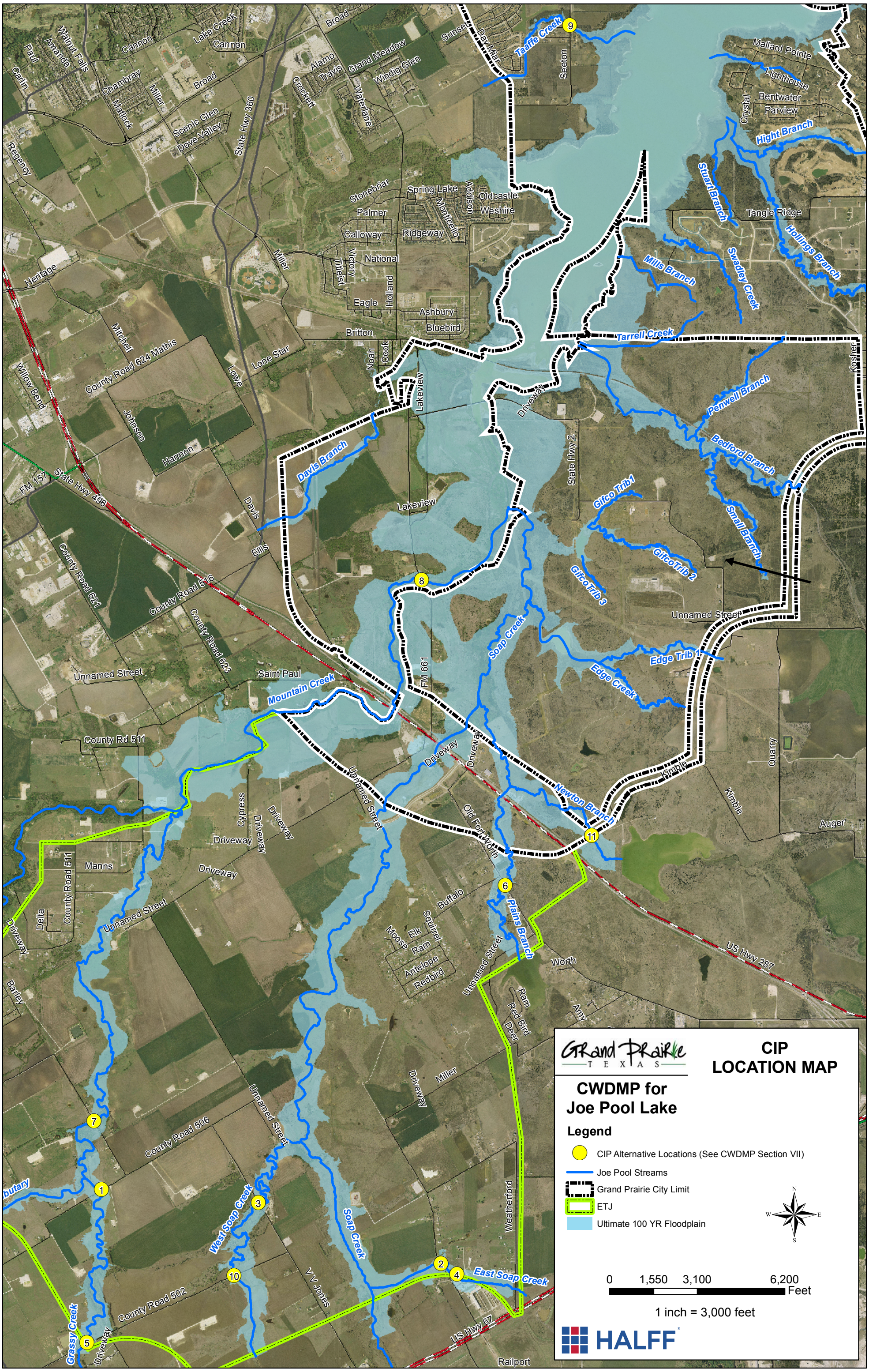


Figure XIII-1 CIP Location Map

Table XIII-1 Preliminary Short-Term & Long-Term Implementation Plan

Joe Pool Lake Watershed

	Capital Improvement Project	Project Size & Short-Term/Long-Term	Step 1 - Initial Ranking Factor - Estimate of Probable Cost vs. # Structures Benefited [1]			Step 2 - Second Ranking Factor - Cost to Benefit of Roadway Number of Citizens Impacted [2]							Step 3 - Tax Value of Benefited Property Structures [7]		Sum of 1st, 2nd, and 3rd Factors - Step 4	Initial Rank - Step 4	100-Year Ultimate Discharge at CIP Location - Step 5		Final Rank - Step 6
			# Structures	Cost	1st Factor [1]	Type	Roadway Flood Event Protection	Roadway % Citizens Protected [3]	Roadway % Citizens Impacted [4]	Roadway # Citizens Impacted [5]	Cost to Benefit Roadway # Citizens Impacted [6]	2nd Factor	Tax Value of Property Structures Benefited	3rd Factor	Total	Rank [8]	Ultimate Q_{100}	Sorting [9]	Rank [10]
1	**Alt. 1 -** CR 506 at Grassy Creek	Medium/Long-Term	0	$1,183,000	4	P4D	1	0%	100%	7800	$151.67	2	$0	20	26	2	7,730		1
2	**Alt. 2 -** Miller Road at East Soap Creek	Medium/Long-Term	0	$675,000	4	P4D	10	50%	50%	3900	$173.08	3	$0	20	27	3	6,100		2
3	**Alt. 3 -** Jones Road at West Soap Creek	Medium/Long-Term	0	$1,327,000	4	M3U	1	0%	100%	5070	$261.74	4	$0	20	28	4	7,500		3
4	**Alt. 4 -**Turner Road at East Soap Creek	Medium/Long-Term	0	$659,000	4	C2U	2	15%	85%	2320.5	$283.99	5	$0	20	29	5	5,500		4
5	**Alt. 5 -** CR 502 at Grassy Creek	Large/Long-Term	0	$1,685,000	5	M3U	1	0%	100%	5070	$332.35	6	$0	20	31	6	7,000	5	5
6	**Alt. 6 -** Old Fort Worth Road at Plains Branch	Large/Long-Term	0	$1,685,000	5	M3U	1	0%	100%	5070	$332.35	6	$0	20	31	6	4,800	6	6
7	**Alt. 7 -** CR 619 at Grassy Creek	Large/Long-Term	0	$1,924,000	5	M3U	1	0%	100%	5070	$379.49	8	$0	20	33	8	10,740		7
8	**Alt. 8 -** FM 661 at Mountain Creek	Large/Long-Term	0	$2,616,000	5	P4D	2	15%	85%	6630	$394.57	9	$0	20	34	9	39,320	8	8
9	**Alt. 9 -** Seeton Road at Taaffe Creek	Small/Long-Term	0	$433,000	3	C2U	25	70%	30%	819	$528.69	11	$0	20	34	9	2,090	9	9
10	**Alt. 10 -** CR 502 at West Soap Creek	Large/Long-Term	0	$2,017,000	5	M3U	1	0%	100%	5070	$397.83	10	$0	20	35	11	7,500		10
11	**Alt. 11 -** Kimble Road at Newton Branch	Medium/Long-Term	0	$1,449,000	4	C2U	2	15%	85%	2320.5	$624.43	12	$0	20	36	12	6,600		11

1 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 1
2 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 2
3 Based on approximation, using logarithmic chart, with 1-Year Event coverage protecting 0% of traffic volume and 100-Year Event coverage protecting 100% of traffic volume
4 Percent Impacted = 100% minus % of Roadway Citizens Protected (approximate)
5 Number Impacted = % Impacted multiplied by [No. Lanes * 4 Hours Impacted * Hourly Volume Per Lane * Level of Service "C" Traffic Volume]
6 Cost of CIP divided by Roadway # Citizens Impacted
7 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 3
8 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 4
9 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 5
10 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 6

Additional Notes:

a. Phased projects shall be ranked in order of Phasing (i.e. Phase 1 shall be ranked higher than Phase 2, etc.)

b. In Step 5, when comparing projects between two different watersheds: If two projects have same rank in Step 4 and need to be sorted, but have similar 100-Year Ultimate Discharges, then projects should be ranked in order of lowest cost estimate

XIV. Short Term Priorities & Long Term Plan

XIV. SHORT TERM PRIORITIES & LONG TERM PLAN

A. SHORT-TERM PRIORITIES IMPLEMENTATION

Due to the undeveloped nature of the Joe Pool Lake watershed, all proposed Capital Improvement Project (CIP) alternatives are currently considered long term priorities. Proposed CIP alternatives will need to be reevaluated to establish short-term priorities as development increases in the Joe Pool Lake watershed.

B. LONG-TERM PLAN IMPLEMENTATION

The City should consider long-term CIPs in the Joe Pool Lake watershed only as development increases and the demand for infrastructure improvements are needed. The majority of proposed CIP alternative locations are currently not developed and do not appear to be planned for development in the near future. Currently, the proposed roadway alternatives do not directly benefit any structures. Therefore, a benefit-to-cost ratio could not be calculated because there are no directly quantifiable benefits from the roadway improvement alternatives at this time.

Prior to implementation of long-term CIPs, Halff Associates recommends an "active" and "passive" approach to warning citizens of potential danger due to flooding at proposed CIP alternative locations. A passive flood warning approach involves the placement of flood warning signage at potentially overtopped roadway crossings, and an active approach involves incorporating a roadway crossing into the City's flood warning system. The time from the rainfall event to the peak discharge at each proposed CIP alternative location was analyzed to determine which locations would have enough lead tme to be included in the actve flood warning system. Halff Associates recommends FM 661 at Mountain Creek to be incorporated into the City's flood warning system. The roadway crossing at FM 661 at Mountain Creek was the only CIP location with enough lead time to allow for an active flood warning approach. Halff Associates recommends flood warning signage be placed at all proposed CIP alternative locations as soon as possible to warn citizens of a potential hazardous roadway.

XV. Master Plan Study Wrap-up & Recommendations for Future Action

XV. MASTER PLAN STUDY WRAP-UP & RECOMMENDATIONS

The City-wide Drainage Master Plan for Joe Pool Lake provides comprehensive, updated technical data for the management of the Joe Pool Lake watershed tributaries and storm water infrastructure. This report addresses existing flooding, erosion, and sedimentation problems within the watershed and provides planning alternatives and design concepts to help alleviate potential flood damages. The information presented in this report will provide the City of Grand Prairie with the necessary updated drainage information to coordinate future development and help minimize exiting and potential flood damages within the Joe Pool Lake watershed.

The majority of the Joe Pool Lake watershed is currently undeveloped, except for the peninsula area near the Mira Lagos development. The watershed offers an opportunity for the City to plan future development in a way that will reduce flood losses, protect residents and infrastructure, improve water quality for Joe Pool Lake, and reduce unnecessary capital expenditures in the future. Based on the findings of this report, Halff Associates recommends the following actions:

A. STREAMS AND OPEN CHANNELS

A relatively small number of structures are currently inundated by the 100-year floodplain in the Joe Pool Lake watershed. The watershed is mostly undeveloped at this time and the developed area in the peninsula near Mira Lagos has been constructed relatively recently utilizing the City's current drainage criteria. Therefore, Halff recommends the following Non-Structural action items for the Joe Pool Lake streams and tributaries:

- **Continue floodplain regulation and encourage responsible development of the watershed.**
- Provide CWDMP report and updated technical data to Ellis and Johnson Counties to improve floodplain management in the ETJ.
- Place flood warning signage at all undersized roadways (proposed CIP alternative locations) and incorporate FM 661 at Mountain Creek into the City's flood warning system.
- Budget for future thoroughfares and infrastructure improvements based on the conceptual roadway sizings provided with this report.
- Investigate the feasibility of Regional Detention for Soap Creek and Grassy Creek based on anticipated future development in the watersheds.

B. STREAM BANK STABILITY

Since the watershed is mostly undeveloped, **Halff recommends that the City utilize Non-Structural Erosion Hazard Setbacks to manage new development in the Joe Pool Lake watershed**, which will minimize both existing and future costs of improvements to control creek erosion that could threaten development.

The structural stream stability alternatives included in this report are recommended on an "as-needed" basis. As development occurs, the Floodplain Workmaps should be utilized to determine whether a site is in a high risk area for bank erosion. If so, then the Erosion Hazard Setback should either be increased or else **stream bank stability alternatives should be implemented**. These alternatives would be considered Private based on City Resolution No. 3919 and Halff recommends that the City consider requirements that would force the developer to contribute funds towards the stream bank stabilization improvements.

As development increases along a stream that is expected to experience significant channel flowline degradation according to the Floodplain Workmaps, it is recommended that **grade control structures be utilized** to help stabilize the channel. These structures will help control the degradation and the resulting bank and wedge failures that threaten adjacent property. It is recommended that these grade control structures be considered public benefits based on City Resolution No. 3919.

C. MAINTENANCE

Maintenance should be considered an ongoing task in the Joe Pool Lake watershed and should follow the recommendations of the CWDMP Roadmap Section F.6.

1. Storm Drain Outfalls

Storm drain outfall maintenance issues identified in this report include four main categories: **1) Good** (requires no remedial maintenance- continued normal inspections), **2) Fair** (may require some remedial maintenance – not immediate), **3) Poor** (requires immediate remedial maintenance), **4) Failure** (requires immediate assistance beyond remedial maintenance).

For the storm drain outfalls, refer to Table XI-1 for a list of the condition of each outfall. Halff Associates recommends the City proceed with maintenance and repairs for the outfalls with a condition of poor as soon as possible. Remedial maintenance of the fair outfalls and continued field inspection for the good outfalls should be conducted in a regularly scheduled cycle determined by the City.

2. Detention Ponds

Detention ponds were also evaluated for maintenance. Seven (7) ponds were found to be experiencing some form of erosion whether it be gullies/rills or symptoms of slope failure that would be considered fair. It is recommended that these ponds be maintained with remedial erosion control measures as soon as the budget allows. Pond No. 18 (Mira Lagos Phase F-2) along Taaffe Creek was categorized as poor (due to erosion) and it is recommended that immediate measures be taken to prevent any future sedimentation of the pond. **Pond No. 20 was also categorized as poor due to the need for further investigation to confirm whether storage volumes are adequate based on the design plans.**

D. FUTURE STUDIES & REPORT UPDATES

Future studies and technical data should be incorporated into this report as they become available. The following watershed studies are known to be ongoing and should be incorporated into this report once they become final.

- **Taaffe Creek Master Drainage Plan (Mansfield)** – Incorporate discharges into Taaffe Creek hydraulics model. Evaluate Seeton Road bridge crossing based on ultimate discharges.
- **Lynn Creek** – An updated hydraulic model for Lynn Creek is currently ongoing and results should be incorporated into this report

Maintenance of the CWDMP document will be critical to keeping the document accurate. Future LOMRs and watershed studies should be included as attachments in this same document. Final hydrology and hydraulic models should be added to Appendix I.

Appendix A
Figures

Watershed Workmaps

OVERALL WATERSHED MAP

CWDMP for Joe Pool Lake

Grand Prairie TEXAS

Legend

- Master Thoroughfare Plan
- Joe Pool Streams
- Grand Prairie City Limit
- ETJ

Joe Pool Watersheds

Study Year

- 1985
- 1986
- 2002
- 2005
- 2006
- 2010
- County Boundary
- Ultimate 100 YR Floodplain
- City Limits

N W E S

1 inch = 2,500 feet

0 2,500 5,000 7,500 10,000 Feet

HALFF

INTERIOR
WEBB BRANCH
FOSTER BRANCH
HANGER CREEK
N. HANGER CREEK

JOE POOL TRIBS
STUART BRANCH
SWADLEY CREEK
MILLS BRANCH
TERRELL CREEK
BEDFORD BRANCH
PENWELL BRANCH
SMALL BRANCH
EDGE CREEK
EDGE CREEK TRIB 1
JOE POOL TRIB 1
JOE POOL TRIB 2
JOE POOL TRIB 3

LYNN
LYNN TRIBUTARY
BOWMAN
LOYD
TEN
TAAFFE
UNIDENTIFIED
HIGHT
HOLLINGS
DAVIS
Exclusive ETJ
NEWTON
MOUNTAIN
SOAP
GRASSY
PLAINS
Statutory ETJ
WEST SOAP CREEK
EAST SOAP CREEK

Arlington
Dallas
Cedar Hill
Mansfield
Midlothian
Venus
TARRANT COUNTY
DALLAS COUNTY
ELLIS COUNTY
JOHNSON COUNTY

Joe Pool Lake

HIGHWAY 360
PRAIRIE OAK BLVD
KINGSWOOD BLVD
LYNN RD
CAMP WISDOM RD
MAGNA CARTA
WEBB LYNN RD
LAKERIDGE PKWY
POLO RD
MATTHEW RD
ROBINSON RD
CARRIER PKWY
BARDIN RD
BELT LINE RD
CLARK TRL
PRAIRIE LN
SANDRA LN
Lynn Creek
Bowman Creek
Loyd Creek
Ten Branch
Hanger Creek
N. Hanger Creek
Webb Branch
Foster Branch
Taaffe Creek
Hight Branch
Stuart Branch
Hollings Branch
Mills Branch
Swadley Creek
Terrell Creek
Penwell Branch
Bedford Branch
Davis Branch
Gifco Trib1
Gifco Trib 2
Gifco Trib 3
Small Branch
Soap Creek
Edge Creek
Edge Trib 1
Mountain Creek
Newton Branch
Plains Branch
Grassy Creek
Grassy Creek Tributary
West Soap Creek
East Soap Creek
NAUTICAL DR
HANGAR LOWE RD
GRAND PENINSULA BLVD
ARLINGTON WEBB BRITTON RD
BROAD ST
CAMINO LAGOS
DAYMIAR RD
SETON RD
HOLLAND RD
MANSFIELD
MANSFIELD RD
LAKE VIEW DR
EMERALD SOUND DR
BENTWATER DR
PARKRIDGE DR
LAKERIDGE PKWY
COLLECTOR A
COLLECTOR B
COLLECTOR C
COLLECTOR D
PRAIRIEVIEW BLVD
LOOP 9
MILLER RD
OLD FORT WORTH RD
HIGHWAY 287
TP0027
TP0028
TP0029
TP0030
TP0026
S. WEATHERFORD RD
WYATT RD
W.J. JONES RD

ID	Watershed
1	Bedford
2	Bowman
3	Davis
4	East Soap
5	Edge
6	Foster
7	Gifco
8	Grassy
9	Hanger
10	Hight
11	Hollings
12	Loyd
13	Lynn
14	Lynn Trib
15	Mills
16	Mountain
17	Newton
18	North Hanger
19	Penwell
20	Plains
21	Small
22	Soap
23	Stuart
24	Swadley
25	Taaffe
26	Tarrell
27	Ten
28	Unidentified
29	Webb
30	West Soap

JOE POOL LAKE
DALLAS
TARRANT
ELLIS
JOHNSON
Lake Ridge
Exclusive ETJ
Statutory ETJ
20
360
287
67
35

OVERALL WATERSHED EXHIBIT

CWDMP for Joe Pool Lake

Legend

- 7 — CWDMP Watershed ID
- Railroad
- Streams
- County Boundary
- Grand Prairie City Limit
- Floodplains - 100yr Ult

NOTES:

1. Floodplains were mapped based on the City of Grand Prairie 2009 Lidar data.
2. Refer to Table II-1 for information corresponding to Watershed ID.

Note: The floodplains depicted on these exhibits should not be used for flood insurance purposes. These floodplain delineations are based on preliminary H&H studies mapped against the City of Grand Prairie 2009 Lidar data.

0 3,500 7,000 10,500 14,000 Feet

HALFF

Figure II-1 Watersheds

ID	Watershed
1	Bedford
2	Bowman
3	Davis
4	East Soap
5	Edge
6	Foster
7	Gifco
8	Grassy
9	Hanger
10	Hight
11	Hollings
12	Loyd
13	Lynn
14	Lynn Trib
15	Mills
16	Mountain
17	Newton
18	North Hanger
19	Penwell
20	Plains
21	Small
22	Soap
23	Stuart
24	Swadley
25	Taaffe
26	Tarrell
27	Ten
28	Unidentified
29	Webb
30	West Soap

JOE POOL LAKE

DALLAS

TARRANT

ELLIS

JOHNSON

Lake Ridge

20 360 287 67 35

Grand Prairie TEXAS

CWDMP for Joe Pool Lake

EXISTING LANDUSE EXHIBIT

Legend

- Railroad
- Streams
- County Boundary
- Grand Prairie City Limit
- Joe Pool Watersheds
- Floodplains - 100yr Ult
- 7 CWDMP Watershed ID

Existing Landuse

- Commercial
- Dedicated Parks
- Government/Education
- High Density Residential
- Industrial
- Low Density Residential
- Multi-family Residential
- Open Space
- Roadway
- Single Family Residential
- Under Construction
- Utilities
- Water-2006
- Water-2010

NOTES:

1. Floodplains were mapped based on the City of Grand Prairie 2009 Lidar data.

2. Refer to Table II-1 for information corresponding to Watershed ID.

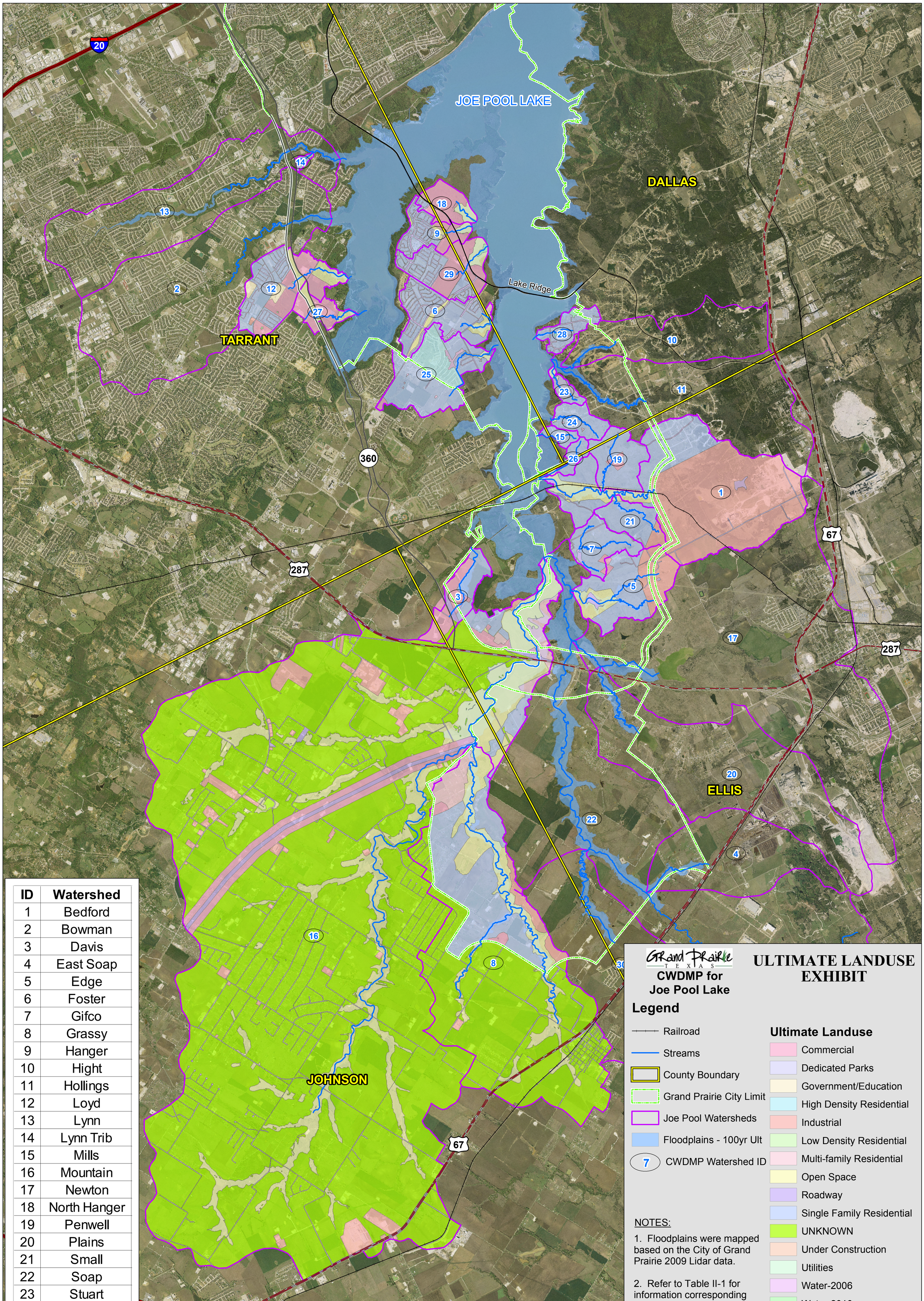
Note: The floodplains depicted on these exhibits should not be used for flood insurance purposes. These floodplain delineations are based on preliminary H&H studies mapped against the City of Grand Prairie 2009 Lidar data.

N E S W

0 3,500 7,000 10,500 14,000 Feet

HALFF

Figure II-2 Existing Landuse



ID	Watershed
1	Bedford
2	Bowman
3	Davis
4	East Soap
5	Edge
6	Foster
7	Gifco
8	Grassy
9	Hanger
10	Hight
11	Hollings
12	Loyd
13	Lynn
14	Lynn Trib
15	Mills
16	Mountain
17	Newton
18	North Hanger
19	Penwell
20	Plains
21	Small
22	Soap
23	Stuart
24	Swadley
25	Taaffe
26	Tarrell
27	Ten
28	Unidentified
29	Webb
30	West Soap

Grand Prairie TEXAS

CWDMP for Joe Pool Lake

ULTIMATE LANDUSE EXHIBIT

Legend

- Railroad
- Streams
- County Boundary
- Grand Prairie City Limit
- Joe Pool Watersheds
- Floodplains - 100yr Ult
- 7 CWDMP Watershed ID

Ultimate Landuse

- Commercial
- Dedicated Parks
- Government/Education
- High Density Residential
- Industrial
- Low Density Residential
- Multi-family Residential
- Open Space
- Roadway
- Single Family Residential
- UNKNOWN
- Under Construction
- Utilities
- Water-2006
- Water-2010

NOTES:

1. Floodplains were mapped based on the City of Grand Prairie 2009 Lidar data.
2. Refer to Table II-1 for information corresponding to Watershed ID.

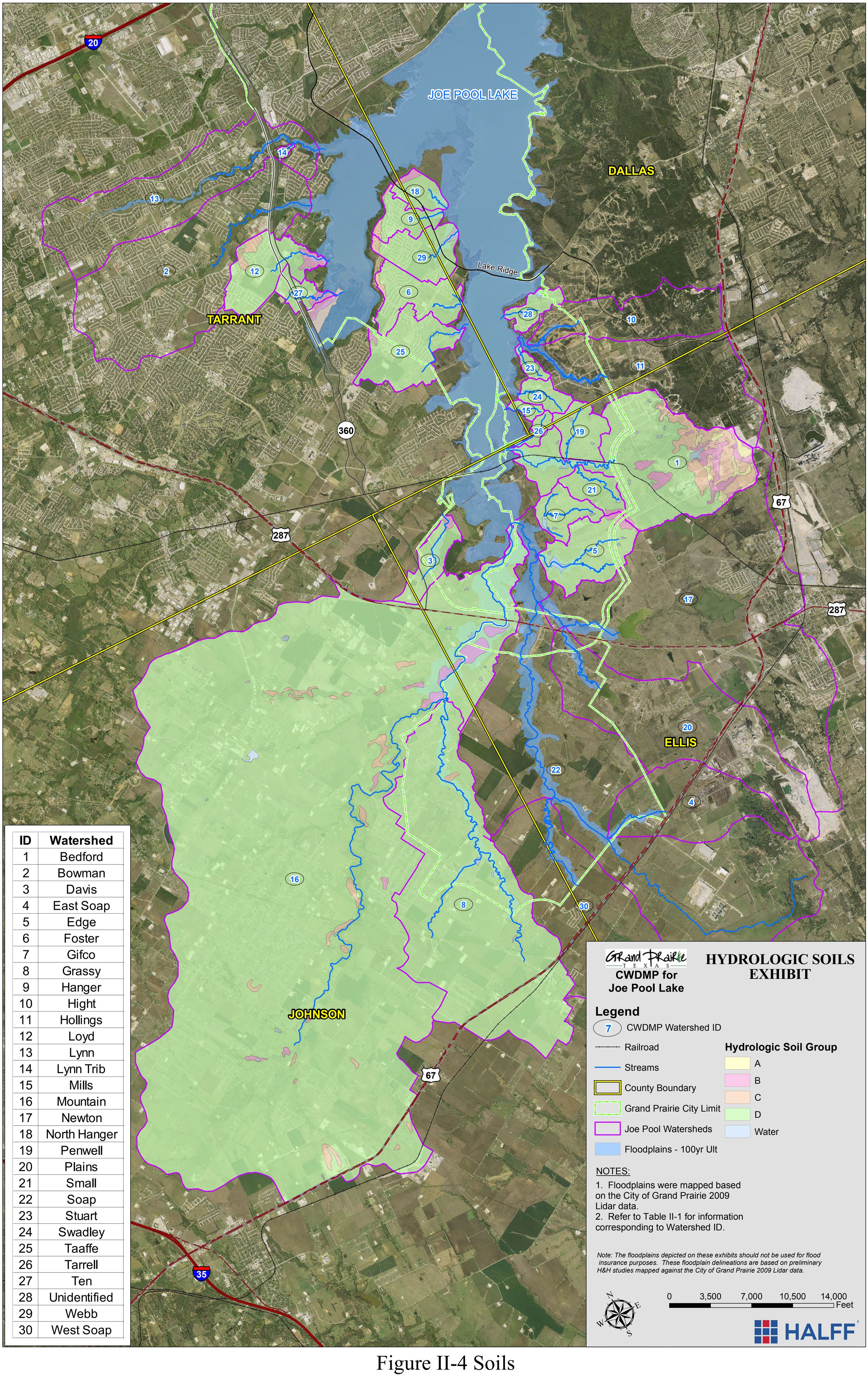
Note: The floodplains depicted on these exhibits should not be used for flood insurance purposes. These floodplain delineations are based on preliminary H&H studies mapped against the City of Grand Prairie 2009 Lidar data.

N W E S

0 3,500 7,000 10,500 14,000 Feet

HALFF

Figure II-3 Ultimate Landuse



ID	Watershed
1	Bedford
2	Bowman
3	Davis
4	East Soap
5	Edge
6	Foster
7	Gifco
8	Grassy
9	Hanger
10	Hight
11	Hollings
12	Loyd
13	Lynn
14	Lynn Trib
15	Mills
16	Mountain
17	Newton
18	North Hanger
19	Penwell
20	Plains
21	Small
22	Soap
23	Stuart
24	Swadley
25	Taaffe
26	Tarrell
27	Ten
28	Unidentified
29	Webb
30	West Soap

GRand PRairie TEXAS

CWDMP for Joe Pool Lake

HYDROLOGIC SOILS EXHIBIT

Legend

- 7 — CWDMP Watershed ID
- Railroad
- Streams
- County Boundary
- Grand Prairie City Limit
- Joe Pool Watersheds
- Floodplains - 100yr Ult

Hydrologic Soil Group

- A
- B
- C
- D
- Water

NOTES:

1. Floodplains were mapped based on the City of Grand Prairie 2009 Lidar data.
2. Refer to Table II-1 for information corresponding to Watershed ID.

Note: The floodplains depicted on these exhibits should not be used for flood insurance purposes. These floodplain delineations are based on preliminary H&H studies mapped against the City of Grand Prairie 2009 Lidar data.

HALFF

Figure II-4 Soils

Floodplain Workmaps

GRand Prairie TEXAS

FLOODPLAIN WORKMAPS

CWDMP for Joe Pool Lake

Joe Pool Lake - 1 of 6

NOTES:

1. Limits of foodplains are based on the City of Grand Prairie 2009 Lidar data.

DATUM:

NAD 83 Texas State Plane North Central Zone NAVD 88

0 300 600 1,200 Feet

LEGEND

- BFE (Ultimate)
- Mapping XS
- USACE Flowage Easement
- Potential Bank Erosion
- Potential Channel Erosion
- Potential Deposition
- Potential Bank Erosion (USACE Property)
- Potential Channel Erosion (USACE Property)
- Potential Deposition (USACE Property)
- Stream CL
- Floodway
- Existing 500 Yr Floodplain
- Existing 100 Yr Floodplain
- Ultimate 100 Yr Floodplain
- Grand Prairie City Limit
- Railroad

HALFF

MAP INDEX

1 of 6
2 of 6
3 of 6
4 of 6
5 of 6
6 of 6

Figure V-1 Floodplain Workmap

Figure V-2 Floodplain Workmap

FLOODPLAIN WORKMAPS

Joe Pool Lake - 3 of 6

CWDMP for Joe Pool Lake

NOTES:

1. Limits of foodplains are based on the City of Grand Prairie 2009 Lidar data.

DATUM:

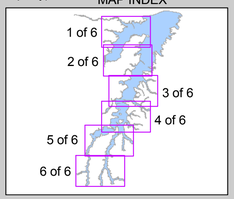
NAD 83 Texas State Plane
North Central Zone
NAVD 88

0 300 600 1,200 Feet

LEGEND

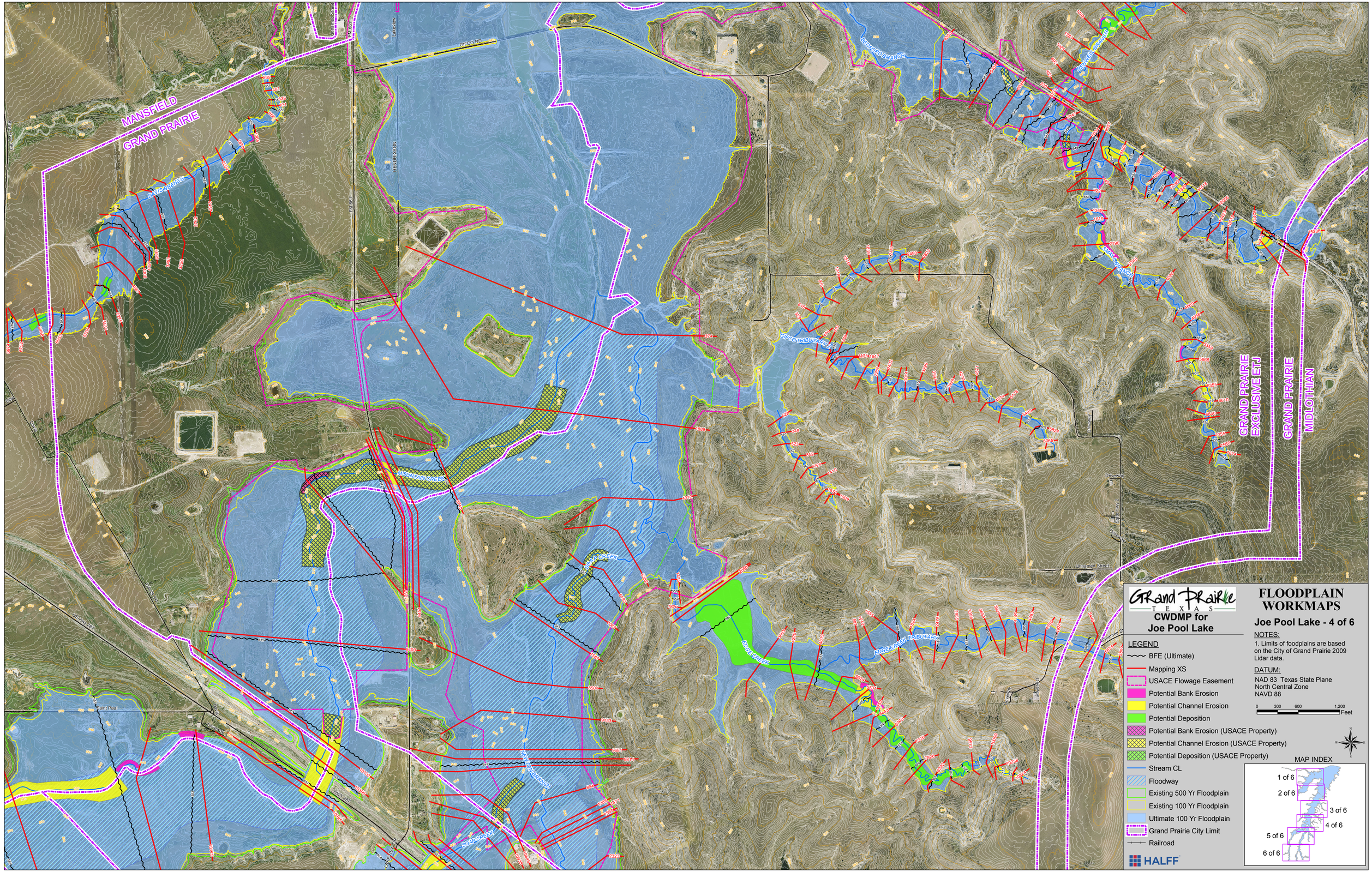
- BFE (Ultimate)
- Mapping XS
- USACE Flowage Easement
- Potential Bank Erosion
- Potential Channel Erosion
- Potential Deposition
- Potential Bank Erosion (USACE Property)
- Potential Channel Erosion (USACE Property)
- Potential Deposition (USACE Property)
- Stream CL
- Floodway
- Existing 500 Yr Floodplain
- Existing 100 Yr Floodplain
- Ultimate 100 Yr Floodplain
- Grand Prairie City Limit
- Railroad

MAP INDEX



HALFF

Figure V-3 Floodplain Workmap


MANSFIELD
GRAND PRAIRIE
GRAND PRAIRIE
EXCLUSIVE ETJ
GRAND PRAIRIE
MIDLOTHIAN
DAVIS RANCH
GIFFORD RANCH
PEWEE BRANCH
GIFFORD TRIBUTARY 2
MOUNTAIN CREEK
SOAP CREEK
KEENEY BRANCH
EDGE CREEK
EDGE CREEK TRIBUTARY
HENDRICKSON
Gifford Rd
Lakeview
Duncanville Rd
Dallas Dr
Mansfield Rd
Saint Paul
Pleasant Run Rd
Wintergreen Rd
Mt Lebanon Rd
Mansfield Webb Rd
Dewberry
Shiloh Rd
Mansfield Cemetery Rd
Mansfield Street
Channel 5
Channel 6
Channel 7
Channel 8
Channel 9
Channel 10
Channel 11
Channel 12
Channel 13
Channel 14
Channel 15
Channel 16
Channel 17
Channel 18
Channel 19
Channel 20
Channel 21
Channel 22
Channel 23
Channel 24
Channel

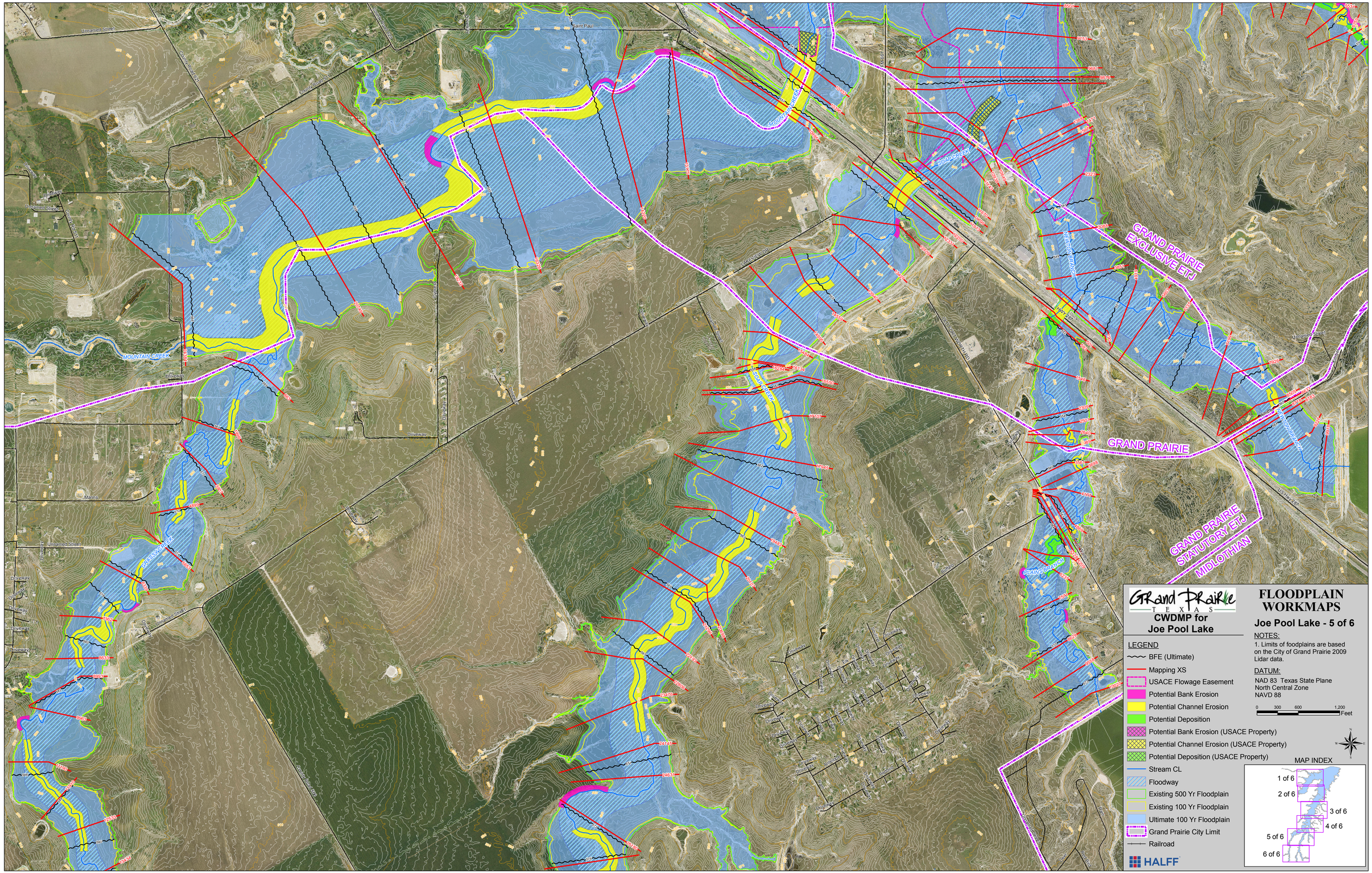


Figure V-5 Floodplain Workmap

GRAND PRAIRIE TEXAS

CWDMP for Joe Pool Lake

FLOODPLAIN WORKMAPS

Joe Pool Lake - 6 of 6

LEGEND

- BFE (Ultimate)
- Mapping XS
- USACE Flowage Easement
- Potential Bank Erosion
- Potential Channel Erosion
- Potential Deposition
- Potential Bank Erosion (USACE Property)
- Potential Channel Erosion (USACE Property)
- Potential Deposition (USACE Property)
- Stream CL
- Floodway
- Existing 500 Yr Floodplain
- Existing 100 Yr Floodplain
- Ultimate 100 Yr Floodplain
- Grand Prairie City Limit
- Railroad

HALFF

NOTES:

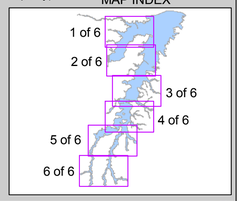
1. Limits of foodplains are based on the City of Grand Prairie 2009 Lidar data.

DATUM:

NAD 83 Texas State Plane North Central Zone
NAVD 88

0 300 600 1,200 Feet

MAP INDEX



GRASS CREEK
WASTECAP CREEK
EAST CAP CREEK
GRAND PRAIRIE STATUTORY ETJ
MIDLOTHIAN
Camp Wisdom Rd
Wintergreen Rd
Duncanville Rd
Lancaster Rd
Houston School Rd
Belt Line Rd
Dallas Rd
Mt Lebanon Rd
Pleasant Run Rd
Simpson Stuart Rd
Parkerville Rd
Dowdy Ferry Rd
Old Fort Worth Rd
Old Hwy 67
US Hwy 67

Figure V-6 Floodplain Workmap

Appendix B
Hydrologic and Hydraulic Data

Hydrologic Parameters

Appendix B - Hydrologic Parameters for the Joe Pool Lake Watersheds (Snyder's UH Method)

HEC-HMS Basin Name	Area (mi2)	L (mi)	Lca (mi)	Sst (ft/mi)	% Urbanization		Lag Time (Tp)				Composite Lag Time (Tp)		Peaking Coefficient (Cp)		Composite CN	
					Existing	Ultimate	Existing		Ultimate		Existing	Ultimate	Existing	Ultimate	Existing	Ultimate
							Clay	Sand	Clay	Sand						
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
East Soap Creek		**6.042**														
EFORK1	1.17	2.48	1.00	73.4	20	95	0.51	0.96	0.30	0.60	0.61	0.72	0.61	0.72	73	85
EFORK2	0.41	1.06	0.55	29.2	10	95	0.37	0.70	0.21	0.41	0.58	0.71	0.58	0.71	72	85
EFORK3	0.23	0.78	0.53	39.9	5	100	0.32	0.60	0.17	0.33	0.58	0.71	0.58	0.71	71	86
EFORK4	0.22	0.55	0.42	16.4	0	90	0.31	0.58	0.17	0.33	0.55	0.70	0.55	0.70	70	84
EFORK5	0.19	0.68	0.32	36.7	0	100	0.26	0.49	0.13	0.26	0.58	0.71	0.58	0.71	70	86
EFORK6	0.19	0.49	0.36	14.2	0	85	0.29	0.54	0.16	0.32	0.55	0.70	0.55	0.70	70	84
Hight Branch		**4.010**														
HIGHT1	0.87	1.35	0.72	80.7	-	90	-	-	0.21	0.43	-	0.21	-	0.72	-	85
HIGHT2	0.66	1.41	0.94	103.5	-	90	-	-	0.23	0.46	-	0.23	-	0.72	-	85
HIGHT3	0.49	1.25	0.91	19.2	-	75	-	-	0.33	0.65	-	0.33	-	0.72	-	84
Hollings Branch		**7.530**														
HOLLINGS1	1.19	1.18	0.64	46.6	-	100	-	-	0.20	0.40	-	0.25	-	0.72	-	80
HOLLINGS2	1.26	1.95	1.16	83.1	-	90	-	-	0.30	0.59	-	0.33	-	0.72	-	76
HOLLINGS3	1.11	2.40	1.19	51.3	-	90	-	-	0.35	0.70	-	0.38	-	0.72	-	74
HOLLINGS4	0.62	2.00	0.87	60.0	-	75	-	-	0.32	0.62	-	0.32	-	0.72	-	71
Newton Branch		**21.439**														
NEWTON1	1.62	3.75	1.91	45.9	25	95	0.81	1.53	0.50	0.99	0.87	0.54	0.61	0.70	74	84
NEWTON2	1.81	2.78	1.17	64.7	35	90	0.52	1.00	0.36	0.71	0.56	0.38	0.69	0.70	74	82
NEWTON3	0.77	2.14	0.81	48.1	15	90	0.50	0.94	0.30	0.59	0.50	0.30	0.61	0.63	71	78
NEWTON4	1.21	1.86	1.17	57.1	40	100	0.44	0.85	0.29	0.58	0.47	0.31	0.69	0.70	74	82
NEWTON5	0.56	1.89	1.10	68.1	60	95	0.37	0.71	0.29	0.57	0.38	0.30	0.69	0.63	76	81
NEWTON6	0.84	2.37	1.19	19.0	30	95	0.65	1.23	0.41	0.82	0.70	0.45	0.63	0.70	72	78
NEWTON7	0.63	1.33	0.68	49.0	0	70	0.43	0.80	0.26	0.52	0.43	0.26	0.61	0.66	70	76
NEWTON8	1.62	2.42	1.12	28.1	15	70	0.66	1.23	0.45	0.88	0.66	0.45	0.58	0.63	71	78
NEWTON9	0.40	1.14	0.45	46.6	0	85	0.35	0.65	0.19	0.38	0.35	0.19	0.61	0.71	70	78
NEWTON10	0.54	1.16	0.44	27.7	5	75	0.37	0.69	0.23	0.45	0.37	0.23	0.58	0.71	71	80
NEWTON11	0.25	0.61	0.32	13.2	0	65	0.31	0.57	0.20	0.38	0.31	0.20	0.55	0.69	70	77
Plains Branch		**10.824**														
PLAINS1	1.11	2.64	1.52	57.5	35	95	0.58	1.10	0.38	0.76	0.66	0.44	0.69	0.70	76	85
PLAINS2	0.96	1.65	0.83	26.1	25	90	0.48	0.91	0.30	0.60	0.48	0.30	0.58	0.70	74	82
PLAINS3	0.92	2.48	1.46	40.3	30	90	0.62	1.17	0.41	0.81	0.62	0.41	0.66	0.70	74	82
PLAINS4	1.07	1.78	0.53	28.6	50	70	0.34	0.66	0.30	0.58	0.34	0.30	0.66	0.63	74	75
PLAINS5	0.42	1.16	0.45	37.2	35	80	0.29	0.55	0.21	0.42	0.29	0.21	0.66	0.71	73	76
PLAINS6	0.38	1.12	0.53	49.2	10	85	0.34	0.64	0.20	0.40	0.34	0.20	0.61	0.71	71	80
Soap Creek		**25.909**														
SOAP1	1.41	2.56	1.31	50.5	15	100	0.63	1.19	0.35	0.70	0.69	0.39	0.61	0.72	72	85
SOAP2	1.09	1.38	0.44	25.3	15	100	0.38	0.71	0.21	0.42	0.38	0.21	0.55	0.70	72	84
SOAP3	1.11	1.65	1.02	14.0	10	90	0.65	1.21	0.37	0.74	0.65	0.37	0.55	0.70	72	83
SOAP4	1.78	3.13	1.50	49.6	20	95	0.70	1.32	0.42	0.83	0.74	0.44	0.61	0.72	73	85
SOAP5	0.59	0.93	0.63	10.8	10	90	0.45	0.85	0.26	0.51	0.45	0.26	0.55	0.70	72	84
SOAP6	0.33	0.64	0.36	9.3	0	85	0.35	0.65	0.19	0.38	0.35	0.19	0.55	0.70	70	80
SOAP7	0.31	1.04	0.55	45.1	5	90	0.35	0.66	0.20	0.39	0.35	0.20	0.61	0.72	70	84
SOAP8	0.21	0.83	0.45	6.6	0	80	0.45	0.84	0.26	0.51	0.45	0.26	0.55	0.70	70	80
SOAP9	0.46	1.38	0.74	33.3	0	85	0.48	0.90	0.27	0.53	0.48	0.27	0.58	0.71	70	81
JONES1	0.69	1.55	1.00	26.4	0	90	0.60	1.11	0.32	0.63	0.60	0.32	0.55	0.70	70	75
SOAP10	0.22	0.72	0.34	5.6	0	80	0.39	0.74	0.23	0.45	0.39	0.23	0.55	0.72	70	78
SOAP11	0.54	1.34	0.57	35.0	10	90	0.40	0.75	0.23	0.46	0.40	0.23	0.58	0.71	71	84
SOAP12	0.43	0.95	0.66	15.8	10	80	0.43	0.81	0.27	0.52	0.43	0.27	0.55	0.71	71	83
SOAP13	0.14	0.38	0.27	7.9	0	80	0.26	0.49	0.15	0.30	0.26	0.15	0.55	0.72	70	80
SOAP14	0.63	1.21	0.74	36.3	0	100	0.45	0.84	0.23	0.45	0.45	0.23	0.58	0.71	70	75
SOAP15	0.56	0.74	0.38	6.8	10	85	0.37	0.70	0.22	0.44	0.37	0.22	0.55	0.72	71	79
SOAP16	0.59	1.52	0.85	34.3	10	85	0.49	0.92	0.29	0.58	0.49	0.29	0.58	0.70	71	77
SOAP17	0.38	0.80	0.51	8.8	20	70	0.38	0.72	0.27	0.53	0.38	0.27	0.55	0.69	72	80
SOAP18	0.36	0.93	0.64	6.5	0	50	0.54	1.00	0.38	0.74	0.56	0.40	0.55	0.66	70	73
SOAP19	0.16	0.74	0.42	12.2	0	40	0.37	0.69	0.28	0.54	0.39	0.30	0.55	0.69	70	72
SOAP20	0.63	1.50	0.81	48.8	0	80	0.48	0.90	0.28	0.55	0.50	0.29	0.61	0.70	70	74
West Soap Creek		**5.758**														
WFORK1	2.39	1.97	0.97	19.8	20	95	0.59	1.12	0.35	0.70	0.59	0.35	0.55	0.63	72	79
WFORK2	0.87	1.52	0.80	24.4	0	90	0.55	1.02	0.29	0.58	0.55	0.29	0.55	0.70	70	74
WFORK3	1.03	2.27	1.46	17.6	0	90	0.86	1.60	0.46	0.91	0.86	0.46	0.55	0.70	70	74

Appendix B - Hydrologic Parameters for the Joe Pool Lake Watersheds (SCS UH Method)

HEC-HMS Basin Name (1)	Area (ac) (2)	Area (mi2) (3)	**Lag Time Exist (min) (4)	**Lag Time Future (min) (5)	% Soil Type A (6)	% Soil Type B (7)	% Soil Type C (8)	% Soil Type D (9)	Composite CN (10)	*Initial Abstraction (11)	% Impervious Existing (12)	% Impervious Future (13)
Bedford Branch		**4.378**										
BDFD1010	268	0.418	30	22	0	0	5	95	80	0.50	3	51
BDFD1020	289	0.452	30	16	1	1	27	70	78	0.56	0	65
BDFD2010	1,124	1.757	56	34	9	18	24	51	73	0.74	29	73
BDFD2020	269	0.421	57	39	5	15	28	48	76	0.63	7	73
BDFD2030	197	0.308	42	32	0	9	3	88	78	0.56	0	72
BDFDB010	127	0.198	37	27	0	0	0	100	80	0.50	0	55
BDFDB020	115	0.180	42	29	0	0	0	99	80	0.50	0	64
BDFDB030	46	0.072	22	19	0	0	0	100	80	0.50	0	50
BDFDB040	21	0.033	11	6	0	0	0	95	81	0.47	0	6
BDFDB050	36	0.056	15	11	0	0	0	94	81	0.47	0	20
BDFDB055	75	0.117	18	13	0	0	0	99	80	0.50	0	48
BDFDB060	105	0.164	17	13	0	0	0	100	80	0.50	3	38
BDFDB070	75	0.117	21	16	0	0	0	100	81	0.47	3	28
BDFDB080	54	0.085	34	26	0	0	0	100	80	0.50	0	30
Penwell Branch		**0.623**										
PENWB010	26	0.040	18	10	0	0	0	95	82	0.44	3	51
PENWB020	47	0.074	18	10	0	0	0	96	81	0.47	0	50
PENWB030	129	0.201	27	19	0	0	0	100	80	0.50	1	56
PENWB035	51	0.079	18	14	0	0	0	100	80	0.50	0	50
PENWB040	147	0.229	33	23	0	0	0	99	80	0.50	0	50
Small Branch		**0.478**										
SMALL010	46	0.072	15	6	0	27	0	68	76	0.63	1	71
SMALL020	148	0.231	35	20	0	0	0	100	80	0.50	2	51
SMALL030	102	0.159	19	14	0	0	0	100	80	0.50	2	51
SMALL040	10	0.016	8	5	0	0	0	100	80	0.50	0	12
Davis Branch		**0.600**										
DB1	115	0.179	35	26	0.0	0.0	0.0	100.0	80	0.50	15	86
DB2	100	0.156	22	18	0.0	0.0	0.0	100.0	80	0.50	4	77
DB3	170	0.265	39	33	12.0	12.0	0.0	88.0	78	0.56	0	63
Edge Creek		**1.284**										
EDGEC010	20	0.031	22	12	0	0	0	100	80	0.50	0	72
EDGEC020	72	0.112	18	7	0	0	0	100	80	0.50	0	59
EDGEC030	65	0.102	20	14	0	0	0	100	80	0.50	0	48
EDGEC040	50	0.078	19	12	0	0	0	95	81	0.47	0	24
EDGEC050	132	0.206	30	21	0	0	0	86	85	0.35	15	36
EDGEC060	56	0.088	28	20	0	0	0	97	81	0.47	0	28
EDGT1010	179	0.280	26	10	0	22	0	77	77	0.60	5	73
EDGT1020	248	0.387	37	27	0	0	0	100	80	0.50	3	55
Foster Branch		**0.936**										
FST1	89	0.140	17	10	0.0	0.0	2.3	97.3	80	0.50	31	51
FST2	28	0.044	19	19	0.0	0.0	32.0	68.0	78	0.56	29	60
FST3	113	0.176	14	14	0.0	0.0	7.0	93.0	80	0.50	48	57
FST4	16	0.025	11	11	0.0	0.0	1.6	98.4	80	0.50	26	60
FST5	70	0.110	16	16	0.0	0.0	0.0	100.0	80	0.50	48	55
FST6	39	0.061	40	35	0.0	0.0	0.0	100.0	80	0.50	1	52
FST7	58	0.090	13	13	0.0	0.0	0.0	100.0	80	0.50	55	64
FST8	63	0.098	22	21	0.0	0.0	0.0	100.0	80	0.50	19	55
FST9	25	0.039	31	28	0.0	0.0	0.0	100.0	80	0.50	1	51
FST10	7	0.011	9	8	0.0	0.0	0.0	100.0	80	0.50	31	65
FST11	12	0.019	20	10	0.0	0.0	21.3	78.7	80	0.50	7	17
FST12	79	0.123	13	12	0.0	0.0	0.0	100.0	81	0.47	8	32
Gifco Creek Tribs		**0.541**										
GFC1010	83	0.129	22	18	0	0	0	100	81	0.47	8	53
GFC2010	177	0.277	41	32	0	0	0	99	81	0.47	2	52
GFC3010	58	0.091	18	12	0	0	0	97	81	0.47	0	55
GFCP010	28	0.044	15	9	0	0	0	73	89	0.25	28	60
Grassy Creek		**8.941**										
GRS1	785	1.227	40	33	0.0	0.0	0.0	100.0	80	0.50	24	72
GRS2	937	1.464	65	51	0.0	0.0	0.0	100.0	80	0.50	7	70
GRS3	421	0.658	45	35	0.0	0.0	0.0	100.0	80	0.50	8	65
GRS4	426	0.666	55	42	0.0	0.0	0.0	100.0	80	0.50	3	64
GRS5	236	0.368	42	24	0.0	0.0	0.0	100.0	80	0.50	4	42
GRS6	358	0.560	34	23	0.0	0.0	0.0	100.0	80	0.50	4	71
GRS7	500	0.782	48	36	0.0	0.0	0.0	100.0	80	0.50	10	69
GRS8	148	0.231	38	28	0.0	0.0	0.0	100.0	80	0.50	17	67
GRS9	269	0.420	43	30	0.0	0.0	0.0	100.0	80	0.50	11	61
GRS10	177	0.277	34	30	0.0	0.0	0.0	100.0	80	0.50	4	39
GRS11	139	0.217	21	18	0.0	0.0	0.0	100.0	80	0.50	4	42
GRS12	341	0.532	27	25	0.0	0.0	3.5	96.5	80	0.50	1	28
GRS13	294	0.459	40	28	0.0	0.0	0.0	100.0	80	0.50	8	43
GRS14	192	0.300	36	26	0.0	0.0	0.0	100.0	80	0.50	21	64
GRS15	112	0.175	19	17	0.0	0.0	0.0	100.0	80	0.50	12	41
GRS16	134	0.209	30	20	0.0	0.0	0.0	100.0	80	0.50	9	52
GRS17	138	0.215	26	17	0.0	0.0	0.0	100.0	80	0.50	8	43
GRS18	115	0.179	15	14	0.0	0.0	0.0	100.0	80	0.50	6	20

Appendix B - Hydrologic Parameters for the Joe Pool Lake Watersheds (SCS UH Method)

HEC-HMS Basin Name (1)	Area (ac) (2)	Area (mi2) (3)	**Lag Time Exist (min) (4)	**Lag Time Future (min) (5)	% Soil Type A (6)	% Soil Type B (7)	% Soil Type C (8)	% Soil Type D (9)	Composite CN (10)	*Initial Abstraction (11)	% Impervious Existing (12)	% Impervious Future (13)
Hanger Creek		**0.485**										
HC1	139	0.217	14	14	0.0	0.0	4.9	95.1	80	0.50	57	54
HC2	16	0.025	14	16	0.0	0.0	0.0	100.0	80	0.50	3	85
HC3	67	0.105	13	13	0.0	0.0	28.5	71.5	78	0.56	58	61
HC4	48	0.075	24	14	0.0	0.0	0.0	100.0	80	0.50	7	85
HC5	40	0.063	19	11	0.0	0.0	0.0	100.0	80	0.50	11	45
Loyd Branch		**1.181**										
LYD1	397	0.621	32	29	0.0	0.0	9.0	91.0	79	0.53	33	66
LYD2	169	0.264	25	24	0.0	0.0	14.0	86.0	79	0.53	21	57
LYD3	62	0.097	22	12	0.0	0.0	0.0	100.0	80	0.50	5	86
LYD4	127	0.199	20	13	46.5	46.5	0.0	53.5	71	0.82	3	36
Lynn Creek Trib		**0.040**										
LT1	8	0.012	13	12	0.0	0.0	0.0	100.0	80	0.50	1	50
LT2	12	0.018	11	10	0.0	0.0	0.0	100.0	80	0.50	7	48
LT3	6	0.010	8	7	3.5	3.5	0.0	96.5	85	0.35	20	21
Mills Branch		**0.110**										
MILLS010	13	0.020	9	5	0.0	0.0	0.0	100.0	80	0.50	0	47
MILLS020	33	0.052	11	7	0.0	0.0	0.0	100.0	80	0.50	3	51
MILLS030	24	0.038	12	7	0.0	0.0	0.0	100.0	80	0.50	0	50
Mountain Creek		**40.635**										
MTC1	11,208	17.513	84	82	0.0	0.3	0.9	98.8	80	0.50	9	70
MTC2	7,892	12.332	95	89	0.0	0.5	1.2	98.3	80	0.50	12	70
MTC3	204	0.318	45	40	0.0	2.3	0.0	97.7	80	0.50	3	13
MTC4	3,469	5.420	103	92	0.0	0.9	1.8	97.3	80	0.50	8	67
MTC5	919	1.436	40	31	0.0	13.0	0.0	87.0	78	0.56	8	44
MTC6	1,630	2.547	86	76	0.0	0.0	0.5	99.5	80	0.50	16	70
MTC7	684	1.069	52	40	0.0	0.0	0.0	100.0	80	0.50	4	37
North Hanger Creek		**0.388**										
NHC1	31	0.049	10	10	0.0	0.0	0.1	99.9	80	0.50	39	75
NHC2	20	0.031	16	7	0.0	0.0	0.0	100.0	80	0.50	6	84
NHC3	6	0.010	14	13	0.0	0.0	6.9	93.1	80	0.50	85	80
NHC4	111	0.173	30	20	0.0	21.9	2.4	75.7	76	0.63	0	85
NHC5	23	0.036	14	9	0.0	0.0	0.0	100.0	80	0.50	0	62
NHC6	57	0.089	23	16	0.0	0.0	0.0	100.0	81	0.47	6	34
Stuart Branch		**0.140**										
STUAB010	15	0.024	10	3	0.0	0.0	0.0	100.0	81	0.47	3	8
STUAB020	74	0.116	15	8	0.0	0.0	0.0	100.0	81	0.47	5	52
Swadley Creek		**0.318**										
SWADB010	28	0.044	20	11	0.0	0.0	0.0	100.0	80	0.50	0	50
SWADB020	86	0.135	17	11	0.0	0.0	0.0	100.0	80	0.50	1	51
SWADB030	81	0.127	25	17	0.0	0.0	0.0	100.0	80	0.50	1	50
SWADB040	8	0.012	9	5	0.0	0.0	0.0	100.0	80	0.50	0	30
Taffee Creek		**1.308**										
TAAFC010	429	0.671	66	46	0.0	2.0	0.0	98.0	80	0.50	5	53
TAAFC020	56	0.087	32	23	0.0	0.0	0.0	100.0	82	0.44	15	52
TAAFC025	294	0.460	36	31	0.0	0.0	0.0	100.0	84	0.38	46	64
TAAFC030	58	0.090	27	26	0.0	0.0	0.0	89.0	84	0.38	12	39
Tarrell Creek		**0.153**										
TARRC010	22	0.035	10	6	0.0	0.0	0.0	100.0	80	0.50	0	0
TARRC020	45	0.070	12	8	0.0	0.0	0.0	93.0	82	0.44	3	3
TARRC030	31	0.048	13	9	0.0	0.0	0.0	100.0	80	0.50	0	0
Ten Branch		**0.320**										
TEN1	52	0.0820	20	11	0.0	64.2	0.8	35.0	68	0.94	3	48
TEN2	49	0.0760	25	12	0.0	1.5	0.0	98.5	80	0.50	19	85
TEN3	104	0.1620	17	12	0.0	0.0	0.0	100.0	80	0.50	20	62
Unidentified Tributary		**0.332**										
UNID1	26	0.040	17	17	0.0	0.0	0.0	100.0	80	0.50	40	63
UNID2	29	0.045	7	7	0.0	0.0	0.0	100.0	80	0.50	23	57
UNID3	27	0.043	12	11	0.0	0.0	0.0	100.0	82	0.44	24	55
UNID4	27	0.041	5	4	0.0	0.0	0.0	100.0	81	0.47	23	54
UNID5	5	0.008	5	4	0.0	0.0	0.0	100.0	82	0.44	37	59
UNID6	12	0.019	10	4	0.0	0.0	0.0	100.0	80	0.50	22	56
UNID7	6	0.010	7	4	0.0	0.0	0.0	100.0	80	0.50	20	55
UNID8	80	0.125	11	10	0.0	0.0	0.0	100.0	82	0.44	27	57
Webb Branch		**0.868**										
WB1	61	0.0950	18	14	0.0	0.0	35.0	65.0	78	0.56	50	60
WB2	44	0.0680	14	14	0.0	0.0	0.5	99.5	80	0.50	43	61
WB3	48	0.0750	14	14	0.0	0.0	0.0	100.0	80	0.50	60	64
WB4	37	0.0580	11	11	0.0	0.0	0.0	100.0	80	0.50	57	62
WB5	97	0.1510	38	26	0.0	0.0	0.0	100.0	80	0.50	1	85
WB6	68	0.1070	21	21	0.0	0.0	0.0	100.0	80	0.50	33	62
WB7	42	0.0650	23	14	0.0	0.0	0.0	100.0	80	0.50	10	85
WB8	15	0.0230	7	5	0.0	0.0	0.0	100.0	80	0.50	41	85
WB9	145	0.2260	37	27	0.0	0.0	9.0	91.0	81	0.47	11	57

Time of Concentration Spreadsheets

Existing Lag Time Calculations for Joe Pool Lake Tributaries (2006 and 2010 Streams)

		Overland Flow						Shallow Concentrated Flow						Channel Flow										
HMS Program Basin Name	Longest Flowpath (ft) (1)	Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (f/s)	Manning's n (5)	T_O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (f/s)	K (10)	T_S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (f/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
Bedford Br.																									
BDFD1010	7233	300	0.0161	Grass-Range, short		0.15	0.386	360	0.0612	Unpaved		16.1	0.025	3010	0.02341	0.05	90	81	4.86		0.172				
								1310	0.07263	Unpaved		16.1	0.084	1800	0.01	0.05	153	160	2.89		0.173				
						T_O Total	**0.386**					T_S Total	**0.109**								T_C Total	**0.345**	**0.840**	**0.504**		**8.8**
BDFD1020	8062	300	0.0160	Grass-Range, short		0.15	0.387	1260	0.0377	Unpaved		16.1	0.112	2130	0.0214	0.05	90	54	6.1		0.097				
								610	0.0676	Unpaved		16.1	0.040	3450	0.0206	0.05	106	78	5.24		0.183				
						T_O Total	**0.387**					T_S Total	**0.152**								T_C Total	**0.280**	**0.819**	**0.492**		**8.6**
BDFD2010	16505	300	0.0050	Grass-Range, short		0.15	0.616	1890	0.0321	Unpaved		16.1	0.182	4470	0.01342	0.05	272	102	6.6		0.187				
														5310	0.0094	0.05	460	290	3.9		0.375				
														4000	0.0095	0.05	294	96	6.1		0.181				
						T_O Total	**0.616**					T_S Total	**0.182**						**5.53**		T_C Total	**0.743**	**1.541**	**0.925**		**16.1**
BDFD2020	10810	300	0.0188	Grass-Range, short		0.15	0.363	1310	0.0309	Unpaved		16.1	0.129	2550	0.0189	0.05	93	59	5.53		0.128				
								650	0.0347	Unpaved		16.1	0.060	2870	0.0144	0.05	110	73	4.69		0.17				
								1520	0.0015	Unpaved		16.1	0.677												
								1090	0.092	Unpaved		16.1	0.062												
						T_O Total	**0.363**					T_S Total	**0.928**						**5.11**		T_C Total	**0.298**	**1.589**	**0.953**		**16.6**
BDFD2030	8445	300	0.0267	Grass-Range, short		0.15	0.315	140	0.2491	Unpaved		16.1	0.005	2830	0.027	0.05	47	57	4.3		0.183				
								450	0.0728	Unpaved		16.1	0.029	1870	0.0235	0.05	41	37	5.2		0.1				
														2410	0.005	0.05	116	76	2.8		0.24				
						T_O Total	**0.315**					T_S Total	**0.034**						**4.1**		T_C Total	**0.821**	**1.170**	**0.702**		**12.2**
BDFDB010	5939	300	0.0133	Grass-Range, short		0.15	0.417	290	0.0048	Unpaved		16.1	0.072	3611	0.0055	0.05	80	60	2.68		0.375				
								410	0.0064	Unpaved		16.1	0.088												
								310	0.0339	Unpaved		16.1	0.029												
								710	0.0563	Unpaved		16.1	0.052												
						T_O Total	**0.417**					T_S Total	**0.241**						3		T_C Total	**0.375**	**1.033**	**0.620**		**10.8**
BDFDB020	6365	300	0.0247	Grass-Range, short		0.15	0.325	1250	0.0227	Unpaved		16.1	0.143												
								4820	0.0145	Unpaved		16.1	0.691												
						T_O Total	**0.325**					T_S Total	**0.834**						3.21		T_C Total	0.000	**1.159**	**0.695**		**12.1**
BDFDB030	5872	300	0.1496	Grass-Range, short		0.15	0.158	70	0.1544	Unpaved		16.1	0.003	3085	0.0026	0.05	159	104	5.95		0.144				
														2141	0.0037	0.05	160	140	1.98		0.3				
						T_O Total	**0.158**					T_S Total	**0.003**						**3.97**		T_C Total	**0.444**	**0.605**	**0.363**		**6.3**
BDFDB040	2393	300	0.0756	Grass-Range, short		0.15	0.208	140	0.0810	Unpaved		16.1	0.008	3031	0.0033	0.05	128	94	2.11		0.04				
								550	0.0433	Unpaved		16.1	0.046												
						T_O Total	**0.208**					T_S Total	**0.054**								T_C Total	**0.040**	**0.302**	**0.181**		**3.2**
BDFDB050	3028	300	0.1388	Grass-Range, short		0.15	0.163	200	0.1315	Unpaved		16.1	0.010	1490	0.0027	0.05	145	60	2.8		0.148				
								700	0.0658	Unpaved		16.1	0.047												
								330	0.0114	Unpaved		16.1	0.053												
						T_O Total	**0.163**					T_S Total	**0.110**								T_C Total	**0.148**	**0.421**	**0.253**		**4.4**
BDFDB055	3497	300	0.0433	Grass-Range, short		0.15	0.260	160	0.0701	Unpaved		16.1	0.010	1400	0.0214	0.05	37	43	3.93		0.099				
														1490	0.0224	0.05	45	72	3.26		0.127				
						T_O Total	**0.260**					T_S Total	**0.010**						**3.60**		T_C Total	**0.226**	**0.496**	**0.298**		**5.2**
BDFDB060	3880	300	0.1235	Grass-Range, short		0.15	0.171	200	0.0804	Unpaved		16.1	0.012	2458	0.0098	0.05	30	27	3.16		0.216				
								920	0.0478	Unpaved		16.1	0.073												
						T_O Total	**0.171**					T_S Total	**0.085**								T_C Total	**0.216**	**0.472**	**0.283**		**4.9**
BDFDB070	3112	300	0.0614	Grass-Range, short		0.15	0.226	290	0.0606	Unpaved		16.1	0.020	500	0.012	0.05	18	17	3.39		0.041				
								290	0.0276	Unpaved		16.1	0.030	1630	0.0013	0.05	84	39	1.79		0.253				
						T_O Total	**0.226**					T_S Total	**0.050**						**2.59**		T_C Total	**0.294**	**0.570**	**0.342**		**6.0**
BDFDB080	3944	300	0.0283	Grass-Range, short		0.15	0.308	360	0.1190	Unpaved		16.1	0.018	1540	0.0007	0.05	217	123	1.15		0.372				
								290	0.0294	Unpaved		16.1	0.029												
								1290	0.0109	Unpaved		16.1	0.213												
						T_O Total	**0.308**					T_S Total	**0.260**								T_C Total	**0.372**	**0.940**	**0.564**		**9.8**
PENWB010	1590	300	0.0210	Grass-Range, short		0.15	0.347	520	0.0907	Unpaved		16.1	0.030												
								740	0.0135	Unpaved		16.1	0.110												
						T_O Total	**0.347**					T_S Total	**0.140**								T_C Total	**0.000**	**0.487**	**0.292**		**5.1**
PENWB020	2512	300	0.0193	Grass-Range, short		0.15	0.359	375	0.1275	Unpaved		16.1	0.018	1072	0.0149	0.05	213	134	4.96		0.06				
								640	0.0488	Unpaved		16.1	0.050												
						T_O Total	**0.359**					T_S Total	**0.068**								T_C Total	**0.060**	**0.487**	**0.292**		**5.1**
PENWB030	4846	300	0.0213	Grass-Range, short		0.15	0.345	490	0.0203	Unpaved		16.1	0.059	1715	0.0117	0.05	50	57	2.96		0.161				
								440	0.0898	Unpaved		16.1	0.025	1000	0.008	0.05	322	255	3.19		0.087				
								745	0.0268	Unpaved		16.1	0.079												
						T_O Total	**0.345**					T_S Total	**0.163**						**3.08**		T_C Total	**0.248**	**0.757**	**0.454**		**7.9**
PENWB035	3063	300	0.0736	Grass-Range, short		0.15	0.210	440	0.0272	Unpaved		16.1	0.046	1773	0.0136	0.05	31	49	2.57		0.192				
								550	0.0218	Unpaved		16.1	0.064												
						T_O Total	**0.210**					T_S Total	**0.110**								T_C Total	**0.192**	**0.512**	**0.307**		**5.4**

		Overland Flow						Shallow Concentrated Flow						Channel Flow										
HMS Program Basin Name	Longest Flowpath (ft) (1)	Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (f/s)	Manning's n (5)	T_O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (f/s)	K (10)	T_S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (f/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
PENWB040	5157	300	0.0072	Grass-Range, short		0.15	0.533	330	0.0199	Unpaved		16.1	0.040	2690	0.0154	0.05	53	73	2.99		0.25				
								470	0.0889	Unpaved		16.1	0.027	850	0.0126	0.05	40	30	4		0.058				
														350	0.0114	0.05	200	63	6.94		0.014				
						T_O Total	**0.533**					**T_S Total**	**0.068**						**4.64**	**T_C Total**	**0.322**	**0.922**	**0.553**		**9.6**
SMALL010	2389	300	0.0374	Grass-Range, short		0.15	0.276	150	0.0451	Unpaved		16.1	0.012	730	0.0138	0.05	33.7	66	2.23		0.091				
								1100	0.1450	Unpaved		16.1	0.050												
						T_O Total	**0.276**					**T_S Total**	**0.062**							**T_C Total**	**0.091**	**0.429**	**0.257**		**4.5**
SMALL020	6236	300	0.0133	Grass-Range, short		0.15	0.416	225	0.0267	Unpaved		16.1	0.024	3611	0.0089	0.05	292	260	3		0.33				
								1400	0.0257	Unpaved		16.1	0.151												
								700	0.0514	Unpaved		16.1	0.053												
						T_O Total	**0.416**					**T_S Total**	**0.228**							**T_C Total**	**0.330**	**0.974**	**0.584**		**10.2**
SMALL030	4057	300	0.1215	Grass-Range, short		0.15	0.172	410	0.0766	Unpaved		16.1	0.026	940	0.0064	0.05	370	160	4.15		0.063				
								2060	0.0175	Unpaved		16.1	0.269												
						T_O Total	**0.172**					**T_S Total**	**0.294**							**T_C Total**	**0.063**	**0.529**	**0.318**		**5.5**
SMALL040	1573	300	0.1291	Grass-Range, short		0.15	0.168	235	0.1487	Unpaved		16.1	0.011	930	0.0086	0.05	367	137	5.38		0.048				
						T_O Total	**0.168**					**T_S Total**	**0.011**							**T_C Total**	**0.048**	**0.226**	**0.136**		**2.4**
Davis																									
DB1	3896	100	0.005	Short Grass	0.11	0.15	0.256	3136	0.0080	Unpaved	1.44	16.1	0.605	660	0.001				1.6	NA	0.115				
						T_O Total	**0.256**					**T_S Total**	**0.605**							**T_C Total**	**0.115**	**0.975**	**0.585**	**35**	**10.2**
DB2	3676	100	0.019	Short Grass	0.19	0.15	0.150	1018	0.0130	Unpaved	1.84	16.1	0.154	2558	0.006				2.36	NA	0.301				
						T_O Total	**0.150**					**T_S Total**	**0.154**							**T_C Total**	**0.301**	**0.605**	**0.363**	**22**	**6.3**
DB3	6055	100	0.014	Short Grass	0.16	0.15	0.170	3720	0.0080	Unpaved	1.44	16.1	0.718	2235	0.01				3.37	NA	0.184				
						T_O Total	**0.170**					**T_S Total**	**0.718**							**T_C Total**	**0.184**	**1.071**	**0.643**	**39**	**11.2**
Edge Cr.																									
EDGEC010	1404	300	0.0103	Grass-Range, short	0.18	0.15	0.461	778	0.0108	Unpaved	1.67	16.1	0.129												
								324	0.0864	Unpaved	4.73	16.1	0.019												
							0.461					**T_S Total**	**0.148**							**T_C Total**	**0.000**	**0.609**	**0.365**		**6.4**
EDGEC020	3631	300	0.0237	Grass-Range, short	0.25	0.15	0.331	633	0.0379	Unpaved	3.13	16.1	0.056	2625	0.0158	0.05	122.98	53.482	6.52		0.112				
								73	0.2192	Unpaved	7.54	16.1	0.003												
							0.331					**T_S Total**	**0.059**							**T_C Total**	**0.112**	**0.502**	**0.301**		**5.2**
EDGEC030	3936	300	0.0707	Grass-Range, short	0.39	0.15	0.214	359	0.0905	Unpaved	4.84	16.1	0.021	2230	0.0110	0.05	133.79	123.71	3.29		0.188				
								1047	0.0210	Unpaved	2.33	16.1	0.125												
							0.214					**T_S Total**	**0.145**							**T_C Total**	**0.188**	**0.547**	**0.328**		**5.7**
EDGEC040	2389	300	0.0290	Grass-Range, short	0.27	0.15	0.305	466	0.0324	Unpaved	2.90	16.1	0.045	917	0.0049	0.05	123.46	111.43	2.20		0.114				
								706	0.0425	Unpaved	3.32	16.1	0.059												
							0.305					**T_S Total**	**0.104**							**T_C Total**	**0.114**	**0.523**	**0.314**		**5.5**
EDGEC050	4717	300	0.0133	Grass-Range, short	0.20	0.15	0.416	404	0.0624	Unpaved	4.02	16.1	0.028	3230	0.0041				0.269	8.112	0.300				
								783	0.0281	Unpaved	2.70	16.1	0.081												
							0.416					**T_S Total**	**0.108**							**T_C Total**	**0.300**	**0.825**	**0.495**		**8.6**
EDGEC060	3950	300	0.0313	Grass-Range, short	0.28	0.15	0.296	632	0.0432	Unpaved	3.35	16.1	0.052	1783	0.0056	0.05	202.5	196.3	2.27		0.218				
								1235	0.0243	Unpaved	2.51	16.1	0.137												
								570	0.0246	Unpaved	2.53	16.1	0.063												
							0.296					**T_S Total**	**0.252**							**T_C Total**	**0.218**	**0.766**	**0.459**		**8.0**
EDGT1010	3862	300	0.0122	Grass-Range, short	0.19	0.15	0.432	645	0.0194	Unpaved	2.24	16.1	0.080	1603	0.0315	0.05	72	63	5.8		0.077				
								1170	0.0226	Unpaved	2.42	16.1	0.134												
							0.432					**T_S Total**	**0.214**							**T_C Total**	**0.077**	**0.723**	**0.434**		**7.5**
EDGT1020	6598	300	0.0267	Grass-Range, short	0.26	0.15	0.315	410	0.0098	Unpaved	1.59	16.1	0.071	1310	0.0137	0.05	146	160	2.8		0.131				
								230	0.0957	Unpaved	4.98	16.1	0.013	1212	0.0048	0.05	146	140	2.1		0.159				
								1790	0.0089	Unpaved	1.52	16.1	0.327												
								1410	0.0270	Unpaved	2.65	16.1	0.148												
							0.315					**T_S Total**	**0.412**							**T_C Total**	**0.290**	**1.017**	**0.610**		**10.6**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow: Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Shallow Concentrated Flow: Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Channel Flow: Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (ft/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
Foster																									
FST1		100	0.023	Woods	0.09	0.4	0.307	1162	0.0180	Unpaved	2.16	16.1	0.149	752	0.0223						0.012				
						T_O Total	**0.307**					**T_S Total**	**0.149**							**T_C Total**	**0.012**	**0.469**	**0.281**	**17**	**4.9**
FST2		100	0.002	Short Grass	0.07	0.15	0.377	30	0.0350	Unpaved	3.01	16.1	0.003	1055	0.0106						0.043				
								592	0.0054	Paved	1.49	20.3	0.110												
						T_O Total	**0.377**					**T_S Total**	**0.113**							**T_C Total**	**0.043**	**0.533**	**0.320**	**19**	**5.6**
FST3		100	0.026	Short Grass	0.21	0.15	0.133	334	0.0191	Paved	2.81	20.3	0.033	1041	0.008						0.097				
														1958	0.0032				4.63		0.117				
						T_O Total	**0.133**					**T_S Total**	**0.033**							**T_C Total**	**0.215**	**0.380**	**0.228**	**14**	**4.0**
FST4		100	0.015	Short Grass	0.17	0.15	0.167	554	0.0093	Paved	1.96	20.3	0.079	718	0.0057						0.060				
						T_O Total	**0.167**					**T_S Total**	**0.079**							**T_C Total**	**0.060**	**0.306**	**0.183**	**11**	**3.2**
FST5		100	0.012	Short Grass	0.15	0.15	0.183	360	0.0064	Paved	1.62	20.3	0.062	296	0.0052						0.023				
														2523	0.003				4.03		0.174				
						T_O Total	**0.183**					**T_S Total**	**0.062**							**T_C Total**	**0.196**	**0.441**	**0.265**	**16**	**11.5**
FST6		100	0.002	Short Grass	0.07	0.15	0.385	2052	0.0028	Unpaved	0.85	16.1	0.669	926	0.0023						0.049				
						T_O Total	**0.385**					**T_S Total**	**0.669**							**T_C Total**	**0.049**	**1.103**	**0.662**	**40**	**11.5**
FST7		100	0.015	Short Grass	0.17	0.15	0.166	423	0.0052	Paved	1.46	20.3	0.080	205	0.0143						0.020				
														1978	0.0025				5.89		0.093				
						T_O Total	**0.166**					**T_S Total**	**0.080**							**T_C Total**	**0.114**	**0.360**	**0.216**	**13**	**3.8**
FST8		100	0.003	Short Grass	0.08	0.15	0.327	870	0.0135	Unpaved	1.87	16.1	0.129	829	0.002						0.049				
														779	0.0084				2.26		0.096				
						T_O Total	**0.327**					**T_S Total**	**0.129**							**T_C Total**	**0.144**	**0.601**	**0.361**	**22**	**6.3**
FST9		100	0.007	Short Grass	0.12	0.15	0.224	1180	0.0023	Unpaved	0.77	16.1	0.425	2042	0.0093				2.53		0.224				
						T_O Total	**0.224**					**T_S Total**	**0.425**							**T_C Total**	**0.224**	**0.872**	**0.523**	**31**	**9.1**
FST10		65	0.008	Short Grass	0.12	0.15	0.154	319	0.0038	Paved	1.25	20.3	0.071												
								127	0.0339	Unpaved	2.96	16.1	0.012												
						T_O Total	**0.154**					**T_S Total**	**0.083**							**T_C Total**	**0.000**	**0.237**	**0.142**	**9**	**2.5**
FST11		100	0.007	Woods	0.06	0.4	0.496	333	0.0380	Unpaved	3.14	16.1	0.029	839	0.0066				7.48		0.031				
						T_O Total	**0.496**					**T_S Total**	**0.029**							**T_C Total**	**0.031**	**0.557**	**0.334**	**20**	**5.8**
FST12		100	0.020	Short Grass	0.19	0.15	0.147	1032	0.0166	Unpaved	2.07	16.1	0.138	1003	0.0035				4.05		0.069				
						T_O Total	**0.147**					**T_S Total**	**0.138**							**T_C Total**	**0.069**	**0.354**	**0.212**	**13**	**3.7**
Grassy																									
GRS1	9694	100	0.015	Short Grass	0.17	0.15	0.167	1212	0.0164	Unpaved	2.06	16.1	0.163	8382	0.0038				3.01		0.774				
						T_O Total	**0.167**					**T_S Total**	**0.163**							**T_C Total**	**0.774**	**1.104**	**0.662**	**40**	**11.5**
GRS2	11249	100	0.010	Short Grass	0.14	0.15	0.193	5300	0.0077	Unpaved	1.41	16.1	1.042	5849	0.0051				2.83		0.574				
						T_O Total	**0.193**					**T_S Total**	**1.042**							**T_C Total**	**0.574**	**1.809**	**1.086**	**65**	**18.9**
GRS3	5112	100	0.010	Short Grass	0.14	0.15	0.195	2134	0.0052	Unpaved	1.16	16.1	0.511	2878	0.0073				2.43		0.329				
														2088	0.0011				2.75		0.211				
						T_O Total	**0.195**					**T_S Total**	**0.511**							**T_C Total**	**0.540**	**1.245**	**0.747**	**45**	**13.0**
GRS4	8041	100	0.010	Short Grass	0.14	0.15	0.194	4868	0.0086	Unpaved	1.49	16.1	0.906	3073	0.009				1.97		0.433				
						T_O Total	**0.194**					**T_S Total**	**0.906**							**T_C Total**	**0.433**	**1.533**	**0.920**	**55**	**16.0**
GRS5	6735	100	0.001	Short Grass	0.07	0.15	0.426	3288	0.0125	Unpaved	1.80	16.1	0.507	3347	0.0024				3.9		0.238				
						T_O Total	**0.426**					**T_S Total**	**0.507**							**T_C Total**	**0.238**	**1.172**	**0.703**	**42**	**12.2**
GRS6	4945	100	0.010	Short Grass	0.14	0.15	0.196	3927	0.0092	Unpaved	1.54	16.1	0.706	918	0.0109				4.59		0.056				
						T_O Total	**0.196**					**T_S Total**	**0.706**							**T_C Total**	**0.056**	**0.957**	**0.574**	**34**	**10.0**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow: Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Shallow Concentrated Flow: Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Channel Flow: Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (ft/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
GRS7	7933	100	0.017	Short Grass	0.17	0.15	0.159	4769	0.0073	Unpaved	1.38	16.1	0.963	3064	0.0046				3.86		0.220				
						T_O Total	**0.159**					**T_S Total**	**0.963**							**T_C Total**	**0.220**	**1.342**	**0.805**	**48**	**14.0**
GRS8	6300	100	0.022	Short Grass	0.20	0.15	0.141	3241	0.0071	Unpaved	1.36	16.1	0.664	2959	0.0105				3.38		0.243				
						T_O Total	**0.141**					**T_S Total**	**0.664**							**T_C Total**	**0.243**	**1.048**	**0.629**	**38**	**10.9**
GRS9	7608	100	0.006	Short Grass	0.11	0.15	0.246	4346	0.0104	Unpaved	1.64	16.1	0.735	3162	0.0162				4		0.220				
						T_O Total	**0.246**					**T_S Total**	**0.735**							**T_C Total**	**0.220**	**1.201**	**0.721**	**43**	**12.5**
GRS10	4392	100	0.029	Short Grass	0.22	0.15	0.126	2880	0.0108	Unpaved	1.67	16.1	0.478	1412 924	0.0018 0.0017				1.5 3.73		0.261 0.069				
						T_O Total	**0.126**					**T_S Total**	**0.478**							**T_C Total**	**0.330**	**0.935**	**0.561**	**34**	**9.8**
GRS11	3636	100	0.020	Short Grass	0.19	0.15	0.146	2567	0.0140	Unpaved	1.90	16.1	0.374	969	0.0255				4.45		0.060				
						T_O Total	**0.146**					**T_S Total**	**0.374**							**T_C Total**	**0.060**	**0.581**	**0.349**	**21**	**6.1**
GRS12	7122	100	0.023	Short Grass	0.20	0.15	0.139	2122	0.0251	Unpaved	2.55	16.1	0.231	4900	0.0017				3.69		0.369				
						T_O Total	**0.139**					**T_S Total**	**0.231**							**T_C Total**	**0.369**	**0.739**	**0.443**	**27**	**7.7**
GRS13	7098	100	0.011	Short Grass	0.15	0.15	0.185	4857	0.0099	Unpaved	1.60	16.1	0.842	2141	0.0101				6.16		0.097				
						T_O Total	**0.185**					**T_S Total**	**0.842**							**T_C Total**	**0.097**	**1.123**	**0.674**	**40**	**11.7**
GRS14	5907	100	0.035	Short Grass	0.24	0.15	0.117	4269	0.0092	Unpaved	1.54	16.1	0.768	1538	0.0133				4.1		0.104				
						T_O Total	**0.117**					**T_S Total**	**0.768**							**T_C Total**	**0.104**	**0.989**	**0.594**	**36**	**10.3**
GRS15	4227	100	0.023	Short Grass	0.20	0.15	0.138	2620	0.0197	Unpaved	2.26	16.1	0.322	1507	0.0082				5.21		0.080				
						T_O Total	**0.138**					**T_S Total**	**0.322**							**T_C Total**	**0.080**	**0.540**	**0.324**	**19**	**5.6**
GRS16	5518	100	0.017	Short Grass	0.18	0.15	0.157	4158	0.0149	Unpaved	1.97	16.1	0.588	1260	0.0024				4.38		0.080				
						T_O Total	**0.157**					**T_S Total**	**0.588**							**T_C Total**	**0.080**	**0.825**	**0.495**	**30**	**8.6**
GRS17	3752	100	0.016	Short Grass	0.17	0.15	0.159	3652	0.0121	Unpaved	1.77	16.1	0.573												
						T_O Total	**0.159**					**T_S Total**	**0.573**							**T_C Total**	**0.000**	**0.732**	**0.439**	**26**	**7.6**
GRS18	3944	100	0.017	Short Grass	0.18	0.15	0.157	1247	0.0519	Unpaved	3.67	16.1	0.094	2597	0.006				4.62		0.156				
						T_O Total	**0.157**					**T_S Total**	**0.094**							**T_C Total**	**0.156**	**0.408**	**0.245**	**15**	**4.3**
Hanger																									
HC1		100	0.014	Short Grass	0.16	0.15	0.169	74 255	0.0310 0.0100	Unpaved Paved	2.83 2.03	16.1 20.3	0.007 0.035	3455	0.0062						0.178				
						T_O Total	**0.169**					**T_S Total**	**0.042**							**T_C Total**	**0.178**	**0.389**	**0.233**	**14**	**4.1**
HC2		100	0.045	Short Grass	0.26	0.15	0.107	1256	0.0064	Unpaved	1.29	16.1	0.271	192	0.0201				4.26		0.013				
						T_O Total	**0.107**					**T_S Total**	**0.271**							**T_C Total**	**0.013**	**0.390**	**0.234**	**14**	**4.1**
HC3		100	0.013	Short Grass	0.16	0.15	0.176	311 207	0.0098 0.0080	Unpaved Paved	1.59 1.82	16.1 20.3	0.054 0.032	2477	0.0074						0.108				
						T_O Total	**0.176**					**T_S Total**	**0.086**							**T_C Total**	**0.108**	**0.370**	**0.222**	**13**	**3.9**
HC4		100	0.007	Short Grass	0.13	0.15	0.220	414 955	0.0029 0.0065	Unpaved Unpaved	0.87 1.30	16.1 16.1	0.133 0.204	1229	0.0103	0.055			3.4		0.100				
						T_O Total	**0.220**					**T_S Total**	**0.337**							**T_C Total**	**0.100**	**0.657**	**0.394**	**24**	**6.9**
HC5		21 70	0.069 0.017	Short Grass Dense Grass	0.23 0.11	0.15 0.24	0.026 0.171	727	0.0038	Unpaved	0.99	16.1	0.203	1315	0.0149	0.055			2.7		0.135				
						T_O Total	**0.197**					**T_S Total**	**0.203**							**T_C Total**	**0.135**	**0.536**	**0.321**	**19**	**5.6**
JP Tribs																									
JPT1010	3874	300	0.0947	Grass-Range, short		0.15	0.190	290 370	0.0569 0.0445	Unpaved Unpaved		16.1 16.1	0.021 0.030	670 2914	0.0224 0.0157	0.05 0.05	24 56	26 106	4.2 2.4		0.04 0.332				
						T_O Total	**0.190**					**T_S Total**	**0.051**							T_C Total	**0.372**	**0.613**	**0.368**		**6.4**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow						Shallow Concentrated Flow						Channel Flow											Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
		Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (ft/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)							
JPT2010	6802	300	0.0135	Grass-Range, short		0.15	0.415	1170	0.0217	Unpaved		16.1	0.137	1494	0.0239	0.05	92	91	4.7		0.089							
								545	0.0421	Unpaved		16.1	0.046	4571	0.0061	0.05	188	139	2.8		0.446							
						T_O Total	**0.415**					**T_S Total**	**0.183**								**T_C Total**	**0.535**	**1.132**	**0.679**		**11.8**
JPT3010	2774	300	0.0284	Grass-Range, short		0.15	0.307	190	0.0864	Unpaved		16.1	0.011	630	0.0319	0.05	20	22	5		0.035							
														400	0.03	0.05	40	26	7		0.016							
														1410	0.01135	0.05	58	71	2.8		0.141							
						T_O Total	**0.307**					**T_S Total**	**0.011**								**T_C Total**	**0.192**	**0.511**	**0.306**		**5.3**
JPTP010	1897	300	0.0667	Grass-Range, short		0.15	0.219	400	0.0750	Unpaved		16.1	0.025															
								1160	0.0130	Unpaved		16.1	0.176															
						T_O Total	**0.219**					**T_S Total**	**0.201**								**T_C Total**	**0.000**	**0.419**	**0.252**		**4.4**
Loyd																												
LYD1		100	0.019	Short Grass	0.19	0.15	0.149	2347	0.0146	Unpaved	1.95	16.1	0.335	1938	0.0101				8		0.067							
														2900	0.0064				2.4		0.336							
						T_O Total	**0.149**					**T_S Total**	**0.335**								**T_C Total**	**0.403**	**0.887**	**0.532**	**32**	**9.3**
LYD2		100	0.011	Short Grass	0.15	0.15	0.189	1101	0.0143	Unpaved	1.93	16.1	0.159	500	0.0169				8		0.017							
								2117	0.0112	Paved	2.15	20.3	0.274	1193	0.0049				5		0.066							
						T_O Total	**0.189**					**T_S Total**	**0.433**								**T_C Total**	**0.084**	**0.706**	**0.423**	**25**	**7.4**
LYD3		100	0.008	Short Grass	0.13	0.15	0.215	2244	0.0144	Unpaved	1.93	16.1	0.323	1198	0.004				4.95		0.067							
						T_O Total	**0.215**					**T_S Total**	**0.323**								**T_C Total**	**0.067**	**0.605**	**0.363**	**22**	**6.3**
LYD4		100	0.016	Short Grass	0.17	0.15	0.160	779	0.0059	Unpaved	1.24	16.1	0.175	2044	0.0173				6		0.095							
														1327	0.0075				3.2		0.115							
						T_O Total	**0.160**					**T_S Total**	**0.175**								**T_C Total**	**0.210**	**0.544**	**0.327**	**20**	**5.7**
Lynn Creek Tributary																												
LT1	1199	100	0.019	Short Grass	0.19	0.15	0.150	1021	0.0070	Unpaved	1.35	16.1	0.211	78	0.02				3.17		0.007							
						T_O Total	**0.150**					**T_S Total**	**0.211**								**T_C Total**	**0.007**	**0.367**	**0.220**	**13**	**3.8**
LT2	1216	100	0.019	Short Grass	0.19	0.15	0.150	981	0.0120	Unpaved	1.76	16.1	0.155	135	0.018				4.38		0.009							
						T_O Total	**0.150**					**T_S Total**	**0.155**								**T_C Total**	**0.009**	**0.313**	**0.188**	**11**	**3.3**
LT3	1041	100	0.014	Short Grass	0.16	0.15	0.170	486	0.0440	Unpaved	3.38	16.1	0.040	455	0.033				4.45									
						T_O Total	**0.170**					**T_S Total**	**0.040**								**T_C Total**	**0.000**	**0.209**	**0.126**	**8**	**2.2**
Mills Br.																												
MILLS010	974	300	0.0919	Grass-Range, short		0.15	0.192	660	0.0286	Unpaved		16.1	0.067															
						T_O Total	**0.192**					**T_S Total**	**0.067**								**T_C Total**	**0.000**	**0.260**	**0.156**		**2.7**
MILLS020	1985	300	0.0899	Grass-Range, short		0.15	0.194	90	0.1110	Unpaved		16.1	0.005	710	0.0169	0.05	90	69	4.59		0.043							
														830	0.0048	0.05	490	176	4.12		0.056							
						T_O Total	**0.194**					**T_S Total**	**0.005**								**T_C Total**	**0.099**	**0.298**	**0.179**		**3.1**
MILLS030	2488	300	0.0908	Grass-Range, short		0.15	0.193	740	0.0286	Unpaved		16.1	0.075	1360	0.0143	0.05	69	29	6.4		0.059							
						T_O Total	**0.193**					**T_S Total**	**0.075**								**T_C Total**	**0.059**	**0.328**	**0.197**		**3.4**
Mountain																												
MTC1	39898	100	0.012	Short Grass	0.15	0.15	0.180	2673	0.0177	Unpaved	2.14	16.1	0.347	2732	0.0138				4.5		0.169							
														34393	0.0041				5.29		1.806							
						T_O Total	**0.180**					**T_S Total**	**0.347**								**T_C Total**	**1.806**	**2.332**	**1.399**	**84**	**24.3**
MTC2	39550	100	0.027	Short Grass	0.21	0.15	0.130	1114	0.0290	Unpaved	2.74	16.1	0.113	18324	0.0063				4.27		1.192							
														20012	0.0025				4.67		1.190							
						T_O Total	**0.130**					**T_S Total**	**0.113**								**T_C Total**	**2.382**	**2.626**	**1.575**	**95**	**27.4**
MTC3	7624	100	0.011	Short Grass	0.15	0.15	0.187	3160	0.0059	Unpaved	1.24	16.1	0.710	3176	0.0155				2.9		0.304							
														800	0.0211				8.04		0.028							
														388	0.0013				4.58		0.024							
						T_O Total	**0.187**					**T_S Total**	**0.710**								**T_C Total**	**0.355**	**1.253**	**0.752**	**45**	**13.1**
MTC4	41498	100	0.009	Short Grass	0.14	0.15	0.202	3618	0.0115	Unpaved	1.73	16.1	0.382	37780	0.0037				5.08		2.066							
						T_O Total	**0.202**					**T_S Total**	**0.582**								**T_C Total**	**2.066**	**2.850**	**1.710**	**103**	**29.8**
MTC5	12232	100	0.009	Short Grass	0.14	0.15	0.201	2516	0.0131	Unpaved	1.84	16.1	0.379	4447	0.0107				5.5		0.225							
														1563	0.0111				4.9		0.089							
														3606	0.0012				4.34		0.231							
						T_O Total	**0.201**					T_S Total	**0.379**								**T_C Total**	**0.544**	**1.125**	**0.675**	**40**	**11.7**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow: Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (f/s)	Manning's n (5)	T_O (hr) (6)	Shallow Concentrated Flow: Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (f/s)	K (10)	T_S (hr) (11)	Channel Flow: Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (f/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
MTC6	28248	100	0.008	Short Grass	0.13	0.15	0.214	2495	0.0163	Unpaved	2.06	16.1	0.337	25653	0.0045				3.89		1.832				
						T_O Total	**0.214**					**T_S Total**	**0.337**							**T_C Total**	**1.832**	**2.383**	**1.430**	**86**	**24.9**
MTC7	12095	100	0.003	Short Grass	0.09	0.15	0.314	1301	0.0153	Unpaved	1.99	16.1	0.181	4207 6487	0.0162 0.0005				3.15 3.15		0.371 0.572				
						T_O Total	**0.314**					**T_S Total**	**0.181**							**T_C Total**	**0.943**	**1.438**	**0.863**	**52**	**15.0**
North Hanger																									
NHC1		100	0.015	Short Grass	0.17	0.15	0.165	95 268	0.0316 0.0105	Unpaved Paved	2.86 2.08	16.1 20.3	0.009 0.036	1427	0.0137						0.064				
						T_O Total	**0.165**					**T_S Total**	**0.045**							**T_C Total**	**0.064**	**0.274**	**0.164**	**10**	**2.9**
NHC2		100	0.040	Short Grass	0.25	0.15	0.111	1782	0.0061	Unpaved	1.26	16.1	0.394												
						T_O Total	**0.111**					**T_S Total**	**0.394**							**T_C Total**	**0.000**	**0.505**	**0.303**	**18**	**5.3**
NHC3		100	0.018	Short Grass	0.18	0.15	0.154	525	0.0055	Unpaved	1.19	16.1	0.122	2176	0.0104						0.111				
						T_O Total	**0.154**					**T_S Total**	**0.122**							**T_C Total**	**0.111**	**0.387**	**0.232**	**14**	**4.0**
NHC4		100	0.018	Short Grass	0.18	0.15	0.153	3406	0.0072	Unpaved	1.37	16.1	0.693							N/A	0.000				
						T_O Total	**0.153**					**T_S Total**	**0.693**							**T_C Total**	**0.000**	**0.846**	**0.508**	**30**	**8.8**
NHC5		100	0.024	Short Grass	0.20	0.15	0.136	897	0.0088	Unpaved	1.51	16.1	0.165	714	0.0073	0.055	29.21	27.62	2.4	N/A	0.083				
						T_O Total	**0.136**					**T_S Total**	**0.165**							**T_C Total**	**0.083**	**0.384**	**0.230**	**14**	**4.0**
NHC6		100	0.010	Short Grass	0.14	0.15	0.193	1837	0.0108	Unpaved	1.67	16.1	0.305	1263	0.0011	0.055	92.15	87.69	2.7	N/A	0.130				
						T_O Total	**0.193**					**T_S Total**	**0.305**							**T_C Total**	**0.130**	**0.628**	**0.377**	**23**	**6.6**
Stuart Br.																									
STUAB010	1307	300	0.0817	Grass-Range, short		0.15	0.202	325 230	0.0723 0.0261	Unpaved Unpaved		16.1 16.1	0.021 0.025	400	0.006	0.05	338	162	3.83		0.029				
						T_O Total	**0.202**					**T_S Total**	**0.045**							**T_C Total**	**0.029**	**0.276**	**0.166**		**2.9**
STUAB020	4608	300	0.0717	Grass-Range, short		0.15	0.212	260 350	0.1019 0.0371	Unpaved Unpaved		16.1 16.1	0.014 0.031	1417 1270	0.016 0.008	0.05 0.05	170 180	90 100	5.788 3.964		0.068 0.089				
						T_O Total	**0.212**					**T_S Total**	**0.045**						4.88	**T_C Total**	**0.157**	**0.415**	**0.249**		**4.3**
Swad Br																									
SWADB010	1700	300	0.0111	Grass-Range, short	0.19	0.15	0.449	560 800	0.1167 0.0314	Unpaved Unpaved	5.50 2.85	16.1 16.1	0.028 0.078												
						T_O Total	**0.449**					**T_S Total**	**0.106**							**T_C Total**	**0.000**	**0.555**	**0.333**		**5.8**
SWADB020	3510	300	0.0395	Grass-Range, short	0.31	0.15	0.270	1060	0.1167	Unpaved	5.50	16.1	0.054	2000	0.01	0.05	111	60	4		0.138				
						T_O Total	**0.270**					**T_S Total**	**0.054**							**T_C Total**	**0.138**	**0.461**	**0.277**		**4.8**
SWADB030	4321	300	0.0438	Grass-Range, short	0.32	0.15	0.259	1000	0.4690	Unpaved	11.03	16.1	0.025	2800	0.0021	0.05	143	91	1.85		0.421				
						T_O Total	**0.259**					**T_S Total**	**0.025**							**T_C Total**	**0.421**	**0.705**	**0.423**		**7.4**
SWADB040	1381	300	0.1050	Grass-Range, short	0.46	0.15	0.182	720	0.0850	Unpaved	4.69	16.1	0.043	492	0.03	0.05	181	168	5.5		0.025				
						T_O Total	**0.182**					**T_S Total**	**0.043**							**T_C Total**	**0.025**	**0.250**	**0.150**		**2.6**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow: Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (f/s)	Manning's n (5)	T_O (hr) (6)	Shallow Concentrated Flow: Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (f/s)	K (10)	T_S (hr) (11)	Channel Flow: Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (f/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_t (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
Taaffe Cr.																									
TAAFC010	9050	300	0.0102	Grass-Range, short	0.18	0.15	0.463	2600	0.0079	Unpaved	1.43	16.1	0.505	2665	0.0024	0.04	25.2	26	1.78		0.414				
								600	0.0040	Unpaved	1.02	16.1	0.164												
								1960	0.0089	Unpaved	1.52	16.1	0.358												
						T_O Total	**0.463**					**T_S Total**	**1.027**							**T_C Total**	**0.414**	**1.904**	**1.143**		**19.9**
TAAFC020	2863	100	0.0120	Grass-Range, short	0.15	0.15	0.180	326	0.0207	Unpaved	2.32	16.1	0.039	4122	0.0047	0.045	250	127	3.60		0.321				
								200	0.0001	Unpaved	0.16	16.1	0.345												
						T_O Total	**0.180**					**T_S Total**	**0.384**							**T_C Total**	**0.321**	**0.885**	**0.531**		**9.2**
TAAFC025	6620	200	0.0100	Grass-Range, short	0.16	0.15	0.338							830	0.0066	0.016	11.25	46	2.95		0.078				
														290	0.0034	0.016	11.25	46	2.12		0.038				
														720	0.0031	0.016	11.25	46	2.02		0.099				
														930	0.003	0.016	11.25	46	1.99		0.130				
														1160	0.003	0.016	11.25	46	1.99		0.162				
														2300	0.001	0.045	1224	150	4.23		0.151				
						T_O Total	**0.338**					**T_S Total**	**0.000**							**T_C Total**	**0.658**	**0.996**	**0.597**		**10.4**
TAAFC030	3300	100	0.0010	Grass-Range, short	0.06	0.15	0.487	490	0.0105	Unpaved	1.65	16.1	0.083	2664	0.045	0.0106	210	90	6		0.123				
								250	0.0800	Unpaved	4.55	16.1	0.015												
								200	0.0048	Unpaved	1.12	16.1	0.050												
						T_O Total	**0.487**					**T_S Total**	**0.148**							**T_C Total**	**0.123**	**0.758**	**0.455**		**7.9**
Ten Branch																									
Ten1	4481	100	0.005	Short Grass	0.11	0.15	0.256	1034	0.0218	Unpaved	2.38	16.1	0.121	3347	0.0071				5.16		0.180				
						T_O Total	**0.256**					**T_S Total**	**0.121**							**T_C Total**	**0.180**	**0.557**	**0.334**	**20**	**5.8**
Ten2	3073	100	0.002	Short Grass	0.08	0.15	0.369	996	0.0123	Unpaved	1.79	16.1	0.155	1977	0.0038				3.25		0.169				
						T_O Total	**0.369**					**T_S Total**	**0.155**							**T_C Total**	**0.169**	**0.693**	**0.416**	**25**	**7.2**
Ten3	3668	100	0.035	Short Grass	0.24	0.15	0.118	1610	0.0165	Unpaved	2.07	16.1	0.216	1958	0.0041				3.88		0.140				
						T_O Total	**0.118**					**T_S Total**	**0.216**							**T_C Total**	**0.140**	**0.474**	**0.285**	**17**	**5.0**
Unidentified Basins																									
UNID1	2663	100	0.008	Short Grass	0.13	0.15	0.212	1935	0.0120	Paved	2.22	20.3	0.242	628	0.038	0.055	59.12	36.86	7.4	NA	0.02				
						T_O Total	**0.212**					**T_S Total**	**0.242**							**T_C Total**	**0.024**	**0.478**	**0.287**	**17**	**5.0**
UNID2	2280	50	0.015	Smooth Surface	1.19	0.011	0.012	971	0.0230	Paved	3.08	20.3	0.088	1259	0.029				3.86	NA	0.091				
						T_O Total	**0.012**					**T_S Total**	**0.088**							**T_C Total**	**0.091**	**0.190**	**0.114**	**7**	**2.0**
UNID3	2195	100	0.030	Dense Grass	0.15	0.24	0.182	985	0.0300	Unpaved	2.79	16.1	0.098	1110	0.021	0.055	208.7	88.99	7.4	NA	0.042				
						T_O Total	**0.182**					**T_S Total**	**0.098**							**T_C Total**	**0.042**	**0.322**	**0.193**	**12**	**3.4**
UNID4	1761	50	0.063	Smooth Surface	2.11	0.011	0.007	377	0.0700	Unpaved	4.26	16.1	0.025	1334	0.021				3.79	NA	0.098				
						T_O Total	**0.007**					**T_S Total**	**0.025**							**T_C Total**	**0.098**	**0.129**	**0.077**	**5**	**1.3**
UNID5	550	100	0.040	Short Grass	0.25	0.15	0.111	397	0.0530	Unpaved	3.71	16.1	0.030	53	0.095	0.055	86.41	84.23	6.14		0.002				
						T_O Total	**0.111**					**T_S Total**	**0.030**							**T_C Total**	**0.002**	**0.143**	**0.086**	**5**	**1.5**
UNID6	1564	100	0.025	Dense Grass	0.14	0.24	0.196	352	0.0700	Unpaved	4.26	16.1	0.023	1112	0.056	0.055	38.42	37.83	6.46	NA	0.03				
						T_O Total	**0.196**					**T_S Total**	**0.023**							**T_C Total**	**0.048**	**0.266**	**0.160**	**10**	**2.8**
UNID7	1537	100	0.030	Short Grass	0.22	0.15	0.125	225	0.0900	Unpaved	4.83	16.1	0.013	1212	0.05	0.055	86.41	84.23	6.14		0.05				
						T_O Total	**0.125**					**T_S Total**	**0.013**							**T_C Total**	**0.055**	**0.193**	**0.116**	**7**	**2.0**
UNID8	2827	100	0.040	Dense Grass	0.17	0.24	0.162	546	0.0900	Unpaved	4.83	16.1	0.031	2181	0.016	0.055	319.85	142.12	5.87		0.10				
						T_O Total	**0.162**					**T_S Total**	**0.031**							**T_C Total**	**0.103**	**0.297**	**0.178**	**11**	**3.1**
Webb																									
WB1		100	0.007	Dense Grass	0.08	0.24	0.336	178	0.0144	Unpaved	1.93	16.1	0.026	2466	0.012						0.077				
								250	0.0045	Paved	1.36	20.3	0.051												
						T_O Total	**0.336**					**T_S Total**	**0.077**							**T_C Total**	**0.077**	**0.489**	**0.293**	**18**	**5.1**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow						Shallow Concentrated Flow						Channel Flow								Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
		Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (f/s)	Manning's n (5)	T_O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (f/s)	K (10)	T_S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (f/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)				
WB2		100	0.008	Short Grass	0.13	0.15	0.210	34	0.0077	Unpaved	1.41	16.1	0.007	2157	0.0068						0.093				
								489	0.0053	Paved	1.48	20.3	0.092												
						T_O Total	**0.210**					**T_S Total**	**0.099**							**T_C Total**	**0.093**	**0.401**	**0.241**	**14**	**4.2**
WB3		100	0.014	Short Grass	0.16	0.15	0.169	332	0.0078	Paved	1.79	20.3	0.082	2316	0.0076						0.144				
						T_O Total	**0.169**					**T_S Total**	**0.082**							**T_C Total**	**0.144**	**0.395**	**0.237**	**14**	**4.1**
WB4		75	0.049	Short Grass	0.25	0.15	0.082	755	0.0073	Paved	1.73	20.3	0.121	1403	0.0098						0.090				
						T_O Total	**0.082**					**T_S Total**	**0.121**							**T_C Total**	**0.090**	**0.293**	**0.176**	**11**	**3.1**
WB5		100	0.026	Short Grass	0.21	0.15	0.132	2856	0.0038	Unpaved	0.99	16.1	0.799	774	0.0113				1.89		0.114				
						T_O Total	**0.132**					**T_S Total**	**0.799**							**T_C Total**	**0.114**	**1.045**	**0.627**	**38**	**10.9**
WB6		100	0.003	Short Grass	0.08	0.15	0.332	27	0.0206	Unpaved	2.31	16.1	0.003	1525	0.0042						0.108				
								389	0.0049	Paved	1.42	20.3	0.076	664	0.0038				2.57		0.072				
						T_O Total	**0.332**					**T_S Total**	**0.079**							**T_C Total**	**0.180**	**0.592**	**0.355**	**21**	**6.2**
WB7		100	0.063	Short Grass	0.30	0.15	0.093	1685	0.0032	Unpaved	0.91	16.1	0.514	813	0.0035						0.0444				
														700	0.0215				4.95		0.039				
						T_O Total	**0.093**					**T_S Total**	**0.514**							**T_C Total**	**0.039**	**0.646**	**0.388**	**23**	**6.7**
WB8		100	0.021	Short Grass	0.19	0.15	0.144	0	0.0000	Unpaved	#DIV/0!	16.1	0.000	930	0.014				4.45		0.0444				
														982	0.0087				5.52		0.049				
						T_O Total	**0.144**					**T_S Total**	**0.000**							**T_C Total**	**0.049**	**0.193**	**0.116**	**7**	**2.0**
WB9		100	0.008	Short Grass	0.13	0.15	0.211	1908	0.0040	Unpaved	1.02	16.1	0.520	5689	0.0077				5.15		0.307				
						T_O Total	**0.211**					**T_S Total**	**0.520**							**T_C Total**	**0.307**	**1.038**	**0.623**	**37**	**10.8**

Notes:
(1) GeoHMS Longest Flowpath
(2) Overland flow length (Maximum allowed in WinTR55 is 100 ft.)
(3) Slope of the ground
(4) WinTR55 surface type
(5) WinTR55 Manning's n
(6) WinTR55 Overland time of concentration: $T_O=0.42(nL)^{0.8}/(3.95^{0.5}S^{0.4}60)$
(7) Shallow concentrated flow length
(8) Slope of the ground
(9) WinTR55 surface type
(10) 16.1 for unpaved and 20.3 for paved soil cover
(11) WinTR55 Shallow Concentrated time of concentration: $T_S=L/(60^2KS^{0.5})$
(12) Channelized flow length
(13) Slope of the ground
(14) Manning's n (taken from HEC-RAS routing model)
(15) Area (Average channel area, based on flow with profile near or at full bank flow.)
(16) Wetted Perimeter (Average channel wetted perimeter, based on flow with profile near or at full bank flow.)
(17) Channel Velocity: $V=1.486/n(\text{area/wetted perimeter})^{2/3}S^{0.5}$
(18) Average depth of flow in pond
(19) Channelized time of concentration, $T_h=L/(60^2V)$, for flow through ponds, T_h=wave celerity$=(32.2d)^{0.5}/60$
(20) Total time of concentration: $T_C=T_O+T_S+T_h$
(21) Total lag time: $T_L=0.6T_C$
(22) Time Step : $T=0.29T_L$

Ultimate Lag Time Calculations for Joe Pool Lake Tributaries (2006 Streams)

		Overland Flow						Shallow Concentrated Flow						Channel Flow										
HMS Program Basin Name	Longest Flowpath (ft) (1)	Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (f/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_b (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
Bedford Br.																									
BDFD1010	7233	100	0.0161	Developed	0.17	0.15	0.160	360	0.0612	Paved	5.02	20.3	0.020	3010	0.02341	0.05	90	81	4.86		0.172				
								1310	0.07263	Paved	5.47	20.3	0.067	1800	0.01	0.05	153	160	2.89		0.173				
								200	0.0161	Paved	2.58	20.3	0.022												
						T_O Total	**0.160**					**T_S Total**	**0.108**								**T_c Total**	**0.345**	**0.613**	**0.368**		**6.4**
BDFD1020	8062	50	0.0160	Paved	1.22	0.011	0.011	1260	0.0377	Paved	3.94	20.3	0.089	2130	0.0214	0.05	90	54	6.1		0.097				
								610	0.0676	Paved	5.28	20.3	0.032	3450	0.0206	0.05	106	78	5.24		0.183				
								250	0.0160	Paved	2.57	20.3	0.027												
						T_O Total	**0.011**					**T_S Total**	**0.148**								**T_c Total**	**0.280**	**0.439**	**0.264**		**4.6**
BDFD2010	16505	50	0.0050	Paved	0.76	0.011	0.018	1890	0.0321	Paved	3.64	20.3	0.144	4470	0.01342	0.05	272	102	6.6		0.187				
								250	0.0050	Paved	1.44	20.3	0.048	5310	0.0094	0.05	460	290	3.9		0.375				
														4000	0.0095	0.05	294	96	6.1		0.181				
						T_O Total	**0.018**					**T_S Total**	**0.193**						**5.53**	**T_c Total**	**0.743**	**0.954**	**0.572**		**10.0**
BDFD2020	10810	50	0.0188	Paved	1.30	0.011	0.011	1310	0.0309	Paved	3.57	20.3	0.102	2550	0.0189	0.05	93	59	5.53		0.128				
								650	0.0347	Paved	3.78	20.3	0.048	2870	0.0144	0.05	110	73	4.69		0.17				
								250	0.0188	Paved	2.78	20.3	0.025												
								1520	0.0015	Paved	0.79	20.3	0.537												
								1090	0.092	Paved	6.16	20.3	0.049												
						T_O Total	**0.011**					**T_S Total**	**0.761**						**5.11**	**T_c Total**	**0.298**	**1.070**	**0.642**		**11.2**
BDFD2030	8445	50	0.0267	Paved	1.49	0.011	0.009	140	0.2491	Paved	10.13	20.3	0.004	2830	0.027	0.05	47	57	4.3		0.183				
								450	0.0728	Paved	5.48	20.3	0.023	1870	0.0235	0.05	41	37	5.2		0.1				
								250	0.0267	Paved	3.32	20.3	0.021	2410	0.005	0.05	116	76	2.8		0.24				
						T_O Total	**0.009**					**T_S Total**	**0.048**						**4.1**	**T_c Total**	**0.821**	**0.878**	**0.527**		**9.2**
BDFDB010	5939	100	0.0133	Developed	0.16	0.15	0.173	290	0.0048	Paved	1.41	20.3	0.057	3611	0.0055	0.05	80	60	2.68		0.375				
								410	0.0064	Paved	1.62	20.3	0.070												
								310	0.0339	Paved	3.74	20.3	0.023												
								200	0.0133	Paved	2.34	20.3	0.024												
								710	0.0563	Paved	4.82	20.3	0.041												
						T_O Total	**0.173**					**T_S Total**	**0.215**						3	**T_c Total**	**0.375**	**0.763**	**0.458**		**8.0**
BDFDB020	6365	100	0.0247	Open Space	0.21	0.15	0.135	1250	0.0227	Paved	3.06	20.3	0.114												
								4820	0.0145	Paved	2.44	20.3	0.548												
								200	0.0247	Paved	3.19	20.3	0.017												
						T_O Total	**0.135**					**T_S Total**	**0.679**						3.21	**T_c Total**	**0.000**	**0.814**	**0.488**		**8.5**
BDFDB030	5872	100	0.1496	Developed	0.42	0.15	0.066	70	0.1544	Paved	7.98	20.3	0.002	3085	0.0026	0.05	159	104	5.95		0.144				
								200	0.1496	Paved	7.85	20.3	0.007	2141	0.0037	0.05	160	140	1.98		0.3				
						T_O Total	**0.066**					**T_S Total**	**0.010**						**3.97**	**T_c Total**	**0.444**	**0.519**	**0.312**		**5.4**
BDFDB040	2393	100	0.0756	Developed	0.32	0.15	0.086	140	0.0810	Paved	5.78	20.3	0.007	3031	0.0033	0.05	128	94	2.11		0.04				
								550	0.0433	Paved	4.22	20.3	0.036												
								200	0.0756	Paved	5.58	20.3	0.010												
						T_O Total	**0.086**					**T_S Total**	**0.053**							**T_c Total**	**0.040**	**0.179**	**0.108**		**1.9**
BDFDB050	3028	100	0.1388	Developed	0.41	0.15	0.068	200	0.1315	Paved	7.36	20.3	0.008	1490	0.0027	0.05	145	60	2.8		0.148				
								700	0.0658	Paved	5.21	20.3	0.037												
								200	0.1388	Paved	7.56	20.3	0.007												
								330	0.0114	Paved	2.17	20.3	0.042												
						T_O Total	**0.068**					**T_S Total**	**0.095**							**T_c Total**	**0.148**	**0.310**	**0.186**		**3.2**
BDFDB055	3497	100	0.0433	Developed	0.26	0.15	0.108	160	0.0701	Paved	5.37	20.3	0.008	1400	0.0214	0.05	37	43	3.93		0.099				
								200	0.0433	Paved	4.22	20.3	0.013	1490	0.0224	0.05	45	72	3.26		0.127				
						T_O Total	**0.108**					**T_S Total**	**0.021**						**3.60**	**T_c Total**	**0.226**	**0.355**	**0.213**		**3.7**
BDFDB060	3880	100	0.1235	Developed	0.39	0.15	0.071	200	0.0804	Paved	5.76	20.3	0.010	2458	0.0098	0.05	30	27	3.16		0.216				
								920	0.0478	Paved	4.44	20.3	0.058												
								200	0.1235	Paved	7.13	20.3	0.008												
						T_O Total	**0.071**					**T_S Total**	**0.075**							**T_c Total**	**0.216**	**0.362**	**0.217**		**3.8**
BDFDB070	3112	100	0.0614	Developed	0.30	0.15	0.094	290	0.0606	Paved	5.00	20.3	0.016	500	0.012	0.05	18	17	3.39		0.041				
								290	0.0276	Paved	3.37	20.3	0.024	1630	0.0013	0.05	84	39	1.79		0.253				
								200	0.0614	Paved	5.03	20.3	0.011												
						T_O Total	**0.094**					**T_S Total**	**0.051**						**2.59**	**T_c Total**	**0.294**	**0.439**	**0.263**		**4.6**
BDFDB080	3944	100	0.0283	Developed	0.22	0.15	0.128	360	0.1190	Paved	7.00	20.3	0.014	1540	0.0007	0.05	217	123	1.15		0.372				
								290	0.0294	Paved	3.48	20.3	0.023												
								200	0.0283	Paved	3.42	20.3	0.016												
								1290	0.0109	Paved	2.12	20.3	0.169												
						T_O Total	**0.128**					**T_S Total**	**0.223**							**T_c Total**	**0.372**	**0.723**	**0.434**		**7.5**

		Overland Flow						Shallow Concentrated Flow						Channel Flow											
HMS Program Basin Name	Longest Flowpath (ft) (1)	Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (f/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
PENWB010	1590	100	0.0210	Developed	0.19	0.15	0.144	520	0.0907	Paved	6.11	20.3	0.024												
								740	0.0135	Paved	2.36	20.3	0.087												
								200	0.0210	Paved	2.94	20.3	0.019												
						T_O Total	**0.144**					**T_S Total**	**0.130**							**T_C Total**	**0.000**	**0.274**	**0.164**		**2.9**
PENWB020	2512	100	0.0193	Developed	0.19	0.15	0.149	375	0.1275	Paved	7.25	20.3	0.014	1072	0.0149	0.05	213	134	4.96		0.06				
								640	0.0488	Paved	4.48	20.3	0.040												
								200	0.0193	Paved	2.82	20.3	0.020												
						T_O Total	**0.149**					**T_S Total**	**0.074**							**T_C Total**	**0.060**	**0.283**	**0.170**		**3.0**
PENWB030	4846	100	0.0213	Developed	0.19	0.15	0.143	490	0.0703	Paved	2.89	20.3	0.047	1715	0.0117	0.05	50	57	2.96		0.161				
								440	0.0898	Paved	6.08	20.3	0.020	1000	0.008	0.05	322	255	3.19		0.087				
								200	0.0213	Paved	2.96	20.3	0.019												
								745	0.0268	Paved	3.32	20.3	0.062												
						T_O Total	**0.143**					**T_S Total**	**0.148**						**3.08**	**T_C Total**	**0.248**	**0.540**	**0.324**		**5.6**
PENWB035	3063	100	0.0736	Developed	0.32	0.15	0.087	440	0.0272	Paved	3.35	20.3	0.037	1773	0.0136	0.05	31	49	2.57		0.192				
								550	0.0218	Paved	3.00	20.3	0.051												
								200	0.0736	Paved	5.51	20.3	0.010												
						T_O Total	**0.087**					**T_S Total**	**0.098**							**T_C Total**	**0.192**	**0.377**	**0.226**		**3.9**
PENWB040	5157	100	0.0072	Developed	0.13	0.15	0.221	330	0.0199	Paved	2.86	20.3	0.032	2690	0.0154	0.05	53	73	2.99		0.25				
								470	0.0889	Paved	6.05	20.3	0.022	850	0.0126	0.05	40	30	4		0.058				
								200	0.0072	Paved	1.72	20.3	0.032	350	0.0114	0.05	200	63	6.94		0.014				
						T_O Total	**0.221**					**T_S Total**	**0.086**						**4.64**	**T_C Total**	**0.322**	**0.629**	**0.377**		**6.6**
SMALL010	2389	50	0.0374	Paved	1.71	0.011	0.008	150	0.0451	Paved	4.31	20.3	0.010	730	0.0138	0.05	33.7	66	2.23		0.091				
								1100	0.1450	Paved	7.73	20.3	0.040												
								250	0.0374	Paved	3.93	20.3	0.018												
						T_O Total	**0.008**					**T_S Total**	**0.067**							**T_C Total**	**0.091**	**0.166**	**0.100**		**1.7**
SMALL020	6236	50	0.0133	Paved	1.13	0.011	0.012	225	0.0267	Paved	3.32	20.3	0.019	3611	0.0089	0.05	292	260	3		0.33				
								1400	0.0257	Paved	3.25	20.3	0.119												
								250	0.0133	Paved	2.34	20.3	0.030												
								700	0.0514	Paved	4.60	20.3	0.042												
						T_O Total	**0.012**					**T_S Total**	**0.210**							**T_C Total**	**0.330**	**0.552**	**0.331**		**5.8**
SMALL030	4057	100	0.1215	Developed	0.39	0.15	0.071	410	0.0766	Paved	5.62	20.3	0.020	940	0.0064	0.05	370	160	4.15		0.063				
								2060	0.0175	Paved	2.69	20.3	0.213												
								200	0.1215	Paved	7.08	20.3	0.008												
						T_O Total	**0.071**					**T_S Total**	**0.241**							**T_C Total**	**0.063**	**0.376**	**0.225**		**3.9**
SMALL040	1573	100	0.1291	Developed	0.40	0.15	0.070	235	0.1487	Paved	7.83	20.3	0.008	930	0.0086	0.05	367	137	5.38		0.048				
								200	0.1291	Paved	7.29	20.3	0.008												
						T_O Total	**0.070**					**T_S Total**	**0.016**							**T_C Total**	**0.048**	**0.134**	**0.080**		**1.4**
Davis Basins																									
DB1	3896	50	0.005	Paved	0.12	0.011	0.115	3186	0.0080	Paved	1.82	20.3	0.487	660	0.001	0.04	138.25	156.35	1.6	NA	0.11				
						TO Total	**0.115**					**TS Total**	**0.487**							**TC Total**	**0.115**	**0.717**	**0.430**	**26**	**7.5**
DB2	3676	50	0.014	Paved	0.18	0.011	0.076	1068	0.0140	Paved	2.40	20.3	0.124	2558	0.006	0.04	296.42	330.04	2.36	NA	0.30				
						TO Total	**0.076**					**TS Total**	**0.124**							**TC Total**	**0.301**	**0.501**	**0.300**	**18**	**5.2**
DB3	6055	100	0.014	Residential	0.16	0.15	0.170	3720	0.0080	Paved	1.82	20.3	0.569	2235	0.01	0.04	207.76	217.54	3.37	NA	0.184				
						TO Total	**0.170**					**TS Total**	**0.569**							**TC Total**	**0.184**	**0.923**	**0.554**	**33**	**9.6**
Edge Cr.																									
EDGEC010	1404	100	0.0103	Developed	0.15	0.15	0.191	778	0.0108	Paved	2.11	20.3	0.102												
								324	0.0864	Paved	5.97	20.3	0.015												
								200	0.0103	Paved	2.06	20.3	0.027												
							0.191					**T_S Total**	**0.144**							**T_C Total**	**0.000**	**0.336**	**0.202**		**3.5**
EDGEC020	3631	50	0.0237	Paved	1.42	0.011	0.010	633	0.0379	Paved	3.95	20.3	0.044	2625	0.0158	0.05	122.98	53.482	6.52		0.112				
								73	0.2192	Paved	9.50	20.3	0.002												
								250	0.0237	Paved	3.12	20.3	0.023												
							0.010					**T_S Total**	**0.069**							**T_C Total**	**0.112**	**0.190**	**0.114**		**2.0**
EDGEC030	3936	100	0.0707	Developed	0.31	0.15	0.089	359	0.0905	Paved	6.11	20.3	0.016	2230	0.0110	0.05	133.79	123.71	3.29		0.188				
								1047	0.0210	Paved	2.94	20.3	0.099												
								200	0.0707	Paved	5.40	20.3	0.010												
							0.089					**T_S Total**	**0.125**							**T_C Total**	**0.188**	**0.403**	**0.242**		**4.2**
EDGEC040	2389	100	0.0290	Developed	0.22	0.15	0.127	466	0.0324	Paved	3.65	20.3	0.035	917	0.0049	0.05	123.46	111.43	2.20		0.116				
								706	0.0425	Paved	4.18	20.3	0.047												
								200	0.0290	Paved	3.46	20.3	0.016												
							0.127					**T_S Total**	**0.098**							**T_C Total**	**0.116**	**0.341**	**0.204**		**3.6**
EDGEC050	4717	100	0.0133	Developed	0.16	0.15	0.173	404	0.0624	Paved	5.07	20.3	0.022	3230	0.0041				0.269	8.112	0.300				
								783	0.0281	Paved	3.40	20.3	0.064												
								200	0.0133	Paved	2.34	20.3	0.024												
							0.173					**T_S Total**	**0.110**							**T_C Total**	**0.300**	**0.583**	**0.350**		**6.1**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow: Length (ft) (2)	Slope (ft/ft) (3)	Surface Type	(4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Shallow Concentrated Flow: Length (ft) (7)	Slope (ft/ft) (8)	Surface Type	(9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Channel Flow: Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (ft/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)	Total Time of Conc, (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
EDGEC060	3950	100	0.0313	Developed		0.23	0.15	0.123	632	0.0432	Paved		4.22	20.3	0.042	1783	0.0056	0.05	202.5	196.3	2.27		0.218				
									1235	0.0243	Paved		3.16	20.3	0.108												
									570	0.0246	Paved		3.18	20.3	0.050												
									200	0.0313	Paved		3.59	20.3	0.015												
								0.123							**T_S Total**								**T_c Total**	**0.218**	**0.556**	**0.334**		**5.8**
EDGT1010	3862	50	0.0122	Paved		1.09	0.011	0.013	645	0.0194	Paved		2.83	20.3	0.063	1603	0.0315	0.05	72	63	5.8		0.077				
									1170	0.0226	Paved		3.05	20.3	0.106												
									250	0.0122	Paved		2.24	20.3	0.031												
								0.013							**T_S Total**								**T_c Total**	**0.077**	**0.290**	**0.174**		**3.0**
EDGT1020	6598	100	0.0267	Developed		0.21	0.15	0.131	410	0.0098	Paved		2.01	20.3	0.057	1310	0.0137	0.05	146	160	2.8		0.130				
									230	0.0957	Paved		6.28	20.3	0.010	1212	0.0048	0.05	146	140	2.1		0.160				
									1790	0.0089	Paved		1.92	20.3	0.260												
									1410	0.0270	Paved		3.34	20.3	0.117												
									200	0.0267	Paved		3.31	20.3	0.017												
								0.131							**T_S Total**								**T_c Total**	**0.290**	**0.748**	**0.449**		**7.8**
Foster																											
FST1		100	0.023	Short Grass		0.20	0.15	0.140	1162	0.0180	Paved		2.72	20.3	0.119	752	0.0223						0.012				
								T_O Total	**0.140**						**T_S Total**	**0.119**							**T_c Total**	**0.012**	**0.271**	**0.162**	**10**	**2.8**
FST2		100	0.002	Short Grass		0.07	0.15	0.377	30	0.0350	Paved		3.80	20.3	0.002	1055	0.0106						0.043				
									592	0.0054	Paved		1.49	20.3	0.110												
								T_O Total	**0.377**						**T_S Total**	**0.112**							**T_c Total**	**0.043**	**0.532**	**0.319**	**19**	**5.6**
FST3		100	0.026	Short Grass		0.21	0.15	0.133	334	0.0191	Paved		2.81	20.3	0.033	1041	0.008						0.097				
																1958	0.0032				4.63		0.117				
								T_O Total	**0.133**						**T_S Total**	**0.033**							**T_c Total**	**0.215**	**0.380**	**0.228**	**14**	**4.0**
FST4		100	0.015	Short Grass		0.17	0.15	0.167	554	0.0093	Paved		1.96	20.3	0.079	718	0.0057						0.060				
								T_O Total	**0.167**						**T_S Total**	**0.079**							**T_c Total**	**0.060**	**0.306**	**0.183**	**11**	**3.2**
FST5		100	0.012	Short Grass		0.15	0.15	0.183	360	0.0064	Paved		1.62	20.3	0.062	296	0.0052						0.023				
																2523	0.003				4.03		0.174				
								T_O Total	**0.183**						**T_S Total**	**0.062**							**T_c Total**	**0.196**	**0.441**	**0.265**	**16**	**4.6**
FST6		100	0.002	Short Grass		0.07	0.15	0.385	2052	0.0028	Paved		1.07	20.3	0.531	926	0.0023						0.049				
								T_O Total	**0.385**						**T_S Total**	**0.531**							**T_c Total**	**0.049**	**0.964**	**0.579**	**35**	**10.1**
FST7		100	0.015	Short Grass		0.17	0.15	0.166	423	0.0052	Paved		1.46	20.3	0.080	205	0.0143						0.020				
																1978	0.0025				5.89		0.093				
								T_O Total	**0.166**						**T_S Total**	**0.080**							**T_c Total**	**0.114**	**0.360**	**0.216**	**13**	**3.8**
FST8		100	0.003	Short Grass		0.08	0.15	0.327	870	0.0135	Paved		2.36	20.3	0.102	829	0.002						0.049				
																779	0.0084				2.26		0.096				
								T_O Total	**0.327**						**T_S Total**	**0.102**							**T_c Total**	**0.144**	**0.574**	**0.344**	**21**	**6.0**
FST9		100	0.007	Short Grass		0.12	0.15	0.224	1180	0.0023	Paved		0.97	20.3	0.337	2042	0.0093					2.53		0.224				
								T_O Total	**0.224**						**T_S Total**	**0.337**							**T_c Total**	**0.224**	**0.785**	**0.471**	**28**	**8.2**
FST10		65	0.008	Short Grass		0.12	0.15	0.154	319	0.0038	Paved		1.25	20.3	0.071												
									127	0.0339	Paved		3.74	20.3	0.009												
								T_O Total	**0.154**						**T_S Total**	**0.080**							**T_c Total**	**0.000**	**0.234**	**0.141**	**8**	**2.4**
FST11		100	0.007	Short Grass		0.12	0.15	0.226	333	0.0380	Paved		3.96	20.3	0.023	839	0.0066					7.48		0.031				
								T_O Total	**0.226**						**T_S Total**	**0.023**							**T_c Total**	**0.031**	**0.281**	**0.168**	**10**	**2.9**
FST12		100	0.020	Short Grass		0.19	0.15	0.147	1032	0.0166	Paved		2.62	20.3	0.110	1003	0.0035					4.05		0.069				
								T_O Total	**0.147**						**T_S Total**	**0.110**							**T_c Total**	**0.069**	**0.325**	**0.195**	**12**	**3.4**
Grassy																											
GRS1	9694	50	0.015	Paved		1.17	0.011	0.012	1262	0.0164	Paved		2.60	20.3	0.135	8382	0.0038					3.01		0.774				
								T_O Total	**0.012**						**T_S Total**	**0.135**							**T_c Total**	**0.774**	**0.920**	**0.552**	**33**	**9.6**
GRS2	11249	50	0.010	Paved		1.01	0.011	0.014	5350	0.0077	Paved		1.78	20.3	0.834	5849	0.0051					2.83		0.574				
								T_O Total	**0.014**						**T_S Total**	**0.834**							**T_c Total**	**0.574**	**1.422**	**0.853**	**51**	**14.8**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow: Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Shallow Concentrated Flow: Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Channel Flow: Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (ft/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_t (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
GRS3	5112	50	0.010	Paved	1.00	0.011	0.014	2184	0.0052	Paved	1.46	20.3	0.414	2878	0.0073				2.43		0.329				
														2088	0.0011				2.75		0.211				
						T_O Total	**0.014**					**T_S Total**	**0.414**								**T_C Total**	**0.540**	**0.968**	**0.581**	35	**10.1**
GRS4	8041	50	0.010	Paved	1.01	0.011	0.014	4918	0.0086	Paved	1.88	20.3	0.726	3073	0.009				1.97		0.433				
						T_O Total	**0.014**					**T_S Total**	**0.726**								**T_C Total**	**0.433**	**1.173**	**0.704**	42	**12.2**
GRS5	6735	50	0.001	Paved	0.46	0.011	0.030	3338	0.0125	Paved	2.27	20.3	0.409	3347	0.0024				3.9		0.238				
						T_O Total	**0.030**					**T_S Total**	**0.409**								**T_C Total**	**0.238**	**0.677**	**0.406**	24	**7.1**
GRS6	4945	50	0.010	Paved	1.00	0.011	0.014	3977	0.0092	Paved	1.95	20.3	0.567	918	0.0109				4.59		0.056				
						T_O Total	**0.014**					**T_S Total**	**0.567**								**T_C Total**	**0.056**	**0.637**	**0.382**	23	**6.6**
GRS7	7933	50	0.017	Paved	1.23	0.011	0.011	4819	0.0073	Paved	1.73	20.3	0.772	3064	0.0046				3.86		0.220				
						T_O Total	**0.011**					**T_S Total**	**0.772**								**T_C Total**	**0.220**	**1.004**	**0.602**	36	**10.5**
GRS8	6300	50	0.022	Paved	1.39	0.011	0.010	3291	0.0071	Paved	1.71	20.3	0.534	2959	0.0105				3.38		0.243				
						T_O Total	**0.010**					**T_S Total**	**0.534**								**T_C Total**	**0.243**	**0.788**	**0.473**	28	**8.2**
GRS9	7608	50	0.006	Paved	0.79	0.011	0.017	4396	0.0104	Paved	2.07	20.3	0.590	3162	0.0162				4		0.220				
						T_O Total	**0.017**					**T_S Total**	**0.590**								**T_C Total**	**0.220**	**0.827**	**0.496**	30	**8.6**
GRS10	4392	100	0.029	Short Grass	0.22	0.15	0.126	2880	0.0108	Paved	2.11	20.3	0.379	1412	0.0018				1.5		0.261				
														924	0.0017				3.73		0.069				
						T_O Total	**0.126**					**T_S Total**	**0.379**								**T_C Total**	**0.330**	**0.836**	**0.502**	30	**8.7**
GRS11	3636	100	0.020	Short Grass	0.19	0.15	0.146	2567	0.0140	Paved	2.40	20.3	0.297	969	0.0255				4.45		0.060				
						T_O Total	**0.146**					**T_S Total**	**0.297**								**T_C Total**	**0.060**	**0.503**	**0.302**	18	**5.3**
GRS12	7122	100	0.023	Short Grass	0.20	0.15	0.139	2122	0.0251	Paved	3.22	20.3	0.183	4900	0.0017				3.69		0.369				
						T_O Total	**0.139**					**T_S Total**	**0.183**								**T_C Total**	**0.369**	**0.691**	**0.415**	25	**7.2**
GRS13	7098	50	0.011	Paved	1.06	0.011	0.013	4907	0.0099	Paved	2.02	20.3	0.675	2141	0.0101				6.16		0.097				
						T_O Total	**0.013**					**T_S Total**	**0.675**								**T_C Total**	**0.097**	**0.785**	**0.471**	28	**8.2**
GRS14	5907	50	0.035	Paved	1.67	0.011	0.008	4319	0.0092	Paved	1.95	20.3	0.616	1538	0.0133				4.1		0.104				
						T_O Total	**0.008**					**T_S Total**	**0.616**								**T_C Total**	**0.104**	**0.729**	**0.437**	26	**7.6**
GRS15	4227	100	0.023	Short Grass	0.20	0.15	0.138	2620	0.0197	Paved	2.85	20.3	0.255	1507	0.0082				5.21		0.080				
						T_O Total	**0.138**					**T_S Total**	**0.255**								**T_C Total**	**0.080**	**0.474**	**0.284**	17	**4.9**
GRS16	5518	50	0.017	Paved	1.24	0.011	0.011	4208	0.0149	Paved	2.48	20.3	0.472	1260	0.0024				4.38		0.080				
						T_O Total	**0.011**					**T_S Total**	**0.472**								**T_C Total**	**0.080**	**0.563**	**0.338**	20	**5.9**
GRS17	3752	50	0.016	Paved	1.23	0.011	0.011	3702	0.0121	Paved	2.23	20.3	0.461												
						T_O Total	**0.011**					**T_S Total**	**0.461**								**T_C Total**	**0.000**	**0.472**	**0.283**	17	**4.9**
GRS18	3944	100	0.017	Short Grass	0.18	0.15	0.157	1247	0.0519	Paved	4.62	20.3	0.075	2597	0.006				4.62		0.156				
						T_O Total	**0.157**					**T_S Total**	**0.075**								**T_C Total**	**0.156**	**0.388**	**0.233**	14	**4.1**
Hanger																									
HC1		100	0.014	Short Grass	0.16	0.15	0.169	74	0.0310	Paved	3.57	20.3	0.006	3455	0.0062						0.178				
								255	0.0100	Paved	2.03	20.3	0.035												
						T_O Total	**0.169**					**T_S Total**	**0.041**								**T_C Total**	**0.178**	**0.387**	**0.232**	14	**4.0**
HC2		100	0.040	Short Grass	0.25	0.15	0.111	1782	0.0061	Paved	1.59	20.3	0.312	192	0.0201				4.26		0.013				
						T_O Total	**0.111**					**T_S Total**	**0.312**								**T_C Total**	**0.013**	**0.436**	**0.262**	16	**4.6**
HC3		100	0.013	Short Grass	0.16	0.15	0.176	311	0.0110	Paved	2.13	20.3	0.041	2477	0.0074						0.108				
								207	0.0080	Paved	1.82	20.3	0.032												
						T_O Total	**0.176**					**T_S Total**	**0.072**								**T_C Total**	**0.108**	**0.356**	**0.214**	13	**3.7**
HC4		50	0.013	Paved	1.10	0.011	0.013	462	0.0028	Paved	1.07	20.3	0.119	1229	0.0103				3.4		0.100				
								955	0.0065	Paved	1.64	20.3	0.162												
						T_O Total	**0.013**					**T_S Total**	**0.282**								**T_C Total**	**0.100**	**0.395**	**0.237**	14	**4.1**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow: Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Shallow Concentrated Flow: Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Channel Flow: Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (ft/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
HC5		50	0.017	Paved	1.23	0.011	0.011	770	0.0041	Paved	1.30	20.3	0.165	1315	0.0149				2.7		0.135				
						T_O Total	**0.011**					**T_S Total**	**0.165**							**T_C Total**	**0.135**	**0.311**	**0.187**	**11**	**3.2**
JP Tribs																									
JPT1010	3874	100	0.0947	Developed	0.35	0.15	0.079	290	0.0569	Paved	4.84	20.3	0.017	670	0.0224	0.05	24	26	4.2		0.04				
								370	0.0445	Paved	4.28	20.3	0.024	2914	0.0157	0.05	56	106	2.4		0.332				
								200	0.0947	Paved	6.25	20.3	0.009												
						T_O Total	**0.079**					**T_S Total**	**0.050**							**T_C Total**	**0.372**	**0.500**	**0.300**		**5.2**
JPT2010	6802	100	0.0135	Developed	0.16	0.15	0.172	1170	0.0217	Paved	2.99	20.3	0.109	1494	0.0239	0.05	92	91	4.7		0.089				
								545	0.0421	Paved	4.17	20.3	0.036	4571	0.0061	0.05	188	139	2.8		0.446				
								200	0.0135	Paved	2.36	20.3	0.024												
						T_O Total	**0.172**					**T_S Total**	**0.169**							**T_C Total**	**0.535**	**0.876**	**0.525**		**9.1**
JPT3010	2774	100	0.0284	Developed	0.22	0.15	0.128	190	0.0864	Paved	5.97	20.3	0.009	630	0.0319	0.05	20	22	5		0.035				
								200	0.0284	Paved	3.42	20.3	0.016	400	0.03	0.05	40	26	7		0.016				
														1410	0.01135	0.05	58	71	2.8		0.141				
						T_O Total	**0.128**					**T_S Total**	**0.025**							**T_C Total**	**0.192**	**0.345**	**0.207**		**3.6**
JPTP010	1897	100	0.0667	Open Space	0.31	0.15	0.091	400	0.0750	Paved	5.56	20.3	0.020												
								1160	0.0130	Paved	2.31	20.3	0.139												
								200	0.0667	Paved	5.24	20.3	0.011												
						T_O Total	**0.091**					**T_S Total**	**0.170**							**T_C Total**	**0.000**	**0.261**	**0.156**		**2.7**
Loyd																									
LYD1		100	0.019	Short Grass	0.19	0.15	0.149	2347	0.0146	Paved	2.45	20.3	0.266	1938	0.0101				8		0.067				
														2900	0.0064				2.4		0.336				
						T_O Total	**0.149**					**T_S Total**	**0.266**							**T_C Total**	**0.403**	**0.818**	**0.491**	**29**	**8.5**
LYD2		100	0.011	Short Grass	0.15	0.15	0.189	1101	0.0143	Paved	2.43	20.3	0.126	500	0.0169				8		0.017				
								2117	0.0112	Paved	2.15	20.3	0.274	1193	0.0049				5		0.066				
						T_O Total	**0.189**					**T_S Total**	**0.400**							**T_C Total**	**0.084**	**0.673**	**0.404**	**24**	**7.0**
LYD3		50	0.008	Paved	0.91	0.011	0.015	2294	0.0144	Paved	2.44	20.3	0.262	1198	0.004				4.95		0.067				
						T_O Total	**0.015**					**T_S Total**	**0.262**							**T_C Total**	**0.067**	**0.344**	**0.206**	**12**	**3.6**
LYD4		50	0.016	Paved	1.23	0.011	0.011	829	0.0059	Paved	1.56	20.3	0.148	2044	0.0173				6		0.095				
														1327	0.0075				3.2		0.115				
						T_O Total	**0.011**					**T_S Total**	**0.148**							**T_C Total**	**0.210**	**0.369**	**0.221**	**13**	**3.9**
Lynn Creek Tributary																									
LT1	1199	100	0.019	Short Grass	0.19	0.15	0.150	1021	0.0070	Paved	1.70	20.3	0.167	78	0.02				3.17		0.007				
						T_O Total	**0.150**					**T_S Total**	**0.167**							**T_C Total**	**0.007**	**0.324**	**0.194**	**12**	**3.4**
LT2	1216	100	0.019	Short Grass	0.19	0.15	0.150	981	0.0120	Paved	2.22	20.3	0.123	135	0.018				4.38		0.009				
						T_O Total	**0.150**					**T_S Total**	**0.123**							**T_C Total**	**0.009**	**0.281**	**0.169**	**10**	**2.9**
LT3	1041	100	0.014	Short Grass	0.16	0.15	0.170	486	0.0440	Paved	4.26	20.3	0.032	455	0.033				4.45						
						T_O Total	**0.170**					**T_S Total**	**0.032**							**T_C Total**	**0.000**	**0.201**	**0.121**	**7**	**2.1**
Mills Br.																									
MILLS010	974	100	0.0919	Developed	0.35	0.15	0.080	660	0.0286	Paved	3.43	20.3	0.053												
								200	0.0919	Paved	#DIV/0!														
						T_O Total	**0.080**					**T_S Total**	**0.053**							**T_C Total**	**0.000**	**0.133**	**0.080**		**1.4**
MILLS020	1985	100	0.0899	Developed	0.34	0.15	0.081	90	0.1110	Paved	6.76	20.3	0.004	710	0.0169	0.05	90	69	4.59		0.043				
								200	0.0899	Paved	#DIV/0!			830	0.0048	0.05	490	176	4.12		0.056				
						T_O Total	**0.081**					**T_S Total**	**0.004**							**T_C Total**	**0.099**	**0.183**	**0.110**		**1.9**
MILLS030	2488	100	0.0908	Developed	0.35	0.15	0.080	740	0.0286	Paved	3.43	20.3	0.060	1360	0.0143	0.05	69	29	6.4		0.059				
								200	0.0908	Paved	#DIV/0!														
						T_O Total	**0.080**					**T_S Total**	**0.060**							**T_C Total**	**0.059**	**0.199**	**0.119**		**2.1**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow: Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Shallow Concentrated Flow: Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Channel Flow: Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (ft/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_t (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
Mountain																									
MTC1		50	0.012	Paved	1.09	0.011	0.013	2723	0.0177	Paved	2.70	20.3	0.280	2732	0.0138				4.5		0.169				
														34393	0.0041				5.29		1.806				
						T_O Total	**0.013**					**T_S Total**	**0.280**								**T_C Total**	**1.975**	**2.267**	**1.360**	**82**	**23.7**
MTC2		50	0.027	Paved	1.50	0.011	0.009	1164	0.0290	Paved	3.46	20.3	0.094	18324	0.0063				4.27		1.192				
														20012	0.0025				4.67		1.190				
						T_O Total	**0.009**					**T_S Total**	**0.094**								**T_C Total**	**2.382**	**2.485**	**1.491**	**89**	**25.9**
MTC3		100	0.011	Short Grass	0.15	0.15	0.187	3160	0.0059	Paved	1.56	20.3	0.563	3176	0.0155				2.9		0.304				
														800	0.0211				8.04		0.028				
														388	0.0013				4.58		0.024				
						T_O Total	**0.187**					**T_S Total**	**0.563**								**T_C Total**	**0.355**	**1.106**	**0.663**	**40**	**11.5**
MTC4		50	0.009	Paved	0.97	0.011	0.014	3668	0.0115	Paved	2.18	20.3	0.468	37780	0.0037				5.08		2.066				
						T_O Total	**0.014**					**T_S Total**	**0.468**								**T_C Total**	**2.066**	**2.548**	**1.529**	**92**	**26.6**
MTC5		50	0.009	Paved	0.97	0.011	0.014	2566	0.0131	Paved	2.32	20.3	0.307	4447	0.0107				5.5		0.225				
														1563	0.0111				4.9		0.089				
														3606	0.0012				4.34		0.231				
						T_O Total	**0.014**					**T_S Total**	**0.307**								**T_C Total**	**0.544**	**0.865**	**0.519**	**31**	**9.0**
MTC6		50	0.008	Paved	0.91	0.011	0.015	2545	0.0163	Paved	2.59	20.3	0.273	25653	0.0045				3.89		1.832				
						T_O Total	**0.015**					**T_S Total**	**0.273**								**T_C Total**	**1.832**	**2.120**	**1.272**	**76**	**22.1**
MTC7		50	0.003	Paved	0.62	0.011	0.022	1351	0.0153	Paved	2.51	20.3	0.149	4207	0.0162				3.15		0.371				
														6487	0.0005				3.15		0.572				
						T_O Total	**0.022**					**T_S Total**	**0.149**								**T_C Total**	**0.943**	**1.115**	**0.669**	**40**	**11.6**
North Hanger																									
NHC1		100	0.015	Short Grass	0.17	0.15	0.165	95	0.0316	Paved	3.61	20.3	0.007	1427	0.0137						0.064				
								268	0.0105	Paved	2.08	20.3	0.036												
						T_O Total	**0.165**					**T_S Total**	**0.043**								**T_C Total**	**0.064**	**0.272**	**0.163**	**10**	**2.8**
NHC2		50	0.021	Paved	1.35	0.011	0.010	1148	0.0064	Paved	1.62	20.3	0.196												
						T_O Total	**0.010**					**T_S Total**	**0.196**								**T_C Total**	**0.000**	**0.207**	**0.124**	**7**	**2.2**
NHC3		100	0.018	Short Grass	0.18	0.15	0.154	525	0.0055	Paved	1.51	20.3	0.097	2176	0.0104						0.111				
						T_O Total	**0.154**					**T_S Total**	**0.097**								**T_C Total**	**0.111**	**0.361**	**0.217**	**13**	**3.8**
NHC4		50	0.019	Paved	1.29	0.011	0.011	3406	0.0072	Paved	1.72	20.3	0.549												
						T_O Total	**0.011**					**T_S Total**	**0.549**								**T_C Total**	**0.000**	**0.560**	**0.336**	**20**	**5.8**
NHC5		50	0.044	Paved	1.82	0.011	0.008	947	0.0086	Paved	1.88	20.3	0.140	714	0.0073				2		0.099				
						T_O Total	**0.008**					**T_S Total**	**0.140**								**T_C Total**	**0.099**	**0.247**	**0.148**	**9**	**2.6**
NHC6		50	0.017	Paved	1.23	0.011	0.011	1889	0.0106	Paved	2.09	20.3	0.251	1263	0.0011				2		0.175				
						T_O Total	**0.011**					**T_S Total**	**0.251**								**T_C Total**	**0.175**	**0.438**	**0.263**	**16**	**4.6**
Stuart Br.																									
STUAB010	1307	50	0.0817	Paved	2.34	0.011	0.006	325	0.0723	Paved	5.46	20.3	0.017	400	0.006	0.05	338	162	3.83		0.029				
								230	0.0261	Paved	3.28	20.3	0.019												
								250	0.0817	Paved	5.80	20.3	0.012												
						T_O Total	**0.006**					**T_S Total**	**0.048**								**T_C Total**	**0.029**	**0.083**	**0.050**		**0.9**
STUAB020	4608	50	0.0717	Paved	2.22	0.011	0.006	260	0.1019	Paved	6.48	20.3	0.011	1417	0.016	0.05	170	90	5.788		0.068				
								350	0.0371	Paved	3.91	20.3	0.025	1270	0.008	0.05	180	100	3.964		0.089				
								250	0.0717	Paved	5.43	20.3	0.013												
						T_O Total	**0.006**					**T_S Total**	**0.049**						4.88		**T_C Total**	**0.157**	**0.212**	**0.127**		**2.2**
Swad Cr.																									
SWADB010	1700	100	0.0111	Developed	0.15	0.15	0.186	560	0.1167	Paved	6.93	20.3	0.022												
								800	0.0314	Paved	3.60	20.3	0.062												
								200	0.0111	Paved	2.14	20.3	0.026												
						T_O Total	**0.186**					**T_S Total**	**0.110**								**T_C Total**	**0.000**	**0.296**	**0.178**		**3.1**
SWADB020	3510	100	0.0395	Developed	0.25	0.15	0.112	1060	0.1167	Paved	6.93	20.3	0.042	2000	0.01	0.05	111	60	4		0.138				
								200	0.0395	Paved	4.04	20.3	0.014												
						T_O Total	**0.112**					**T_S Total**	**0.056**								**T_C Total**	**0.138**	**0.306**	**0.184**		**3.2**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow: Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Shallow Concentrated Flow: Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Channel Flow: Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (ft/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)	Total Time of Conc. (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
SWADB030	4321	50	0.0438	Paved	1.82	0.011	0.008	1000	0.4690	Paved	13.90	20.3	0.020	2500	0.0021	0.05	143	91	1.85		0.421				
								250	0.0438	Paved	4.25	20.3	0.016												
						T_O Total	**0.008**					**T_S Total**	**0.036**							**T_C Total**	**0.421**	**0.465**	**0.279**		**4.9**
SWADB040	1381	100	0.1050	Developed	0.37	0.15	0.076	720	0.0850	Paved	5.92	20.3	0.034	492	0.03	0.05	181	168	5.5		0.025				
								200	0.1050	Paved	6.58	20.3	0.008												
						T_O Total	**0.076**					**T_S Total**	**0.042**							**T_C Total**	**0.025**	**0.143**	**0.086**		**1.5**
Taaffe Cr.																									
TAAFC010	9050	50	0.0102	Paved	1.02	0.011	0.014	2600	0.0079	Paved	1.80	20.3	0.400	2665	0.0024	0.04	25.2	26	1.78		0.414				
								600	0.0040	Paved	1.28	20.3	0.130												
								1960	0.0089	Paved	1.92	20.3	0.284												
								250	0.0102	Paved	2.05	20.3	0.034												
						T_O Total	**0.014**					**T_S Total**	**0.848**							**T_C Total**	**0.414**	**1.276**	**0.766**		**13.3**
TAAFC020	2863	50	0.0120	Paved	1.08	0.011	0.013	326	0.0207	Paved	2.92	20.3	0.031	4122	0.0047	0.045	250	127	3.60		0.321				
								200	0.0001	Paved	0.20	20.3	0.274												
								50	0.0120	Paved	2.22	20.3	0.006												
						T_O Total	**0.013**					**T_S Total**	**0.311**							**T_C Total**	**0.321**	**0.645**	**0.387**		**6.7**
TAAFC025	6620	100	0.0100	Developed	0.14	0.15	0.194	100	0.0100	Paved	2.03	20.3	0.014	830	0.0066	0.016	11.25	46	2.95		0.078				
														290	0.0034	0.016	11.25	46	2.12		0.038				
														720	0.0031	0.016	11.25	46	2.02		0.099				
														930	0.003	0.016	11.25	46	1.99		0.130				
														1160	0.003	0.016	11.25	46	1.99		0.162				
														2300	0.001	0.045	1224	150	4.23		0.151				
						T_O Total	**0.194**					**T_S Total**	**0.014**							**T_C Total**	**0.658**	**0.865**	**0.519**		**9.0**
TAAFC030	3300	100	0.0010	Developed	0.06	0.15	0.487	490	0.0105	Paved	2.08	20.3	0.065	2664	0.045	0.0106	210	90	6		0.123				
								250	0.0800	Paved	5.74	20.3	0.012												
								200	0.0048	Paved	1.41	20.3	0.040												
						T_O Total	**0.487**					**T_S Total**	**0.117**							**T_C Total**	**0.123**	**0.727**	**0.436**		**7.6**
Tarrell Cr.																									
TARRC010	1415	100	0.078	Developed	0.33	0.15	0.085	280	0.0456	Paved		20.3	0.018	430	0.0326	0.05	12	21	3.7		0.032				
								200	0.0779	Paved		20.3	0.010	380	0.0263	0.05	150	86	7		0.015				
						T_O Total	**0.085**					**T_S Total**	**0.028**							**T_C Total**	**0.047**	**0.160**	**0.096**		**1.7**
TARRC020	2290	100	0.084	Developed	0.34	0.15	0.083	1200	0.0302	Paved		20.3	0.094	1060	0.0019	0.05	average velocity less than 3fps			4.6	0.024				
								200	0.0844	Paved		20.3	0.009												
						T_O Total	**0.083**					**T_S Total**	**0.104**							**T_C Total**	**0.024**	**0.211**	**0.126**		**2.2**
TARRC030	3555	100	0.062	Developed	0.30	0.15	0.094	300	0.0897	Paved		20.3	0.014	2750	0.0112	0.05	142	54	6		0.127				
								200	0.0618	Paved		20.3	0.011												
						T_O Total	**0.094**					**T_S Total**	**0.025**							**T_C Total**	**0.127**	**0.245**	**0.147**		**2.6**
Ten Branch																									
Ten1	4481	50	0.005	Paved	0.76	0.011	0.018	1084	0.0218	Paved	3.00	20.3	0.100	3347	0.0071				5.16		0.180				
						T_O Total	**0.018**					**T_S Total**	**0.100**							**T_C Total**	**0.180**	**0.299**	**0.179**	**11**	**3.1**
Ten2	3073	50	0.002	Paved	0.53	0.011	0.026	1046	0.0123	Paved	2.25	20.3	0.129	1977	0.0038				3.25		0.169				
						T_O Total	**0.026**					**T_S Total**	**0.129**							**T_C Total**	**0.169**	**0.324**	**0.195**	**12**	**3.4**
Ten3	3668	50	0.035	Paved	1.66	0.011	0.008	1660	0.0165	Paved	2.61	20.3	0.177	1958	0.0041				3.88		0.140				
						T_O Total	**0.008**					**T_S Total**	**0.177**							**T_C Total**	**0.140**	**0.325**	**0.195**	**12**	**3.4**
Unidentified Basins																									
UNID1	2663	100	0.008	Short Grass	0.13	0.15	0.212	1935	0.0120	Paved	2.22	20.3	0.242	628	0.038	0.055	59.12	36.86	7.4	NA	0.02				
						T_O Total	**0.212**					**T_S Total**	**0.242**							**T_C Total**	**0.024**	**0.478**	**0.287**	**17**	**5.0**
UNID2	2280	50	0.015	Smooth Surface	1.19	0.011	0.012	971	0.0230	Paved	3.08	20.3	0.088	1259	0.029				3.86	NA	0.091				
						T_O Total	**0.012**					**T_S Total**	**0.088**							**T_C Total**	**0.091**	**0.190**	**0.114**	**7**	**2.0**
UNID3	2195	100	0.030	Dense Grass	0.15	0.24	0.182	985	0.0300	Paved	3.52	20.3	0.078	1110	0.021	0.055	208.7	88.99	7.4	NA	0.042				
						T_O Total	**0.182**					**T_S Total**	**0.078**							**T_C Total**	**0.042**	**0.302**	**0.181**	**11**	**3.1**
UNID4	1761	50	0.063	Smooth Surface	2.11	0.011	0.007	377	0.0700	Paved	5.37	20.3	0.019	1334	0.021				3.79	NA	0.098				
						T_O Total	**0.007**					**T_S Total**	**0.019**							**T_C Total**	**0.098**	**0.124**	**0.074**	**4**	**1.3**
UNID5	550	100	0.040	Short Grass	0.25	0.15	0.111	397	0.0530	Paved	4.67	20.3	0.024	53	0.095	0.055	86.41	84.23	6.14		0.002				
						T_O Total	**0.111**					**T_S Total**	**0.024**							**T_C Total**	**0.002**	**0.137**	**0.060**	**4**	**1.0**

HMS Program Basin Name	Longest Flowpath (ft) (1)	Overland Flow						Shallow Concentrated Flow						Channel Flow								Total Time of Conc, (hr) (20)	Total Lag Time (hr) (21)		Time Step (min) (22)
		Length (ft) (2)	Slope (ft/ft) (3)	Surface Type (4)	Velocity (ft/s)	Manning's n (5)	T_O (hr) (6)	Length (ft) (7)	Slope (ft/ft) (8)	Surface Type (9)	Velocity (ft/s)	K (10)	T_S (hr) (11)	Length (ft) (12)	Slope (ft/ft) (13)	Manning's n (14)	Area (ft^2) (15)	WP (ft) (16)	Channel Velocity (ft/s) (17)	Average Depth of Flow (Pond Only) (ft) (18)	T_h (hr) (19)				
UNID6	1564	100	0.025	Dense Grass	0.14	0.24	0.196	352	0.0700	Paved	5.37	20.3	0.018	1112	0.056	0.055	38.42	37.83	6.46	NA	0.05				
						T_O Total	**0.196**					**T_S Total**	**0.018**							**T_c Total**	**0.048**	**0.262**	**0.060**	**4**	**1.0**
UNID7	1537	100	0.030	Short Grass	0.22	0.15	0.125	225	0.0900	Paved	6.09	20.3	0.010	1212	0.05	0.055	86.41	84.23	6.14		0.05				
						T_O Total	**0.125**					**T_S Total**	**0.010**							**T_c Total**	**0.055**	**0.190**	**0.060**	**4**	**1.0**
UNID8	2827	100	0.040	Dense Grass	0.17	0.24	0.162	546	0.0900	Paved	6.09	20.3	0.025	2181	0.016	0.055	319.85	142.12	5.87		0.10				
						T_O Total	**0.162**					**T_S Total**	**0.025**							**T_c Total**	**0.103**	**0.290**	**0.174**	**10**	**3.0**
Webb																									
WB1		100	0.007	Short Grass	0.12	0.15	0.230	178	0.0144	Paved	2.44	20.3	0.020	2466	0.012						0.077				
								250	0.0045	Paved	1.36	20.3	0.051												
						T_O Total	**0.230**					**T_S Total**	**0.071**							**T_c Total**	**0.077**	**0.378**	**0.227**	**14**	**3.9**
WB2		100	0.008	Short Grass	0.13	0.15	0.210	34	0.0077	Paved	1.78	20.3	0.005	2157	0.0068						0.093				
								489	0.0053	Paved	1.48	20.3	0.092												
						T_O Total	**0.210**					**T_S Total**	**0.097**							**T_c Total**	**0.093**	**0.400**	**0.240**	**14**	**4.2**
WB3		100	0.014	Short Grass	0.16	0.15	0.169	532	0.0078	Paved	1.79	20.3	0.082	2316	0.0076						0.144				
						T_O Total	**0.169**					**T_S Total**	**0.082**							**T_c Total**	**0.144**	**0.395**	**0.237**	**14**	**4.1**
WB4		75	0.049	Short Grass	0.25	0.15	0.082	755	0.0073	Paved	1.73	20.3	0.121	1403	0.0098						0.090				
						T_O Total	**0.082**					**T_S Total**	**0.121**							**T_c Total**	**0.090**	**0.293**	**0.176**	**11**	**3.1**
WB5		50	0.018	Paved	1.26	0.011	0.011	2905	0.0043	Paved	1.33	20.3	0.606	774	0.0113				1.89		0.114				
						T_O Total	**0.011**					**T_S Total**	**0.606**							**T_c Total**	**0.114**	**0.731**	**0.439**	**26**	**7.6**
WB6		100	0.003	Short Grass	0.08	0.15	0.332	27	0.0206	Paved	2.91	20.3	0.003	1525	0.0042						0.108				
								389	0.0049	Paved	1.42	20.3	0.076	664	0.0038				2.57		0.072				
						T_O Total	**0.332**					**T_S Total**	**0.079**							**T_c Total**	**0.180**	**0.591**	**0.355**	**21**	**6.2**
WB7		50	0.057	Paved	2.02	0.011	0.007	1737	0.0052	Paved	1.46	20.3	0.330	813	0.0035						0.0444				
														700	0.0215				4.95		0.039				
						T_O Total	**0.007**					**T_S Total**	**0.330**							**T_c Total**	**0.039**	**0.376**	**0.225**	**14**	**3.9**
WB8		50	0.021	Paved	0.17	0.15	0.082	50	0.0210	Paved	2.94	20.3	0.005	930	0.014				4.45		0.0444				
														982	0.0087				5.52		0.049				
						T_O Total	**0.082**					**T_S Total**	**0.005**							**T_c Total**	**0.049**	**0.137**	**0.082**	**5**	**1.4**
WB9		50	0.019	Paved	1.30	0.011	0.011	1959	0.0038	Paved	1.25	20.3	0.435	5689	0.0077				5.15		0.307				
						T_O Total	**0.011**					**T_S Total**	**0.435**							**T_c Total**	**0.307**	**0.752**	**0.451**	**27**	**7.9**

Notes:
(1) GeoHMS Longest Flowpath
(2) Overland flow length (Maximum allowed in WinTR55 is 100 ft.)
(3) Slope of the ground
(4) WinTR55 surface type
(5) WinTR55 Manning's n
(6) WinTR55 Overland time of concentration: $T_O=0.42(nL)^{0.8}/(3.95^{0.5}S^{0.4}60)$
(7) Shallow concentrated flow length
(8) Slope of the ground
(9) WinTR55 surface type
(10) 16.1 for unpaved and 20.3 for paved soil cover
(11) WinTR55 Shallow Concentrated time of concentration: $T_S=L/(60^2KS^{0.5})$
(12) Channelized flow length
(13) Slope of the ground
(14) Manning's n (taken from HEC-RAS routing model)
(15) Area (Average channel area, based on flow with profile near or at full bank flow.)
(16) Wetted Perimeter (Average channel wetted perimeter, based on flow with profile near or at full bank flow.)
(17) Channel Velocity: $V=1.486/n(\text{area wetted perimeter})^{2/3}S^{0.5}$
(18) Average depth of flow in pond
(19) Channelized time of concentration. $T_h=L/(60^2V)$, for flow through ponds, T_h=wave celerity=$(32.2d)^{0.5}/60$
(20) Total time of concentration: $T_c=T_r+T_S+T_h$
(21) Total lag time: $T_L=0.6T_c$
(22) Time Step : $T=0.29T_L$

Technical Release 55, Table 2-2c

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

HEC-RAS Multi-Profile Output

HEC-RAS Plan: Bedford_Multi River: Bedford_Reach Reach: Main_Reach

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main_Reach	4353	10-Year	3140.00	526.00	535.47	533.77	535.67	0.002000	4.72	1204.53	383.64	0.32
Main_Reach	4353	50-Year	4900.00	526.00	536.83	534.54	537.05	0.002001	5.32	1965.52	713.84	0.32
Main_Reach	4353	100-Year	5740.00	526.00	537.21	534.76	537.43	0.002002	5.48	2246.42	750.43	0.33
Main_Reach	4353	500-Year	7900.00	526.00	538.08	535.45	538.31	0.002003	5.84	2939.06	845.91	0.33
Main_Reach	4353	100-Year_Ult	7690.00	526.00	538.01	535.37	538.23	0.002001	5.81	2875.19	839.14	0.33
Main_Reach	5404	10-Year	3140.00	528.00	537.42		537.67	0.002087	4.83	1140.59	430.47	0.32
Main_Reach	5404	50-Year	4900.00	528.00	538.69		538.94	0.001938	5.20	1716.83	486.82	0.32
Main_Reach	5404	100-Year	5740.00	528.00	539.09		539.36	0.002027	5.48	1918.07	506.08	0.33
Main_Reach	5404	500-Year	7900.00	528.00	540.00		540.31	0.002199	6.10	2393.07	545.52	0.35
Main_Reach	5404	100-Year_Ult	7690.00	528.00	539.92		540.22	0.002182	6.04	2350.15	542.07	0.34
Main_Reach	6026	10-Year	3140.00	530.00	538.94		539.21	0.003292	5.27	1163.67	621.13	0.39
Main_Reach	6026	50-Year	4900.00	530.00	540.01		540.22	0.002524	5.19	1853.01	668.31	0.35
Main_Reach	6026	100-Year	5740.00	530.00	540.42		540.64	0.002375	5.24	2137.27	688.04	0.35
Main_Reach	6026	500-Year	7900.00	530.00	541.36		541.57	0.002163	5.43	2800.16	732.31	0.34
Main_Reach	6026	100-Year_Ult	7690.00	530.00	541.27		541.48	0.002176	5.41	2739.49	728.37	0.34
Main_Reach	6731	10-Year	3140.00	532.00	540.64	539.09	540.80	0.001979	4.13	1447.42	695.69	0.31
Main_Reach	6731	50-Year	4900.00	532.00	541.43	539.91	541.61	0.002100	4.65	2007.55	727.67	0.32
Main_Reach	6731	100-Year	5740.00	532.00	541.78	540.29	541.96	0.002095	4.80	2265.32	785.57	0.33
Main_Reach	6731	500-Year	7900.00	532.00	542.59	540.72	542.79	0.002056	5.14	2982.84	901.07	0.33
Main_Reach	6731	100-Year_Ult	7690.00	532.00	542.52	540.69	542.72	0.002070	5.12	2917.42	900.40	0.33
Main_Reach	7347	10-Year	2700.00	532.00	541.88	540.30	542.21	0.003088	5.50	779.22	275.77	0.39
Main_Reach	7347	50-Year	4150.00	532.00	542.74	541.15	543.20	0.003850	6.69	1016.99	570.22	0.44
Main_Reach	7347	100-Year	4860.00	532.00	543.09	541.44	543.60	0.004158	7.17	1120.33	585.29	0.46
Main_Reach	7347	500-Year	6570.00	532.00	543.86	542.22	544.48	0.004630	8.07	1367.26	619.00	0.49
Main_Reach	7347	100-Year_Ult	6520.00	532.00	543.81	542.18	544.43	0.004710	8.11	1349.56	616.65	0.50
Main_Reach	8034	10-Year	2700.00	536.00	543.76	542.00	543.99	0.003087	5.32	1012.80	529.14	0.38
Main_Reach	8034	50-Year	4150.00	536.00	544.75	543.27	544.94	0.002538	5.35	1801.66	767.50	0.36
Main_Reach	8034	100-Year	4860.00	536.00	545.12	543.53	545.30	0.002333	5.31	2091.70	789.08	0.35
Main_Reach	8034	500-Year	6570.00	536.00	545.93	544.33	546.09	0.002003	5.27	2746.32	830.23	0.33
Main_Reach	8034	100-Year_Ult	6520.00	536.00	545.90	544.31	546.06	0.002018	5.28	2724.05	828.86	0.33
Main_Reach	8255	10-Year	2700.00	535.56	545.42		545.55	0.001326	4.12	1569.62	731.65	0.26
Main_Reach	8255	50-Year	4150.00	535.56	546.22		546.35	0.001362	4.45	2171.78	760.02	0.26
Main_Reach	8255	100-Year	4860.00	535.56	546.53		546.66	0.001396	4.61	2409.89	762.38	0.27
Main_Reach	8255	500-Year	6570.00	535.56	547.23		547.37	0.001430	4.90	2943.92	767.65	0.27
Main_Reach	8255	100-Year_Ult	6520.00	535.56	547.21		547.35	0.001430	4.89	2928.18	767.50	0.27
Main_Reach	8815	10-Year	2720.00	539.91	546.12		546.20	0.001472	3.52	1546.11	614.82	0.27
Main_Reach	8815	50-Year	4160.00	539.91	546.91		547.01	0.001550	3.95	2037.23	632.34	0.28
Main_Reach	8815	100-Year	4870.00	539.91	547.23		547.33	0.001606	4.16	2239.20	639.41	0.29
Main_Reach	8815	500-Year	6580.00	539.91	547.92		548.05	0.001693	4.57	2691.31	654.55	0.30
Main_Reach	8815	100-Year_Ult	6550.00	539.91	547.91		548.03	0.001701	4.57	2679.05	654.19	0.30
Main_Reach	9057	10-Year	2270.00	540.00	546.47	545.39	546.57	0.001941	3.77	1224.85	578.61	0.30
Main_Reach	9057	50-Year	3490.00	540.00	547.26	545.76	547.36	0.001813	4.02	1685.44	589.99	0.29
Main_Reach	9057	100-Year	4080.00	540.00	547.58	545.92	547.69	0.001795	4.14	1877.34	594.67	0.29
Main_Reach	9057	500-Year	5490.00	540.00	548.29	546.28	548.42	0.001752	4.40	2303.64	606.38	0.30
Main_Reach	9057	100-Year_Ult	5550.00	540.00	548.28	546.29	548.40	0.001814	4.47	2293.87	606.08	0.30
Main_Reach	9488	10-Year	2270.00	540.00	547.50		548.33	0.009254	8.99	425.72	169.06	0.65
Main_Reach	9488	50-Year	3490.00	540.00	548.08		549.47	0.014094	11.81	537.48	287.46	0.82
Main_Reach	9488	100-Year	4080.00	540.00	548.39		549.80	0.014254	12.25	625.31	290.92	0.83
Main_Reach	9488	500-Year	5490.00	540.00	549.06		550.46	0.013846	12.86	823.67	298.46	0.83
Main_Reach	9488	100-Year_Ult	5550.00	540.00	549.08		550.49	0.013862	12.89	830.72	298.73	0.83
Main_Reach	9860	10-Year	2270.00	542.00	549.82		550.00	0.002671	3.72	811.95	433.61	0.34
Main_Reach	9860	50-Year	3490.00	542.00	550.90		551.07	0.001987	3.79	1315.81	478.65	0.30
Main_Reach	9860	100-Year	4080.00	542.00	551.22		551.40	0.002016	3.98	1471.56	483.15	0.31
Main_Reach	9860	500-Year	5490.00	542.00	551.87		552.09	0.002138	4.43	1787.91	492.13	0.32
Main_Reach	9860	100-Year_Ult	5550.00	542.00	551.90		552.12	0.002140	4.45	1801.04	492.50	0.32
Main_Reach	10589	10-Year	2270.00	546.00	551.75	550.20	551.89	0.002631	2.97	763.25	279.09	0.32
Main_Reach	10589	50-Year	3490.00	546.00	552.49	550.66	552.68	0.002769	3.55	1036.67	431.30	0.34
Main_Reach	10589	100-Year	4080.00	546.00	552.80	550.86	553.02	0.002756	3.76	1174.67	447.56	0.34
Main_Reach	10589	500-Year	5490.00	546.00	553.46	551.30	553.72	0.002733	4.17	1481.42	479.96	0.35
Main_Reach	10589	100-Year_Ult	5550.00	546.00	553.49	551.31	553.75	0.002732	4.18	1494.00	481.20	0.35
Main_Reach	11199	10-Year	2250.00	548.00	553.23	552.70	553.33	0.002432	3.44	1022.84	417.32	0.32
Main_Reach	11199	50-Year	3460.00	548.00	554.03	552.71	554.15	0.002435	3.92	1367.17	448.49	0.33
Main_Reach	11199	100-Year	4030.00	548.00	554.35	552.71	554.48	0.002442	4.11	1511.50	451.11	0.33
Main_Reach	11199	500-Year	5400.00	548.00	555.03	552.70	555.20	0.002483	4.54	1821.28	456.76	0.34
Main_Reach	11199	100-Year_Ult	5460.00	548.00	555.06	552.71	555.22	0.002487	4.56	1833.43	456.98	0.34
Main_Reach	11327	10-Year	2250.00	548.00	554.13	554.13	555.04	0.028357	7.64	296.80	183.25	0.98
Main_Reach	11327	50-Year	3460.00	548.00	554.88	554.88	555.84	0.020238	8.05	495.02	328.83	0.87
Main_Reach	11327	100-Year	4030.00	548.00	555.15	555.15	556.13	0.018605	8.24	589.69	362.00	0.85
Main_Reach	11327	500-Year	5400.00	548.00	555.64	555.64	556.72	0.017609	8.88	772.71	387.83	0.85
Main_Reach	11327	100-Year_Ult	5460.00	548.00	555.66	555.66	556.75	0.017575	8.91	780.59	389.95	0.85

HEC-RAS Plan: Bedford_Multi River: Bedford_Reach Reach: Main_Reach (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main_Reach	11518	10-Year	2250.00	548.00	556.04		556.30	0.002685	4.25	637.53	250.01	0.35
Main_Reach	11518	50-Year	3460.00	548.00	556.81		557.19	0.003394	5.29	850.72	306.26	0.40
Main_Reach	11518	100-Year	4030.00	548.00	557.08		557.53	0.003720	5.73	939.43	328.13	0.42
Main_Reach	11518	500-Year	5400.00	548.00	557.67		558.23	0.004355	6.61	1142.69	369.20	0.46
Main_Reach	11518	100-Year_Ult	5460.00	548.00	557.69		558.26	0.004377	6.65	1151.50	370.81	0.47
Main_Reach	12006	10-Year	2250.00	550.00	557.15		557.30	0.001657	3.52	961.65	368.96	0.28
Main_Reach	12006	50-Year	3460.00	550.00	558.14		558.31	0.001706	4.02	1345.50	416.31	0.29
Main_Reach	12006	100-Year	4030.00	550.00	558.52		558.71	0.001757	4.25	1511.30	446.45	0.30
Main_Reach	12006	500-Year	5400.00	550.00	559.31		559.53	0.001856	4.72	1887.92	507.23	0.31
Main_Reach	12006	100-Year_Ult	5460.00	550.00	559.34		559.56	0.001860	4.74	1903.87	509.58	0.31
Main_Reach	12423	10-Year	2250.00	550.00	557.88	556.21	558.17	0.002781	5.05	654.90	263.73	0.37
Main_Reach	12423	50-Year	3460.00	550.00	558.87	556.98	559.18	0.002777	5.60	1055.70	324.70	0.38
Main_Reach	12423	100-Year	4030.00	550.00	559.27	557.27	559.59	0.002780	5.81	1187.07	338.36	0.38
Main_Reach	12423	500-Year	5400.00	550.00	560.08	557.92	560.44	0.002839	6.30	1473.56	369.85	0.39
Main_Reach	12423	100-Year_Ult	5460.00	550.00	560.12	558.20	560.47	0.002844	6.33	1485.52	372.30	0.39
Main_Reach	12715	10-Year	2250.00	552.00	558.85		559.09	0.003669	3.89	590.37	212.93	0.38
Main_Reach	12715	50-Year	3460.00	552.00	559.77		560.09	0.003639	4.58	800.08	248.42	0.40
Main_Reach	12715	100-Year	4030.00	552.00	560.14		560.50	0.003628	4.85	896.15	265.65	0.40
Main_Reach	12715	500-Year	5400.00	552.00	560.93		561.36	0.003645	5.41	1123.13	316.36	0.42
Main_Reach	12715	100-Year_Ult	5460.00	552.00	560.96		561.40	0.003645	5.43	1133.25	318.45	0.42
Main_Reach	14280	10-Year	2250.00	556.00	563.46		563.66	0.002733	4.57	819.48	327.19	0.36
Main_Reach	14280	50-Year	3460.00	556.00	564.37		564.61	0.002790	5.15	1143.36	379.73	0.37
Main_Reach	14280	100-Year	4030.00	556.00	564.74		564.99	0.002793	5.36	1286.99	398.62	0.37
Main_Reach	14280	500-Year	5400.00	556.00	565.53		565.81	0.002779	5.78	1618.02	439.07	0.38
Main_Reach	14280	100-Year_Ult	5460.00	556.00	565.56		565.84	0.002779	5.80	1631.93	440.69	0.38
Main_Reach	14411	10-Year	2060.00	558.00	563.79	562.84	564.36	0.007491	6.45	400.41	266.34	0.57
Main_Reach	14411	50-Year	3150.00	558.00	564.66	563.84	565.38	0.007734	7.47	540.41	375.79	0.60
Main_Reach	14411	100-Year	3680.00	558.00	565.00	564.15	565.80	0.007978	7.94	595.68	383.08	0.61
Main_Reach	14411	500-Year	5210.00	558.00	565.70	564.90	566.80	0.009616	9.47	707.62	397.85	0.69
Main_Reach	14411	100-Year_Ult	5040.00	558.00	565.75	564.83	566.76	0.008680	9.05	716.18	398.98	0.65
Main_Reach	14443 Southern Pacific		Bridge									
Main_Reach	14475	10-Year	2060.00	558.00	564.77	562.48	565.27	0.004241	5.73	404.30	154.28	0.44
Main_Reach	14475	50-Year	3150.00	558.00	566.23	563.71	566.71	0.003309	5.97	745.77	663.33	0.41
Main_Reach	14475	100-Year	3680.00	558.00	566.89	564.34	567.32	0.002799	5.85	919.85	754.89	0.38
Main_Reach	14475	500-Year	5210.00	558.00	568.41	566.06	568.80	0.002198	5.87	1320.30	977.84	0.35
Main_Reach	14475	100-Year_Ult	5040.00	558.00	568.25	565.93	568.64	0.002250	5.87	1277.68	970.97	0.35
Main_Reach	15286	10-Year	1970.00	560.00	566.89		567.00	0.001589	3.98	941.34	337.94	0.28
Main_Reach	15286	50-Year	3060.00	560.00	568.07		568.19	0.001520	4.36	1407.86	447.42	0.28
Main_Reach	15286	100-Year	3580.00	560.00	568.52		568.65	0.001445	4.43	1614.36	466.50	0.28
Main_Reach	15286	500-Year	5080.00	560.00	569.75		569.87	0.001233	4.50	2219.94	518.43	0.26
Main_Reach	15286	100-Year_Ult	4940.00	560.00	569.62		569.74	0.001268	4.52	2151.92	512.86	0.27

HEC-RAS Plan: Davis_Multi River: Davis Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	265	10-Year	460.00	543.56	549.19	547.81	549.51	0.005003	4.90	143.29	81.19	0.43
1	265	50-Year	760.00	543.56	550.17	549.01	550.54	0.005000	5.66	236.38	104.99	0.44
1	265	100-Year	890.00	543.56	550.52	549.27	550.91	0.004998	5.92	274.19	124.19	0.45
1	265	500-Year	1210.00	543.56	551.23	549.79	551.66	0.005002	6.43	377.95	156.73	0.46
1	265	100-Year Ult	1070.00	543.56	550.95	549.69	551.37	0.005010	6.24	335.52	149.51	0.46
1	357	10-Year	460.00	543.24	549.63	546.83	549.84	0.002688	3.81	158.05	89.63	0.32
1	357	50-Year	760.00	543.24	550.62	547.96	550.90	0.003043	4.63	251.96	101.97	0.35
1	357	100-Year	890.00	543.24	550.97	548.40	551.27	0.003151	4.90	288.36	106.52	0.36
1	357	500-Year	1210.00	543.24	551.65	549.79	552.04	0.003632	5.67	367.87	135.90	0.39
1	357	100-Year Ult	1070.00	543.24	551.40	549.48	551.74	0.003300	5.26	336.10	114.70	0.37
1	481	10-Year	460.00	544.98	550.00		550.51	0.009821	5.89	105.28	95.84	0.59
1	481	50-Year	760.00	544.98	551.06		551.49	0.006791	5.95	216.37	115.83	0.51
1	481	100-Year	890.00	544.98	551.42		551.84	0.006187	6.01	259.55	120.31	0.50
1	481	500-Year	1210.00	544.98	552.18		552.59	0.005455	6.25	353.86	129.25	0.48
1	481	100-Year Ult	1070.00	544.98	551.88		552.28	0.005615	6.10	315.62	125.16	0.48
1	638	10-Year	460.00	546.51	551.68	551.06	552.48	0.015097	7.31	77.46	76.45	0.72
1	638	50-Year	760.00	546.51	552.50	552.50	553.35	0.013792	8.13	162.52	118.04	0.71
1	638	100-Year	890.00	546.51	552.71	552.71	553.62	0.014358	8.59	188.54	123.52	0.73
1	638	500-Year	1210.00	546.51	553.04		554.23	0.018148	10.14	230.62	138.54	0.84
1	638	100-Year Ult	1070.00	546.51	552.77		554.00	0.019391	10.06	195.36	125.08	0.86
1	731	10-Year	460.00	548.33	553.13		553.76	0.012174	6.62	102.05	103.78	0.66
1	731	50-Year	760.00	548.33	553.88		554.52	0.011187	7.31	195.21	138.22	0.65
1	731	100-Year	890.00	548.33	554.16		554.78	0.010524	7.43	235.55	145.90	0.64
1	731	500-Year	1210.00	548.33	554.87		555.41	0.008438	7.39	345.58	169.85	0.59
1	731	100-Year Ult	1070.00	548.33	554.68		555.20	0.008284	7.12	313.20	167.07	0.58
1	956	10-Year	460.00	549.47	555.28		555.64	0.006022	5.32	152.17	161.39	0.46
1	956	50-Year	760.00	549.47	555.93		556.25	0.005619	5.67	268.09	193.86	0.46
1	956	100-Year	890.00	549.47	556.14		556.45	0.005531	5.79	309.64	201.00	0.46
1	956	500-Year	1210.00	549.47	556.58		556.88	0.005328	6.02	404.59	218.63	0.46
1	956	100-Year Ult	1070.00	549.47	556.38		556.70	0.005610	6.02	361.08	214.87	0.47
1	1365	10-Year	460.00	553.21	557.97		558.43	0.007712	5.49	95.78	57.09	0.53
1	1365	50-Year	760.00	553.21	558.61		559.27	0.009777	6.93	160.63	154.16	0.62
1	1365	100-Year	890.00	553.21	558.80		559.50	0.010133	7.28	192.86	179.00	0.63
1	1365	500-Year	1210.00	553.21	559.18		559.89	0.010445	7.84	274.74	235.28	0.65
1	1365	100-Year Ult	1070.00	553.21	559.06		559.75	0.010069	7.55	245.28	228.41	0.64
1	1873	10-Year	460.00	555.34	561.33	559.69	561.68	0.005407	4.85	113.27	143.34	0.45
1	1873	50-Year	760.00	555.34	562.03	560.79	562.28	0.004062	4.73	259.24	245.61	0.40
1	1873	100-Year	890.00	555.34	562.23	561.89	562.46	0.003887	4.77	309.64	270.14	0.40
1	1873	500-Year	1210.00	555.34	562.58	562.13	562.81	0.003808	4.96	408.10	289.81	0.40
1	1873	100-Year Ult	1070.00	555.34	562.43	562.03	562.67	0.003875	4.91	366.78	280.20	0.40
1	2234	10-Year	460.00	558.91	563.56	562.51	563.95	0.007379	5.09	101.91	134.81	0.52
1	2234	50-Year	760.00	558.91	564.00	563.87	564.61	0.010348	6.62	152.66	207.39	0.63
1	2234	100-Year	890.00	558.91	564.12	564.10	564.63	0.009480	6.48	210.32	246.55	0.61
1	2234	500-Year	1210.00	558.91	564.44	564.11	564.94	0.009411	6.84	307.46	331.31	0.62
1	2234	100-Year Ult	1070.00	558.91	564.32	564.11	564.83	0.009604	6.76	268.58	310.45	0.62
1	2457.	10-Year	310.00	561.55	565.38	564.99	565.64	0.007714	4.45	89.17	286.63	0.52
1	2457.	50-Year	440.00	561.55	566.03	565.33	566.19	0.004012	3.79	157.30	368.39	0.39
1	2457.	100-Year	500.00	561.55	566.07	565.48	566.27	0.004786	4.18	161.86	383.37	0.43
1	2457.	500-Year	650.00	561.55	566.37	565.77	566.59	0.004874	4.49	197.88	462.89	0.44
1	2457.	100-Year Ult	630.00	561.55	566.29	565.74	566.52	0.005182	4.56	188.35	434.65	0.45
1	2762	10-Year	310.00	564.07	567.82	567.18	568.10	0.008435	4.37	81.54	288.95	0.53
1	2762	50-Year	440.00	564.07	567.90	567.59	568.41	0.014606	5.89	87.54	329.69	0.71
1	2762	100-Year	500.00	564.07	568.11	567.86	568.59	0.012648	5.84	104.46	434.10	0.67
1	2762	500-Year	650.00	564.07	568.41	568.21	568.95	0.012638	6.32	129.65	503.92	0.68
1	2762	100-Year Ult	630.00	564.07	568.40	568.14	568.92	0.012077	6.16	128.78	502.27	0.67
1	3222	10-Year	310.00	567.55	571.84	571.82	572.13	0.009476	5.26	101.59	517.03	0.56
1	3222	50-Year	440.00	567.55	572.22	572.04	572.39	0.005911	4.53	176.73	645.38	0.45
1	3222	100-Year	500.00	567.55	572.29	572.10	572.47	0.006284	4.73	192.24	676.53	0.47
1	3222	500-Year	650.00	567.55	572.51	572.25	572.68	0.005914	4.81	248.35	754.00	0.46
1	3222	100-Year Ult	630.00	567.55	572.48	572.23	572.65	0.006127	4.86	239.39	741.80	0.46
1	3453	10-Year	310.00	569.96	573.96	573.83	574.25	0.008924	5.02	93.53	529.95	0.55
1	3453	50-Year	440.00	569.96	574.17	574.17	574.51	0.010290	5.69	123.49	634.71	0.60
1	3453	100-Year	500.00	569.96	574.24	574.24	574.60	0.010949	5.97	134.41	671.37	0.62
1	3453	500-Year	650.00	569.96	574.40	574.40	574.80	0.012113	6.51	161.22	705.57	0.66
1	3453	100-Year Ult	630.00	569.96	574.38	574.38	574.78	0.011901	6.43	158.18	702.64	0.65
1	3695	10-Year	310.00	572.98	575.92	575.61	576.03	0.006227	3.49	127.01	553.75	0.45

HEC-RAS Plan: Davis_Multi River: Davis Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	3695	50-Year	440.00	572.98	576.19	575.77	576.31	0.005683	3.65	171.37	694.04	0.44
1	3695	100-Year	500.00	572.98	576.29	575.83	576.41	0.005503	3.70	188.64	697.15	0.43
1	3695	500-Year	650.00	572.98	576.51	576.01	576.65	0.005332	3.86	226.57	705.13	0.43
1	3695	100-Year Ult	630.00	572.98	576.48	575.99	576.62	0.005348	3.84	221.81	703.80	0.43
1	4121	10-Year	310.00	577.20	579.54	579.27	579.80	0.012359	4.20	86.74	941.85	0.62
1	4121	50-Year	440.00	577.20	579.75	579.61	580.07	0.013836	4.86	111.30	965.78	0.67
1	4121	100-Year	500.00	577.20	579.83	579.72	580.18	0.014430	5.12	121.36	974.47	0.69
1	4121	500-Year	650.00	577.20	580.02	579.93	580.42	0.015117	5.62	147.31	1014.36	0.71
1	4121	100-Year Ult	630.00	577.20	579.99	579.90	580.39	0.015064	5.56	144.01	1009.75	0.71
1	4306	10-Year	310.00	577.72	580.99	580.39	581.09	0.004523	3.49	143.16	943.27	0.40
1	4306	50-Year	440.00	577.72	581.26	580.47	581.36	0.004211	3.62	196.67	1005.61	0.39
1	4306	100-Year	500.00	577.72	581.36	580.85	581.46	0.004078	3.65	218.39	1021.07	0.39
1	4306	500-Year	650.00	577.72	581.59	581.01	581.70	0.003925	3.77	270.92	1043.98	0.38
1	4306	100-Year Ult	630.00	577.72	581.56	581.01	581.67	0.003934	3.76	264.47	1039.73	0.38
1	4587	10-Year	310.00	578.77	582.18	581.49	582.28	0.003975	3.08	138.97	703.76	0.37
1	4587	50-Year	440.00	578.77	582.42	581.71	582.54	0.004236	3.42	172.92	715.02	0.39
1	4587	100-Year	500.00	578.77	582.52	581.81	582.65	0.004365	3.56	186.45	722.26	0.40
1	4587	500-Year	650.00	578.77	582.76	582.04	582.91	0.004650	3.90	222.36	760.53	0.41
1	4587	100-Year Ult	630.00	578.77	582.72	581.87	582.87	0.004634	3.86	217.27	758.48	0.41
1	4867	10-Year	310.00	580.24	583.78	583.73	584.06	0.010683	5.34	93.01	633.33	0.59
1	4867	50-Year	440.00	580.24	584.05	583.93	584.30	0.009336	5.33	128.00	649.09	0.56
1	4867	100-Year	500.00	580.24	584.15	584.00	584.40	0.008956	5.35	142.35	661.28	0.55
1	4867	500-Year	650.00	580.24	584.41	584.14	584.67	0.008363	5.47	180.00	695.25	0.54
1	4867	100-Year Ult	630.00	580.24	584.39	584.12	584.64	0.008315	5.43	176.20	692.05	0.54
1	5275	10-Year	310.00	583.24	585.51		585.55	0.001790	1.85	247.69	272.06	0.24
1	5275	50-Year	440.00	583.24	585.76		585.81	0.001935	2.10	321.39	314.13	0.26
1	5275	100-Year	500.00	583.24	585.86		585.91	0.001952	2.17	353.01	333.80	0.26
1	5275	500-Year	650.00	583.24	586.11		586.15	0.001989	2.36	441.45	389.90	0.27
1	5275	100-Year Ult	630.00	583.24	586.08		586.13	0.002001	2.35	430.97	385.42	0.27
1	5531	10-Year	270.00	585.29	586.44	586.43	586.77	0.037563	5.18	63.55	100.66	0.99
1	5531	50-Year	390.00	585.29	586.71		587.05	0.027340	5.34	93.62	128.18	0.88
1	5531	100-Year	440.00	585.29	586.80		587.13	0.025686	5.42	104.36	134.07	0.87
1	5531	500-Year	570.00	585.29	587.02		587.35	0.021033	5.49	140.18	182.99	0.81
1	5531	100-Year Ult	570.00	585.29	587.02		587.35	0.021276	5.51	139.55	182.67	0.81
1	5708	10-Year	270.00	586.67	588.91	588.51	589.03	0.006281	3.35	126.93	231.88	0.45
1	5708	50-Year	390.00	586.67	589.10	588.84	589.23	0.006923	3.78	174.97	263.53	0.48
1	5708	100-Year	440.00	586.67	589.16	588.90	589.30	0.007032	3.89	192.24	269.40	0.49
1	5708	500-Year	570.00	586.67	589.30	589.06	589.45	0.007550	4.22	229.27	278.09	0.51
1	5708	100-Year Ult	570.00	586.67	589.30	589.06	589.45	0.007503	4.21	229.83	278.26	0.51
1	6053	10-Year	270.00	589.71	592.13	591.81	592.33	0.015482	4.78	81.36	108.73	0.68
1	6053	50-Year	390.00	589.71	592.40		592.61	0.014233	5.12	117.13	150.30	0.67
1	6053	100-Year	440.00	589.71	592.50		592.71	0.014059	5.26	132.75	186.55	0.67
1	6053	500-Year	570.00	589.71	592.72		592.92	0.013406	5.52	177.85	227.18	0.66
1	6053	100-Year Ult	570.00	589.71	592.72		592.92	0.013483	5.53	177.39	226.75	0.67
1	6230	10-Year	270.00	592.60	593.81	593.38	593.87	0.005615	2.10	135.68	237.99	0.39
1	6230	50-Year	390.00	592.60	594.04		594.11	0.005512	2.42	200.38	326.05	0.40
1	6230	100-Year	440.00	592.60	594.11		594.18	0.005460	2.50	224.32	345.52	0.40
1	6230	500-Year	570.00	592.60	594.28		594.34	0.005281	2.68	282.55	368.34	0.40
1	6230	100-Year Ult	570.00	592.60	594.28		594.35	0.005270	2.67	282.78	368.36	0.40
1	6468	10-Year	270.00	593.37	594.98		595.03	0.004301	1.79	156.74	174.61	0.33
1	6468	50-Year	390.00	593.37	595.22		595.28	0.004594	1.97	203.83	232.85	0.35
1	6468	100-Year	440.00	593.37	595.31		595.37	0.004722	2.11	224.87	257.84	0.36
1	6468	500-Year	570.00	593.37	595.47		595.55	0.004984	2.39	271.61	298.52	0.38
1	6468	100-Year Ult	570.00	593.37	595.47		595.55	0.004988	2.39	271.52	298.46	0.38
1	6752	10-Year	270.00	594.93	596.73		596.82	0.009472	2.91	113.58	166.12	0.51
1	6752	50-Year	390.00	594.93	596.97		597.07	0.008605	3.20	159.56	202.37	0.50
1	6752	100-Year	440.00	594.93	597.06		597.16	0.008387	3.31	178.94	225.93	0.50
1	6752	500-Year	570.00	594.93	597.25		597.36	0.008038	3.54	224.37	257.89	0.50
1	6752	100-Year Ult	570.00	594.93	597.25		597.36	0.008032	3.54	224.43	257.94	0.50
1	6974	10-Year	270.00	596.75	598.14		598.20	0.004615	2.29	146.57	213.14	0.37
1	6974	50-Year	390.00	596.75	598.34		598.42	0.004750	2.58	193.29	243.64	0.38
1	6974	100-Year	440.00	596.75	598.42		598.50	0.004748	2.67	211.61	259.42	0.39
1	6974	500-Year	570.00	596.75	598.59		598.68	0.004830	2.89	259.56	297.33	0.40
1	6974	100-Year Ult	570.00	596.75	598.59		598.68	0.004832	2.89	259.52	297.29	0.40

HEC-RAS Plan: ESoapMultiP River: East_Soap Reach: East_Soap

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
East_Soap	766	2Year	680.00	585.59	590.99	589.12	591.19	0.004002	3.89	212.62	136.43	0.36
East_Soap	766	5-Year	1460.00	585.59	592.17	590.87	592.39	0.004005	4.55	537.26	390.30	0.37
East_Soap	766	10-Year	2000.00	585.59	592.62	591.74	592.84	0.004001	4.84	718.34	430.72	0.38
East_Soap	766	25-Year	2540.00	585.59	592.95	592.16	593.17	0.004000	5.05	864.06	460.67	0.38
East_Soap	766	50-Year	3000.00	585.59	593.22	592.28	593.45	0.004001	5.22	994.15	484.20	0.39
East_Soap	766	100-Year	3500.00	585.59	593.47	592.61	593.70	0.004002	5.37	1114.01	493.56	0.39
East_Soap	766	500-Year	4900.00	585.59	594.07	592.94	594.33	0.004001	5.73	1423.29	521.92	0.40
East_Soap	766	100-Year_Ult	5700.00	585.59	594.39	593.15	594.66	0.004002	5.91	1592.99	539.33	0.40
East_Soap	1539	2Year	680.00	588.68	593.81		594.01	0.003360	3.62	189.17	57.30	0.34
East_Soap	1539	5-Year	1460.00	588.68	595.32		595.74	0.004528	5.28	309.29	140.77	0.41
East_Soap	1539	10-Year	2000.00	588.68	595.91		596.44	0.005196	6.09	442.15	312.84	0.45
East_Soap	1539	25-Year	2540.00	588.68	596.32		596.89	0.005555	6.59	579.19	356.68	0.47
East_Soap	1539	50-Year	3000.00	588.68	596.62		597.19	0.005666	6.87	687.84	375.58	0.48
East_Soap	1539	100-Year	3500.00	588.68	596.90		597.49	0.005786	7.14	796.33	395.62	0.49
East_Soap	1539	500-Year	4900.00	588.68	597.54		598.16	0.005981	7.73	1056.25	406.14	0.50
East_Soap	1539	100-Year_Ult	5700.00	588.68	597.87		598.50	0.006023	7.98	1191.54	421.16	0.51
East_Soap	2029	2Year	680.00	590.72	595.70	593.87	595.93	0.004568	3.88	175.55	57.96	0.38
East_Soap	2029	5-Year	1460.00	590.72	597.41	595.28	597.67	0.003435	4.46	442.21	224.17	0.36
East_Soap	2029	10-Year	2000.00	590.72	598.13	596.50	598.39	0.003048	4.61	615.64	440.15	0.34
East_Soap	2029	25-Year	2540.00	590.72	598.64	597.14	598.91	0.003092	4.92	796.73	627.66	0.35
East_Soap	2029	50-Year	3000.00	590.72	598.97	597.50	599.25	0.003123	5.12	928.20	655.46	0.36
East_Soap	2029	100-Year	3500.00	590.72	599.28	597.74	599.57	0.003162	5.32	1056.10	678.73	0.36
East_Soap	2029	500-Year	4900.00	590.72	600.01	598.54	600.34	0.003336	5.85	1360.14	766.52	0.38
East_Soap	2029	100-Year_Ult	5700.00	590.72	600.37	598.88	600.71	0.003419	6.11	1512.25	792.04	0.39
East_Soap	2360	2Year	680.00	592.59	597.24	595.54	597.43	0.004436	3.46	196.64	72.56	0.37
East_Soap	2360	5-Year	1460.00	592.59	598.76	596.75	599.09	0.004829	4.61	320.14	91.73	0.41
East_Soap	2360	10-Year	2000.00	592.59	599.40	597.42	599.85	0.005365	5.38	384.00	126.85	0.44
East_Soap	2360	25-Year	2540.00	592.59	599.94	597.97	600.48	0.005723	5.98	488.53	305.16	0.47
East_Soap	2360	50-Year	3000.00	592.59	600.29	598.35	600.89	0.005975	6.39	586.91	351.85	0.48
East_Soap	2360	100-Year	3500.00	592.59	600.64	598.77	601.27	0.006049	6.70	687.02	365.46	0.49
East_Soap	2360	500-Year	4900.00	592.59	601.48	600.50	602.08	0.005516	7.00	1079.11	419.26	0.48
East_Soap	2360	100-Year_Ult	5700.00	592.59	601.89	600.88	602.50	0.005449	7.24	1258.59	454.35	0.48
East_Soap	2588	2Year	710.00	593.94	598.18	596.32	598.38	0.003910	3.59	198.73	80.47	0.36
East_Soap	2588	5-Year	1470.00	593.94	599.76	597.47	600.10	0.004062	4.72	331.19	230.12	0.39
East_Soap	2588	10-Year	2000.00	593.94	600.52	598.23	600.94	0.004296	5.37	403.11	242.44	0.41
East_Soap	2588	25-Year	2550.00	593.94	601.13	598.85	601.65	0.004682	6.02	465.30	330.04	0.43
East_Soap	2588	50-Year	3000.00	593.94	601.53	599.37	602.15	0.005057	6.54	522.77	484.37	0.45
East_Soap	2588	100-Year	3400.00	593.94	601.89	599.70	602.56	0.005189	6.86	580.03	492.50	0.46
East_Soap	2588	500-Year	5000.00	593.94	602.65	600.87	603.40	0.005764	7.77	985.81	535.49	0.50
East_Soap	2588	100-Year_Ult	6100.00	593.94	603.05	601.91	603.91	0.006420	8.49	1142.65	556.93	0.53
East_Soap	2629	2Year	710.00	593.77	598.34	596.56	598.55	0.004194	3.68	192.96	109.08	0.37
East_Soap	2629	5-Year	1470.00	593.77	599.90	597.74	600.29	0.004686	5.01	295.82	214.53	0.41
East_Soap	2629	10-Year	2000.00	593.77	600.64	598.42	601.17	0.005201	5.83	354.13	236.02	0.45
East_Soap	2629	25-Year	2550.00	593.77	601.25	599.01	601.91	0.005741	6.59	407.94	275.43	0.48
East_Soap	2629	50-Year	3000.00	593.77	601.64	599.42	602.43	0.006274	7.19	444.97	413.54	0.50
East_Soap	2629	100-Year	3400.00	593.77	601.98	599.81	602.86	0.006666	7.67	480.29	454.67	0.52
East_Soap	2629	500-Year	5000.00	593.77	602.71	601.32	603.77	0.007834	8.92	824.36	566.73	0.58
East_Soap	2629	100-Year_Ult	6100.00	593.77	603.15	602.35	604.30	0.008360	9.57	978.12	600.11	0.60
East_Soap	2692	2Year	710.00	593.69	598.63	596.99	598.95	0.005984	4.60	154.46	45.22	0.44
East_Soap	2692	5-Year	1470.00	593.69	600.23	598.40	600.86	0.007862	6.36	231.29	50.48	0.52
East_Soap	2692	10-Year	2000.00	593.69	601.00	599.19	601.85	0.009199	7.37	271.28	53.05	0.57
East_Soap	2692	25-Year	2550.00	593.69	601.64	599.91	602.72	0.010503	8.34	305.72	59.66	0.62
East_Soap	2692	50-Year	3000.00	593.69	602.07	600.45	603.36	0.011444	9.12	329.76	179.93	0.66
East_Soap	2692	100-Year	3400.00	593.69	602.41	600.92	603.89	0.012156	9.76	350.16	316.62	0.68
East_Soap	2692	500-Year	5000.00	593.69	603.24	602.53	604.75	0.012458	10.72	746.45	405.89	0.71
East_Soap	2692	100-Year_Ult	6100.00	593.69	604.03	604.03	605.16	0.009396	9.98	1089.39	462.72	0.62
East_Soap	2716	2Year	710.00	592.93	598.83	596.42	599.09	0.003676	4.04	175.81	42.50	0.35
East_Soap	2716	5-Year	1470.00	592.93	600.51	597.92	601.04	0.005609	5.87	250.25	46.41	0.45
East_Soap	2716	10-Year	2000.00	592.93	601.33	598.78	602.07	0.006899	6.92	288.92	48.57	0.50
East_Soap	2716	25-Year	2550.00	592.93	602.01	599.57	602.98	0.008225	7.90	322.86	50.72	0.55
East_Soap	2716	50-Year	3000.00	592.93	602.47	600.16	603.64	0.009025	8.66	346.96	76.65	0.58
East_Soap	2716	100-Year	3400.00	592.93	602.86	600.64	604.19	0.009661	9.29	367.62	258.62	0.61
East_Soap	2716	500-Year	5000.00	592.93	604.04	604.04	605.29	0.008752	9.78	827.23	402.03	0.60
East_Soap	2716	100-Year_Ult	6100.00	592.93	604.52	604.52	605.81	0.009039	10.32	1029.18	431.02	0.61
East_Soap	2740		Bridge									
East_Soap	2780	2Year	710.00	592.88	599.70	596.61	599.78	0.001063	2.34	310.71	122.90	0.20
East_Soap	2780	5-Year	1470.00	592.88	601.55	597.70	601.72	0.001391	3.37	460.10	180.94	0.24
East_Soap	2780	10-Year	2000.00	592.88	602.78	598.29	602.99	0.001357	3.75	592.35	264.62	0.24
East_Soap	2780	25-Year	2550.00	592.88	605.22	598.83	605.32	0.000535	2.84	1155.56	667.06	0.16
East_Soap	2780	50-Year	3000.00	592.88	605.86	599.22	605.97	0.000577	3.08	1258.04	693.51	0.17
East_Soap	2780	100-Year	3400.00	592.88	606.16	599.56	606.30	0.000662	3.36	1306.64	719.57	0.18
East_Soap	2780	500-Year	5000.00	592.88	606.62	600.81	606.75	0.000806	3.81	2296.10	748.88	0.20

HEC-RAS Plan: ESoapMultiP River: East_Soap Reach: East_Soap (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
East_Soap	2780	100-Year_Ult	6100.00	592.88	607.13	601.63	607.29	0.000935	4.22	2517.53	800.56	0.22
East_Soap	2820	2Year	710.00	593.78	599.78	596.67	599.83	0.000617	1.69	419.75	154.44	0.15
East_Soap	2820	5-Year	1470.00	593.78	601.69	597.54	601.78	0.000725	2.38	623.60	188.97	0.17
East_Soap	2820	10-Year	2000.00	593.78	602.95	597.97	603.05	0.000700	2.65	793.72	265.72	0.17
East_Soap	2820	25-Year	2550.00	593.78	605.30	598.38	605.35	0.000244	1.81	1665.55	530.20	0.11
East_Soap	2820	50-Year	3000.00	593.78	605.96	598.69	606.01	0.000257	1.95	1835.49	575.14	0.11
East_Soap	2820	100-Year	3400.00	593.78	606.28	598.96	606.34	0.000291	2.12	1919.20	618.10	0.12
East_Soap	2820	500-Year	5000.00	593.78	606.72	599.92	606.80	0.000421	2.63	2776.41	653.10	0.14
East_Soap	2820	100-Year_Ult	6100.00	593.78	607.24	600.49	607.34	0.000496	2.94	3038.13	709.29	0.16
East_Soap	3347	2Year	650.00	595.37	600.16	597.56	600.29	0.001219	2.87	260.45	132.67	0.25
East_Soap	3347	5-Year	1350.00	595.37	602.09	598.71	602.25	0.001048	3.44	554.98	158.97	0.25
East_Soap	3347	10-Year	1800.00	595.37	603.31	599.36	603.46	0.000856	3.52	754.38	168.54	0.23
East_Soap	3347	25-Year	2340.00	595.37	605.42	600.30	605.55	0.000545	3.33	1171.46	263.36	0.19
East_Soap	3347	50-Year	2700.00	595.37	606.08	600.77	606.21	0.000529	3.43	1347.23	293.41	0.19
East_Soap	3347	100-Year	3200.00	595.37	606.41	601.17	606.58	0.000648	3.88	1441.31	312.05	0.21
East_Soap	3347	500-Year	4600.00	595.37	606.88	602.08	607.18	0.001117	5.25	1580.14	352.99	0.28
East_Soap	3347	100-Year_Ult	5500.00	595.37	607.42	602.57	607.78	0.001269	5.79	1754.59	378.10	0.30
East_Soap	3588	2Year	650.00	596.60	600.48	599.86	600.98	0.007263	5.97	152.70	106.26	0.59
East_Soap	3588	5-Year	1350.00	596.60	602.33	601.18	602.71	0.003816	5.88	387.53	138.86	0.46
East_Soap	3588	10-Year	1800.00	596.60	603.49	601.75	603.80	0.002599	5.58	552.02	144.24	0.40
East_Soap	3588	25-Year	2340.00	596.60	605.53	602.21	605.73	0.001273	4.72	856.86	162.96	0.29
East_Soap	3588	50-Year	2700.00	596.60	606.17	602.48	606.39	0.001245	4.91	967.90	190.06	0.29
East_Soap	3588	100-Year	3200.00	596.60	606.53	602.83	606.80	0.001493	5.52	1040.01	211.12	0.32
East_Soap	3588	500-Year	4600.00	596.60	607.08	603.66	607.54	0.002387	7.25	1166.32	240.37	0.41
East_Soap	3588	100-Year_Ult	5500.00	596.60	607.65	604.16	608.18	0.002611	7.88	1306.29	250.06	0.43
East_Soap	3633	2Year	650.00	597.31	600.78		601.34	0.008431	6.13	123.72	69.66	0.63
East_Soap	3633	5-Year	1350.00	597.31	602.33		603.01	0.006598	7.19	271.88	109.41	0.60
East_Soap	3633	10-Year	1800.00	597.31	603.45		604.02	0.004505	6.89	399.83	118.76	0.51
East_Soap	3633	25-Year	2340.00	597.31	605.49		605.84	0.002054	5.72	658.26	139.53	0.36
East_Soap	3633	50-Year	2700.00	597.31	606.14		606.50	0.001932	5.85	751.47	149.12	0.36
East_Soap	3633	100-Year	3200.00	597.31	606.48		606.93	0.002271	6.52	805.38	166.30	0.39
East_Soap	3633	500-Year	4600.00	597.31	607.00		607.75	0.003625	8.57	901.22	198.53	0.50
East_Soap	3633	100-Year_Ult	5500.00	597.31	607.55		608.41	0.004003	9.36	1013.61	213.09	0.53
East_Soap	3765	2Year	650.00	598.22	601.89		602.11	0.003464	3.93	201.80	95.28	0.41
East_Soap	3765	5-Year	1350.00	598.22	603.35		603.68	0.003297	5.03	350.17	109.14	0.43
East_Soap	3765	10-Year	1800.00	598.22	604.15		604.54	0.003161	5.51	441.29	120.04	0.43
East_Soap	3765	25-Year	2340.00	598.22	605.74		606.10	0.002094	5.37	681.31	202.43	0.36
East_Soap	3765	50-Year	2700.00	598.22	606.37		606.73	0.001919	5.46	818.67	239.73	0.35
East_Soap	3765	100-Year	3200.00	598.22	606.78		607.20	0.002132	5.96	921.10	260.53	0.38
East_Soap	3765	500-Year	4600.00	598.22	607.60		608.17	0.002701	7.18	1142.78	276.86	0.43
East_Soap	3765	100-Year_Ult	5500.00	598.22	608.27		608.88	0.002736	7.59	1337.37	305.29	0.44
East_Soap	3816		Culvert									
East_Soap	3843	2Year	650.00	602.40	607.53	604.46	607.58	0.000545	1.87	347.70	124.97	0.17
East_Soap	3843	5-Year	1350.00	602.40	610.24	605.42	610.28	0.000275	1.90	1050.29	535.92	0.13
East_Soap	3843	10-Year	1800.00	602.40	610.58	605.93	610.65	0.000372	2.29	1201.30	552.80	0.15
East_Soap	3843	25-Year	2340.00	602.40	610.86	606.44	610.95	0.000509	2.75	1323.58	565.06	0.18
East_Soap	3843	50-Year	2700.00	602.40	611.07	606.72	611.18	0.000579	2.99	1417.88	580.76	0.19
East_Soap	3843	100-Year	3200.00	602.40	611.31	607.09	611.44	0.000690	3.34	1520.02	586.27	0.21
East_Soap	3843	500-Year	4600.00	602.40	611.87	608.02	612.06	0.000982	4.17	1767.81	674.26	0.26
East_Soap	3843	100-Year_Ult	5500.00	602.40	612.12	608.57	612.36	0.001195	4.70	1882.26	685.88	0.29
East_Soap	3895	2Year	650.00	602.51	607.52	604.86	607.68	0.001652	3.19	203.89	54.29	0.29
East_Soap	3895	5-Year	1350.00	602.51	610.20	606.20	610.37	0.000999	3.53	513.27	243.65	0.24
East_Soap	3895	10-Year	1800.00	602.51	610.52	606.90	610.78	0.001414	4.34	609.28	361.75	0.29
East_Soap	3895	25-Year	2340.00	602.51	610.77	607.60	611.14	0.002015	5.30	711.85	468.41	0.35
East_Soap	3895	50-Year	2700.00	602.51	610.98	607.99	611.39	0.002238	5.70	809.51	501.86	0.37
East_Soap	3895	100-Year	3200.00	602.51	611.19	608.87	611.68	0.002623	6.29	914.11	506.75	0.40
East_Soap	3895	500-Year	4600.00	602.51	611.75	610.62	612.35	0.003261	7.36	1185.20	596.12	0.46
East_Soap	3895	100-Year_Ult	5500.00	602.51	612.01	611.50	612.69	0.003747	8.06	1309.05	641.65	0.49
East_Soap	3932	2Year	650.00	603.24	607.52	605.89	607.81	0.003867	4.34	149.94	46.77	0.43
East_Soap	3932	5-Year	1350.00	603.24	610.18	607.24	610.45	0.001838	4.38	413.02	232.98	0.32
East_Soap	3932	10-Year	1800.00	603.24	610.51	607.95	610.88	0.002461	5.27	506.18	347.81	0.38
East_Soap	3932	25-Year	2340.00	603.24	610.76	608.63	611.28	0.003328	6.30	605.04	413.93	0.44
East_Soap	3932	50-Year	2700.00	603.24	610.98	609.68	611.54	0.003618	6.71	696.70	455.72	0.46
East_Soap	3932	100-Year	3200.00	603.24	611.21	610.42	611.85	0.004060	7.28	804.43	510.92	0.49
East_Soap	3932	500-Year	4600.00	603.24	611.81	611.55	612.54	0.004727	8.32	1108.71	606.92	0.54
East_Soap	3932	100-Year_Ult	5500.00	603.24	612.12	611.89	612.87	0.004984	8.78	1268.49	692.03	0.56
East_Soap	4016	2Year	650.00	602.59	607.80	605.96	608.17	0.004183	4.92	133.16	42.91	0.45
East_Soap	4016	5-Year	1350.00	602.59	610.31	607.65	610.64	0.002249	5.09	442.30	293.99	0.36
East_Soap	4016	10-Year	1800.00	602.59	610.72	608.54	611.10	0.002621	5.73	590.43	462.93	0.39
East_Soap	4016	25-Year	2340.00	602.59	611.15	610.35	611.56	0.002787	6.16	817.95	553.09	0.41
East_Soap	4016	50-Year	2700.00	602.59	611.47	610.76	611.83	0.002546	6.07	998.19	608.77	0.39

HEC-RAS Plan: ESoapMultiP River: East_Soap Reach: East_Soap (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
East_Soap	4016	100-Year	3200.00	602.59	611.81	610.94	612.14	0.002456	6.14	1203.58	682.75	0.39
East_Soap	4016	500-Year	4600.00	602.59	612.56	611.63	612.86	0.002322	6.35	1671.56	758.22	0.38
East_Soap	4016	100-Year_Ult	5500.00	602.59	612.90	611.97	613.21	0.002404	6.64	1887.82	785.05	0.39
East_Soap	4094	2Year	650.00	603.00	608.12	606.40	608.49	0.003985	4.90	134.63	41.73	0.44
East_Soap	4094	5-Year	1350.00	603.00	610.58	607.95	610.85	0.001907	4.73	552.58	436.54	0.33
East_Soap	4094	10-Year	1800.00	603.00	611.11	609.03	611.36	0.001839	4.90	813.16	546.57	0.33
East_Soap	4094	25-Year	2340.00	603.00	611.61	610.53	611.82	0.001691	4.92	1115.95	648.68	0.32
East_Soap	4094	50-Year	2700.00	603.00	611.89	610.90	612.09	0.001640	4.97	1295.52	706.66	0.32
East_Soap	4094	100-Year	3200.00	603.00	612.22	611.15	612.41	0.001572	5.01	1524.96	753.08	0.31
East_Soap	4094	500-Year	4600.00	603.00	612.95	611.68	613.13	0.001554	5.28	2025.31	813.47	0.32
East_Soap	4094	100-Year_Ult	5500.00	603.00	613.30	611.78	613.49	0.001605	5.51	2273.20	829.40	0.32
East_Soap	4363	2Year	650.00	603.25	609.22	607.73	609.45	0.003124	3.88	172.25	62.97	0.39
East_Soap	4363	5-Year	1350.00	603.25	611.14	608.83	611.38	0.001994	4.26	486.63	317.05	0.33
East_Soap	4363	10-Year	1800.00	603.25	611.63	609.47	611.89	0.002145	4.69	642.52	406.20	0.35
East_Soap	4363	25-Year	2340.00	603.25	612.08	610.43	612.36	0.002258	5.07	815.40	503.83	0.37
East_Soap	4363	50-Year	2700.00	603.25	612.33	611.03	612.66	0.002498	5.49	928.82	603.64	0.39
East_Soap	4363	100-Year	3200.00	603.25	612.64	611.37	612.98	0.002586	5.76	1078.26	636.95	0.40
East_Soap	4363	500-Year	4600.00	603.25	613.35	611.94	613.71	0.002737	6.35	1450.43	733.90	0.41
East_Soap	4363	100-Year_Ult	5500.00	603.25	613.72	612.66	614.09	0.002797	6.63	1647.33	799.43	0.42
East_Soap	4765	2Year	660.00	604.00	610.04		610.13	0.001042	2.44	279.65	110.41	0.23
East_Soap	4765	5-Year	1360.00	604.00	611.78		611.89	0.000839	2.84	644.88	285.27	0.22
East_Soap	4765	10-Year	1900.00	604.00	612.33		612.46	0.000992	3.30	808.26	310.80	0.24
East_Soap	4765	25-Year	2420.00	604.00	612.82		612.97	0.001065	3.60	966.37	336.00	0.25
East_Soap	4765	50-Year	2900.00	604.00	613.15		613.32	0.001160	3.89	1078.28	341.73	0.26
East_Soap	4765	100-Year	3400.00	604.00	613.49		613.68	0.001225	4.12	1195.14	356.39	0.27
East_Soap	4765	500-Year	4700.00	604.00	614.25		614.48	0.001381	4.69	1480.67	385.74	0.29
East_Soap	4765	100-Year_Ult	5800.00	604.00	614.66		614.94	0.001666	5.32	1642.92	420.13	0.33
East_Soap	5135	2Year	660.00	604.34	610.72		610.98	0.006780	4.20	166.79	103.68	0.52
East_Soap	5135	5-Year	1360.00	604.34	612.24		612.46	0.003079	4.12	416.71	211.43	0.39
East_Soap	5135	10-Year	1900.00	604.34	612.84		613.09	0.002973	4.50	558.32	257.45	0.39
East_Soap	5135	25-Year	2420.00	604.34	613.35		613.62	0.002872	4.77	694.02	291.88	0.39
East_Soap	5135	50-Year	2900.00	604.34	613.71		614.00	0.002869	5.02	805.34	324.74	0.40
East_Soap	5135	100-Year	3400.00	604.34	614.07		614.38	0.002917	5.30	930.44	373.72	0.40
East_Soap	5135	500-Year	4700.00	604.34	614.88		615.20	0.002713	5.61	1265.92	441.86	0.40
East_Soap	5135	100-Year_Ult	5800.00	604.34	615.39		615.73	0.002729	5.93	1506.86	493.24	0.40
East_Soap	5749	2Year	660.00	608.21	612.73		612.84	0.001728	3.26	274.31	93.32	0.30
East_Soap	5749	5-Year	1360.00	608.21	614.05		614.29	0.002997	5.26	445.22	181.79	0.41
East_Soap	5749	10-Year	1900.00	608.21	614.70		615.00	0.003348	6.03	582.00	231.26	0.45
East_Soap	5749	25-Year	2420.00	608.21	615.20		615.51	0.003447	6.47	716.82	322.61	0.46
East_Soap	5749	50-Year	2900.00	608.21	615.65		616.01	0.003885	7.20	884.59	410.57	0.49
East_Soap	5749	100-Year	3400.00	608.21	616.03		616.40	0.003897	7.49	1052.33	466.46	0.50
East_Soap	5749	500-Year	4700.00	608.21	616.72		617.07	0.003649	7.71	1398.69	547.36	0.49
East_Soap	5749	100-Year_Ult	5800.00	608.21	617.23		617.57	0.003517	7.90	1688.87	594.36	0.49
East_Soap	5930	2Year	660.00	608.70	613.05		613.14	0.001747	3.07	296.82	110.48	0.30
East_Soap	5930	5-Year	1360.00	608.70	614.55		614.71	0.001915	4.12	474.97	135.85	0.33
East_Soap	5930	10-Year	1900.00	608.70	615.29		615.54	0.002979	5.64	617.92	275.30	0.42
East_Soap	5930	25-Year	2420.00	608.70	615.80		616.11	0.003465	6.45	777.17	342.08	0.46
East_Soap	5930	50-Year	2900.00	608.70	616.33		616.61	0.003072	6.42	970.20	402.18	0.44
East_Soap	5930	100-Year	3400.00	608.70	616.71		616.99	0.002935	6.51	1131.46	438.13	0.43
East_Soap	5930	500-Year	4700.00	608.70	617.35		617.67	0.003290	7.31	1434.95	511.23	0.47
East_Soap	5930	100-Year_Ult	5800.00	608.70	617.83		618.16	0.003322	7.64	1691.30	557.75	0.47
East_Soap	6027	2Year	660.00	609.26	613.21		613.29	0.001482	2.75	341.66	163.07	0.27
East_Soap	6027	5-Year	1360.00	609.26	614.75		614.86	0.001213	3.23	628.13	205.59	0.26
East_Soap	6027	10-Year	1900.00	609.26	615.61		615.73	0.001246	3.66	846.60	306.38	0.27
East_Soap	6027	25-Year	2420.00	609.26	616.18		616.31	0.001240	3.89	1029.19	328.65	0.28
East_Soap	6027	50-Year	2900.00	609.26	616.66		616.81	0.001300	4.19	1195.75	379.36	0.29
East_Soap	6027	100-Year	3400.00	609.26	617.02		617.19	0.001383	4.48	1341.59	434.85	0.30
East_Soap	6027	500-Year	4700.00	609.26	617.68		617.90	0.001683	5.25	1648.46	494.84	0.33
East_Soap	6027	100-Year_Ult	5800.00	609.26	618.14		618.40	0.001951	5.88	1898.10	563.37	0.36

HEC-RAS Plan: Edge_Multi River: Edge_Creek_River Reach: Reach_1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	958	10-Year	140.00	532.00	533.22	532.82	533.33	0.011002	2.57	54.57	63.28	0.49
Reach_1	958	50-Year	200.00	532.00	533.46	533.00	533.59	0.011011	2.84	70.51	70.35	0.50
Reach_1	958	100-Year	320.00	532.00	533.84	533.29	534.00	0.011014	3.23	99.16	81.54	0.52
Reach_1	958	500-Year	870.00	532.00	534.72	534.26	535.01	0.011001	4.50	237.67	216.97	0.56
Reach_1	958	100-Year_Ult	630.00	532.00	534.42	533.84	534.67	0.011006	4.04	177.62	184.14	0.55
Reach_1	1475	10-Year	140.00	537.52	538.41		538.47	0.008995	1.99	73.37	115.84	0.42
Reach_1	1475	50-Year	160.00	537.52	538.49	538.16	538.55	0.008156	2.03	82.30	117.05	0.41
Reach_1	1475	100-Year	300.00	537.52	538.82	538.37	538.92	0.008234	2.60	122.15	122.28	0.44
Reach_1	1475	500-Year	830.00	537.52	539.69		539.91	0.008264	3.85	234.38	133.90	0.48
Reach_1	1475	100-Year_Ult	600.00	537.52	539.36	538.73	539.53	0.008133	3.39	191.12	129.98	0.47
Reach_1	1654	10-Year	140.00	549.27	550.06	550.06	550.29	0.057332	3.85	36.74	87.06	1.00
Reach_1	1654	50-Year	160.00	549.27	550.10	550.10	550.35	0.054957	4.00	40.58	87.80	0.99
Reach_1	1654	100-Year	300.00	549.27	550.36	550.36	550.72	0.047308	4.89	63.57	91.55	0.99
Reach_1	1654	500-Year	830.00	549.27	551.06	551.06	551.74	0.037832	6.77	130.90	100.09	0.99
Reach_1	1654	100-Year_Ult	600.00	549.27	550.78	550.78	551.34	0.040924	6.11	103.58	96.69	0.99
Reach_1	1877	10-Year	140.00	558.16	559.04	558.99	559.24	0.029678	3.59	39.05	77.96	0.89
Reach_1	1877	50-Year	160.00	558.16	559.08	559.04	559.30	0.030645	3.80	42.10	78.87	0.92
Reach_1	1877	100-Year	300.00	558.16	559.32	559.32	559.68	0.034283	4.82	62.23	88.76	1.01
Reach_1	1877	500-Year	830.00	558.16	560.02	560.02	560.66	0.027685	6.43	129.18	102.18	1.01
Reach_1	1877	100-Year_Ult	600.00	558.16	559.75	559.75	560.29	0.029771	5.88	101.95	96.96	1.01
Reach_1	1960	10-Year	140.00	555.60	559.31		559.31	0.000059	0.41	338.42	119.45	0.04
Reach_1	1960	50-Year	160.00	555.60	559.39		559.39	0.000071	0.46	347.26	120.20	0.05
Reach_1	1960	100-Year	300.00	555.60	559.83		559.83	0.000166	0.75	401.47	127.07	0.07
Reach_1	1960	500-Year	830.00	555.60	560.95		560.98	0.000530	1.49	555.74	148.52	0.14
Reach_1	1960	100-Year_Ult	600.00	555.60	560.52		560.54	0.000380	1.21	494.17	140.35	0.11
Reach_1	2060	10-Year	950.00	556.00	559.30	558.23	559.51	0.006215	3.65	260.26	1130.13	0.43
Reach_1	2060	50-Year	1670.00	556.00	559.29	558.87	559.93	0.019519	6.45	258.85	1129.17	0.76
Reach_1	2060	100-Year	2020.00	556.00	559.73	559.15	560.38	0.016538	6.49	311.21	1156.70	0.71
Reach_1	2060	500-Year	2850.00	556.00	560.88	559.75	561.47	0.009546	6.20	473.70	1206.89	0.57
Reach_1	2060	100-Year_Ult	2780.00	556.00	560.40	559.70	561.16	0.014768	7.02	402.79	1199.91	0.70
Reach_1	3803	10-Year	950.00	548.00	559.54		559.54	0.000002	0.16	6167.16	693.85	0.01
Reach_1	3803	50-Year	1670.00	548.00	560.03		560.03	0.000004	0.26	6508.39	704.24	0.01
Reach_1	3803	100-Year	2020.00	548.00	560.48		560.48	0.000005	0.30	6833.42	715.45	0.02
Reach_1	3803	500-Year	2850.00	548.00	561.57		561.57	0.000008	0.39	7627.98	743.31	0.02
Reach_1	3803	100-Year_Ult	2780.00	548.00	561.29		561.29	0.000008	0.39	7417.25	735.89	0.02
Reach_1	4220	10-Year	950.00	550.00	559.54		559.54	0.000008	0.27	3507.16	553.79	0.02
Reach_1	4220	50-Year	1670.00	550.00	560.03		560.03	0.000020	0.45	3780.80	564.61	0.03
Reach_1	4220	100-Year	2020.00	550.00	560.49		560.49	0.000023	0.51	4041.72	574.19	0.03
Reach_1	4220	500-Year	2850.00	550.00	561.58		561.58	0.000030	0.62	4680.36	597.01	0.04
Reach_1	4220	100-Year_Ult	2780.00	550.00	561.29		561.30	0.000031	0.63	4511.19	591.25	0.04
Reach_1	4613	10-Year	1010.00	552.00	559.54		559.54	0.000020	0.38	2708.65	527.59	0.03
Reach_1	4613	50-Year	1670.00	552.00	560.04		560.04	0.000041	0.57	2972.72	539.97	0.04
Reach_1	4613	100-Year	2010.00	552.00	560.50		560.50	0.000046	0.64	3223.08	549.07	0.04
Reach_1	4613	500-Year	2770.00	552.00	561.59		561.60	0.000051	0.74	3834.78	570.55	0.05
Reach_1	4613	100-Year_Ult	2780.00	552.00	561.31		561.31	0.000059	0.78	3673.74	564.99	0.05
Reach_1	5024	10-Year	190.00	556.00	559.55	557.24	559.55	0.000048	0.38	681.17	282.98	0.04
Reach_1	5024	50-Year	360.00	556.00	560.06	557.78	560.06	0.000099	0.61	831.01	323.83	0.06
Reach_1	5024	100-Year	470.00	556.00	560.52	558.00	560.53	0.000105	0.69	984.44	338.99	0.06
Reach_1	5024	500-Year	720.00	556.00	561.62	558.00	561.62	0.000096	0.77	1376.55	376.29	0.06
Reach_1	5024	100-Year_Ult	680.00	556.00	561.34	558.00	561.34	0.000107	0.79	1272.67	366.80	0.06
Reach_1	5531	10-Year	190.00	560.00	562.26	562.26	562.44	0.013853	3.93	93.05	277.00	0.59
Reach_1	5531	50-Year	360.00	560.00	562.46	562.46	562.69	0.018857	5.01	145.26	308.76	0.70
Reach_1	5531	100-Year	470.00	560.00	562.58	562.58	562.80	0.018491	5.21	193.97	341.27	0.70
Reach_1	5531	500-Year	720.00	560.00	562.73	562.73	563.00	0.022853	6.13	246.02	344.05	0.79
Reach_1	5531	100-Year_Ult	680.00	560.00	562.71	562.71	562.97	0.022292	6.00	238.22	343.63	0.78
Reach_1	6259	10-Year	190.00	566.00	567.40	567.39	567.43	0.004661	1.20	158.97	304.39	0.29
Reach_1	6259	50-Year	360.00	566.00	567.67	567.40	567.71	0.004346	1.48	242.75	319.08	0.30
Reach_1	6259	100-Year	470.00	566.00	567.79	567.39	567.84	0.004601	1.67	281.98	324.64	0.32
Reach_1	6259	500-Year	720.00	566.00	568.07	567.44	568.13	0.004440	1.92	374.24	338.22	0.32
Reach_1	6259	100-Year_Ult	680.00	566.00	568.03	567.42	568.09	0.004462	1.89	360.44	336.67	0.32
Reach_1	6443	10-Year	190.00	566.00	568.27	568.00	568.30	0.004813	1.39	136.97	214.58	0.31
Reach_1	6443	50-Year	360.00	566.00	568.55	568.06	568.60	0.005418	1.82	198.21	226.54	0.34
Reach_1	6443	100-Year	470.00	566.00	568.70	568.16	568.77	0.005512	2.01	234.10	233.19	0.35
Reach_1	6443	500-Year	720.00	566.00	568.99	568.34	569.08	0.005909	2.38	302.18	245.31	0.38

HEC-RAS Plan: Edge_Multi River: Edge_Creek_River Reach: Reach_1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	6443	100-Year_Ult	680.00	566.00	568.95	568.31	569.03	0.005852	2.33	292.00	243.54	0.37
Reach_1	6773	10-Year	240.00	570.00	570.95		571.04	0.014448	2.43	98.97	153.32	0.53
Reach_1	6773	50-Year	350.00	570.00	571.15		571.26	0.013291	2.68	130.57	163.47	0.53
Reach_1	6773	100-Year	400.00	570.00	571.23		571.35	0.012857	2.78	144.01	166.74	0.53
Reach_1	6773	500-Year	530.00	570.00	571.45		571.58	0.011245	2.93	181.16	175.49	0.51
Reach_1	6773	100-Year_Ult	570.00	570.00	571.48		571.63	0.011742	3.04	187.31	176.68	0.52
Reach_1	7326	10-Year	240.00	574.79	576.32	575.81	576.38	0.006869	1.83	130.94	176.71	0.38
Reach_1	7326	50-Year	350.00	574.79	576.50	576.08	576.58	0.007269	2.15	163.03	181.09	0.40
Reach_1	7326	100-Year	400.00	574.79	576.58	576.13	576.66	0.007409	2.27	176.32	182.87	0.41
Reach_1	7326	500-Year	530.00	574.79	576.73	576.22	576.83	0.008128	2.59	204.75	186.75	0.44
Reach_1	7326	100-Year_Ult	570.00	574.79	576.79	576.26	576.90	0.007890	2.63	216.54	188.35	0.43
Reach_1	7826	10-Year	240.00	579.45	580.58		580.64	0.010882	2.05	116.92	188.05	0.46
Reach_1	7826	50-Year	350.00	579.45	580.76		580.84	0.010146	2.30	152.30	196.16	0.46
Reach_1	7826	100-Year	400.00	579.45	580.84		580.93	0.009915	2.39	167.27	199.50	0.46
Reach_1	7826	500-Year	530.00	579.45	581.03		581.13	0.009114	2.57	205.96	206.59	0.45
Reach_1	7826	100-Year_Ult	570.00	579.45	581.07		581.18	0.009324	2.66	214.38	208.26	0.46
Reach_1	8322	10-Year	240.00	582.96	584.23		584.27	0.005239	1.61	149.23	200.01	0.33
Reach_1	8322	50-Year	350.00	582.96	584.41		584.46	0.005509	1.88	186.56	206.08	0.35
Reach_1	8322	100-Year	400.00	582.96	584.48		584.55	0.005590	1.98	202.21	208.58	0.35
Reach_1	8322	500-Year	530.00	582.96	584.65		584.73	0.005895	2.23	238.14	214.19	0.37
Reach_1	8322	100-Year_Ult	570.00	582.96	584.71		584.79	0.005832	2.28	250.46	216.09	0.37
Reach_1	8857	10-Year	240.00	588.00	589.28		589.52	0.023870	3.93	60.99	66.29	0.72
Reach_1	8857	50-Year	350.00	588.00	589.67	589.45	589.84	0.023384	3.37	103.89	140.63	0.69
Reach_1	8857	100-Year	400.00	588.00	589.75	589.53	589.93	0.022711	3.48	115.09	145.47	0.69
Reach_1	8857	500-Year	530.00	588.00	589.94	589.69	590.15	0.020786	3.67	144.50	157.62	0.68
Reach_1	8857	100-Year_Ult	570.00	588.00	589.98	589.72	590.20	0.021224	3.78	150.73	159.53	0.69
Reach_1	9573	10-Year	50.00	596.00	597.22		597.23	0.001609	0.91	55.21	72.23	0.18
Reach_1	9573	50-Year	80.00	596.00	597.49		597.51	0.001823	1.04	76.60	88.84	0.20
Reach_1	9573	100-Year	90.00	596.00	597.56		597.58	0.001854	1.08	83.43	93.38	0.20
Reach_1	9573	500-Year	120.00	596.00	597.72		597.74	0.002058	1.22	98.72	99.88	0.22
Reach_1	9573	100-Year_Ult	120.00	596.00	597.76		597.78	0.001839	1.17	102.56	100.97	0.20
Reach_1	10009	10-Year	50.00	602.82	603.23	603.23	603.35	0.071571	2.82	17.72	72.62	1.01
Reach_1	10009	50-Year	80.00	602.82	603.32	603.32	603.48	0.067052	3.22	24.86	79.69	1.02
Reach_1	10009	100-Year	90.00	602.82	603.35	603.35	603.52	0.064747	3.32	27.15	81.06	1.01
Reach_1	10009	500-Year	120.00	602.82	603.43	603.43	603.62	0.060403	3.51	34.21	89.06	1.00
Reach_1	10009	100-Year_Ult	120.00	602.82	603.43	603.43	603.62	0.060983	3.52	34.08	88.85	1.00
Reach_1	10238	10-Year	50.00	606.89	609.09	608.62	609.22	0.013026	2.82	17.75	18.69	0.51
Reach_1	10238	50-Year	80.00	606.89	609.43	608.93	609.60	0.014248	3.22	24.84	23.11	0.55
Reach_1	10238	100-Year	90.00	606.89	609.52	609.02	609.70	0.014703	3.34	26.91	24.28	0.56
Reach_1	10238	500-Year	120.00	606.89	609.75	609.25	609.96	0.015755	3.66	32.79	27.33	0.59
Reach_1	10238	100-Year_Ult	120.00	606.89	609.75	609.25	609.96	0.015685	3.65	32.84	27.35	0.59
Reach_1	10645	10-Year	50.00	621.05	621.76	621.76	621.98	0.060972	3.73	13.41	31.92	1.01
Reach_1	10645	50-Year	80.00	621.05	621.92	621.92	622.20	0.056523	4.26	18.77	34.49	1.02
Reach_1	10645	100-Year	90.00	621.05	621.99	621.99	622.27	0.050153	4.28	21.04	35.13	0.97
Reach_1	10645	500-Year	120.00	621.05	622.12	622.12	622.43	0.055026	4.43	27.06	45.90	1.02
Reach_1	10645	100-Year_Ult	120.00	621.05	622.12	622.12	622.43	0.055026	4.43	27.06	45.90	1.02
Reach_1	10814	10-Year	50.00	626.00	627.77	627.50	628.03	0.023444	4.06	12.32	12.06	0.71
Reach_1	10814	50-Year	80.00	626.00	628.12	627.87	628.47	0.025996	4.75	16.83	14.03	0.76
Reach_1	10814	100-Year	90.00	626.00	628.18	627.97	628.58	0.028582	5.07	17.73	14.38	0.81
Reach_1	10814	500-Year	120.00	626.00	628.47	628.24	628.93	0.028024	5.42	22.14	16.01	0.81
Reach_1	10814	100-Year_Ult	120.00	626.00	628.47	628.24	628.93	0.028024	5.42	22.14	16.01	0.81

HEC-RAS Plan: Edge Trib-Multi River: Edge Tributary 1 Reach: Reach_1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	887	10-Year	890.00	556.00	559.53	558.64	559.65	0.007061	2.83	314.67	226.12	0.42
Reach_1	887	50-Year	1350.00	556.00	560.03	559.03	560.18	0.006534	3.09	436.85	261.37	0.42
Reach_1	887	100-Year	1550.00	556.00	560.48	559.19	560.60	0.003897	2.79	559.11	282.09	0.34
Reach_1	887	500-Year	2060.00	556.00	561.45	559.49	561.55	0.001906	2.51	854.50	327.04	0.25
Reach_1	887	100-Year_Ult	2180.00	556.00	561.45	559.55	561.56	0.002135	2.66	854.50	327.04	0.27
Reach_1	1212	10-Year	890.00	559.16	561.41		561.49	0.004585	2.28	390.11	279.95	0.34
Reach_1	1212	50-Year	1350.00	559.16	561.85		561.95	0.004626	2.61	518.13	306.66	0.35
Reach_1	1212	100-Year	1550.00	559.16	561.94		562.06	0.005236	2.84	546.31	312.21	0.38
Reach_1	1212	500-Year	2060.00	559.16	562.35		562.49	0.004835	3.03	679.67	331.35	0.37
Reach_1	1212	100-Year_Ult	2180.00	559.16	562.42		562.57	0.004859	3.10	704.07	333.70	0.38
Reach_1	1555	10-Year	890.00	562.23	564.33	564.24	564.67	0.025343	4.67	190.59	218.79	0.88
Reach_1	1555	50-Year	1350.00	562.23	564.67	564.65	565.02	0.022425	4.71	286.69	400.65	0.98
Reach_1	1555	100-Year	1550.00	562.23	564.85	564.74	565.14	0.017967	4.28	362.19	431.78	0.82
Reach_1	1555	500-Year	2060.00	562.23	565.08		565.39	0.017550	4.47	461.08	440.25	0.77
Reach_1	1555	100-Year_Ult	2180.00	562.23	565.14		565.45	0.016990	4.47	487.47	442.14	0.75
Reach_1	1824	10-Year	890.00	564.00	566.70		566.78	0.003728	2.32	383.49	229.67	0.32
Reach_1	1824	50-Year	1350.00	564.00	567.13		567.25	0.004226	2.77	486.97	245.37	0.35
Reach_1	1824	100-Year	1550.00	564.00	567.24		567.38	0.004760	3.02	513.17	248.61	0.37
Reach_1	1824	500-Year	2060.00	564.00	567.58		567.77	0.005259	3.43	600.05	258.48	0.40
Reach_1	1824	100-Year_Ult	2180.00	564.00	567.65		567.84	0.005417	3.53	617.09	260.37	0.40
Reach_1	2475	10-Year	430.00	566.00	569.40		569.48	0.005223	2.16	198.63	169.66	0.35
Reach_1	2475	50-Year	630.00	566.00	569.88		569.96	0.003993	2.20	286.71	195.83	0.32
Reach_1	2475	100-Year	720.00	566.00	570.10		570.18	0.003461	2.18	330.39	205.25	0.30
Reach_1	2475	500-Year	950.00	566.00	570.51		570.59	0.002994	2.27	417.88	218.58	0.29
Reach_1	2475	100-Year_Ult	1160.00	566.00	570.71		570.80	0.003361	2.52	460.08	224.70	0.31
Reach_1	2955	10-Year	430.00	571.59	573.00		573.11	0.011855	2.59	165.88	200.43	0.50
Reach_1	2955	50-Year	630.00	571.59	573.15		573.31	0.014893	3.21	196.38	204.49	0.58
Reach_1	2955	100-Year	720.00	571.59	573.19		573.38	0.017408	3.54	203.40	205.41	0.63
Reach_1	2955	500-Year	950.00	571.59	573.34		573.59	0.019175	4.04	235.29	209.73	0.67
Reach_1	2955	100-Year_Ult	1160.00	571.59	573.59		573.84	0.015389	4.04	287.31	217.15	0.62
Reach_1	3356	10-Year	430.00	576.00	577.67		577.75	0.011298	2.30	186.78	260.03	0.48
Reach_1	3356	50-Year	630.00	576.00	577.92		578.02	0.009438	2.48	253.78	275.70	0.46
Reach_1	3356	100-Year	720.00	576.00	578.03	577.55	578.13	0.008543	2.52	285.29	280.58	0.44
Reach_1	3356	500-Year	950.00	576.00	578.25		578.36	0.008050	2.75	345.26	285.22	0.44
Reach_1	3356	100-Year_Ult	1160.00	576.00	578.36		578.50	0.009064	3.08	376.89	287.64	0.47
Reach_1	3684	10-Year	430.00	578.76	580.34		580.41	0.006085	2.09	206.07	209.11	0.37
Reach_1	3684	50-Year	630.00	578.76	580.56		580.65	0.006946	2.51	251.02	213.22	0.41
Reach_1	3684	100-Year	720.00	578.76	580.63		580.74	0.007421	2.69	267.35	214.69	0.43
Reach_1	3684	500-Year	950.00	578.76	580.84		580.98	0.007850	3.04	312.79	218.74	0.45
Reach_1	3684	100-Year_Ult	1160.00	578.76	581.05		581.22	0.007522	3.22	359.83	222.86	0.45
Reach_1	3907	10-Year	430.00	580.00	581.70		581.76	0.006014	1.96	219.05	241.50	0.36
Reach_1	3907	50-Year	630.00	580.00	581.98		582.06	0.005720	2.16	291.32	267.51	0.37
Reach_1	3907	100-Year	720.00	580.00	582.10		582.18	0.005596	2.22	323.77	280.46	0.36
Reach_1	3907	500-Year	950.00	580.00	582.33		582.42	0.005391	2.44	388.60	283.94	0.37
Reach_1	3907	100-Year_Ult	1160.00	580.00	582.51		582.62	0.005327	2.63	441.38	286.74	0.37
Reach_1	4147	10-Year	430.00	582.00	583.57		583.66	0.010869	2.45	175.30	215.46	0.48
Reach_1	4147	50-Year	630.00	582.00	583.79		583.92	0.010887	2.80	224.76	226.44	0.50
Reach_1	4147	100-Year	720.00	582.00	583.88		584.02	0.010930	2.94	245.09	230.80	0.50
Reach_1	4147	500-Year	950.00	582.00	584.13		584.27	0.011720	3.08	308.70	285.73	0.52
Reach_1	4147	100-Year_Ult	1160.00	582.00	584.28		584.45	0.011458	3.29	352.30	289.67	0.53
Reach_1	4483	10-Year	430.00	584.00	585.71		585.76	0.004018	1.70	252.77	255.22	0.30
Reach_1	4483	50-Year	630.00	584.00	585.98		586.04	0.004101	1.95	322.38	268.46	0.31
Reach_1	4483	100-Year	720.00	584.00	586.08		586.15	0.004139	2.05	351.03	273.73	0.32
Reach_1	4483	500-Year	950.00	584.00	586.34		586.42	0.003995	2.26	421.01	277.01	0.32
Reach_1	4483	100-Year_Ult	1160.00	584.00	586.52		586.61	0.004111	2.46	472.09	279.24	0.33
Reach_1	4750	10-Year	430.00	586.00	587.76		588.00	0.024924	3.94	109.18	122.97	0.74
Reach_1	4750	50-Year	630.00	586.00	588.10		588.35	0.026140	3.97	158.54	182.63	0.75
Reach_1	4750	100-Year	720.00	586.00	588.19		588.45	0.025501	4.11	175.03	187.90	0.75
Reach_1	4750	500-Year	950.00	586.00	588.37		588.69	0.025983	4.51	210.84	200.24	0.77
Reach_1	4750	100-Year_Ult	1160.00	586.00	588.55		588.89	0.024333	4.68	247.71	211.37	0.76
Reach_1	4921	10-Year	430.00	588.00	590.28	589.84	590.38	0.008775	2.47	173.96	180.03	0.44
Reach_1	4921	50-Year	630.00	588.00	590.57		590.69	0.008325	2.79	226.21	188.14	0.45
Reach_1	4921	100-Year	720.00	588.00	590.67		590.80	0.008490	2.94	245.11	190.99	0.46
Reach_1	4921	500-Year	950.00	588.00	590.91		591.08	0.008597	3.25	292.56	197.97	0.47

HEC-RAS Plan: Edge Trib-Multi River: Edge Tributary 1 Reach: Reach_1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	4921	100-Year_Ult	1160.00	588.00	591.09		591.29	0.008986	3.53	328.83	203.14	0.49
Reach_1	5446	10-Year	430.00	594.00	595.41		595.57	0.011148	3.24	132.59	109.23	0.52
Reach_1	5446	50-Year	630.00	594.00	595.71	595.18	595.93	0.012091	3.78	166.53	115.71	0.56
Reach_1	5446	100-Year	720.00	594.00	595.85		596.09	0.012013	3.94	182.61	118.66	0.56
Reach_1	5446	500-Year	950.00	594.00	596.31		596.51	0.012643	3.65	260.58	197.99	0.56
Reach_1	5446	100-Year_Ult	1160.00	594.00	596.51	595.73	596.74	0.012123	3.85	301.15	204.13	0.56
Reach_1	5675	10-Year	430.00	596.00	598.05		598.19	0.011715	2.95	145.79	143.84	0.52
Reach_1	5675	50-Year	630.00	596.00	598.38		598.54	0.010697	3.21	196.30	159.40	0.51
Reach_1	5675	100-Year	720.00	596.00	598.51		598.68	0.010586	3.33	216.03	164.45	0.51
Reach_1	5675	500-Year	950.00	596.00	598.83		599.02	0.009500	3.51	270.64	175.74	0.50
Reach_1	5675	100-Year_Ult	1160.00	596.00	599.02		599.25	0.009902	3.79	305.79	182.33	0.52
Reach_1	5897	10-Year	430.00	600.83	602.27	602.22	602.66	0.040550	4.98	86.27	98.30	0.94
Reach_1	5897	50-Year	630.00	600.83	602.49	602.49	603.01	0.044645	5.81	108.47	105.61	1.01
Reach_1	5897	100-Year	720.00	600.83	602.60	602.60	603.16	0.043581	6.00	119.97	109.20	1.01
Reach_1	5897	500-Year	950.00	600.83	602.84	602.84	603.48	0.041700	6.43	147.71	117.23	1.01
Reach_1	5897	100-Year_Ult	1160.00	600.83	603.04	603.04	603.75	0.040352	6.75	171.80	123.67	1.01

HEC-RAS Plan: Foster_Multi River: Foster Reach: Foster

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Foster	938	10-Year	470.00	518.98	520.56	520.28	520.76	0.012000	3.58	131.29	133.14	0.64
Foster	938	50-Year	670.00	518.98	520.80	520.49	521.06	0.012004	4.08	164.41	137.25	0.66
Foster	938	100-Year	760.00	518.98	520.90	520.57	521.19	0.012003	4.28	177.74	138.03	0.66
Foster	938	500-Year	990.00	518.98	521.13	520.77	521.48	0.012023	4.73	209.35	139.91	0.68
Foster	938	100-Year Ult	820.00	518.98	520.96	520.63	521.26	0.012003	4.40	186.32	138.54	0.67
Foster	1039	10-Year	470.00	520.28	522.74	522.74	523.24	0.027537	5.72	86.22	88.20	0.97
Foster	1039	50-Year	670.00	520.28	522.99	522.99	523.64	0.027555	6.57	108.48	90.32	1.00
Foster	1039	100-Year	760.00	520.28	523.11	523.11	523.81	0.026323	6.81	119.49	91.35	1.00
Foster	1039	500-Year	990.00	520.28	523.38	523.38	524.21	0.025020	7.43	144.30	93.64	1.00
Foster	1039	100-Year Ult	820.00	520.28	523.19	523.19	523.92	0.025330	6.93	127.12	92.06	0.99
Foster	1259	10-Year	470.00	522.67	525.05		525.16	0.004115	2.71	173.22	119.01	0.40
Foster	1259	50-Year	670.00	522.67	525.40		525.55	0.004041	3.11	215.96	121.51	0.41
Foster	1259	100-Year	760.00	522.67	525.54		525.71	0.004055	3.27	233.04	122.53	0.41
Foster	1259	500-Year	990.00	522.67	525.88		526.08	0.004032	3.63	274.85	125.04	0.42
Foster	1259	100-Year Ult	820.00	522.67	525.63		525.80	0.004091	3.38	243.51	123.16	0.42
Foster	1516	10-Year	250.00	523.44	526.71	526.71	527.23	0.029616	5.79	43.70	49.52	0.99
Foster	1516	50-Year	350.00	523.44	527.02	527.02	527.61	0.024023	6.18	62.06	76.86	0.93
Foster	1516	100-Year	400.00	523.44	527.14	527.14	527.76	0.023107	6.41	72.10	91.80	0.93
Foster	1516	500-Year	510.00	523.44	527.44	527.44	528.05	0.018360	6.47	104.72	112.77	0.85
Foster	1516	100-Year Ult	440.00	523.44	527.29	527.29	527.88	0.019436	6.28	87.86	110.11	0.87
Foster	1807	10-Year	250.00	525.25	530.01	528.96	530.30	0.005434	4.62	86.19	80.12	0.47
Foster	1807	50-Year	350.00	525.25	530.36	529.72	530.73	0.006263	5.35	117.65	98.56	0.51
Foster	1807	100-Year	400.00	525.25	530.51	530.00	530.90	0.006494	5.61	132.90	101.77	0.53
Foster	1807	500-Year	510.00	525.25	530.73	530.41	531.20	0.007711	6.36	155.06	104.29	0.58
Foster	1807	100-Year Ult	440.00	525.25	530.57	530.13	531.00	0.007179	5.96	139.08	102.48	0.56
Foster	1941	10-Year	250.00	525.95	530.71		530.99	0.004803	4.19	59.64	22.74	0.44
Foster	1941	50-Year	350.00	525.95	531.17		531.56	0.006037	4.99	73.33	36.25	0.50
Foster	1941	100-Year	400.00	525.95	531.34		531.79	0.006513	5.38	81.12	53.86	0.53
Foster	1941	500-Year	510.00	525.95	531.67		532.23	0.007325	6.08	104.14	85.89	0.57
Foster	1941	100-Year Ult	440.00	525.95	531.47		531.96	0.006839	5.65	88.60	64.38	0.54

HEC-RAS Plan: FosterTrib_Multi River: Foster_Trib Reach: Foster_Trib

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Foster_Trib	282	10-Year	510.00	518.47	520.66	520.51	521.25	0.020009	6.15	82.95	54.39	0.88
Foster_Trib	282	50-Year	750.00	518.47	521.09	520.95	521.85	0.020036	7.01	107.00	57.53	0.91
Foster_Trib	282	100-Year	850.00	518.47	521.25	521.11	522.08	0.020005	7.30	116.38	58.69	0.91
Foster_Trib	282	500-Year	1080.00	518.47	521.58	521.46	522.56	0.020013	7.94	136.08	60.44	0.93
Foster_Trib	282	100-Year Ult	890.00	518.47	521.31	521.18	522.17	0.020005	7.42	120.02	59.14	0.92
Foster_Trib	442	10-Year	510.00	518.52	522.95	522.01	523.50	0.010512	5.95	85.75	34.92	0.67
Foster_Trib	442	50-Year	750.00	518.52	523.55		524.30	0.012111	6.95	107.99	38.67	0.73
Foster_Trib	442	100-Year	850.00	518.52	523.76		524.59	0.012684	7.33	115.97	39.61	0.75
Foster_Trib	442	500-Year	1080.00	518.52	524.18		525.20	0.013775	8.12	132.95	41.22	0.80
Foster_Trib	442	100-Year Ult	890.00	518.52	523.83		524.70	0.012920	7.48	118.98	39.94	0.76
Foster_Trib	563	10-Year	510.00	521.45	524.80	524.80	526.01	0.024493	8.84	57.72	24.15	1.01
Foster_Trib	563	50-Year	750.00	521.45	525.56	525.56	527.03	0.023280	9.74	77.00	26.54	1.01
Foster_Trib	563	100-Year	850.00	521.45	525.84	525.84	527.41	0.022899	10.04	84.64	27.43	1.01
Foster_Trib	563	500-Year	1080.00	521.45	526.45	526.45	528.20	0.022056	10.60	101.90	29.45	1.00
Foster_Trib	563	100-Year Ult	890.00	521.45	525.95	525.95	527.55	0.022753	10.15	87.65	27.77	1.01
Foster_Trib	761	10-Year	490.00	523.33	528.65	527.90	529.54	0.013160	7.57	64.71	19.34	0.73
Foster_Trib	761	50-Year	720.00	523.33	529.50	528.80	530.70	0.014775	8.79	81.87	20.89	0.78
Foster_Trib	761	100-Year	810.00	523.33	529.81	529.11	531.11	0.015235	9.16	88.44	21.64	0.80
Foster_Trib	761	500-Year	1020.00	523.33	530.47	529.81	531.98	0.016400	9.85	103.54	24.13	0.84
Foster_Trib	761	100-Year Ult	870.00	523.33	529.94	529.31	531.35	0.016166	9.52	91.37	22.03	0.82
Foster_Trib	988	10-Year	490.00	528.04	532.13	531.91	533.13	0.018979	8.01	61.21	24.41	0.89
Foster_Trib	988	50-Year	720.00	528.04	533.10		534.17	0.015663	8.32	86.49	27.92	0.83
Foster_Trib	988	100-Year	810.00	528.04	533.44		534.54	0.014771	8.42	96.23	29.15	0.82
Foster_Trib	988	500-Year	1020.00	528.04	534.16		535.32	0.013041	8.64	118.08	31.03	0.78
Foster_Trib	988	100-Year Ult	870.00	528.04	533.68		534.78	0.013870	8.42	103.38	29.77	0.80
Foster_Trib	1121	10-Year	490.00	531.94	535.05	535.05	536.13	0.024766	8.35	58.70	27.15	1.00
Foster_Trib	1121	50-Year	720.00	531.94	535.72	535.72	537.06	0.023396	9.28	77.57	29.00	1.00
Foster_Trib	1121	100-Year	810.00	531.94	535.96	535.96	537.38	0.023001	9.58	84.54	29.66	1.00
Foster_Trib	1121	500-Year	1020.00	531.94	536.46	536.46	538.08	0.022579	10.21	99.88	31.25	1.01
Foster_Trib	1121	100-Year Ult	870.00	531.94	536.11	536.11	537.59	0.022768	9.76	89.14	30.14	1.00

HEC-RAS Plan: Gifco1-Multi River: Gifco_Trib 1 Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	323	10-Year	240.00	549.41	550.46	549.93	550.48	0.001701	1.04	231.21	297.81	0.21
1	323	50-Year	340.00	549.41	550.64	550.01	550.67	0.001701	1.19	286.32	301.95	0.21
1	323	100-Year	380.00	549.41	550.71	550.04	550.74	0.001700	1.25	306.34	303.43	0.22
1	323	500-Year	490.00	549.41	550.88	550.11	550.91	0.001700	1.38	357.72	307.21	0.22
1	323	100-Year_Ult	450.00	549.41	550.82	550.08	550.85	0.001701	1.33	339.52	305.88	0.22
1	616	10-Year	240.00	550.00	551.25		551.34	0.005770	2.35	102.01	95.76	0.40
1	616	50-Year	340.00	550.00	551.46		551.58	0.006728	2.78	122.40	100.48	0.44
1	616	100-Year	380.00	550.00	551.53		551.67	0.007026	2.92	130.03	102.19	0.46
1	616	500-Year	490.00	550.00	551.71		551.88	0.007901	3.30	148.50	106.22	0.49
1	616	100-Year_Ult	450.00	550.00	551.65		551.81	0.007600	3.17	142.00	104.81	0.48
1	913	10-Year	240.00	555.00	555.47	555.47	555.69	0.047939	3.82	62.79	139.41	1.00
1	913	50-Year	340.00	555.00	555.59	555.59	555.87	0.044222	4.26	79.84	141.86	1.00
1	913	100-Year	380.00	555.00	555.63	555.63	555.93	0.042554	4.39	86.57	142.81	0.99
1	913	500-Year	490.00	555.00	555.80	555.75	556.11	0.032101	4.42	110.77	146.19	0.90
1	913	100-Year_Ult	450.00	555.00	555.74	555.70	556.04	0.034953	4.40	102.27	145.01	0.92
1	1218	10-Year	240.00	560.00	561.10	560.71	561.22	0.009393	2.78	86.48	91.35	0.50
1	1218	50-Year	340.00	560.00	561.31	560.88	561.47	0.009946	3.18	107.02	96.32	0.53
1	1218	100-Year	380.00	560.00	561.39	560.95	561.56	0.010209	3.32	114.32	98.02	0.54
1	1218	500-Year	490.00	560.00	561.53	561.11	561.76	0.011994	3.81	128.53	101.26	0.60
1	1218	100-Year_Ult	450.00	560.00	561.48	561.05	561.69	0.011399	3.65	123.45	100.11	0.58
1	1516	10-Year	240.00	565.99	567.10	567.10	567.41	0.042699	4.53	52.96	83.51	1.00
1	1516	50-Year	340.00	565.99	567.28	567.28	567.65	0.041229	4.94	68.78	92.71	1.01
1	1516	100-Year	380.00	565.99	567.34	567.34	567.74	0.040544	5.07	74.95	96.06	1.01
1	1516	500-Year	490.00	565.99	567.51	567.51	567.95	0.038491	5.34	91.77	104.65	1.00
1	1516	100-Year_Ult	450.00	565.99	567.45	567.45	567.88	0.038860	5.23	85.98	101.77	1.00
1	1835	10-Year	240.00	568.36	570.38		570.47	0.004123	2.52	109.37	99.25	0.36
1	1835	50-Year	340.00	568.36	570.67		570.79	0.004281	2.89	139.45	108.62	0.38
1	1835	100-Year	380.00	568.36	570.77		570.90	0.004370	3.03	150.43	112.47	0.39
1	1835	500-Year	490.00	568.36	571.02		571.17	0.004574	3.36	179.20	121.98	0.40
1	1835	100-Year_Ult	450.00	568.36	570.93		571.07	0.004510	3.24	168.89	118.66	0.40
1	2147	10-Year	240.00	574.00	574.74	574.74	575.05	0.043139	4.49	53.43	86.02	1.00
1	2147	50-Year	340.00	574.00	574.91	574.91	575.29	0.040630	4.93	68.99	92.37	1.01
1	2147	100-Year	380.00	574.00	574.98	574.98	575.37	0.039425	5.05	75.19	94.78	1.00
1	2147	500-Year	490.00	574.00	575.13	575.13	575.59	0.038016	5.43	90.28	100.53	1.00
1	2147	100-Year_Ult	450.00	574.00	575.08	575.08	575.51	0.038765	5.31	84.70	98.43	1.01
1	2490	10-Year	240.00	576.00	578.36		578.47	0.004327	2.80	98.31	87.75	0.38
1	2490	50-Year	340.00	576.00	578.66		578.81	0.004609	3.22	127.08	100.90	0.40
1	2490	100-Year	380.00	576.00	578.77		578.92	0.004722	3.37	137.78	105.37	0.41
1	2490	500-Year	490.00	576.00	579.03		579.21	0.004935	3.72	166.54	116.16	0.42
1	2490	100-Year_Ult	450.00	576.00	578.94		579.11	0.004849	3.60	156.50	112.65	0.42
1	2823	10-Year	240.00	582.86	583.97	583.97	584.33	0.041355	4.83	49.69	69.50	1.01
1	2823	50-Year	340.00	582.86	584.16	584.16	584.61	0.038180	5.38	63.42	74.49	1.00
1	2823	100-Year	380.00	582.86	584.23	584.23	584.71	0.036233	5.54	69.16	76.34	0.99
1	2823	500-Year	490.00	582.86	584.42	584.42	584.97	0.033475	5.98	83.60	80.82	0.98
1	2823	100-Year_Ult	450.00	582.86	584.35	584.35	584.88	0.034388	5.83	78.39	79.23	0.98

HEC-RAS Plan: Gifco2-Multi River: Gifco_Trib 2 Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	471	10-Year	360.00	550.00	550.67	550.45	550.77	0.013000	2.54	141.95	219.15	0.56
1	471	50-Year	530.00	550.00	550.84	550.58	550.97	0.013009	2.94	180.06	222.41	0.58
1	471	100-Year	600.00	550.00	550.90	550.63	551.05	0.013004	3.09	194.42	223.63	0.58
1	471	500-Year	790.00	550.00	551.06	550.76	551.25	0.013001	3.43	230.58	226.66	0.60
1	471	100-Year_Ult	740.00	550.00	551.02	550.73	551.20	0.013003	3.34	221.39	225.89	0.59
1	731	10-Year	360.00	550.00	551.74	550.71	551.78	0.001822	1.64	218.87	148.12	0.24
1	731	50-Year	530.00	550.00	552.06		552.12	0.002194	1.97	268.53	158.88	0.27
1	731	100-Year	600.00	550.00	552.18		552.25	0.002321	2.08	288.00	163.91	0.28
1	731	500-Year	790.00	550.00	552.47		552.55	0.002621	2.34	336.90	175.91	0.30
1	731	100-Year_Ult	740.00	550.00	552.40		552.48	0.002547	2.28	324.53	172.96	0.29
1	948	10-Year	360.00	556.57	558.11	558.11	558.49	0.040146	4.99	72.08	105.59	1.00
1	948	50-Year	530.00	556.57	558.36	558.36	558.82	0.038152	5.40	98.19	132.62	1.00
1	948	100-Year	600.00	556.57	558.45	558.45	558.93	0.037225	5.57	107.75	141.70	1.00
1	948	500-Year	790.00	556.57	558.66	558.66	559.22	0.034770	5.98	132.10	166.18	0.99
1	948	100-Year_Ult	740.00	556.57	558.61	558.61	559.15	0.035304	5.88	125.87	162.93	1.00
1	1175	10-Year	360.00	557.92	560.32	559.60	560.38	0.003502	2.15	237.44	395.47	0.33
1	1175	50-Year	530.00	557.92	560.55	559.91	560.61	0.003391	2.35	329.44	399.73	0.33
1	1175	100-Year	600.00	557.92	560.63	560.17	560.70	0.003367	2.42	362.61	401.25	0.33
1	1175	500-Year	790.00	557.92	560.84	560.30	560.91	0.003265	2.58	447.19	405.11	0.33
1	1175	100-Year_Ult	740.00	557.92	560.79	560.27	560.86	0.003305	2.55	425.11	404.11	0.33
1	1647	10-Year	360.00	555.04	560.44		560.44	0.000040	0.42	875.70	302.56	0.04
1	1647	50-Year	530.00	555.04	560.70		560.71	0.000067	0.57	956.15	307.96	0.05
1	1647	100-Year	600.00	555.04	560.80		560.80	0.000078	0.62	985.73	309.92	0.06
1	1647	500-Year	790.00	555.04	561.04		561.05	0.000109	0.77	1061.01	314.86	0.07
1	1647	100-Year_Ult	740.00	555.04	560.98		560.98	0.000101	0.73	1041.54	313.59	0.07
1	1954	10-Year	360.00	560.00	560.79	560.79	561.15	0.041021	4.78	75.39	106.64	1.00
1	1954	50-Year	530.00	560.00	561.01	561.01	561.45	0.038265	5.36	98.94	113.00	1.00
1	1954	100-Year	600.00	560.00	561.08	561.08	561.57	0.037227	5.59	107.65	115.37	1.00
1	1954	500-Year	790.00	560.00	561.28	561.28	561.86	0.034200	6.07	131.38	121.60	0.99
1	1954	100-Year_Ult	740.00	560.00	561.23	561.23	561.78	0.034935	5.96	125.18	120.00	1.00
1	2257	10-Year	360.00	560.00	562.48	561.01	562.54	0.001613	2.03	184.02	108.72	0.24
1	2257	50-Year	530.00	560.00	562.91	561.29	563.00	0.001847	2.44	236.67	133.55	0.26
1	2257	100-Year	600.00	560.00	563.06	561.40	563.16	0.001933	2.59	257.73	145.06	0.27
1	2257	500-Year	790.00	560.00	563.42	561.67	563.54	0.002126	2.94	313.58	168.72	0.29
1	2257	100-Year_Ult	740.00	560.00	563.33	561.60	563.45	0.002080	2.86	299.08	162.90	0.29
1	2432	10-Year	360.00	560.00	562.86		563.13	0.007679	4.19	91.99	60.57	0.51
1	2432	50-Year	530.00	560.00	563.31		563.67	0.008112	4.91	121.64	72.31	0.55
1	2432	100-Year	600.00	560.00	563.47		563.85	0.008283	5.17	133.14	75.82	0.56
1	2432	500-Year	790.00	560.00	563.83		564.30	0.008820	5.80	162.00	84.59	0.59
1	2432	100-Year_Ult	740.00	560.00	563.74		564.19	0.008684	5.64	154.63	82.56	0.58
1	2707	10-Year	360.00	562.00	565.29		565.65	0.010962	4.80	75.07	38.46	0.60
1	2707	50-Year	530.00	562.00	565.86		566.31	0.011473	5.41	98.06	43.39	0.63
1	2707	100-Year	600.00	562.00	566.03		566.53	0.011581	5.67	106.52	66.75	0.64
1	2707	500-Year	790.00	562.00	566.44	565.74	567.04	0.011439	6.26	138.45	90.87	0.66
1	2707	100-Year_Ult	740.00	562.00	566.34	565.63	566.91	0.011523	6.13	129.50	84.48	0.65
1	3014	10-Year	360.00	564.00	567.10		567.24	0.003042	3.11	141.63	104.22	0.34
1	3014	50-Year	530.00	564.00	567.67		567.82	0.002837	3.42	211.97	141.31	0.34
1	3014	100-Year	600.00	564.00	567.86		568.02	0.002778	3.52	240.28	152.00	0.34
1	3014	500-Year	790.00	564.00	568.29		568.46	0.002712	3.76	310.91	169.99	0.34
1	3014	100-Year_Ult	740.00	564.00	568.19		568.36	0.002727	3.71	293.51	167.40	0.34
1	3299	10-Year	360.00	566.00	569.02	569.02	569.91	0.031801	7.57	47.57	27.07	1.01
1	3299	50-Year	530.00	566.00	569.60	569.60	570.65	0.030472	8.21	64.55	31.46	1.01
1	3299	100-Year	600.00	566.00	569.81	569.81	570.91	0.029764	8.40	71.46	33.08	1.01
1	3299	500-Year	790.00	566.00	570.64	570.64	571.33	0.014293	7.07	148.47	130.38	0.73
1	3299	100-Year_Ult	740.00	566.00	570.56	570.56	571.24	0.014271	6.94	138.65	127.82	0.73
1	3591	10-Year	360.00	570.00	572.96		573.12	0.005276	3.85	140.29	117.71	0.44
1	3591	50-Year	530.00	570.00	573.43		573.60	0.004680	4.08	198.76	128.68	0.42
1	3591	100-Year	600.00	570.00	573.60		573.78	0.004512	4.16	221.44	132.68	0.42
1	3591	500-Year	790.00	570.00	573.77		574.02	0.006093	5.01	243.29	136.44	0.49
1	3591	100-Year_Ult	740.00	570.00	573.68		573.92	0.006107	4.92	231.42	134.41	0.49
1	3928	10-Year	360.00	572.00	575.07	574.89	575.47	0.012674	5.86	103.10	136.07	0.67
1	3928	50-Year	530.00	572.00	575.35	575.35	575.79	0.013548	6.53	144.14	150.99	0.70
1	3928	100-Year	600.00	572.00	575.43	575.43	575.90	0.014307	6.84	156.74	154.18	0.73
1	3928	500-Year	790.00	572.00	575.79		576.19	0.011573	6.68	214.64	168.05	0.67

HEC-RAS Plan: Gifco2-Multi River: Gifco_Trib 2 Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	3928	100-Year_Ult	740.00	572.00	575.72		576.12	0.011599	6.59	203.47	165.49	0.67
1	4277	10-Year	360.00	576.00	577.81		577.91	0.004636	2.49	146.78	118.09	0.38
1	4277	50-Year	530.00	576.00	578.14		578.27	0.004770	2.93	187.63	127.12	0.39
1	4277	100-Year	600.00	576.00	578.27		578.42	0.004740	3.06	204.42	130.90	0.40
1	4277	500-Year	790.00	576.00	578.49		578.68	0.005567	3.58	233.43	136.74	0.44
1	4277	100-Year_Ult	740.00	576.00	578.42		578.61	0.005489	3.47	224.29	134.95	0.43
1	4571	10-Year	360.00	578.00	580.56	580.56	581.30	0.031071	6.94	53.09	40.03	0.98
1	4571	50-Year	530.00	578.00	581.05	581.05	581.92	0.025718	7.58	75.11	50.91	0.94
1	4571	100-Year	600.00	578.00	581.23	581.23	582.14	0.024188	7.78	84.79	56.03	0.92
1	4571	500-Year	790.00	578.00	581.70	581.70	582.65	0.020409	8.12	114.05	69.65	0.87
1	4571	100-Year_Ult	740.00	578.00	581.56	581.56	582.52	0.021825	8.12	104.95	65.54	0.90
1	4874	10-Year	360.00	584.00	585.87		586.02	0.009171	3.14	114.67	100.03	0.51
1	4874	50-Year	530.00	584.00	586.16		586.37	0.009283	3.65	150.79	140.64	0.54
1	4874	100-Year	600.00	584.00	586.27		586.49	0.009280	3.82	165.49	142.53	0.54
1	4874	500-Year	790.00	584.00	586.51	585.97	586.78	0.009466	4.26	200.70	146.95	0.56
1	4874	100-Year_Ult	740.00	584.00	586.46	585.90	586.71	0.009263	4.13	192.98	145.99	0.55
1	5176	10-Year	360.00	588.00	589.39		589.61	0.015747	3.74	96.24	95.70	0.66
1	5176	50-Year	530.00	588.00	589.69		589.97	0.015758	4.18	126.73	106.65	0.68
1	5176	100-Year	600.00	588.00	589.80		590.09	0.015863	4.34	138.15	110.40	0.68
1	5176	500-Year	790.00	588.00	590.06		590.40	0.015813	4.71	167.92	119.50	0.70
1	5176	100-Year_Ult	740.00	588.00	589.99		590.32	0.016021	4.62	160.01	117.24	0.70
1	5499	10-Year	360.00	596.00	597.24	597.24	597.62	0.040615	4.93	73.32	104.27	1.01
1	5499	50-Year	530.00	596.00	597.48	597.48	597.94	0.035103	5.50	99.08	117.03	0.98
1	5499	100-Year	600.00	596.00	597.56	597.56	598.06	0.033733	5.70	109.27	121.71	0.97
1	5499	500-Year	790.00	596.00	597.78	597.78	598.35	0.030533	6.13	137.06	133.75	0.95
1	5499	100-Year_Ult	740.00	596.00	597.72	597.72	598.28	0.031402	6.04	129.59	130.63	0.96
1	5824	10-Year	360.00	603.05	604.23	603.92	604.35	0.012462	2.84	126.73	159.89	0.56
1	5824	50-Year	530.00	603.05	604.42		604.60	0.013279	3.33	159.11	165.80	0.60
1	5824	100-Year	600.00	603.05	604.50		604.69	0.013564	3.51	171.17	167.87	0.61
1	5824	500-Year	790.00	603.05	604.67		604.91	0.014209	3.92	201.45	172.86	0.64
1	5824	100-Year_Ult	740.00	603.05	604.63		604.86	0.014012	3.81	194.00	171.74	0.63
1	6065	10-Year	360.00	613.61	616.09	616.09	616.90	0.032285	7.24	49.75	30.95	1.01
1	6065	50-Year	530.00	613.61	616.61	616.61	617.58	0.030707	7.92	66.90	34.92	1.01
1	6065	100-Year	600.00	613.61	616.81	616.81	617.83	0.029682	8.10	74.06	36.46	1.00
1	6065	500-Year	790.00	613.61	617.26	617.26	618.43	0.027895	8.68	91.29	39.89	1.00
1	6065	100-Year_Ult	740.00	613.61	617.15	617.15	618.28	0.028331	8.54	86.78	39.02	1.00

HEC-RAS Plan: Gifco3_Multi River: Gifco_Trib 3 Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	122	10-Year	180.00	546.00	548.00	546.33	548.00	0.000108	0.46	391.55	215.49	0.06
1	122	50-Year	260.00	546.00	548.00	546.41	548.01	0.000226	0.66	391.55	215.49	0.09
1	122	100-Year	290.00	546.00	548.00	546.44	548.01	0.000281	0.74	391.55	215.49	0.10
1	122	500-Year	370.00	546.00	548.00	546.52	548.01	0.000457	0.94	391.55	215.49	0.12
1	122	100-Year_Ult	360.00	546.00	548.00	546.51	548.01	0.000433	0.92	391.55	215.49	0.12
1	349	10-Year	180.00	548.00	549.09	549.09	549.45	0.041919	4.81	37.45	53.21	1.01
1	349	50-Year	260.00	548.00	549.31	549.31	549.73	0.039107	5.21	49.87	59.53	1.00
1	349	100-Year	290.00	548.00	549.38	549.38	549.83	0.038952	5.37	54.00	61.49	1.01
1	349	500-Year	370.00	548.00	549.56	549.56	550.05	0.037273	5.66	65.39	66.59	1.01
1	349	100-Year_Ult	360.00	548.00	549.53	549.53	550.03	0.037701	5.64	63.84	65.92	1.01
1	523	10-Year	180.00	552.00	553.07		553.22	0.013152	3.15	57.15	64.18	0.59
1	523	50-Year	260.00	552.00	553.30		553.50	0.013628	3.59	72.48	68.77	0.62
1	523	100-Year	290.00	552.00	553.38		553.59	0.013648	3.72	78.04	70.31	0.62
1	523	500-Year	370.00	552.00	553.56		553.82	0.013987	4.05	91.47	73.88	0.64
1	523	100-Year_Ult	360.00	552.00	553.54		553.79	0.013922	4.00	89.90	73.47	0.64
1	812	10-Year	180.00	554.00	556.23		556.44	0.009484	3.70	50.30	42.69	0.54
1	812	50-Year	260.00	554.00	556.55		556.83	0.009784	4.29	64.40	44.57	0.57
1	812	100-Year	290.00	554.00	556.66		556.96	0.009936	4.49	69.09	45.18	0.58
1	812	500-Year	370.00	554.00	556.91		557.28	0.010210	4.96	80.99	46.69	0.60
1	812	100-Year_Ult	360.00	554.00	556.88		557.24	0.010181	4.91	79.55	46.51	0.59
1	1121	10-Year	180.00	558.00	560.21		560.67	0.020681	5.47	33.15	24.91	0.79
1	1121	50-Year	260.00	558.00	560.55	560.37	561.17	0.020979	6.34	42.57	29.40	0.83
1	1121	100-Year	290.00	558.00	560.67	560.50	561.34	0.020994	6.61	46.10	30.92	0.84
1	1121	500-Year	370.00	558.00	560.95	560.83	561.74	0.021231	7.26	55.15	34.52	0.86
1	1121	100-Year_Ult	360.00	558.00	560.92	560.79	561.70	0.021194	7.19	54.04	34.10	0.86
1	1410	10-Year	180.00	562.00	563.84		563.99	0.007202	3.11	57.91	41.75	0.47
1	1410	50-Year	260.00	562.00	564.24		564.42	0.006882	3.45	75.43	44.91	0.47
1	1410	100-Year	290.00	562.00	564.37		564.57	0.006794	3.56	81.38	45.61	0.47
1	1410	500-Year	370.00	562.00	564.68		564.92	0.006558	3.86	95.95	47.29	0.47
1	1410	100-Year_Ult	360.00	562.00	564.65		564.88	0.006587	3.82	94.23	47.09	0.47
1	1671	10-Year	180.00	568.00	570.20	570.20	570.94	0.034566	6.93	25.99	17.71	1.01
1	1671	50-Year	260.00	568.00	570.67	570.67	571.52	0.032769	7.41	35.07	20.71	1.00
1	1671	100-Year	290.00	568.00	570.82	570.82	571.71	0.032289	7.57	38.31	21.68	1.00
1	1671	500-Year	370.00	568.00	571.18	571.18	572.16	0.031334	7.95	46.55	23.93	1.00
1	1671	100-Year_Ult	360.00	568.00	571.14	571.14	572.11	0.031437	7.91	45.54	23.67	1.00
1	1809	10-Year	180.00	574.00	577.30	577.30	578.27	0.036507	7.90	22.78	11.77	1.00
1	1809	50-Year	260.00	574.00	577.90	577.90	579.03	0.035432	8.55	30.40	13.59	1.01
1	1809	100-Year	290.00	574.00	578.09	578.09	579.28	0.034415	8.78	33.07	14.42	1.00
1	1809	500-Year	370.00	574.00	578.58	578.58	579.90	0.029622	9.23	41.07	18.22	0.96
1	1809	100-Year_Ult	360.00	574.00	578.52	578.52	579.82	0.030061	9.17	40.04	17.79	0.96

HEC-RAS Plan: Grassy_Multi River: Grassy Reach: Grassy

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Grassy	863	2-Year	2550.00	544.55	563.47	553.61	563.48	0.000055	1.31	3668.79	791.78	0.06
Grassy	863	5-Year	4110.00	544.55	564.09	557.01	564.11	0.000101	1.81	4161.86	798.72	0.08
Grassy	863	10-Year	5370.00	544.55	564.44	557.68	564.47	0.000144	2.19	4442.46	804.64	0.09
Grassy	863	25-Year	7070.00	544.55	565.11	558.38	565.15	0.000180	2.51	4984.83	814.69	0.10
Grassy	863	50-Year	8530.00	544.55	564.57	558.83	564.64	0.000340	3.39	4547.17	806.29	0.14
Grassy	863	100-Year	9910.00	544.55	564.57	559.18	564.67	0.000460	3.94	4547.17	806.29	0.16
Grassy	863	500-Year	13610.00	544.55	564.57	560.01	564.76	0.000867	5.41	4547.17	806.29	0.22
Grassy	863	100-Year_Ult	11360.00	544.55	564.57	559.56	564.70	0.000604	4.51	4547.17	806.29	0.19
Grassy	1996	2-Year	2550.00	551.36	563.48		563.70	0.000983	4.44	948.56	413.61	0.24
Grassy	1996	5-Year	4110.00	551.36	564.14		564.49	0.001577	5.85	1238.52	462.83	0.30
Grassy	1996	10-Year	5370.00	551.36	564.54		564.98	0.002023	6.77	1433.39	496.95	0.34
Grassy	1996	25-Year	7070.00	551.36	565.28		565.74	0.002104	7.19	1828.68	556.92	0.35
Grassy	1996	50-Year	8530.00	551.36	564.89		565.76	0.003997	9.71	1615.21	530.51	0.49
Grassy	1996	100-Year	9910.00	551.36	565.07		566.11	0.004796	10.73	1709.63	541.86	0.53
Grassy	1996	500-Year	13610.00	551.36	565.77		567.00	0.005719	12.16	2107.56	597.43	0.59
Grassy	1996	100-Year_Ult	11360.00	551.36	565.32		566.46	0.005312	11.44	1846.14	558.33	0.56
Grassy	3907	2-Year	2550.00	557.06	565.86		566.22	0.003130	6.20	900.19	571.96	0.39
Grassy	3907	5-Year	4120.00	557.06	566.89		567.12	0.002349	5.82	1521.33	642.95	0.34
Grassy	3907	10-Year	5380.00	557.06	567.52		567.73	0.002137	5.81	1941.61	687.02	0.33
Grassy	3907	25-Year	7080.00	557.06	568.14		568.35	0.002096	5.99	2371.58	707.25	0.33
Grassy	3907	50-Year	8540.00	557.06	568.82		569.01	0.001782	5.77	2862.43	734.77	0.31
Grassy	3907	100-Year	9920.00	557.06	569.28		569.48	0.001725	5.84	3208.73	751.76	0.30
Grassy	3907	500-Year	13580.00	557.06	570.27		570.50	0.001763	6.23	3972.67	799.82	0.31
Grassy	3907	100-Year_Ult	11350.00	557.06	569.70		569.91	0.001735	5.99	3525.32	773.85	0.31
Grassy	4899	2-Year	2550.00	561.53	568.88		569.09	0.003322	5.20	914.80	436.23	0.37
Grassy	4899	5-Year	4120.00	561.53	569.52		569.80	0.004225	6.27	1196.98	461.48	0.43
Grassy	4899	10-Year	5380.00	561.53	570.00		570.32	0.004461	6.75	1423.70	478.44	0.45
Grassy	4899	25-Year	7080.00	561.53	570.59		570.96	0.004650	7.27	1709.31	491.78	0.46
Grassy	4899	50-Year	8540.00	561.53	571.01		571.42	0.004866	7.71	1919.56	504.72	0.48
Grassy	4899	100-Year	9920.00	561.53	571.41		571.85	0.004889	7.97	2122.39	509.47	0.48
Grassy	4899	500-Year	13580.00	561.53	572.40		572.90	0.004894	8.58	2643.19	545.35	0.49
Grassy	4899	100-Year_Ult	11350.00	561.53	571.82		572.28	0.004878	8.22	2333.73	526.07	0.48
Grassy	5653	2-Year	2550.00	563.60	570.92		571.07	0.002233	4.67	1165.69	479.71	0.33
Grassy	5653	5-Year	4120.00	563.60	571.84		572.01	0.002272	5.16	1616.49	502.61	0.34
Grassy	5653	10-Year	5380.00	563.60	572.44		572.62	0.002344	5.53	1920.80	523.05	0.35
Grassy	5653	25-Year	7080.00	563.60	573.12		573.33	0.002427	5.95	2282.55	536.56	0.36
Grassy	5653	50-Year	8540.00	563.60	573.64		573.88	0.002493	6.28	2568.17	553.82	0.37
Grassy	5653	100-Year	9920.00	563.60	574.09		574.34	0.002570	6.58	2817.48	577.03	0.38
Grassy	5653	500-Year	13580.00	563.60	575.14		575.45	0.002677	7.21	3441.11	609.62	0.39
Grassy	5653	100-Year_Ult	11350.00	563.60	574.52		574.80	0.002618	6.85	3072.13	593.07	0.39
Grassy	6339	2-Year	2550.00	564.24	572.75		572.94	0.003526	5.64	1003.59	484.54	0.39
Grassy	6339	5-Year	4110.00	564.24	573.63		573.83	0.003315	5.95	1458.33	557.50	0.38
Grassy	6339	10-Year	5360.00	564.24	574.23		574.43	0.003167	6.12	1807.04	603.52	0.38
Grassy	6339	25-Year	7050.00	564.24	574.92		575.13	0.003017	6.31	2239.83	649.69	0.38
Grassy	6339	50-Year	8510.00	564.24	575.45		575.66	0.002896	6.43	2591.41	679.39	0.37
Grassy	6339	100-Year	9890.00	564.24	575.90		576.13	0.002793	6.52	2908.23	711.93	0.37
Grassy	6339	500-Year	13520.00	564.24	576.96		577.20	0.002590	6.73	3689.85	770.21	0.36
Grassy	6339	100-Year_Ult	11310.00	564.24	576.34		576.57	0.002698	6.60	3225.90	741.94	0.37
Grassy	7362	2-Year	2550.00	566.62	575.53		575.85	0.003033	6.36	862.88	417.62	0.41
Grassy	7362	5-Year	4110.00	566.62	576.38		576.72	0.003318	7.15	1238.10	472.30	0.44
Grassy	7362	10-Year	5360.00	566.62	576.92		577.28	0.003451	7.61	1503.15	506.95	0.45
Grassy	7362	25-Year	7050.00	566.62	577.56		577.95	0.003596	8.14	1844.48	559.78	0.47
Grassy	7362	50-Year	8510.00	566.62	578.02		578.43	0.003639	8.45	2108.53	581.02	0.47
Grassy	7362	100-Year	9890.00	566.62	578.41		578.84	0.003661	8.70	2337.63	592.48	0.48
Grassy	7362	500-Year	13520.00	566.62	579.36		579.84	0.003777	9.37	2928.37	651.95	0.49
Grassy	7362	100-Year_Ult	11310.00	566.62	578.81		579.25	0.003722	8.99	2577.24	619.97	0.48
Grassy	8633	2-Year	2550.00	568.71	577.95		578.14	0.001683	5.17	1103.27	499.83	0.33
Grassy	8633	5-Year	4100.00	568.71	578.86		579.05	0.001747	5.66	1589.95	590.01	0.34
Grassy	8633	10-Year	5350.00	568.71	579.45		579.65	0.001810	6.03	1958.32	630.48	0.35
Grassy	8633	25-Year	7050.00	568.71	580.12		580.33	0.001807	6.30	2393.03	665.31	0.35
Grassy	8633	50-Year	8490.00	568.71	580.60		580.82	0.001841	6.57	2719.06	692.43	0.36
Grassy	8633	100-Year	9860.00	568.71	581.01		581.25	0.001884	6.82	3011.51	719.31	0.36
Grassy	8633	500-Year	13460.00	568.71	582.00		582.27	0.001910	7.27	3751.14	769.78	0.37
Grassy	8633	100-Year_Ult	11270.00	568.71	581.43		581.68	0.001892	7.00	3313.47	742.40	0.37
Grassy	8993	2-Year	2460.00	569.98	578.47		578.61	0.001238	4.47	1305.74	741.76	0.28
Grassy	8993	5-Year	3970.00	569.98	579.38		579.50	0.001108	4.55	2012.98	802.46	0.27
Grassy	8993	10-Year	5160.00	569.98	579.99		580.11	0.001057	4.65	2517.48	896.50	0.27
Grassy	8993	25-Year	6790.00	569.98	580.66		580.78	0.001056	4.86	3176.76	1027.76	0.27

HEC-RAS Plan: Grassy_Multi River: Grassy Reach: Grassy (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Grassy	8993	50-Year	8160.00	569.98	581.15		581.26	0.001003	4.89	3683.19	1041.81	0.27
Grassy	8993	100-Year	9470.00	569.98	581.57		581.69	0.000973	4.95	4131.10	1058.74	0.26
Grassy	8993	500-Year	12830.00	569.98	582.58		582.70	0.000911	5.08	5211.09	1095.17	0.26
Grassy	8993	100-Year_Ult	10900.00	569.98	581.99		582.11	0.000955	5.02	4575.13	1069.52	0.26
Grassy	9963	2-Year	2460.00	570.83	579.82		579.95	0.001819	4.55	1185.23	609.26	0.29
Grassy	9963	5-Year	3970.00	570.83	580.60		580.73	0.001790	4.82	1664.30	630.40	0.30
Grassy	9963	10-Year	5160.00	570.83	581.13		581.27	0.001740	4.95	2003.01	641.71	0.29
Grassy	9963	25-Year	6790.00	570.83	581.77		581.92	0.001704	5.13	2420.44	657.61	0.29
Grassy	9963	50-Year	8160.00	570.83	582.22		582.39	0.001750	5.37	2717.60	678.23	0.30
Grassy	9963	100-Year	9470.00	570.83	582.61		582.80	0.001770	5.54	2989.19	690.31	0.30
Grassy	9963	500-Year	12830.00	570.83	583.55		583.77	0.001795	5.91	3647.99	722.41	0.31
Grassy	9963	100-Year_Ult	10900.00	570.83	583.01		583.21	0.001791	5.71	3262.40	704.96	0.31
Grassy	11190	2-Year	2460.00	573.44	582.44		582.96	0.005193	7.34	670.88	452.26	0.50
Grassy	11190	5-Year	3970.00	573.44	583.11		583.62	0.005454	8.01	989.87	490.75	0.52
Grassy	11190	10-Year	5160.00	573.44	583.55		584.07	0.005529	8.38	1216.98	527.87	0.53
Grassy	11190	25-Year	6790.00	573.44	584.10		584.61	0.005376	8.64	1513.93	558.26	0.52
Grassy	11190	50-Year	8160.00	573.44	584.53		585.03	0.005124	8.72	1758.43	571.07	0.52
Grassy	11190	100-Year	9470.00	573.44	584.91		585.41	0.004982	8.84	1977.12	591.49	0.51
Grassy	11190	500-Year	12830.00	573.44	585.78		586.31	0.004645	9.07	2508.37	622.91	0.50
Grassy	11190	100-Year_Ult	10900.00	573.44	585.28		585.80	0.004857	8.96	2203.34	605.52	0.51
Grassy	11910	2-Year	2460.00	574.56	584.86		585.02	0.001812	4.56	1012.38	413.44	0.29
Grassy	11910	5-Year	3970.00	574.56	585.68		585.87	0.002078	5.21	1366.71	455.73	0.31
Grassy	11910	10-Year	5160.00	574.56	586.20		586.41	0.002235	5.62	1605.92	470.19	0.33
Grassy	11910	25-Year	6790.00	574.56	586.80		587.06	0.002478	6.17	1901.13	508.56	0.35
Grassy	11910	50-Year	8160.00	574.56	587.22		587.51	0.002634	6.54	2121.83	533.10	0.36
Grassy	11910	100-Year	9470.00	574.56	587.61		587.92	0.002779	6.89	2333.11	557.62	0.37
Grassy	11910	500-Year	12830.00	574.56	588.46		588.84	0.003003	7.54	2830.00	607.52	0.39
Grassy	11910	100-Year_Ult	10900.00	574.56	587.99		588.33	0.002864	7.16	2548.39	579.39	0.38
Grassy	12533	2-Year	2480.00	575.10	586.00		586.23	0.002309	5.32	876.92	356.25	0.32
Grassy	12533	5-Year	4000.00	575.10	586.96		587.22	0.002551	6.01	1254.20	424.30	0.35
Grassy	12533	10-Year	5220.00	575.10	587.57		587.85	0.002730	6.49	1535.75	487.93	0.36
Grassy	12533	25-Year	6870.00	575.10	588.28		588.58	0.002806	6.89	1921.07	585.38	0.37
Grassy	12533	50-Year	8180.00	575.10	588.77		589.08	0.002804	7.10	2210.55	617.41	0.38
Grassy	12533	100-Year	9470.00	575.10	589.20		589.52	0.002776	7.25	2491.12	665.34	0.38
Grassy	12533	500-Year	12730.00	575.10	590.14		590.47	0.002700	7.53	3148.29	728.36	0.38
Grassy	12533	100-Year_Ult	10850.00	575.10	589.62		589.94	0.002764	7.40	2773.53	691.09	0.38
Grassy	13434	2-Year	2480.00	576.89	587.86		588.08	0.002145	5.12	907.33	368.73	0.31
Grassy	13434	5-Year	4000.00	576.89	588.91		589.14	0.002162	5.56	1311.67	412.56	0.32
Grassy	13434	10-Year	5220.00	576.89	589.59		589.83	0.002169	5.83	1598.62	437.91	0.32
Grassy	13434	25-Year	6870.00	576.89	590.34		590.60	0.002228	6.19	1937.35	466.32	0.33
Grassy	13434	50-Year	8180.00	576.89	590.83		591.12	0.002292	6.47	2169.91	479.87	0.34
Grassy	13434	100-Year	9470.00	576.89	591.26		591.57	0.002364	6.73	2379.08	491.18	0.34
Grassy	13434	500-Year	12730.00	576.89	592.20		592.57	0.002547	7.35	2854.07	517.71	0.36
Grassy	13434	100-Year_Ult	10850.00	576.89	591.68		592.02	0.002447	7.01	2589.98	505.15	0.35
Grassy	14296	2-Year	2480.00	579.26	589.37		589.58	0.001590	4.64	1001.23	454.45	0.28
Grassy	14296	5-Year	4000.00	579.26	590.41		590.62	0.001566	4.99	1492.91	494.85	0.29
Grassy	14296	10-Year	5220.00	579.26	591.09		591.30	0.001559	5.21	1836.49	520.20	0.29
Grassy	14296	25-Year	6870.00	579.26	591.87		592.09	0.001566	5.49	2256.34	552.31	0.29
Grassy	14296	50-Year	8180.00	579.26	592.40		592.63	0.001582	5.70	2553.39	572.36	0.30
Grassy	14296	100-Year	9470.00	579.26	592.87		593.12	0.001605	5.90	2831.09	602.12	0.30
Grassy	14296	500-Year	12730.00	579.26	593.91		594.19	0.001641	6.31	3478.38	647.79	0.31
Grassy	14296	100-Year_Ult	10850.00	579.26	593.34		593.59	0.001609	6.06	3114.41	617.13	0.30
Grassy	15035	2-Year	2480.00	581.01	590.68		591.01	0.002640	5.72	777.28	354.47	0.36
Grassy	15035	5-Year	4000.00	581.01	591.68		592.02	0.002677	6.24	1147.30	381.94	0.37
Grassy	15035	10-Year	5220.00	581.01	592.34		592.68	0.002670	6.54	1405.26	396.88	0.37
Grassy	15035	25-Year	6870.00	581.01	593.12		593.49	0.002749	6.99	1731.63	438.78	0.38
Grassy	15035	50-Year	8180.00	581.01	593.65		594.03	0.002766	7.25	1969.44	465.42	0.39
Grassy	15035	100-Year	9470.00	581.01	594.13		594.54	0.002811	7.53	2199.20	480.55	0.39
Grassy	15035	500-Year	12730.00	581.01	595.18		595.63	0.002838	8.02	2716.71	511.44	0.40
Grassy	15035	100-Year_Ult	10850.00	581.01	594.59		595.02	0.002813	7.73	2422.09	491.21	0.40
Grassy	15758	2-Year	2480.00	581.57	592.54		593.02	0.003065	6.56	616.07	234.54	0.40
Grassy	15758	5-Year	4000.00	581.57	593.64		594.22	0.003715	7.83	950.12	368.65	0.44
Grassy	15758	10-Year	5220.00	581.57	594.31		594.91	0.003864	8.35	1222.69	435.35	0.46
Grassy	15758	25-Year	6870.00	581.57	595.10		595.68	0.003720	8.61	1597.30	504.56	0.46
Grassy	15758	50-Year	8180.00	581.57	595.63		596.18	0.003616	8.75	1870.89	539.68	0.45
Grassy	15758	100-Year	9470.00	581.57	596.11		596.66	0.003500	8.85	2142.84	576.99	0.45
Grassy	15758	500-Year	12730.00	581.57	597.13		597.66	0.003268	9.03	2758.54	624.98	0.44
Grassy	15758	100-Year_Ult	10850.00	581.57	596.56		597.09	0.003397	8.93	2405.97	602.60	0.44

HEC-RAS Plan: Grassy_Multi River: Grassy Reach: Grassy (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Grassy	16509	2-Year	2480.00	583.27	594.25		594.55	0.001556	5.15	781.88	274.53	0.29
Grassy	16509	5-Year	4000.00	583.27	595.64		595.98	0.001746	5.97	1209.20	359.56	0.32
Grassy	16509	10-Year	5220.00	583.27	596.40		596.78	0.001911	6.53	1508.38	452.69	0.34
Grassy	16509	25-Year	6870.00	583.27	597.15		597.56	0.002064	7.07	1874.92	510.85	0.35
Grassy	16509	50-Year	8180.00	583.27	597.65		598.07	0.002172	7.44	2137.55	542.97	0.36
Grassy	16509	100-Year	9470.00	583.27	598.09		598.53	0.002233	7.72	2382.51	566.87	0.37
Grassy	16509	500-Year	12730.00	583.27	599.03		599.51	0.002383	8.34	2937.77	608.06	0.39
Grassy	16509	100-Year_Ult	10850.00	583.27	598.51		598.97	0.002319	8.02	2623.21	589.17	0.38
Grassy	17236	2-Year	2480.00	585.69	595.38		595.60	0.001790	4.96	947.41	322.49	0.30
Grassy	17236	5-Year	4000.00	585.69	596.78		596.99	0.001632	5.24	1416.99	355.06	0.29
Grassy	17236	10-Year	5220.00	585.69	597.59		597.83	0.001700	5.64	1718.21	389.73	0.30
Grassy	17236	25-Year	6870.00	585.69	598.40		598.67	0.001865	6.20	2044.41	423.17	0.32
Grassy	17236	50-Year	8180.00	585.69	598.94		599.25	0.002010	6.63	2282.91	452.27	0.34
Grassy	17236	100-Year	9470.00	585.69	599.41		599.75	0.002152	7.04	2503.44	495.73	0.35
Grassy	17236	500-Year	12730.00	585.69	600.41		600.82	0.002444	7.89	3041.99	568.09	0.38
Grassy	17236	100-Year_Ult	10850.00	585.69	599.86		600.23	0.002280	7.41	2738.63	533.87	0.36
Grassy	17784	2-Year	2470.00	586.48	596.49		596.89	0.004476	6.30	806.24	292.80	0.39
Grassy	17784	5-Year	3990.00	586.48	597.75		598.19	0.004781	7.16	1219.51	370.75	0.41
Grassy	17784	10-Year	5210.00	586.48	598.57		598.98	0.004529	7.36	1565.26	445.89	0.40
Grassy	17784	25-Year	6860.00	586.48	599.43		599.83	0.004380	7.64	1990.86	528.38	0.40
Grassy	17784	50-Year	8150.00	586.48	600.02		600.41	0.004213	7.75	2307.44	547.54	0.40
Grassy	17784	100-Year	9440.00	586.48	600.53		600.92	0.004127	7.89	2593.83	568.54	0.40
Grassy	17784	500-Year	12650.00	586.48	601.62		602.02	0.003980	8.20	3235.01	607.02	0.39
Grassy	17784	100-Year_Ult	10800.00	586.48	601.02		601.41	0.004051	8.02	2878.24	584.85	0.40
Grassy	18499	2-Year	2470.00	586.36	598.66	594.58	598.97	0.002449	5.14	876.46	275.55	0.30
Grassy	18499	5-Year	3990.00	586.36	600.05	596.82	600.42	0.002852	6.10	1456.17	523.06	0.33
Grassy	18499	10-Year	5210.00	586.36	600.78	598.30	601.15	0.002964	6.49	1861.89	596.18	0.34
Grassy	18499	25-Year	6860.00	586.36	601.58	599.51	601.95	0.003025	6.86	2363.10	657.08	0.35
Grassy	18499	50-Year	8150.00	586.36	602.10	599.56	602.46	0.003044	7.08	2717.43	707.06	0.35
Grassy	18499	100-Year	9440.00	586.36	602.57	600.59	602.93	0.003024	7.23	3066.61	754.09	0.35
Grassy	18499	500-Year	12650.00	586.36	603.58	601.45	603.93	0.002940	7.49	3870.63	829.39	0.35
Grassy	18499	100-Year_Ult	10800.00	586.36	603.02	601.03	603.37	0.002991	7.35	3411.50	792.89	0.35
Grassy	18523	2-Year	2470.00	586.90	598.68	595.56	599.09	0.003477	6.02	787.15	261.09	0.35
Grassy	18523	5-Year	3990.00	586.90	600.06	597.98	600.57	0.004221	7.27	1262.91	465.33	0.39
Grassy	18523	10-Year	5210.00	586.90	600.80	598.91	601.30	0.004231	7.61	1641.00	541.50	0.40
Grassy	18523	25-Year	6860.00	586.90	601.60	599.65	602.09	0.004283	8.02	2118.13	636.46	0.40
Grassy	18523	50-Year	8150.00	586.90	602.13	600.69	602.59	0.004193	8.16	2458.17	662.69	0.40
Grassy	18523	100-Year	9440.00	586.90	602.60	601.03	603.05	0.004122	8.29	2789.16	740.04	0.40
Grassy	18523	500-Year	12650.00	586.90	603.62	601.89	604.04	0.003908	8.48	3574.02	815.14	0.40
Grassy	18523	100-Year_Ult	10800.00	586.90	603.06	601.47	603.49	0.004043	8.40	3129.86	765.11	0.40
Grassy	18546		Culvert									
Grassy	18564	2-Year	2470.00	586.90	598.92	595.61	599.12	0.002002	4.51	1039.85	265.45	0.26
Grassy	18564	5-Year	3990.00	586.90	600.37	597.09	600.62	0.002412	5.46	1662.70	540.12	0.30
Grassy	18564	10-Year	5210.00	586.90	601.06	597.89	601.33	0.002594	5.91	2063.14	609.99	0.31
Grassy	18564	25-Year	6860.00	586.90	601.88	598.71	602.15	0.002573	6.17	2571.05	642.65	0.31
Grassy	18564	50-Year	8150.00	586.90	602.32	599.05	602.60	0.002773	6.56	2857.87	682.25	0.33
Grassy	18564	100-Year	9440.00	586.90	602.83	599.42	603.12	0.002756	6.72	3220.28	725.49	0.33
Grassy	18564	500-Year	12650.00	586.90	603.79	601.30	604.10	0.002905	7.24	3947.39	788.06	0.34
Grassy	18564	100-Year_Ult	10800.00	586.90	603.19	600.61	603.51	0.002992	7.13	3486.53	752.98	0.35
Grassy	18576	2-Year	2470.00	587.85	598.91	596.73	599.20	0.003243	5.63	889.82	239.86	0.33
Grassy	18576	5-Year	3990.00	587.85	600.36	597.71	600.71	0.003830	6.76	1474.82	535.70	0.37
Grassy	18576	10-Year	5210.00	587.85	601.07	598.29	601.40	0.003722	6.97	1874.90	585.71	0.37
Grassy	18576	25-Year	6860.00	587.85	601.90	599.07	602.20	0.003511	7.10	2381.63	634.75	0.36
Grassy	18576	50-Year	8150.00	587.85	602.34	600.62	602.66	0.003639	7.40	2665.75	649.96	0.37
Grassy	18576	100-Year	9440.00	587.85	602.86	600.94	603.17	0.003588	7.56	3012.77	702.93	0.37
Grassy	18576	500-Year	12650.00	587.85	603.82	601.54	604.15	0.003654	8.00	3714.18	761.94	0.38
Grassy	18576	100-Year_Ult	10800.00	587.85	603.23	601.21	603.55	0.003743	7.86	3274.62	723.06	0.38
Grassy	19132	2-Year	2470.00	588.66	600.22		600.41	0.001859	4.63	1189.99	349.24	0.26
Grassy	19132	5-Year	3990.00	588.66	601.81		602.00	0.001874	5.14	1977.39	579.09	0.27
Grassy	19132	10-Year	5210.00	588.66	602.50		602.70	0.001969	5.48	2392.83	615.42	0.28
Grassy	19132	25-Year	6860.00	588.66	603.29		603.49	0.002082	5.87	2894.53	666.65	0.29
Grassy	19132	50-Year	8150.00	588.66	603.78		603.99	0.002185	6.17	3224.02	677.44	0.30
Grassy	19132	100-Year	9440.00	588.66	604.28		604.50	0.002201	6.34	3569.38	689.58	0.30
Grassy	19132	500-Year	12650.00	588.66	605.29		605.53	0.002352	6.87	4272.88	713.18	0.31
Grassy	19132	100-Year_Ult	10800.00	588.66	604.71		604.94	0.002299	6.62	3863.02	701.20	0.31
Grassy	19361	2-Year	2470.00	588.27	600.60		600.71	0.001231	3.88	1502.48	407.88	0.21

HEC-RAS Plan: Grassy_Multi River: Grassy Reach: Grassy (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Grassy	19361	5-Year	3990.00	588.27	602.18		602.31	0.001415	4.56	2327.38	608.90	0.23
Grassy	19361	10-Year	5210.00	588.27	602.89		603.03	0.001543	4.94	2774.99	664.70	0.24
Grassy	19361	25-Year	6860.00	588.27	603.69		603.84	0.001661	5.33	3332.07	721.26	0.25
Grassy	19361	50-Year	8150.00	588.27	604.20		604.36	0.001746	5.60	3703.27	739.42	0.26
Grassy	19361	100-Year	9440.00	588.27	604.70		604.87	0.001777	5.78	4078.79	749.26	0.26
Grassy	19361	500-Year	12650.00	588.27	605.73		605.92	0.001910	6.27	4869.07	781.93	0.28
Grassy	19361	100-Year_Ult	10800.00	588.27	605.14		605.32	0.001854	6.02	4414.13	765.71	0.27
Grassy	19713	2-Year	2470.00	589.35	600.88		601.04	0.001222	4.21	1346.61	368.48	0.23
Grassy	19713	5-Year	3990.00	589.35	602.49		602.68	0.001434	5.02	2053.89	525.04	0.26
Grassy	19713	10-Year	5210.00	589.35	603.21		603.43	0.001617	5.55	2445.93	572.15	0.28
Grassy	19713	25-Year	6860.00	589.35	604.02		604.27	0.001836	6.16	2928.70	615.60	0.30
Grassy	19713	50-Year	8150.00	589.35	604.54		604.81	0.002025	6.64	3253.57	634.95	0.31
Grassy	19713	100-Year	9440.00	589.35	605.04		605.33	0.002089	6.90	3578.90	655.44	0.32
Grassy	19713	500-Year	12650.00	589.35	606.09		606.40	0.002275	7.55	4288.24	698.51	0.34
Grassy	19713	100-Year_Ult	10800.00	589.35	605.49		605.79	0.002189	7.21	3878.92	675.30	0.33
Grassy	20530	2-Year	2490.00	591.63	602.04		602.39	0.003409	6.49	976.92	367.39	0.38
Grassy	20530	5-Year	4040.00	591.63	603.68		603.95	0.002757	6.52	1666.09	444.08	0.35
Grassy	20530	10-Year	5280.00	591.63	604.48		604.76	0.002785	6.88	2051.47	505.88	0.36
Grassy	20530	25-Year	6900.00	591.63	605.37		605.65	0.002746	7.18	2523.00	549.56	0.36
Grassy	20530	50-Year	8160.00	591.63	605.96		606.24	0.002752	7.41	2855.35	571.02	0.36
Grassy	20530	100-Year	9410.00	591.63	606.48		606.77	0.002784	7.65	3156.86	589.71	0.37
Grassy	20530	500-Year	12530.00	591.63	607.60		607.91	0.002892	8.22	3834.64	635.70	0.38
Grassy	20530	100-Year_Ult	10720.00	591.63	606.97		607.27	0.002829	7.90	3446.65	604.17	0.37
Grassy	21576	2-Year	2490.00	594.53	603.91		604.02	0.001300	3.84	1291.24	486.32	0.24
Grassy	21576	5-Year	4040.00	594.53	605.16		605.27	0.001176	4.02	1973.63	592.23	0.23
Grassy	21576	10-Year	5280.00	594.53	605.91		606.02	0.001145	4.18	2433.23	641.93	0.23
Grassy	21576	25-Year	6900.00	594.53	606.73		606.85	0.001102	4.32	2976.92	681.28	0.23
Grassy	21576	50-Year	8160.00	594.53	607.32		607.44	0.001111	4.49	3393.66	736.05	0.23
Grassy	21576	100-Year	9410.00	594.53	607.82		607.94	0.001088	4.57	3769.09	755.14	0.23
Grassy	21576	500-Year	12530.00	594.53	608.92		609.06	0.001063	4.79	4627.24	800.78	0.23
Grassy	21576	100-Year_Ult	10720.00	594.53	608.30		608.43	0.001070	4.65	4133.37	768.16	0.23
Grassy	22435	2-Year	2490.00	597.18	605.18		605.46	0.003687	5.73	788.28	310.22	0.42
Grassy	22435	5-Year	4040.00	597.18	606.28		606.61	0.003834	6.56	1165.53	383.57	0.44
Grassy	22435	10-Year	5280.00	597.18	606.96		607.32	0.003801	6.95	1442.97	420.93	0.44
Grassy	22435	25-Year	6900.00	597.18	607.72		608.11	0.003803	7.41	1777.89	466.56	0.45
Grassy	22435	50-Year	8160.00	597.18	608.29		608.69	0.003762	7.69	2060.40	524.90	0.45
Grassy	22435	100-Year	9410.00	597.18	608.76		609.16	0.003677	7.87	2313.96	550.65	0.45
Grassy	22435	500-Year	12530.00	597.18	609.81		610.23	0.003467	8.20	2975.99	722.42	0.45
Grassy	22435	100-Year_Ult	10720.00	597.18	609.21		609.62	0.003624	8.06	2569.55	602.86	0.45
Grassy	23089	2-Year	1850.00	597.13	606.44	602.59	606.55	0.000777	3.20	861.92	246.76	0.20
Grassy	23089	5-Year	2950.00	597.13	607.71	603.51	607.85	0.000937	3.89	1262.11	395.37	0.23
Grassy	23089	10-Year	3780.00	597.13	608.45	604.05	608.61	0.000983	4.20	1578.10	473.40	0.24
Grassy	23089	25-Year	4870.00	597.13	609.25	604.70	609.42	0.001002	4.47	1996.94	558.17	0.24
Grassy	23089	50-Year	5740.00	597.13	609.82	605.14	609.99	0.000989	4.60	2339.30	645.35	0.24
Grassy	23089	100-Year	6620.00	597.13	610.29	605.69	610.45	0.000993	4.73	2657.04	711.12	0.25
Grassy	23089	500-Year	8820.00	597.13	611.31	606.80	611.48	0.000981	4.98	3439.34	804.48	0.25
Grassy	23089	100-Year_Ult	7760.00	597.13	610.75	606.34	610.93	0.001048	4.99	3004.70	768.75	0.25
Grassy	23223	2-Year	1850.00	597.15	606.58	603.34	606.72	0.001527	4.54	810.68	342.89	0.28
Grassy	23223	5-Year	2950.00	597.15	607.90	604.25	608.03	0.001300	4.63	1367.31	483.34	0.26
Grassy	23223	10-Year	3780.00	597.15	608.67	606.00	608.78	0.001132	4.54	1770.40	570.28	0.25
Grassy	23223	25-Year	4870.00	597.15	609.49	606.31	609.59	0.001021	4.53	2269.99	655.77	0.24
Grassy	23223	50-Year	5740.00	597.15	610.05	606.88	610.16	0.000937	4.48	2661.88	709.36	0.23
Grassy	23223	100-Year	6620.00	597.15	610.52	606.88	610.62	0.000912	4.54	3004.08	766.19	0.23
Grassy	23223	500-Year	8820.00	597.15	611.53	607.74	611.64	0.000852	4.63	3800.64	812.36	0.22
Grassy	23223	100-Year_Ult	7760.00	597.15	611.00	607.66	611.11	0.000917	4.67	3375.20	783.34	0.23
Grassy	23244		Bridge									
Grassy	23268	2-Year	1850.00	597.15	608.29	603.52	608.32	0.000212	2.40	1803.34	499.42	0.13
Grassy	23268	5-Year	2950.00	597.15	609.37	604.48	609.41	0.000271	2.90	2400.38	597.28	0.15
Grassy	23268	10-Year	3780.00	597.15	609.77	605.11	609.82	0.000340	3.32	2641.00	616.12	0.17
Grassy	23268	25-Year	4870.00	597.15	610.17	605.88	610.24	0.000437	3.86	2894.06	638.40	0.20
Grassy	23268	50-Year	5740.00	597.15	610.57	606.44	610.65	0.000477	4.12	3154.61	662.87	0.21
Grassy	23268	100-Year	6620.00	597.15	610.95	606.85	611.04	0.000515	4.37	3413.36	692.27	0.22
Grassy	23268	500-Year	8820.00	597.15	611.84	606.85	611.95	0.000582	4.85	4055.16	747.20	0.23
Grassy	23268	100-Year_Ult	7760.00	597.15	611.38	606.85	611.48	0.000573	4.71	3715.24	720.22	0.23
Grassy	23390	2-Year	1850.00	598.37	608.32	603.89	608.35	0.000283	2.52	1645.60	495.97	0.15
Grassy	23390	5-Year	2950.00	598.37	609.40	604.91	609.44	0.000331	2.95	2220.94	565.11	0.17
Grassy	23390	10-Year	3780.00	598.37	609.80	605.31	609.86	0.000409	3.37	2451.28	576.05	0.19

HEC-RAS Plan: Grassy_Multi River: Grassy Reach: Grassy (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Grassy	23390	25-Year	4870.00	598.37	610.22	605.78	610.29	0.000533	3.96	2697.40	608.13	0.22
Grassy	23390	50-Year	5740.00	598.37	610.62	606.14	610.71	0.000594	4.28	2951.74	653.10	0.23
Grassy	23390	100-Year	6620.00	598.37	611.01	606.49	611.10	0.000639	4.55	3214.34	692.85	0.24
Grassy	23390	500-Year	8820.00	598.37	611.91	607.36	612.02	0.000693	4.98	3859.26	750.57	0.25
Grassy	23390	100-Year_Ult	7760.00	598.37	611.44	607.21	611.55	0.000690	4.85	3521.10	719.44	0.25
Grassy	24088	2-Year	1850.00	599.88	608.53		608.71	0.001140	4.70	777.68	283.96	0.30
Grassy	24088	5-Year	2950.00	599.88	609.64		609.86	0.001267	5.44	1159.12	396.89	0.33
Grassy	24088	10-Year	3780.00	599.88	610.10		610.36	0.001543	6.21	1354.40	450.47	0.36
Grassy	24088	25-Year	4870.00	599.88	610.61		610.90	0.001722	6.80	1588.05	475.06	0.39
Grassy	24088	50-Year	5740.00	599.88	611.05		611.36	0.001736	7.04	1803.74	487.73	0.39
Grassy	24088	100-Year	6620.00	599.88	611.47		611.79	0.001780	7.33	2012.75	518.22	0.40
Grassy	24088	500-Year	8820.00	599.88	612.40		612.72	0.001749	7.69	2508.29	554.94	0.40
Grassy	24088	100-Year_Ult	7760.00	599.88	611.94		612.26	0.001790	7.56	2257.23	531.90	0.40
Grassy	24543	2-Year	1850.00	600.22	609.04		609.17	0.001159	4.09	842.00	322.69	0.27
Grassy	24543	5-Year	2950.00	600.22	610.20		610.34	0.001251	4.69	1278.48	414.31	0.28
Grassy	24543	10-Year	3780.00	600.22	610.76		610.92	0.001323	5.04	1525.79	451.10	0.30
Grassy	24543	25-Year	4870.00	600.22	611.32		611.50	0.001416	5.42	1784.46	465.35	0.31
Grassy	24543	50-Year	5740.00	600.22	611.77		611.95	0.001432	5.62	1993.05	474.64	0.31
Grassy	24543	100-Year	6620.00	600.22	612.20		612.39	0.001456	5.83	2201.52	527.75	0.32
Grassy	24543	500-Year	8820.00	600.22	613.12		613.36	0.001681	6.63	2738.14	622.12	0.35
Grassy	24543	100-Year_Ult	7760.00	600.22	612.68		612.91	0.001663	6.42	2470.83	583.73	0.34
Grassy	24985	2-Year	1910.00	600.43	609.52		609.69	0.001560	4.75	783.03	285.45	0.31
Grassy	24985	5-Year	2970.00	600.43	610.69		610.85	0.001410	4.97	1128.85	312.32	0.30
Grassy	24985	10-Year	3740.00	600.43	611.27		611.45	0.001513	5.38	1321.39	343.32	0.31
Grassy	24985	25-Year	4780.00	600.43	611.86		612.07	0.001638	5.83	1532.74	380.70	0.33
Grassy	24985	50-Year	5630.00	600.43	612.32		612.56	0.001816	6.33	1725.14	452.89	0.35
Grassy	24985	100-Year	6470.00	600.43	612.75		613.00	0.001814	6.50	1923.83	477.42	0.35
Grassy	24985	500-Year	8570.00	600.43	613.73		614.00	0.001798	6.87	2428.56	539.44	0.35
Grassy	24985	100-Year_Ult	7740.00	600.43	613.29		613.57	0.001907	6.89	2196.35	522.51	0.36
Grassy	25478	2-Year	1910.00	602.61	610.13		610.22	0.001187	3.74	939.35	331.02	0.26
Grassy	25478	5-Year	2970.00	602.61	611.22		611.32	0.001074	3.95	1311.23	349.63	0.26
Grassy	25478	10-Year	3740.00	602.61	611.83		611.95	0.001110	4.24	1532.16	371.03	0.26
Grassy	25478	25-Year	4780.00	602.61	612.47		612.61	0.001219	4.67	1778.96	397.70	0.28
Grassy	25478	50-Year	5630.00	602.61	612.99		613.14	0.001265	4.95	1990.77	422.21	0.29
Grassy	25478	100-Year	6470.00	602.61	613.42		613.58	0.001304	5.18	2175.43	436.21	0.29
Grassy	25478	500-Year	8570.00	602.61	614.42		614.62	0.001507	5.95	2649.19	523.90	0.32
Grassy	25478	100-Year_Ult	7740.00	602.61	613.99		614.18	0.001375	5.53	2434.10	483.87	0.31
Grassy	26572	2-Year	1910.00	605.48	611.78		612.10	0.003980	6.02	564.91	281.62	0.47
Grassy	26572	5-Year	2970.00	605.48	612.65		612.97	0.003557	6.31	822.84	308.04	0.45
Grassy	26572	10-Year	3740.00	605.48	613.24		613.55	0.003206	6.38	1006.94	319.75	0.44
Grassy	26572	25-Year	4780.00	605.48	613.93		614.25	0.003012	6.60	1233.65	339.73	0.43
Grassy	26572	50-Year	5630.00	605.48	614.45		614.78	0.002889	6.77	1413.55	356.82	0.43
Grassy	26572	100-Year	6470.00	605.48	614.89		615.24	0.002856	6.98	1574.80	372.36	0.43
Grassy	26572	500-Year	8570.00	605.48	616.01		616.38	0.002781	7.50	2053.17	475.12	0.43
Grassy	26572	100-Year_Ult	7740.00	605.48	615.54		615.92	0.003030	7.56	1839.83	440.04	0.45
Grassy	27444	2-Year	1910.00	606.15	614.63		614.82	0.003662	5.05	862.55	331.43	0.35
Grassy	27444	5-Year	2970.00	606.15	615.45		615.69	0.004409	6.00	1159.82	381.58	0.39
Grassy	27444	10-Year	3740.00	606.15	615.92		616.19	0.004793	6.51	1342.82	400.21	0.41
Grassy	27444	25-Year	4780.00	606.15	616.52		616.81	0.004990	6.97	1585.73	418.07	0.42
Grassy	27444	50-Year	5630.00	606.15	617.00		617.32	0.005280	7.44	1799.63	464.15	0.44
Grassy	27444	100-Year	6470.00	606.15	617.44		617.77	0.005411	7.78	2015.56	503.88	0.45
Grassy	27444	500-Year	8570.00	606.15	618.45		618.79	0.005087	8.07	2558.79	565.86	0.44
Grassy	27444	100-Year_Ult	7740.00	606.15	618.13		618.46	0.005078	7.90	2380.16	553.63	0.44
Grassy	28572	2-Year	1910.00	610.10	617.06		617.17	0.001662	3.88	1037.56	279.66	0.28
Grassy	28572	5-Year	2970.00	610.10	618.25		618.40	0.001897	4.70	1423.65	388.61	0.31
Grassy	28572	10-Year	3740.00	610.10	618.91		619.09	0.002021	5.15	1708.78	449.42	0.33
Grassy	28572	25-Year	4780.00	610.10	619.64		619.84	0.002139	5.63	2051.63	529.61	0.34
Grassy	28572	50-Year	5630.00	610.10	620.17		620.38	0.002110	5.83	2355.42	600.87	0.34
Grassy	28572	100-Year	6470.00	610.10	620.64		620.85	0.002102	6.01	2644.53	643.08	0.35
Grassy	28572	500-Year	8570.00	610.10	621.59		621.81	0.002151	6.49	3300.79	737.49	0.36
Grassy	28572	100-Year_Ult	7740.00	610.10	621.25		621.47	0.002131	6.32	3059.92	712.11	0.35
Grassy	29011	2-Year	1910.00	612.29	617.85		618.00	0.001977	3.88	868.37	276.20	0.30
Grassy	29011	5-Year	2970.00	612.29	619.12		619.32	0.002072	4.61	1303.36	397.17	0.32
Grassy	29011	10-Year	3740.00	612.29	619.81		620.02	0.002010	4.86	1590.13	441.45	0.32
Grassy	29011	25-Year	4780.00	612.29	620.56		620.80	0.002070	5.28	1949.60	516.64	0.33
Grassy	29011	50-Year	5630.00	612.29	621.09		621.34	0.002085	5.54	2230.92	549.59	0.34
Grassy	29011	100-Year	6470.00	612.29	621.55		621.81	0.002097	5.76	2498.91	616.88	0.34
Grassy	29011	500-Year	8570.00	612.29	622.51		622.80	0.002147	6.25	3130.41	693.15	0.35

HEC-RAS Plan: Grassy_Multi River: Grassy Reach: Grassy (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Grassy	29011	100-Year_Ult	7740.00	612.29	622.17		622.45	0.002132	6.08	2901.29	668.89	0.35
Grassy	29809	2-Year	1750.00	612.57	619.50		619.71	0.002485	4.91	793.32	321.59	0.35
Grassy	29809	5-Year	2710.00	612.57	620.74		620.95	0.002213	5.25	1251.90	387.96	0.34
Grassy	29809	10-Year	3400.00	612.57	621.40		621.62	0.002220	5.56	1524.75	432.64	0.35
Grassy	29809	25-Year	4280.00	612.57	622.17		622.39	0.002122	5.78	1862.73	459.71	0.34
Grassy	29809	50-Year	4990.00	612.57	622.70		622.92	0.002108	5.99	2131.37	537.13	0.35
Grassy	29809	100-Year	5710.00	612.57	623.16		623.39	0.002085	6.16	2393.27	605.91	0.35
Grassy	29809	500-Year	7510.00	612.57	624.13		624.35	0.001997	6.42	3047.73	737.74	0.35
Grassy	29809	100-Year_Ult	7000.00	612.57	623.81		624.04	0.002105	6.46	2816.96	690.64	0.35
Grassy	30518	2-Year	1750.00	614.42	620.55		620.61	0.000895	2.64	1062.46	304.39	0.20
Grassy	30518	5-Year	2710.00	614.42	621.75		621.81	0.000931	3.09	1515.52	423.20	0.22
Grassy	30518	10-Year	3400.00	614.42	622.39		622.46	0.000904	3.25	1802.69	488.05	0.22
Grassy	30518	25-Year	4280.00	614.42	623.11		623.19	0.000881	3.42	2209.41	617.54	0.22
Grassy	30518	50-Year	4990.00	614.42	623.63		623.71	0.000865	3.54	2561.84	750.06	0.22
Grassy	30518	100-Year	5710.00	614.42	624.08		624.16	0.000857	3.65	2914.74	820.61	0.22
Grassy	30518	500-Year	7510.00	614.42	625.02		625.10	0.000851	3.89	3776.87	1065.02	0.22
Grassy	30518	100-Year_Ult	7000.00	614.42	624.73		624.82	0.000872	3.87	3495.96	963.88	0.22
Grassy	31019	2-Year	1750.00	615.33	621.10		621.20	0.001675	3.64	883.16	352.29	0.28
Grassy	31019	5-Year	2710.00	615.33	622.28		622.37	0.001405	3.82	1340.67	428.46	0.27
Grassy	31019	10-Year	3400.00	615.33	622.92		623.03	0.001487	4.19	1652.86	521.88	0.28
Grassy	31019	25-Year	4280.00	615.33	623.62		623.73	0.001424	4.36	2039.49	563.50	0.28
Grassy	31019	50-Year	4990.00	615.33	624.12		624.23	0.001313	4.37	2323.91	583.42	0.27
Grassy	31019	100-Year	5710.00	615.33	624.56		624.67	0.001266	4.44	2585.49	616.29	0.27
Grassy	31019	500-Year	7510.00	615.33	625.48		625.60	0.001227	4.67	3238.56	841.26	0.27
Grassy	31019	100-Year_Ult	7000.00	615.33	625.21		625.33	0.001254	4.64	3027.66	737.74	0.27
Grassy	31511	2-Year	1750.00	614.70	621.55		621.65	0.000926	2.96	828.25	242.74	0.21
Grassy	31511	5-Year	2710.00	614.70	622.69		622.83	0.001095	3.61	1140.68	311.70	0.24
Grassy	31511	10-Year	3400.00	614.70	623.36		623.53	0.001244	4.09	1381.57	416.17	0.26
Grassy	31511	25-Year	4280.00	614.70	624.04		624.23	0.001284	4.39	1728.84	552.91	0.26
Grassy	31511	50-Year	4990.00	614.70	624.51		624.70	0.001263	4.51	2010.26	631.64	0.27
Grassy	31511	100-Year	5710.00	614.70	624.93		625.12	0.001250	4.63	2295.90	714.55	0.27
Grassy	31511	500-Year	7510.00	614.70	625.83		626.02	0.001191	4.80	2989.32	823.35	0.26
Grassy	31511	100-Year_Ult	7000.00	614.70	625.58		625.76	0.001211	4.76	2781.19	778.04	0.26
Grassy	31661	2-Year	1750.00	614.70	621.71	618.51	621.78	0.000661	2.62	1293.03	533.21	0.18
Grassy	31661	5-Year	2710.00	614.70	622.90	619.48	622.96	0.000563	2.70	1974.09	622.14	0.17
Grassy	31661	10-Year	3400.00	614.70	623.61	620.26	623.66	0.000515	2.73	2422.06	645.20	0.17
Grassy	31661	25-Year	4280.00	614.70	624.30	620.71	624.36	0.000506	2.85	2879.42	678.84	0.17
Grassy	31661	50-Year	4990.00	614.70	624.77	620.99	624.83	0.000517	2.98	3202.83	712.18	0.17
Grassy	31661	100-Year	5710.00	614.70	625.19	621.14	625.25	0.000531	3.11	3512.66	787.96	0.17
Grassy	31661	500-Year	7510.00	614.70	626.08	621.83	626.17	0.000669	3.70	4324.65	1017.80	0.20
Grassy	31661	100-Year_Ult	7000.00	614.70	625.83	621.71	625.90	0.000559	3.32	4071.12	957.23	0.18
Grassy	31701	2-Year	1750.00	614.70	621.73	618.25	621.82	0.000829	2.88	1050.81	410.19	0.20
Grassy	31701	5-Year	2710.00	614.70	622.91	619.97	623.00	0.000767	3.09	1610.23	569.25	0.20
Grassy	31701	10-Year	3400.00	614.70	623.62	620.57	623.70	0.000749	3.24	2051.78	650.01	0.20
Grassy	31701	25-Year	4280.00	614.70	624.31	620.95	624.40	0.000731	3.38	2528.63	728.33	0.20
Grassy	31701	50-Year	4990.00	614.70	624.78	621.21	624.87	0.000723	3.48	2873.78	750.52	0.20
Grassy	31701	100-Year	5710.00	614.70	625.20	621.46	625.29	0.000715	3.56	3193.71	769.64	0.20
Grassy	31701	500-Year	7510.00	614.70	626.10	622.01	626.21	0.000822	4.04	4013.32	1007.50	0.22
Grassy	31701	100-Year_Ult	7000.00	614.70	625.84	621.88	625.95	0.000831	4.00	3750.74	967.11	0.22
Grassy	31737		Bridge									
Grassy	31757	2-Year	1750.00	614.70	622.66	618.27	622.73	0.000577	2.56	1216.32	561.65	0.17
Grassy	31757	5-Year	2710.00	614.70	623.85	619.32	623.92	0.000539	2.74	2069.01	889.99	0.17
Grassy	31757	10-Year	3400.00	614.70	624.23	620.08	624.31	0.000630	3.05	2411.89	919.47	0.18
Grassy	31757	25-Year	4280.00	614.70	624.69	621.49	624.78	0.000662	3.24	2844.89	932.35	0.19
Grassy	31757	50-Year	4990.00	614.70	625.07	621.66	625.15	0.000665	3.34	3200.58	962.67	0.19
Grassy	31757	100-Year	5710.00	614.70	625.43	622.11	625.52	0.000676	3.45	3559.36	1000.62	0.19
Grassy	31757	500-Year	7510.00	614.70	626.28	622.85	626.37	0.000670	3.63	4462.86	1108.28	0.20
Grassy	31757	100-Year_Ult	7000.00	614.70	626.04	622.71	626.12	0.000691	3.63	4191.44	1097.72	0.20
Grassy	31785	2-Year	1750.00	614.70	622.73	618.33	622.76	0.000285	1.87	1751.97	558.64	0.12
Grassy	31785	5-Year	2710.00	614.70	623.90	619.41	623.94	0.000320	2.18	2537.34	733.34	0.13
Grassy	31785	10-Year	3400.00	614.70	624.29	620.01	624.33	0.000381	2.45	2825.54	776.44	0.14
Grassy	31785	25-Year	4280.00	614.70	624.75	620.70	624.80	0.000438	2.72	3199.14	846.75	0.15
Grassy	31785	50-Year	4990.00	614.70	625.12	621.21	625.18	0.000491	2.95	3536.30	966.74	0.16
Grassy	31785	100-Year	5710.00	614.70	625.48	621.21	625.54	0.000505	3.07	3894.26	997.71	0.17
Grassy	31785	500-Year	7510.00	614.70	626.33	621.38	626.39	0.000509	3.24	4786.03	1084.79	0.17
Grassy	31785	100-Year_Ult	7000.00	614.70	626.08	621.27	626.15	0.000514	3.21	4523.42	1076.57	0.17

HEC-RAS Plan: Grassy_Multi River: Grassy Reach: Grassy (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Grassy	32281	2-Year	1750.00	616.53	622.92		623.05	0.001536	3.74	847.75	394.08	0.27
Grassy	32281	5-Year	2710.00	616.53	624.11		624.22	0.001149	3.67	1387.28	519.43	0.24
Grassy	32281	10-Year	3400.00	616.53	624.53		624.66	0.001304	4.06	1618.45	586.69	0.26
Grassy	32281	25-Year	4280.00	616.53	625.03		625.17	0.001392	4.38	1919.53	622.95	0.27
Grassy	32281	50-Year	4990.00	616.53	625.43		625.56	0.001395	4.53	2173.84	662.22	0.28
Grassy	32281	100-Year	5710.00	616.53	625.79		625.94	0.001381	4.64	2423.81	696.28	0.28
Grassy	32281	500-Year	7510.00	616.53	626.63		626.78	0.001300	4.79	3035.92	758.97	0.27
Grassy	32281	100-Year_Ult	7000.00	616.53	626.39		626.54	0.001343	4.78	2858.34	739.79	0.28

HEC-RAS Plan: GRSTrib_Multi River: Grassy_Trib Reach: Grassy_Trib

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Grassy_Trib	696	10-Year	2000.00	600.89	607.82	607.82	610.33	0.025822	12.72	157.22	31.34	1.00
Grassy_Trib	696	50-Year	3020.00	600.89	609.54	609.54	612.61	0.025001	14.05	215.00	35.53	1.01
Grassy_Trib	696	100-Year	3530.00	600.89	610.29	610.29	613.59	0.024682	14.57	242.29	37.35	1.01
Grassy_Trib	696	500-Year	4880.00	600.89	612.91	612.91	615.42	0.015516	13.12	425.16	94.56	0.82
Grassy_Trib	696	100-Year_Ult	4460.00	600.89	612.40	612.40	614.97	0.016176	13.10	379.25	88.38	0.83
Grassy_Trib	786	10-Year	2000.00	603.15	611.10	605.60	611.14	0.000206	1.63	1485.54	431.03	0.11
Grassy_Trib	786	50-Year	3020.00	603.15	613.53	606.22	613.57	0.000167	1.77	2069.64	451.25	0.10
Grassy_Trib	786	100-Year	3530.00	603.15	614.58	606.45	614.62	0.000160	1.85	2336.87	495.66	0.10
Grassy_Trib	786	500-Year	4880.00	603.15	616.16	606.98	616.22	0.000197	2.25	2837.54	675.77	0.11
Grassy_Trib	786	100-Year_Ult	4460.00	603.15	615.72	606.82	615.78	0.000186	2.14	2680.97	632.85	0.11
Grassy_Trib	1217	10-Year	2000.00	609.44	614.44	614.44	615.81	0.024407	9.41	216.56	87.50	0.97
Grassy_Trib	1217	50-Year	3020.00	609.44	615.94	615.94	616.69	0.009306	7.65	644.83	534.84	0.64
Grassy_Trib	1217	100-Year	3530.00	609.44	616.20	616.20	616.92	0.008845	7.75	789.36	564.56	0.63
Grassy_Trib	1217	500-Year	4880.00	609.44	616.60	616.60	617.40	0.009974	8.68	1017.74	594.40	0.68
Grassy_Trib	1217	100-Year_Ult	4460.00	609.44	616.47	616.47	617.26	0.009787	8.46	945.14	587.49	0.67
Grassy_Trib	1685	10-Year	2000.00	608.64	616.31		616.33	0.000251	1.25	1873.69	416.57	0.08
Grassy_Trib	1685	50-Year	3020.00	608.64	617.19		617.22	0.000351	1.59	2260.01	471.55	0.10
Grassy_Trib	1685	100-Year	3530.00	608.64	617.46		617.51	0.000413	1.77	2393.20	483.62	0.11
Grassy_Trib	1685	500-Year	4880.00	608.64	618.10		618.16	0.000565	2.17	2716.71	537.61	0.13
Grassy_Trib	1685	100-Year_Ult	4460.00	608.64	617.92		617.97	0.000520	2.05	2620.73	522.08	0.12
Grassy_Trib	2654	10-Year	2000.00	608.78	616.72		617.06	0.004327	6.12	598.48	226.12	0.44
Grassy_Trib	2654	50-Year	3020.00	608.78	617.77		618.10	0.003799	6.40	850.23	248.59	0.43
Grassy_Trib	2654	100-Year	3530.00	608.78	618.15		618.51	0.003915	6.73	946.42	260.71	0.44
Grassy_Trib	2654	500-Year	4880.00	608.78	619.01		619.44	0.004245	7.54	1194.73	315.23	0.46
Grassy_Trib	2654	100-Year_Ult	4460.00	608.78	618.76		619.18	0.004206	7.35	1118.13	303.05	0.46
Grassy_Trib	3026	10-Year	1620.00	613.68	618.31		618.52	0.003481	4.15	502.44	236.16	0.38
Grassy_Trib	3026	50-Year	2760.00	613.68	619.24		619.52	0.003818	5.05	744.30	275.91	0.42
Grassy_Trib	3026	100-Year	3180.00	613.68	619.62		619.91	0.003582	5.16	850.95	286.15	0.41
Grassy_Trib	3026	500-Year	4230.00	613.68	620.51		620.82	0.003154	5.40	1124.48	329.13	0.39
Grassy_Trib	3026	100-Year_Ult	4080.00	613.68	620.29		620.61	0.003471	5.52	1050.86	317.94	0.41
Grassy_Trib	3497	10-Year	1620.00	614.08	620.19		620.56	0.005281	5.93	366.29	121.89	0.48
Grassy_Trib	3497	50-Year	2760.00	614.08	621.29		621.83	0.006132	7.35	510.43	143.46	0.54
Grassy_Trib	3497	100-Year	3180.00	614.08	621.60		622.20	0.006453	7.80	556.89	157.79	0.56
Grassy_Trib	3497	500-Year	4230.00	614.08	622.36		623.11	0.007343	9.00	698.75	230.59	0.60
Grassy_Trib	3497	100-Year_Ult	4080.00	614.08	622.27		623.01	0.007307	8.90	679.19	218.97	0.60
Grassy_Trib	3821	10-Year	1620.00	615.41	621.66		621.86	0.003081	4.54	502.41	177.87	0.37
Grassy_Trib	3821	50-Year	2760.00	615.41	622.94		623.19	0.002928	5.19	748.39	211.36	0.37
Grassy_Trib	3821	100-Year	3180.00	615.41	623.31		623.58	0.002920	5.40	829.57	218.86	0.38
Grassy_Trib	3821	500-Year	4230.00	615.41	624.23		624.53	0.002773	5.75	1038.21	241.39	0.38
Grassy_Trib	3821	100-Year_Ult	4080.00	615.41	624.13		624.42	0.002739	5.67	1014.30	235.88	0.37
Grassy_Trib	4121	10-Year	1620.00	616.13	622.68		622.88	0.004054	4.62	609.21	303.19	0.41
Grassy_Trib	4121	50-Year	2760.00	616.13	623.87		624.06	0.003064	4.78	987.23	328.43	0.37
Grassy_Trib	4121	100-Year	3180.00	616.13	624.24		624.43	0.002886	4.85	1108.51	332.29	0.36
Grassy_Trib	4121	500-Year	4230.00	616.13	625.11		625.31	0.002584	5.06	1405.28	351.40	0.35
Grassy_Trib	4121	100-Year_Ult	4080.00	616.13	625.00		625.20	0.002603	5.02	1367.61	349.54	0.35
Grassy_Trib	4560	10-Year	1620.00	621.63	625.64		625.83	0.013477	6.19	575.86	330.66	0.64
Grassy_Trib	4560	50-Year	2370.00	621.63	626.16		626.38	0.013090	6.81	751.36	344.34	0.64
Grassy_Trib	4560	100-Year	2730.00	621.63	626.40		626.64	0.012758	7.04	838.90	360.34	0.64
Grassy_Trib	4560	500-Year	3630.00	621.63	627.03		627.28	0.011113	7.29	1073.79	385.76	0.62
Grassy_Trib	4560	100-Year_Ult	3530.00	621.63	626.95		627.20	0.011436	7.30	1043.54	383.31	0.62
Grassy_Trib	5191	10-Year	1620.00	623.85	628.44		628.49	0.002385	2.81	1105.38	449.08	0.28
Grassy_Trib	5191	50-Year	2370.00	623.85	629.05		629.11	0.002537	3.26	1384.75	463.61	0.30
Grassy_Trib	5191	100-Year	2730.00	623.85	629.32		629.38	0.002581	3.44	1507.32	468.60	0.30
Grassy_Trib	5191	500-Year	3630.00	623.85	629.91		629.99	0.002718	3.87	1789.90	486.96	0.32
Grassy_Trib	5191	100-Year_Ult	3530.00	623.85	629.85		629.93	0.002702	3.82	1761.58	486.01	0.31

HEC-RAS Plan: Hanger_Multi River: Hanger Reach: Hanger

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Hanger	489	10-Year	510.00	517.56	520.96	520.55	521.37	0.015013	5.66	127.66	77.93	0.62
Hanger	489	50-Year	920.00	517.56	521.82	521.26	522.36	0.015003	6.84	195.47	80.92	0.65
Hanger	489	100-Year	1140.00	517.56	522.20	521.54	522.81	0.015018	7.34	226.87	82.27	0.66
Hanger	489	500-Year	1750.00	517.56	523.14	522.25	523.92	0.015005	8.48	305.96	87.40	0.68
Hanger	489	100-Year_Ult	1140.00	517.56	522.20	521.56	522.81	0.015018	7.34	226.87	82.27	0.66
Hanger	772	10-Year	510.00	521.60	524.38		524.55	0.008611	3.26	158.29	103.74	0.44
Hanger	772	50-Year	920.00	521.60	525.14		525.38	0.007878	3.98	249.28	134.05	0.45
Hanger	772	100-Year	1140.00	521.60	525.49		525.76	0.007510	4.25	298.87	145.21	0.45
Hanger	772	500-Year	1750.00	521.60	526.35		526.68	0.006655	4.78	426.23	151.70	0.44
Hanger	772	100-Year_Ult	1140.00	521.60	525.49		525.76	0.007510	4.25	298.87	145.21	0.45
Hanger	957	10-Year	510.00	522.53	526.40		526.96	0.019482	7.08	115.11	68.38	0.71
Hanger	957	50-Year	920.00	522.53	527.09		527.96	0.024901	9.17	164.16	73.74	0.83
Hanger	957	100-Year	1140.00	522.53	527.36		528.40	0.027863	10.16	184.30	75.21	0.89
Hanger	957	500-Year	1750.00	522.53	528.02	528.02	529.47	0.033341	12.30	235.42	79.03	1.00
Hanger	957	100-Year_Ult	1140.00	522.53	527.36		528.40	0.027863	10.16	184.30	75.21	0.89
Hanger	1241	10-Year	450.00	526.43	529.84		530.00	0.006279	3.28	142.70	71.60	0.39
Hanger	1241	50-Year	810.00	526.43	530.84		531.08	0.005611	3.99	218.45	80.95	0.39
Hanger	1241	100-Year	1000.00	526.43	531.30		531.57	0.005377	4.27	256.59	85.66	0.39
Hanger	1241	500-Year	1540.00	526.43	532.39		532.75	0.005085	4.94	354.23	94.13	0.40
Hanger	1241	100-Year_Ult	1000.00	526.43	531.30		531.57	0.005377	4.27	256.59	85.66	0.39
Hanger	1332	10-Year	450.00	526.63	530.47		531.10	0.021111	6.61	82.74	56.48	0.72
Hanger	1332	50-Year	810.00	526.63	531.30		532.19	0.022146	8.15	134.71	68.90	0.78
Hanger	1332	100-Year	1000.00	526.63	531.68		532.67	0.021949	8.71	163.35	80.65	0.79
Hanger	1332	500-Year	1540.00	526.63	532.71		533.76	0.018870	9.47	262.44	114.91	0.76
Hanger	1332	100-Year_Ult	1000.00	526.63	531.68		532.67	0.021949	8.71	163.35	80.65	0.79
Hanger	1505	10-Year	450.00	528.39	533.13		533.45	0.009248	5.33	134.59	69.70	0.50
Hanger	1505	50-Year	810.00	528.39	534.20		534.61	0.009293	6.38	215.34	83.47	0.53
Hanger	1505	100-Year	1000.00	528.39	534.65		535.10	0.009427	6.84	254.65	91.58	0.54
Hanger	1505	500-Year	1540.00	528.39	535.61		536.21	0.010634	8.16	365.89	137.42	0.59
Hanger	1505	100-Year_Ult	1000.00	528.39	534.65		535.10	0.009427	6.84	254.65	91.58	0.54
Hanger	1520	10-Year	450.00	528.49	533.32		533.56	0.005586	4.38	146.09	69.01	0.40
Hanger	1520	50-Year	810.00	528.49	534.36		534.73	0.006567	5.60	228.75	91.86	0.45
Hanger	1520	100-Year	1000.00	528.49	534.81		535.22	0.006724	6.02	273.28	102.19	0.46
Hanger	1520	500-Year	1540.00	528.49	535.83		536.35	0.007256	7.03	389.02	128.53	0.50
Hanger	1520	100-Year_Ult	1000.00	528.49	534.81		535.22	0.006724	6.02	273.28	102.19	0.46
Hanger	2058	10-Year	370.00	534.90	537.17		537.36	0.009786	3.48	106.89	65.60	0.47
Hanger	2058	50-Year	660.00	534.90	538.12		538.36	0.006948	3.94	174.44	76.78	0.43
Hanger	2058	100-Year	810.00	534.90	538.52		538.79	0.006451	4.17	206.19	81.97	0.42
Hanger	2058	500-Year	1290.00	534.90	539.55		539.90	0.005913	4.84	303.35	109.93	0.42
Hanger	2058	100-Year_Ult	840.00	534.90	538.56		538.84	0.006656	4.27	209.20	82.36	0.43
Hanger	2167	10-Year	370.00	535.28	537.85		537.91	0.002944	2.09	184.91	107.18	0.26
Hanger	2167	50-Year	660.00	535.28	538.72		538.82	0.002629	2.53	285.13	127.96	0.27
Hanger	2167	100-Year	810.00	535.28	539.11		539.22	0.002507	2.69	337.68	140.82	0.26
Hanger	2167	500-Year	1290.00	535.28	540.16		540.30	0.002288	3.11	501.50	187.31	0.27
Hanger	2167	100-Year_Ult	840.00	535.28	539.17		539.28	0.002537	2.74	345.40	141.91	0.27
Hanger	2302	10-Year	370.00	536.40	538.48	538.42	539.06	0.041610	6.10	60.63	225.42	0.93
Hanger	2302	50-Year	660.00	536.40	539.09	539.06	539.93	0.037488	7.40	93.25	251.76	0.94
Hanger	2302	100-Year	810.00	536.40	539.38	539.35	540.30	0.034239	7.77	112.00	263.12	0.92
Hanger	2302	500-Year	1290.00	536.40	540.55	539.53	540.59	0.001768	2.34	869.44	287.68	0.22
Hanger	2302	100-Year_Ult	840.00	536.40	539.59	539.40	539.62	0.002345	2.16	601.46	269.73	0.24

HEC-RAS Plan: HollingsHightMP River: Hight Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	128.738	10-Year_Ult	2600.00	523.05	533.51	529.16	533.55	0.000572	2.24	1940.81	420.97	0.14
1	128.738	50-Year_Ult	3900.00	523.05	534.59	529.83	534.64	0.000706	2.69	2410.68	452.23	0.15
1	128.738	100-Year_Ult	4490.00	523.05	534.91	530.10	534.97	0.000793	2.92	2557.71	460.40	0.16
1	128.738	500-Year_Ult	6010.00	523.05	535.75	530.61	535.83	0.000935	3.34	2953.75	475.29	0.18
1	417.319	10-Year_Ult	2600.00	524.25	533.67	530.17	533.71	0.000627	2.10	1987.14	472.67	0.14
1	417.319	50-Year_Ult	3900.00	524.25	534.78	530.63	534.82	0.000701	2.44	2523.02	496.69	0.15
1	417.319	100-Year_Ult	4490.00	524.25	535.12	530.81	535.17	0.000765	2.62	2694.83	503.97	0.16
1	417.319	500-Year_Ult	6010.00	524.25	536.00	531.20	536.07	0.000871	2.99	3145.41	522.57	0.17
1	659.292	10-Year_Ult	2600.00	525.54	533.86	531.35	533.97	0.002210	3.48	1137.93	336.53	0.25
1	659.292	50-Year_Ult	3900.00	525.54	534.97	532.10	535.10	0.002192	3.89	1527.09	361.80	0.26
1	659.292	100-Year_Ult	4490.00	525.54	535.33	532.34	535.48	0.002307	4.12	1657.81	369.70	0.27
1	659.292	500-Year_Ult	6010.00	525.54	536.22	532.84	536.40	0.002441	4.57	1998.14	388.94	0.28
1	1654.411	10-Year_Ult	2690.00	530.41	536.92		537.14	0.008408	5.46	851.13	398.31	0.46
1	1654.411	50-Year_Ult	4040.00	530.41	537.77		538.00	0.007197	5.69	1208.95	443.04	0.44
1	1654.411	100-Year_Ult	4680.00	530.41	538.17		538.40	0.006961	5.88	1395.84	497.69	0.44
1	1654.411	500-Year_Ult	6270.00	530.41	538.96		539.20	0.005961	5.94	1803.99	529.50	0.41
1	1915.028	10-Year_Ult	2690.00	531.96	538.50		538.65	0.005360	4.46	1046.97	484.48	0.37
1	1915.028	50-Year_Ult	4040.00	531.96	539.20		539.37	0.005232	4.86	1388.23	495.70	0.38
1	1915.028	100-Year_Ult	4680.00	531.96	539.53		539.71	0.004968	4.94	1556.41	501.02	0.37
1	1915.028	500-Year_Ult	6270.00	531.96	540.19		540.40	0.004929	5.31	1890.71	511.56	0.38
1	1925.038		Bridge									
1	1935.028	10-Year_Ult	2690.00	531.96	538.63	537.55	538.76	0.004504	4.17	1111.04	486.59	0.34
1	1935.028	50-Year_Ult	4040.00	531.96	539.33	537.94	539.48	0.004542	4.61	1454.88	497.82	0.35
1	1935.028	100-Year_Ult	4680.00	531.96	539.66	538.07	539.82	0.004388	4.72	1621.28	503.04	0.35
1	1935.028	500-Year_Ult	6270.00	531.96	540.33	538.40	540.52	0.004427	5.11	1958.42	513.71	0.36
1	3292.698	10-Year_Ult	2690.00	539.16	544.66		545.21	0.013856	8.55	643.64	343.84	0.76
1	3292.698	50-Year_Ult	4040.00	539.16	545.22		545.88	0.014885	9.69	848.72	374.90	0.81
1	3292.698	100-Year_Ult	4680.00	539.16	545.41		546.13	0.015773	10.26	919.98	377.08	0.84
1	3292.698	500-Year_Ult	6270.00	539.16	545.92		546.73	0.015892	11.04	1116.33	382.99	0.86
1	3635.905	10-Year_Ult	2870.00	540.20	547.66		548.07	0.006151	7.02	827.88	350.89	0.54
1	3635.905	50-Year_Ult	4090.00	540.20	548.38		548.83	0.006135	7.63	1090.61	375.41	0.55
1	3635.905	100-Year_Ult	4640.00	540.20	548.68		549.14	0.006065	7.83	1205.09	385.23	0.55
1	3635.905	500-Year_Ult	6050.00	540.20	549.31		549.82	0.006257	8.47	1452.80	405.67	0.56
1	3796.160	10-Year_Ult	2870.00	540.70	548.43	547.47	548.66	0.002163	4.32	831.25	373.62	0.30
1	3796.160	50-Year_Ult	4090.00	540.70	549.10	547.84	549.38	0.001981	4.41	1088.60	395.57	0.29
1	3796.160	100-Year_Ult	4640.00	540.70	549.37	547.99	549.67	0.001923	4.46	1198.63	405.44	0.29
1	3796.160	500-Year_Ult	6050.00	540.70	549.98	548.34	550.34	0.001863	4.63	1453.32	425.13	0.29
1	3810		Culvert									
1	3825.907	10-Year_Ult	2870.00	540.67	548.53	546.93	548.68	0.001035	2.65	1027.94	387.59	0.17
1	3825.907	50-Year_Ult	4090.00	540.67	549.23	547.31	549.43	0.001031	2.80	1306.33	408.76	0.17
1	3825.907	100-Year_Ult	4640.00	540.67	549.52	547.47	549.73	0.001032	2.87	1422.80	417.29	0.17
1	3825.907	500-Year_Ult	6050.00	540.67	550.10	547.84	550.37	0.001096	3.08	1672.94	437.63	0.18
1	3929.943	10-Year_Ult	2870.00	542.80	548.63	548.63	549.19	0.009372	7.37	509.78	387.70	0.64
1	3929.943	50-Year_Ult	4090.00	542.80	549.29		549.74	0.005518	6.23	770.75	409.34	0.50
1	3929.943	100-Year_Ult	4640.00	542.80	549.59		550.01	0.004492	5.85	894.39	419.30	0.46
1	3929.943	500-Year_Ult	6050.00	542.80	550.20		550.63	0.003430	5.51	1157.06	438.26	0.41
1	4402.184	10-Year_Ult	2870.00	545.00	552.77	552.68	553.76	0.009882	9.11	491.34	232.50	0.68
1	4402.184	50-Year_Ult	4090.00	545.00	553.38	553.38	554.53	0.010970	10.29	644.83	271.85	0.73
1	4402.184	100-Year_Ult	4640.00	545.00	553.63	553.63	554.81	0.011158	10.65	714.41	288.30	0.74
1	4402.184	500-Year_Ult	6050.00	545.00	554.27	554.27	555.47	0.010756	11.14	912.72	323.90	0.74
1	4699.184	10-Year_Ult	2870.00	546.30	555.42		555.70	0.004934	5.57	780.21	354.66	0.38
1	4699.184	50-Year_Ult	4090.00	546.30	556.13		556.42	0.004436	5.64	1047.12	397.75	0.36
1	4699.184	100-Year_Ult	4640.00	546.30	556.38		556.68	0.004312	5.68	1147.83	405.52	0.36
1	4699.184	500-Year_Ult	6050.00	546.30	556.92		557.27	0.004233	5.89	1370.02	420.64	0.36
1	4825.182	10-Year_Ult	2870.00	547.40	555.84	553.25	556.11	0.002372	4.51	784.38	388.61	0.34
1	4825.182	50-Year_Ult	4090.00	547.40	556.52	554.76	556.80	0.002326	4.82	1086.50	465.88	0.34
1	4825.182	100-Year_Ult	4640.00	547.40	556.77	555.21	557.06	0.002270	4.89	1204.76	473.88	0.34
1	4825.182	500-Year_Ult	6050.00	547.40	557.33	555.97	557.64	0.002198	5.08	1474.62	491.58	0.34
1	4877		Culvert									

HEC-RAS Plan: HollingsHightMP River: Hight Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	4972.713	10-Year_Ult	2870.00	548.00	557.95	556.36	558.16	0.001468	3.91	793.92	279.59	0.25
1	4972.713	50-Year_Ult	4090.00	548.00	558.51	556.85	558.79	0.002091	4.90	991.85	368.51	0.31
1	4972.713	100-Year_Ult	4640.00	548.00	558.74	557.06	559.03	0.002113	5.02	1074.10	374.88	0.31
1	4972.713	500-Year_Ult	6050.00	548.00	559.26	557.52	559.61	0.002109	5.22	1273.52	391.57	0.31
1	5062.229	10-Year_Ult	2870.00	550.49	557.80	557.80	559.04	0.015553	9.35	329.45	128.64	0.80
1	5062.229	50-Year_Ult	4090.00	550.49	558.65	558.65	559.96	0.013301	9.76	458.54	172.58	0.76
1	5062.229	100-Year_Ult	4640.00	550.49	558.83	558.83	560.31	0.014289	10.36	492.02	185.49	0.79
1	5062.229	500-Year_Ult	6050.00	550.49	559.67	559.67	561.01	0.010647	9.86	682.22	263.74	0.70
1	5077		Culvert									
1	5093.429	10-Year_Ult	2870.00	550.85	560.68	557.99	561.03	0.002925	4.92	720.49	259.03	0.36
1	5093.429	50-Year_Ult	4090.00	550.85	561.19	558.89	561.74	0.004179	6.22	866.89	307.34	0.44
1	5093.429	100-Year_Ult	4640.00	550.85	561.36	559.27	562.00	0.004817	6.80	918.98	322.79	0.47
1	5093.429	500-Year_Ult	6050.00	550.85	561.63	559.97	562.58	0.006860	8.34	1008.91	347.46	0.57
1	5299.095	10-Year_Ult	2870.00	553.00	561.31		561.85	0.004487	6.15	604.76	241.89	0.46
1	5299.095	50-Year_Ult	4090.00	553.00	562.05		562.76	0.005275	7.25	795.03	276.57	0.51
1	5299.095	100-Year_Ult	4640.00	553.00	562.33		563.11	0.005591	7.69	873.46	288.55	0.53
1	5299.095	500-Year_Ult	6050.00	553.00	562.94		563.89	0.006330	8.68	1058.66	315.35	0.57
1	5605.017	10-Year_Ult	2870.00	555.40	563.04		564.22	0.013219	9.64	429.03	207.56	0.74
1	5605.017	50-Year_Ult	4090.00	555.40	564.03		565.25	0.012320	10.33	698.15	337.11	0.72
1	5605.017	100-Year_Ult	4640.00	555.40	564.41		565.52	0.011162	10.19	829.01	349.58	0.69
1	5605.017	500-Year_Ult	6050.00	555.40	565.23		566.20	0.009535	10.12	1126.66	376.27	0.65
1	6011.242	10-Year_Ult	2870.00	558.21	566.38		566.83	0.003766	5.48	577.72	205.80	0.42
1	6011.242	50-Year_Ult	4090.00	558.21	567.29		567.85	0.004000	6.29	807.73	307.76	0.45
1	6011.242	100-Year_Ult	4640.00	558.21	567.52		568.15	0.004411	6.76	880.38	338.29	0.47
1	6011.242	500-Year_Ult	6050.00	558.21	568.06		568.85	0.005202	7.75	1077.02	399.24	0.52
1	6285.351	10-Year_Ult	2870.00	559.50	566.75		568.11	0.002522	9.46	332.17	79.77	0.67
1	6285.351	50-Year_Ult	4090.00	559.50	567.50	566.79	569.60	0.003383	11.83	402.44	116.94	0.79
1	6285.351	100-Year_Ult	4640.00	559.50	567.68	567.62	570.20	0.003943	12.99	424.53	125.59	0.86
1	6285.351	500-Year_Ult	6050.00	559.50	569.28	569.28	571.38	0.002775	12.47	709.21	223.85	0.74
1	6298.5		Culvert									
1	6311.123	10-Year_Ult	2870.00	559.80	568.80	565.47	569.24	0.000701	5.81	686.06	198.13	0.36
1	6311.123	50-Year_Ult	4090.00	559.80	569.85	567.30	570.40	0.000785	6.68	918.33	242.99	0.39
1	6311.123	100-Year_Ult	4640.00	559.80	570.27	567.79	570.90	0.000870	7.25	1033.56	297.33	0.41
1	6311.123	500-Year_Ult	6050.00	559.80	571.18	568.76	571.89	0.000919	7.92	1324.14	340.08	0.43
1	6602.296	10-Year_Ult	2870.00	563.00	568.60	568.60	570.36	0.002476	10.72	292.28	103.06	0.96
1	6602.296	50-Year_Ult	4090.00	563.00	569.63	569.63	571.71	0.002356	11.79	409.41	124.41	0.94
1	6602.296	100-Year_Ult	4640.00	563.00	570.14	570.14	572.24	0.002180	11.94	475.34	138.40	0.90
1	6602.296	500-Year_Ult	6050.00	563.00	571.20	571.20	573.37	0.001928	12.39	656.35	200.33	0.86
1	6845.274	10-Year_Ult	2870.00	565.23	570.80	570.80	572.65	0.014227	10.91	266.17	78.25	0.98
1	6845.274	50-Year_Ult	4090.00	565.23	571.88	571.88	574.07	0.012288	11.97	357.41	91.24	0.95
1	6845.274	100-Year_Ult	4640.00	565.23	572.30	572.30	574.64	0.011806	12.40	397.44	97.67	0.95
1	6845.274	500-Year_Ult	6050.00	565.23	573.35	573.35	575.93	0.010495	13.18	509.32	116.20	0.92

HEC-RAS Plan: HollingsHightMP River: Hollings Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	416.522	10-Year_Ult	6220.00	522.41	528.40	525.04	528.43	0.001001	2.26	4347.25	1208.41	0.17
1	416.522	50-Year_Ult	9470.00	522.41	529.53	525.47	529.58	0.001000	2.55	5777.15	1296.58	0.17
1	416.522	100-Year_Ult	10990.00	522.41	529.99	525.65	530.04	0.001000	2.67	6379.48	1325.49	0.18
1	416.522	500-Year_Ult	15010.00	522.41	531.19	526.09	531.25	0.001000	2.96	8129.93	1524.23	0.18
1	702.883	10-Year_Ult	6220.00	522.41	528.67		528.71	0.001096	2.35	4157.23	1158.56	0.18
1	702.883	50-Year_Ult	9470.00	522.41	529.80		529.85	0.001096	2.66	5505.59	1229.61	0.18
1	702.883	100-Year_Ult	10990.00	522.41	530.27		530.32	0.001174	2.88	6107.44	1349.75	0.19
1	702.883	500-Year_Ult	15010.00	522.41	531.46		531.52	0.001093	3.08	7777.35	1456.80	0.19
1	931.145	10-Year_Ult	6220.00	522.41	528.88		528.93	0.001042	2.28	3858.79	916.00	0.17
1	931.145	50-Year_Ult	9470.00	522.41	530.02		530.08	0.001146	2.72	4925.52	960.17	0.19
1	931.145	100-Year_Ult	10990.00	522.41	530.50		530.57	0.001166	2.87	5386.13	970.98	0.19
1	931.145	500-Year_Ult	15010.00	522.41	531.67		531.76	0.001189	3.21	6541.92	999.83	0.20
1	1192.632	10-Year_Ult	6220.00	522.41	528.97	528.97	531.13	0.037841	12.77	548.50	865.34	1.02
1	1192.632	50-Year_Ult	9470.00	522.41	530.37	530.37	533.23	0.035703	14.68	721.50	911.41	1.03
1	1192.632	100-Year_Ult	10990.00	522.41	530.80	530.61	530.88	0.001501	3.15	4878.20	919.75	0.21
1	1192.632	500-Year_Ult	15010.00	522.41	531.98	530.61	532.08	0.001489	3.49	5974.37	947.75	0.22
1	1258.121	10-Year_Ult	6220.00	522.41	531.01	530.06	532.76	0.017438	11.05	689.58	342.00	0.73
1	1258.121	50-Year_Ult	9470.00	522.41	533.63	532.81	534.15	0.005185	7.44	2479.38	829.63	0.42
1	1258.121	100-Year_Ult	10990.00	522.41	533.08	533.08	534.21	0.011027	10.44	2027.55	813.23	0.61
1	1258.121	500-Year_Ult	15010.00	522.41	533.66	533.66	534.93	0.012782	11.70	2499.09	830.34	0.66

HEC-RAS Plan: HollingsHightMP River: Hollings Reach: 2

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
2	1514.253	10-Year_Ult	3620.00	522.48	533.54	529.18	533.58	0.000570	2.27	2457.20	430.31	0.14
2	1514.253	50-Year_Ult	5570.00	522.48	534.67	529.68	534.74	0.000773	2.87	2952.69	444.02	0.16
2	1514.253	100-Year_Ult	6500.00	522.48	535.01	529.90	535.09	0.000905	3.18	3105.22	448.20	0.18
2	1514.253	500-Year_Ult	9000.00	522.48	535.91	530.40	536.03	0.001194	3.86	3513.01	458.61	0.20
2	1881.656	10-Year_Ult	3620.00	522.91	533.82	530.77	533.89	0.001231	3.04	1823.88	375.44	0.19
2	1881.656	50-Year_Ult	5570.00	522.91	535.03	531.29	535.14	0.001444	3.63	2280.97	379.27	0.21
2	1881.656	100-Year_Ult	6500.00	522.91	535.42	531.51	535.55	0.001610	3.94	2430.83	380.52	0.23
2	1881.656	500-Year_Ult	9000.00	522.91	536.43	532.03	536.61	0.001938	4.63	2816.44	383.72	0.25
2	2165.267	10-Year_Ult	3620.00	524.81	534.21	531.44	534.29	0.001746	3.16	1643.01	377.89	0.22
2	2165.267	50-Year_Ult	5570.00	524.81	535.47	531.97	535.59	0.001847	3.67	2122.23	382.88	0.24
2	2165.267	100-Year_Ult	6500.00	524.81	535.90	532.21	536.04	0.001978	3.95	2289.89	384.76	0.25
2	2165.267	500-Year_Ult	9000.00	524.81	536.99	532.73	537.18	0.002224	4.56	2712.65	389.90	0.27
2	2494.865	10-Year_Ult	3820.00	525.54	534.98		535.13	0.003668	4.37	1499.10	538.12	0.32
2	2494.865	50-Year_Ult	5800.00	525.54	536.22		536.36	0.003011	4.50	2209.24	616.12	0.30
2	2494.865	100-Year_Ult	6740.00	525.54	536.68		536.83	0.002924	4.62	2502.75	648.82	0.30
2	2494.865	500-Year_Ult	9410.00	525.54	537.83		537.99	0.002772	4.95	3302.78	739.49	0.29
2	2880.744	10-Year_Ult	3820.00	527.08	536.89		537.23	0.008253	5.98	1054.74	474.61	0.47
2	2880.744	50-Year_Ult	5800.00	527.08	537.81		538.16	0.007400	6.32	1506.49	512.45	0.46
2	2880.744	100-Year_Ult	6740.00	527.08	538.21		538.56	0.007006	6.42	1713.94	527.22	0.45
2	2880.744	500-Year_Ult	9410.00	527.08	539.23		539.59	0.006183	6.66	2268.32	559.34	0.43
2	3273.453	10-Year_Ult	3820.00	528.74	539.43		539.79	0.005846	6.42	1045.45	412.32	0.41
2	3273.453	50-Year_Ult	5800.00	528.74	540.32		540.75	0.006621	7.36	1468.45	499.97	0.45
2	3273.453	100-Year_Ult	6740.00	528.74	540.66		541.11	0.006816	7.68	1642.36	508.65	0.46
2	3273.453	500-Year_Ult	9410.00	528.74	541.54		542.03	0.007072	8.34	2098.50	531.11	0.47
2	3685.615	10-Year_Ult	3820.00	529.61	541.53		541.93	0.004732	6.24	1050.05	373.74	0.38
2	3685.615	50-Year_Ult	5800.00	529.61	542.62		543.06	0.004950	6.93	1479.46	412.24	0.40
2	3685.615	100-Year_Ult	6740.00	529.61	543.03		543.49	0.005103	7.24	1651.64	425.96	0.41
2	3685.615	500-Year_Ult	9410.00	529.61	544.02		544.55	0.005478	8.00	2091.72	458.86	0.43
2	4348.646	10-Year_Ult	3820.00	534.13	544.43		544.87	0.006572	6.78	942.12	319.65	0.44
2	4348.646	50-Year_Ult	5800.00	534.13	545.46		545.97	0.006876	7.57	1294.98	366.11	0.46
2	4348.646	100-Year_Ult	6740.00	534.13	545.88		546.41	0.006962	7.86	1451.97	384.98	0.47
2	4348.646	500-Year_Ult	9410.00	534.13	546.91		547.51	0.007138	8.57	1872.69	434.29	0.48
2	4775.156	10-Year_Ult	3820.00	536.17	546.11		546.33	0.002389	4.07	1192.57	339.80	0.27
2	4775.156	50-Year_Ult	5800.00	536.17	547.25		547.55	0.002760	4.83	1601.59	377.12	0.30
2	4775.156	100-Year_Ult	6740.00	536.17	547.70		548.03	0.002901	5.13	1775.80	392.26	0.31
2	4775.156	500-Year_Ult	9410.00	536.17	548.80		549.21	0.003229	5.86	2228.59	429.13	0.33
2	5057.791	10-Year_Ult	3820.00	538.00	546.85		547.95	0.014057	8.79	518.26	153.36	0.64
2	5057.791	50-Year_Ult	5800.00	538.00	547.95	547.23	549.49	0.016438	10.64	719.02	294.75	0.71
2	5057.791	100-Year_Ult	6740.00	538.00	548.47		549.98	0.015479	10.83	886.70	341.20	0.69
2	5057.791	500-Year_Ult	9410.00	538.00	549.76		551.11	0.012804	10.94	1387.99	427.65	0.65
2	5122.010	10-Year_Ult	4030.00	538.75	548.27	548.27	549.71	0.017182	10.47	557.83	239.45	0.71
2	5122.010	50-Year_Ult	6000.00	538.75	549.41	549.41	550.86	0.016307	11.31	873.49	320.35	0.71
2	5122.010	100-Year_Ult	6960.00	538.75	549.85	549.85	551.28	0.015827	11.55	1020.69	343.83	0.70
2	5122.010	500-Year_Ult	9410.00	538.75	550.44		552.21	0.019202	13.31	1234.66	378.90	0.78
2	5192.494	10-Year_Ult	4030.00	539.80	550.06		550.26	0.003076	5.03	1411.77	415.25	0.31
2	5192.494	50-Year_Ult	6000.00	539.80	551.19		551.42	0.003309	5.69	1909.58	466.66	0.33
2	5192.494	100-Year_Ult	6960.00	539.80	551.60		551.85	0.003482	6.01	2103.96	483.68	0.34
2	5192.494	500-Year_Ult	9410.00	539.80	552.56		552.85	0.003519	6.43	2573.33	491.91	0.35
2	5595.119	10-Year_Ult	4030.00	541.40	551.21		551.37	0.002645	4.44	1409.16	332.99	0.28
2	5595.119	50-Year_Ult	6000.00	541.40	552.43		552.64	0.002960	5.19	1857.90	408.75	0.31
2	5595.119	100-Year_Ult	6960.00	541.40	552.91		553.14	0.003168	5.56	2062.39	443.63	0.32
2	5595.119	500-Year_Ult	9410.00	541.40	553.93		554.21	0.003545	6.30	2545.91	498.54	0.35
2	5782.378	10-Year_Ult	4030.00	542.40	551.66		551.83	0.002835	3.87	1412.40	401.99	0.28
2	5782.378	50-Year_Ult	6000.00	542.40	552.90		553.10	0.002582	4.21	1917.14	411.33	0.28
2	5782.378	100-Year_Ult	6960.00	542.40	553.40		553.61	0.002561	4.39	2123.66	415.37	0.28
2	5782.378	500-Year_Ult	9410.00	542.40	554.46		554.72	0.002648	4.88	2568.29	428.39	0.29
2	6219.829	10-Year_Ult	4030.00	545.00	553.17		553.61	0.006433	5.73	871.84	280.99	0.43
2	6219.829	50-Year_Ult	6000.00	545.00	554.25		554.80	0.006662	6.56	1218.07	345.24	0.45
2	6219.829	100-Year_Ult	6960.00	545.00	554.72		555.29	0.006591	6.83	1387.77	384.53	0.45
2	6219.829	500-Year_Ult	9410.00	545.00	555.76		556.38	0.006338	7.33	1833.21	469.70	0.45
2	7050.407	10-Year_Ult	4030.00	547.00	557.23		557.60	0.004299	5.19	1049.48	439.46	0.36

HEC-RAS Plan: HollingsHightMP River: Hollings Reach: 2 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
2	7050.407	50-Year_Ult	6000.00	547.00	558.27		558.68	0.004439	5.81	1537.48	510.25	0.37
2	7050.407	100-Year_Ult	6960.00	547.00	558.67		559.11	0.004550	6.09	1753.31	549.32	0.38
2	7050.407	500-Year_Ult	9410.00	547.00	559.55		560.03	0.004749	6.66	2266.47	624.00	0.39
2	7689.822	10-Year_Ult	4030.00	550.40	560.60		561.36	0.008493	7.96	823.99	355.61	0.51
2	7689.822	50-Year_Ult	6000.00	550.40	561.65		562.44	0.008610	8.75	1252.58	471.17	0.53
2	7689.822	100-Year_Ult	6960.00	550.40	562.09		562.88	0.008588	9.03	1471.54	535.25	0.53
2	7689.822	500-Year_Ult	9410.00	550.40	562.95		563.69	0.008012	9.27	1945.28	562.48	0.52
2	8413.969	10-Year_Ult	4030.00	552.60	564.05		564.25	0.002564	5.14	1561.35	444.45	0.29
2	8413.969	50-Year_Ult	6000.00	552.60	565.20		565.42	0.002749	5.74	2108.17	517.24	0.31
2	8413.969	100-Year_Ult	6960.00	552.60	565.67		565.90	0.002834	5.99	2358.91	552.79	0.31
2	8413.969	500-Year_Ult	9410.00	552.60	566.49		566.76	0.003135	6.60	2830.69	577.46	0.33
2	8920.227	10-Year_Ult	4030.00	553.70	564.91		565.20	0.001917	4.53	1179.00	342.15	0.26
2	8920.227	50-Year_Ult	6000.00	553.70	566.11		566.50	0.002415	5.49	1669.79	504.09	0.29
2	8920.227	100-Year_Ult	6960.00	553.70	566.58		567.00	0.002511	5.76	1917.02	528.76	0.30
2	8920.227	500-Year_Ult	9410.00	553.70	567.48		567.96	0.002876	6.49	2410.73	572.54	0.33
2	9229.300	10-Year_Ult	4030.00	555.70	565.35		566.84	0.016699	11.06	523.29	149.66	0.71
2	9229.300	50-Year_Ult	6000.00	555.70	566.63		568.46	0.018152	12.82	752.88	221.24	0.76
2	9229.300	100-Year_Ult	6960.00	555.70	567.06		569.05	0.019091	13.58	856.12	252.60	0.79
2	9229.300	500-Year_Ult	9410.00	555.70	568.04		570.21	0.019973	14.85	1134.64	322.83	0.82
2	9737.502	10-Year_Ult	4030.00	558.60	569.93		570.38	0.004068	5.90	972.39	315.87	0.36
2	9737.502	50-Year_Ult	6000.00	558.60	571.41		571.87	0.003794	6.36	1511.10	411.96	0.36
2	9737.502	100-Year_Ult	6960.00	558.60	572.00		572.47	0.003744	6.57	1764.86	458.93	0.36
2	9737.502	500-Year_Ult	9410.00	558.60	573.12		573.62	0.003762	7.06	2335.08	544.77	0.37
2	10398.79	10-Year_Ult	4030.00	562.50	572.86		573.23	0.005586	6.76	1089.40	326.42	0.41
2	10398.79	50-Year_Ult	6000.00	562.50	574.08		574.47	0.005244	7.18	1508.75	359.86	0.41
2	10398.79	100-Year_Ult	6960.00	562.50	574.60		575.00	0.005151	7.37	1699.46	375.58	0.41
2	10398.79	500-Year_Ult	9410.00	562.50	575.68		576.12	0.005204	7.93	2123.68	408.39	0.42
2	10790.00	10-Year_Ult	4030.00	563.70	575.29		576.13	0.009374	8.02	677.89	206.99	0.52
2	10790.00	50-Year_Ult	6000.00	563.70	576.40		577.45	0.010445	9.31	933.31	251.28	0.57
2	10790.00	100-Year_Ult	6960.00	563.70	576.88		578.00	0.010714	9.78	1058.05	273.28	0.58
2	10790.00	500-Year_Ult	9410.00	563.70	577.95		579.19	0.010992	10.69	1378.03	325.52	0.60
2	11287.76	10-Year_Ult	4030.00	567.70	577.98		578.18	0.002633	4.33	1373.92	368.48	0.28
2	11287.76	50-Year_Ult	6000.00	567.70	579.28		579.52	0.002658	4.86	1905.03	443.10	0.29
2	11287.76	100-Year_Ult	6960.00	567.70	579.81		580.06	0.002677	5.08	2146.38	472.64	0.30
2	11287.76	500-Year_Ult	9410.00	567.70	580.96		581.25	0.002729	5.56	2726.25	536.74	0.31
2	11521.86	10-Year_Ult	4030.00	569.00	578.57		578.73	0.003011	4.44	1525.33	445.03	0.30
2	11521.86	50-Year_Ult	6000.00	569.00	579.86		580.03	0.002703	4.72	2142.11	507.72	0.29
2	11521.86	100-Year_Ult	6960.00	569.00	580.39		580.57	0.002658	4.88	2417.84	538.19	0.29
2	11521.86	500-Year_Ult	9410.00	569.00	581.55		581.75	0.002603	5.25	3082.16	608.83	0.29
2	12035.21	10-Year_Ult	4030.00	571.00	580.43		581.26	0.011896	8.63	733.68	263.55	0.59
2	12035.21	50-Year_Ult	6000.00	571.00	581.46		582.39	0.012173	9.61	1029.98	314.66	0.61
2	12035.21	100-Year_Ult	6960.00	571.00	581.93		582.87	0.011946	9.91	1182.47	341.18	0.61
2	12035.21	500-Year_Ult	9410.00	571.00	582.98		583.94	0.011207	10.41	1574.28	401.17	0.61
2	12496.07	10-Year_Ult	4030.00	574.00	583.99		584.45	0.005698	6.94	983.55	303.50	0.42
2	12496.07	50-Year_Ult	6000.00	574.00	585.10		585.63	0.006099	7.80	1354.53	367.35	0.45
2	12496.07	100-Year_Ult	6960.00	574.00	585.53		586.10	0.006294	8.17	1520.32	392.93	0.46
2	12496.07	500-Year_Ult	9410.00	574.00	586.52		587.15	0.006792	9.05	1940.96	456.40	0.48
2	13194.17	10-Year_Ult	4030.00	576.80	588.07		588.66	0.007629	8.03	922.17	306.97	0.48
2	13194.17	50-Year_Ult	6000.00	576.80	589.23		589.83	0.007403	8.60	1303.38	353.78	0.49
2	13194.17	100-Year_Ult	6960.00	576.80	589.70		590.31	0.007345	8.85	1476.29	373.83	0.49
2	13194.17	500-Year_Ult	9410.00	576.80	590.77		591.40	0.007124	9.31	1898.21	414.71	0.49
2	13456.56	10-Year_Ult	4030.00	578.20	589.61		590.01	0.004249	6.17	1042.31	283.56	0.37
2	13456.56	50-Year_Ult	6000.00	578.20	590.72		591.22	0.004856	7.15	1381.78	322.63	0.40
2	13456.56	100-Year_Ult	6960.00	578.20	591.19		591.73	0.005071	7.54	1534.63	337.75	0.42
2	13456.56	500-Year_Ult	9410.00	578.20	592.20		592.83	0.005510	8.37	1895.37	369.83	0.44

HEC-RAS Plan: Loyd_Multi River: Loyd Reach: Loyd

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Loyd	1811	10-Year	1670.00	527.83	535.35	534.02	535.76	0.004001	6.36	509.19	150.49	0.44
Loyd	1811	50-Year	2400.00	527.83	536.41	534.71	536.87	0.004001	7.03	670.34	154.72	0.45
Loyd	1811	100-Year	2710.00	527.83	536.82	534.93	537.30	0.004002	7.28	733.89	157.20	0.45
Loyd	1811	500-Year	3510.00	527.83	537.81	535.52	538.34	0.004000	7.86	899.01	201.81	0.46
Loyd	1811	100-Year Ult	2850.00	527.83	536.99	535.06	537.48	0.004000	7.38	762.05	158.41	0.45
Loyd	2285	10-Year	1670.00	529.02	537.45		538.83	0.009427	9.81	209.65	44.64	0.66
Loyd	2285	50-Year	2400.00	529.02	538.33		540.45	0.012489	12.25	251.51	49.84	0.78
Loyd	2285	100-Year	2710.00	529.02	538.64		541.09	0.013819	13.22	266.88	51.66	0.82
Loyd	2285	500-Year	3510.00	529.02	539.23	538.86	542.73	0.018094	15.86	299.81	61.13	0.95
Loyd	2285	100-Year Ult	2850.00	529.02	538.76		541.37	0.014435	13.65	273.36	52.41	0.84
Loyd	2943	10-Year	1500.00	532.91	542.08		542.67	0.003763	6.67	314.93	66.77	0.42
Loyd	2943	50-Year	2120.00	532.91	543.90		544.60	0.003467	7.37	454.56	99.00	0.42
Loyd	2943	100-Year	2400.00	532.91	544.60		545.32	0.003344	7.58	532.23	129.89	0.42
Loyd	2943	500-Year	3120.00	532.91	546.30		547.00	0.002877	7.79	832.92	224.92	0.40
Loyd	2943	100-Year Ult	2590.00	532.91	544.96		545.76	0.003500	7.94	582.88	154.14	0.43
Loyd	3211	10-Year	1500.00	533.75	543.08		544.30	0.008454	9.21	208.36	52.55	0.61
Loyd	3211	50-Year	2120.00	533.75	544.76		546.08	0.007305	9.86	306.27	66.86	0.59
Loyd	3211	100-Year	2400.00	533.75	545.37		546.80	0.007297	10.31	355.37	92.64	0.59
Loyd	3211	500-Year	3120.00	533.75	546.89		548.31	0.006436	10.70	557.88	173.37	0.57
Loyd	3211	100-Year Ult	2590.00	533.75	545.79		547.23	0.007087	10.46	398.27	112.10	0.59
Loyd	3445	10-Year	1500.00	536.67	545.21		546.04	0.006272	7.92	284.21	93.64	0.54
Loyd	3445	50-Year	2120.00	536.67	546.76		547.53	0.004931	8.07	479.22	149.58	0.50
Loyd	3445	100-Year	2400.00	536.67	547.43		548.17	0.004461	8.09	596.81	200.22	0.48
Loyd	3445	500-Year	3120.00	536.67	548.84		549.47	0.003544	7.96	942.70	294.48	0.44
Loyd	3445	100-Year Ult	2590.00	536.67	547.83		548.56	0.004271	8.15	680.86	222.37	0.47
Loyd	3491	10-Year	1500.00	537.36	545.84		546.27	0.003091	5.56	354.73	88.13	0.38
Loyd	3491	50-Year	2120.00	537.36	547.20		547.72	0.003050	6.26	509.89	147.76	0.39
Loyd	3491	100-Year	2400.00	537.36	547.80		548.36	0.002963	6.48	611.90	197.28	0.39
Loyd	3491	500-Year	3120.00	537.36	549.09		549.62	0.002586	6.64	950.73	321.62	0.37
Loyd	3491	100-Year Ult	2590.00	537.36	548.20		548.74	0.002812	6.50	695.68	235.96	0.38
Loyd	3553	10-Year	1500.00	542.83	548.84	548.84	549.55	0.009113	7.89	376.82	269.70	0.64
Loyd	3553	50-Year	2120.00	542.83	549.29	549.29	550.06	0.009942	8.75	503.27	305.57	0.67
Loyd	3553	100-Year	2400.00	542.83	549.31	549.31	550.27	0.012409	9.81	509.56	307.75	0.75
Loyd	3553	500-Year	3120.00	542.83	549.85	549.85	550.73	0.011178	9.94	688.28	343.87	0.73
Loyd	3553	100-Year Ult	2590.00	542.83	549.53	549.53	550.41	0.011219	9.59	580.72	328.33	0.72
Loyd	3635	10-Year	1500.00	541.76	549.73		550.04	0.003827	5.76	544.35	284.55	0.41
Loyd	3635	50-Year	2120.00	541.76	550.25		550.60	0.004272	6.44	699.82	309.52	0.44
Loyd	3635	100-Year	2400.00	541.76	550.53		550.86	0.004068	6.45	787.53	325.89	0.44
Loyd	3635	500-Year	3120.00	541.76	550.94		551.32	0.004606	7.14	925.41	344.82	0.47
Loyd	3635	100-Year Ult	2590.00	541.76	550.63		550.98	0.004233	6.65	822.50	327.01	0.45
Loyd	3798	10-Year	1500.00	542.28	550.25		550.52	0.002582	4.84	502.19	218.94	0.35
Loyd	3798	50-Year	2120.00	542.28	550.81		551.15	0.003216	5.73	635.03	259.23	0.39
Loyd	3798	100-Year	2400.00	542.28	551.05		551.41	0.003303	5.95	699.78	275.14	0.40
Loyd	3798	500-Year	3120.00	542.28	551.52		551.95	0.003784	6.65	836.95	297.40	0.43
Loyd	3798	100-Year Ult	2590.00	542.28	551.18		551.57	0.003524	6.22	735.14	286.78	0.41
Loyd	4288	10-Year	1370.00	543.54	551.74		552.48	0.006471	7.30	250.72	116.29	0.54
Loyd	4288	50-Year	1930.00	543.54	552.56		553.37	0.006572	8.03	352.41	134.91	0.55
Loyd	4288	100-Year	2190.00	543.54	552.84		553.73	0.006984	8.51	393.89	167.65	0.57
Loyd	4288	500-Year	2850.00	543.54	553.51		554.54	0.007614	9.47	542.92	267.48	0.61
Loyd	4288	100-Year Ult	2450.00	543.54	553.09		554.09	0.007647	9.12	439.54	206.15	0.60
Loyd	4707	10-Year	1370.00	546.38	554.58		555.33	0.007411	8.36	267.21	118.42	0.58
Loyd	4707	50-Year	1930.00	546.38	555.42		556.18	0.007202	8.93	375.28	138.37	0.58
Loyd	4707	100-Year	2190.00	546.38	555.81		556.55	0.006792	8.98	432.12	148.34	0.57
Loyd	4707	500-Year	2850.00	546.38	556.64		557.35	0.006188	9.17	565.73	170.21	0.55
Loyd	4707	100-Year Ult	2450.00	546.38	556.23		556.92	0.006220	8.89	497.23	162.10	0.55
Loyd	4747	10-Year	1370.00	547.76	555.04		555.57	0.004039	6.22	271.41	72.54	0.44
Loyd	4747	50-Year	1930.00	547.76	555.62		556.47	0.005895	7.97	332.80	136.34	0.54
Loyd	4747	100-Year	2190.00	547.76	555.93		556.88	0.006280	8.48	378.88	154.93	0.56
Loyd	4747	500-Year	2850.00	547.76	556.69		557.69	0.006344	9.11	520.73	224.19	0.57
Loyd	4747	100-Year Ult	2450.00	547.76	556.30		557.25	0.006115	8.65	442.15	188.88	0.56
Loyd	4891	10-Year	1370.00	550.08	555.69		556.28	0.005789	6.53	274.06	129.91	0.52
Loyd	4891	50-Year	1930.00	550.08	556.71		557.26	0.004719	6.68	448.85	204.50	0.48
Loyd	4891	100-Year	2190.00	550.08	557.15		557.66	0.004221	6.62	547.04	243.04	0.46
Loyd	4891	500-Year	2850.00	550.08	557.97		558.41	0.003502	6.54	756.06	269.18	0.43
Loyd	4891	100-Year Ult	2450.00	550.08	557.52		557.98	0.003773	6.50	638.31	250.25	0.44
Loyd	4937	10-Year	1370.00	550.89	555.95		556.64	0.009253	7.71	252.24	122.88	0.64

HEC-RAS Plan: Loyd_Multi River: Loyd Reach: Loyd (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Loyd	4937	50-Year	1930.00	550.89	556.90		557.56	0.007591	7.95	435.91	255.04	0.60
Loyd	4937	100-Year	2190.00	550.89	557.40		557.88	0.005478	7.16	567.07	272.64	0.52
Loyd	4937	500-Year	2850.00	550.89	558.21		558.60	0.004210	6.83	807.68	323.46	0.46
Loyd	4937	100-Year Ult	2450.00	550.89	557.75		558.18	0.004840	6.99	664.75	294.63	0.49
Loyd	5224	10-Year	1370.00	553.18	558.56		559.10	0.007906	7.48	320.27	169.82	0.60
Loyd	5224	50-Year	1930.00	553.18	559.18		559.73	0.007465	7.88	434.14	199.91	0.59
Loyd	5224	100-Year	2190.00	553.18	559.25		559.91	0.008918	8.68	447.79	201.76	0.65
Loyd	5224	500-Year	2850.00	553.18	559.72		560.49	0.010004	9.70	544.35	214.77	0.70
Loyd	5224	100-Year Ult	2450.00	553.18	559.44		560.17	0.009611	9.22	486.53	206.29	0.68
Loyd	5310	10-Year	1370.00	553.43	559.20		559.70	0.006120	6.82	298.90	106.66	0.53
Loyd	5310	50-Year	1930.00	553.43	559.70		560.45	0.008616	8.61	368.94	198.17	0.64
Loyd	5310	100-Year	2190.00	553.43	559.83		560.91	0.011757	10.21	395.82	214.30	0.75
Loyd	5310	500-Year	2850.00	553.43	560.45		561.40	0.010175	10.17	538.28	243.02	0.71
Loyd	5310	100-Year Ult	2450.00	553.43	560.12		561.12	0.010802	10.11	459.98	228.03	0.72
Loyd	5488	10-Year	1370.00	553.63	560.11		560.39	0.002580	4.55	380.49	176.69	0.35
Loyd	5488	50-Year	1930.00	553.63	560.95		561.23	0.002439	4.87	577.85	332.26	0.35
Loyd	5488	100-Year	2190.00	553.63	561.44		561.66	0.001838	4.45	764.33	413.24	0.30
Loyd	5488	500-Year	2850.00	553.63	561.91		562.14	0.001974	4.82	967.39	460.90	0.32
Loyd	5488	100-Year Ult	2450.00	553.63	561.63		561.86	0.001910	4.62	845.84	430.60	0.31
Loyd	5605	10-Year	990.00	554.35	560.43		560.75	0.003686	4.72	287.48	174.45	0.40
Loyd	5605	50-Year	1410.00	554.35	561.23		561.58	0.003462	5.12	449.24	219.02	0.40
Loyd	5605	100-Year	1590.00	554.35	561.63		561.96	0.003083	5.08	540.10	237.46	0.38
Loyd	5605	500-Year	2050.00	554.35	562.09		562.48	0.003527	5.73	654.36	257.67	0.41
Loyd	5605	100-Year Ult	1770.00	554.35	561.83		562.18	0.003245	5.33	587.59	250.56	0.39
Loyd	5858	10-Year	990.00	557.92	562.50	562.50	563.39	0.015029	8.04	161.30	104.41	0.78
Loyd	5858	50-Year	1410.00	557.92	562.90	562.90	564.05	0.018000	9.49	208.31	133.45	0.86
Loyd	5858	100-Year	1590.00	557.92	563.49	563.49	564.29	0.011349	8.31	312.52	209.43	0.70
Loyd	5858	500-Year	2050.00	557.92	563.90	563.90	564.70	0.011039	8.70	411.12	258.64	0.70
Loyd	5858	100-Year Ult	1770.00	557.92	563.70	563.70	564.47	0.010753	8.35	361.30	247.42	0.69
Loyd	6114	10-Year	990.00	557.22	565.02		565.36	0.004547	5.44	313.00	198.48	0.43
Loyd	6114	50-Year	1410.00	557.22	565.73		566.06	0.004215	5.73	489.98	295.62	0.43
Loyd	6114	100-Year	1590.00	557.22	565.76		566.16	0.005121	6.34	499.99	296.24	0.47
Loyd	6114	500-Year	2050.00	557.22	566.15		566.55	0.005180	6.67	617.21	304.91	0.48
Loyd	6114	100-Year Ult	1770.00	557.22	565.91		566.32	0.005212	6.51	544.50	299.22	0.48
Loyd	6554	10-Year	990.00	566.69	569.39	569.39	569.92	0.029503	8.02	200.37	171.54	1.00
Loyd	6554	50-Year	1410.00	566.69	569.69	569.69	570.33	0.030077	8.89	253.63	184.09	1.03
Loyd	6554	100-Year	1590.00	566.69	569.90	569.80	570.49	0.025319	8.63	291.75	191.54	0.96
Loyd	6554	500-Year	2050.00	566.69	570.21	570.07	570.87	0.024093	9.10	353.97	204.78	0.96
Loyd	6554	100-Year Ult	1770.00	566.69	570.03	569.91	570.65	0.024326	8.77	318.90	201.34	0.95

HEC-RAS Plan: Lynn Creek-Multi River: Lynn Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	157	10-Year	100.00	536.45	537.70	537.43	537.87	0.013017	3.36	32.42	44.85	0.60
1	157	50-Year	130.00	536.45	537.85	537.59	538.05	0.013012	3.69	39.41	47.80	0.61
1	157	100-Year	150.00	536.45	537.94	537.68	538.16	0.013012	3.88	43.87	50.08	0.62
1	157	500-Year	190.00	536.45	538.10	537.82	538.36	0.013006	4.22	52.32	53.06	0.63
1	157	100-Year_Ult	160.00	536.45	537.98	537.72	538.21	0.013010	3.97	46.05	51.10	0.62
1	235	10-Year	100.00	540.49	541.43	541.43	541.72	0.039149	4.52	24.47	43.02	0.97
1	235	50-Year	130.00	540.49	541.54	541.54	541.88	0.037836	4.93	29.40	44.04	0.98
1	235	100-Year	150.00	540.49	541.61	541.61	541.98	0.036990	5.16	32.53	44.67	0.98
1	235	500-Year	190.00	540.49	541.74	541.74	542.17	0.035771	5.57	38.41	45.84	0.99
1	235	100-Year_Ult	160.00	540.49	541.64	541.64	542.03	0.036730	5.27	34.02	44.97	0.98
1	358	10-Year	100.00	542.12	543.57		543.67	0.008272	3.12	43.75	49.76	0.49
1	358	50-Year	130.00	542.12	543.73		543.85	0.008559	3.44	52.03	52.37	0.51
1	358	100-Year	150.00	542.12	543.83		543.96	0.008694	3.63	57.24	53.88	0.52
1	358	500-Year	190.00	542.12	544.00		544.16	0.008924	3.96	67.00	56.51	0.54
1	358	100-Year_Ult	160.00	542.12	543.87		544.02	0.008737	3.71	59.80	54.60	0.53
1	462	10-Year	100.00	543.54	544.48		544.54	0.008518	2.37	55.81	85.84	0.47
1	462	50-Year	130.00	543.54	544.62		544.69	0.007657	2.51	68.42	87.93	0.45
1	462	100-Year	150.00	543.54	544.71		544.78	0.007361	2.60	76.07	89.40	0.45
1	462	500-Year	190.00	543.54	544.88		544.96	0.006717	2.75	91.57	92.53	0.44
1	462	100-Year_Ult	160.00	543.54	544.75		544.83	0.007185	2.64	79.98	90.17	0.45
1	603	10-Year	70.00	556.44	557.20	557.20	557.32	0.029656	3.93	33.06	122.33	0.84
1	603	50-Year	100.00	556.44	557.28	557.28	557.43	0.034937	4.56	42.55	139.17	0.93
1	603	100-Year	120.00	556.44	557.32	557.32	557.48	0.034403	4.71	49.11	145.35	0.93
1	603	500-Year	140.00	556.44	557.35	557.35	557.53	0.037712	5.05	53.42	150.93	0.98
1	603	100-Year_Ult	130.00	556.44	557.33	557.33	557.50	0.038202	5.00	50.18	147.02	0.98
1	751	10-Year	70.00	559.42	560.25		560.32	0.014458	2.91	39.12	106.05	0.60
1	751	50-Year	100.00	559.42	560.38		560.46	0.013165	3.09	53.96	118.84	0.59
1	751	100-Year	120.00	559.42	560.44	560.27	560.53	0.013428	3.27	61.48	121.49	0.60
1	751	500-Year	140.00	559.42	560.50	560.34	560.59	0.012840	3.35	69.49	123.20	0.59
1	751	100-Year_Ult	130.00	559.42	560.48	560.31	560.56	0.012711	3.27	66.33	122.82	0.59
1	893	10-Year	70.00	561.45	562.66	562.63	562.84	0.022362	4.32	26.20	69.99	0.78
1	893	50-Year	100.00	561.45	562.77	562.67	562.99	0.025392	4.96	36.86	85.66	0.84
1	893	100-Year	120.00	561.45	562.87	562.87	563.07	0.022571	4.95	45.35	91.91	0.81
1	893	500-Year	140.00	561.45	562.92	562.92	563.14	0.023665	5.21	49.92	93.01	0.83
1	893	100-Year_Ult	130.00	561.45	562.87	562.85	563.11	0.026757	5.38	45.18	91.87	0.88
1	1031	10-Year	30.00	564.81	565.63	565.57	565.70	0.017336	2.50	18.43	69.58	0.61
1	1031	50-Year	40.00	564.81	565.74	565.63	565.79	0.012543	2.40	25.91	76.19	0.54
1	1031	100-Year	50.00	564.81	565.77	565.67	565.84	0.015234	2.74	28.56	78.29	0.60
1	1031	500-Year	60.00	564.81	565.83	565.71	565.90	0.014064	2.80	33.44	81.78	0.58
1	1031	100-Year_Ult	50.00	564.81	565.82	565.67	565.87	0.010779	2.42	32.29	80.60	0.51
1	1177	10-Year	30.00	567.61	568.55	568.49	568.73	0.024720	3.86	10.18	20.88	0.78
1	1177	50-Year	40.00	567.61	568.60	568.60	568.86	0.033051	4.68	11.32	21.59	0.92
1	1177	100-Year	50.00	567.61	568.70	568.69	568.99	0.031580	4.95	13.60	22.93	0.91
1	1177	500-Year	60.00	567.61	568.76	568.76	569.10	0.035426	5.46	14.93	23.73	0.98
1	1177	100-Year_Ult	50.00	567.61	568.69	568.69	568.99	0.033176	5.03	13.35	22.78	0.93

HEC-RAS Plan: Mills-Multi River: Mills_Branch Reach: Reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	631	10-Year	140.00	532.00	534.20	533.71	534.48	0.008003	4.22	33.20	22.55	0.61
Reach 1	631	50-Year	185.00	532.00	534.51	533.97	534.84	0.008001	4.56	40.55	24.42	0.62
Reach 1	631	100-Year	210.00	532.00	534.67	534.10	535.02	0.008002	4.72	44.47	25.42	0.63
Reach 1	631	500-Year	245.00	532.00	534.87	534.27	535.25	0.008015	4.93	49.69	26.63	0.64
Reach 1	631	100-Year_Ult	230.00	532.00	534.79	534.20	535.15	0.008003	4.84	47.54	26.19	0.63
Reach 1	1085	10-Year	140.00	536.00	539.16	538.98	539.80	0.017844	6.42	21.79	13.24	0.88
Reach 1	1085	50-Year	185.00	536.00	539.50	539.35	540.25	0.018479	6.98	26.51	14.60	0.91
Reach 1	1085	100-Year	210.00	536.00	539.66	539.54	540.48	0.018772	7.25	28.98	15.27	0.93
Reach 1	1085	500-Year	245.00	536.00	539.87	539.77	540.77	0.019149	7.59	32.29	16.11	0.94
Reach 1	1085	100-Year_Ult	230.00	536.00	539.78	539.67	540.65	0.019006	7.45	30.88	15.76	0.94
Reach 1	1232	10-Year	60.00	540.00	541.90		542.06	0.010565	3.14	19.09	17.83	0.54
Reach 1	1232	50-Year	65.00	540.00	542.18		542.29	0.006627	2.67	24.31	20.39	0.43
Reach 1	1232	100-Year	70.00	540.00	542.33		542.43	0.005533	2.53	27.62	21.92	0.40
Reach 1	1232	500-Year	75.00	540.00	542.53		542.62	0.004274	2.33	32.18	23.89	0.35
Reach 1	1232	100-Year_Ult	70.00	540.00	542.44		542.52	0.004490	2.34	29.94	22.94	0.36
Reach 1	1579	10-Year	60.00	544.00	545.13		545.21	0.007821	2.23	26.89	34.22	0.44
Reach 1	1579	50-Year	65.00	544.00	545.09		545.19	0.010917	2.56	25.35	33.64	0.52
Reach 1	1579	100-Year	70.00	544.00	545.09		545.21	0.012505	2.75	25.46	33.68	0.56
Reach 1	1579	500-Year	75.00	544.00	545.06		545.21	0.015998	3.06	24.54	33.33	0.63
Reach 1	1579	100-Year_Ult	70.00	544.00	545.03		545.17	0.015522	2.96	23.67	32.99	0.62
Reach 1	1807	10-Year	60.00	544.00	546.11		546.16	0.002582	1.82	33.05	24.59	0.28
Reach 1	1807	50-Year	65.00	544.00	546.19		546.25	0.002567	1.85	35.13	25.27	0.28
Reach 1	1807	100-Year	70.00	544.00	546.27		546.32	0.002581	1.89	37.02	25.88	0.28
Reach 1	1807	500-Year	75.00	544.00	546.35		546.40	0.002553	1.92	39.10	26.53	0.28
Reach 1	1807	100-Year_Ult	70.00	544.00	546.28		546.34	0.002498	1.87	37.46	26.02	0.27
Reach 1	1954	10-Year	130.00	544.00	546.25		546.26	0.000404	0.82	221.97	420.28	0.11
Reach 1	1954	50-Year	190.00	544.00	546.35		546.37	0.000606	1.04	267.26	425.30	0.14
Reach 1	1954	100-Year	210.00	544.00	546.43		546.44	0.000587	1.06	298.44	428.97	0.14
Reach 1	1954	500-Year	270.00	544.00	546.52		546.54	0.000727	1.22	339.52	433.79	0.16
Reach 1	1954	100-Year_Ult	260.00	544.00	546.47		546.48	0.000800	1.25	314.89	431.03	0.16
Reach 1	2354	10-Year	130.00	544.00	546.31		546.31	0.000067	0.36	365.70	219.04	0.05
Reach 1	2354	50-Year	190.00	544.00	546.45		546.46	0.000110	0.48	397.52	224.66	0.06
Reach 1	2354	100-Year	210.00	544.00	546.53		546.53	0.000118	0.51	414.64	227.63	0.06
Reach 1	2354	500-Year	270.00	544.00	546.65		546.66	0.000159	0.62	443.48	232.54	0.07
Reach 1	2354	100-Year_Ult	260.00	544.00	546.60		546.61	0.000160	0.61	431.70	230.54	0.07
Reach 1	2715	10-Year	130.00	548.00	549.07	549.07	549.47	0.040330	5.05	25.72	32.84	1.01
Reach 1	2715	50-Year	190.00	548.00	549.32	549.32	549.80	0.038102	5.51	34.46	36.97	1.01
Reach 1	2715	100-Year	210.00	548.00	549.40	549.40	549.89	0.037603	5.64	37.22	38.19	1.01
Reach 1	2715	500-Year	270.00	548.00	549.60	549.60	550.15	0.036049	5.96	45.34	41.55	1.00
Reach 1	2715	100-Year_Ult	260.00	548.00	549.57	549.57	550.11	0.036275	5.91	44.01	41.02	1.01
Reach 1	3199	10-Year	50.00	558.00	558.84		558.89	0.006010	1.73	28.91	44.36	0.38
Reach 1	3199	50-Year	70.00	558.00	559.01		559.07	0.005938	1.88	37.16	49.71	0.38
Reach 1	3199	100-Year	80.00	558.00	559.08		559.14	0.006156	1.98	40.30	51.23	0.39
Reach 1	3199	500-Year	100.00	558.00	559.21		559.28	0.006121	2.11	47.39	54.70	0.40
Reach 1	3199	100-Year_Ult	100.00	558.00	559.20		559.27	0.006319	2.13	46.85	54.46	0.41
Reach 1	3480	10-Year	50.00	562.00	562.80	562.80	563.12	0.043522	4.51	11.09	17.71	1.00
Reach 1	3480	50-Year	70.00	562.00	562.98	562.98	563.35	0.041199	4.89	14.32	19.40	1.00
Reach 1	3480	100-Year	80.00	562.00	563.05	563.05	563.45	0.040518	5.05	15.83	20.14	1.00
Reach 1	3480	500-Year	100.00	562.00	563.19	563.19	563.63	0.039062	5.32	18.79	21.53	1.00
Reach 1	3480	100-Year_Ult	100.00	562.00	563.19	563.19	563.63	0.039316	5.33	18.75	21.51	1.01
Reach 1	3679	10-Year	50.00	569.53	570.16		570.32	0.030527	3.24	15.44	31.26	0.81
Reach 1	3679	50-Year	70.00	569.53	570.28	570.21	570.48	0.031400	3.64	19.21	33.31	0.85
Reach 1	3679	100-Year	80.00	569.53	570.33	570.26	570.56	0.031526	3.80	21.03	34.25	0.86
Reach 1	3679	500-Year	100.00	569.53	570.43	570.36	570.69	0.032155	4.10	24.36	35.94	0.88
Reach 1	3679	100-Year_Ult	100.00	569.53	570.43	570.36	570.69	0.031897	4.09	24.43	35.97	0.88
Reach 1	3912	10-Year	50.00	578.00	578.92	578.92	579.25	0.043234	4.59	10.89	16.83	1.01
Reach 1	3912	50-Year	70.00	578.00	579.10	579.10	579.48	0.041371	4.96	14.11	18.78	1.01
Reach 1	3912	100-Year	80.00	578.00	579.18	579.18	579.59	0.040600	5.11	15.66	19.65	1.01
Reach 1	3912	500-Year	100.00	578.00	579.33	579.33	579.77	0.039297	5.36	18.65	21.22	1.01
Reach 1	3912	100-Year_Ult	100.00	578.00	579.33	579.33	579.77	0.039297	5.36	18.65	21.22	1.01

HEC-RAS Plan: Mountain_Multi River: Mountain Reach: Mountain

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mountain	374 374	2-Year	9820.00	518.68	529.52	525.73	529.67	0.001001	4.84	5223.80	3337.02	0.27
Mountain	374 374	5-Year	17880.00	518.68	531.17	528.73	531.32	0.001000	5.34	8786.16	3732.60	0.27
Mountain	374 374	10-Year	24200.00	518.68	532.14	529.09	532.28	0.001001	5.63	10880.05	3767.62	0.28
Mountain	374 374	25-Year	33460.00	518.68	533.35	530.07	533.51	0.001000	5.98	13546.52	3801.81	0.28
Mountain	374 374	50-Year	41610.00	518.68	534.30	530.48	534.47	0.001000	6.24	15635.26	3828.31	0.28
Mountain	374 374	100-Year	49780.00	518.68	535.18	530.84	535.36	0.001000	6.48	17556.62	3845.82	0.29
Mountain	374 374	500-Year	71570.00	518.68	537.24	531.65	537.46	0.001001	7.04	22140.18	3896.87	0.29
Mountain	374 374	100-Year_Ult	57400.00	518.68	535.94	531.15	536.13	0.001000	6.69	19238.63	3864.69	0.29
Mountain	1888 1888	2-Year	9820.00	518.51	531.16	527.03	531.44	0.001473	6.25	3653.77	2682.35	0.33
Mountain	1888 1888	5-Year	17880.00	518.51	532.84	530.40	533.10	0.001530	6.99	7143.27	4494.63	0.34
Mountain	1888 1888	10-Year	24200.00	518.51	533.78	531.63	534.02	0.001466	7.16	9572.85	4712.46	0.34
Mountain	1888 1888	25-Year	33460.00	518.51	534.96	532.44	535.18	0.001355	7.27	12693.70	4757.94	0.33
Mountain	1888 1888	50-Year	41610.00	518.51	535.88	532.93	536.09	0.001280	7.34	15164.00	4806.63	0.32
Mountain	1888 1888	100-Year	49780.00	518.51	536.73	533.35	536.94	0.001219	7.42	17458.95	4854.84	0.32
Mountain	1888 1888	500-Year	71570.00	518.51	538.74	534.20	538.96	0.001108	7.62	23025.47	4975.02	0.31
Mountain	1888 1888	100-Year_Ult	57400.00	518.51	537.47	533.35	537.68	0.001175	7.49	19488.48	4918.30	0.31
Mountain	3718 3718	2-Year	8760.00	518.36	534.50	530.80	535.21	0.003013	9.03	2342.26	737.55	0.41
Mountain	3718 3718	5-Year	14300.00	518.36	536.26	532.25	536.96	0.003125	9.92	3443.95	853.46	0.43
Mountain	3718 3718	10-Year	18460.00	518.36	537.08	535.45	537.68	0.002949	9.95	4626.01	879.69	0.42
Mountain	3718 3718	25-Year	24030.00	518.36	538.07	536.31	538.71	0.003138	10.65	5512.24	905.18	0.44
Mountain	3718 3718	50-Year	29150.00	518.36	538.85	536.72	539.53	0.003267	11.17	6225.61	912.22	0.45
Mountain	3718 3718	100-Year	34440.00	518.36	539.59	537.22	540.30	0.003388	11.67	6896.11	918.83	0.46
Mountain	3718 3718	500-Year	48780.00	518.36	541.39	538.38	542.23	0.003784	13.06	8613.18	1011.66	0.49
Mountain	3718 3718	100-Year_Ult	38800.00	518.36	540.22	537.63	540.96	0.003438	12.00	7489.40	945.00	0.47
Mountain	4451	2-Year	8760.00	518.00	536.02	531.01	536.19	0.000682	4.68	4866.47	1842.20	0.20
Mountain	4451	5-Year	14300.00	518.00	537.77	533.19	537.91	0.000654	4.90	7425.76	1987.44	0.20
Mountain	4451	10-Year	18460.00	518.00	538.53	533.90	538.69	0.000745	5.38	8541.68	2027.55	0.22
Mountain	4451	25-Year	24030.00	518.00	539.60	535.92	539.77	0.000782	5.72	10136.02	2076.40	0.23
Mountain	4451	50-Year	29150.00	518.00	540.45	536.39	540.63	0.000814	6.00	11410.86	2143.47	0.23
Mountain	4451	100-Year	34440.00	518.00	541.25	536.79	541.44	0.000842	6.26	12615.22	2203.23	0.24
Mountain	4451	500-Year	48780.00	518.00	543.23	537.69	543.46	0.000880	6.79	15634.22	2311.78	0.25
Mountain	4451	100-Year_Ult	38800.00	518.00	541.91	537.09	542.12	0.000849	6.42	13624.58	2252.31	0.24
Mountain	4550	2-Year	8760.00	518.76	536.07	527.81	536.25	0.000543	4.21	4295.49	1802.20	0.19
Mountain	4550	5-Year	14300.00	518.76	537.82	531.21	537.99	0.000592	4.72	7230.78	1948.81	0.20
Mountain	4550	10-Year	18460.00	518.76	538.58	533.14	538.78	0.000677	5.20	8426.84	2004.25	0.22
Mountain	4550	25-Year	24030.00	518.76	539.66	534.29	539.86	0.000708	5.53	10119.12	2074.14	0.22
Mountain	4550	50-Year	29150.00	518.76	540.51	536.23	540.73	0.000737	5.81	11477.04	2149.03	0.23
Mountain	4550	100-Year	34440.00	518.76	541.31	537.00	541.54	0.000761	6.06	12782.00	2227.31	0.24
Mountain	4550	500-Year	48780.00	518.76	543.31	538.02	543.55	0.000781	6.53	16120.42	2370.81	0.24
Mountain	4550	100-Year_Ult	38800.00	518.76	541.98	537.29	542.21	0.000762	6.20	13894.05	2289.67	0.24
Mountain	4672 FM 661		Bridge									
Mountain	4737	2-Year	8760.00	518.43	536.38	527.45	536.53	0.000457	3.97	4753.10	1690.67	0.17
Mountain	4737	5-Year	14300.00	518.43	538.23	531.23	538.38	0.000496	4.45	7632.65	1883.77	0.18
Mountain	4737	10-Year	18460.00	518.43	538.93	532.72	539.10	0.000595	5.00	8736.68	1918.63	0.20
Mountain	4737	25-Year	24030.00	518.43	539.98	533.96	540.17	0.000638	5.37	10409.43	1987.25	0.21
Mountain	4737	50-Year	29150.00	518.43	540.79	536.23	541.00	0.000688	5.72	11708.49	2040.80	0.22
Mountain	4737	100-Year	34440.00	518.43	541.54	536.92	541.77	0.000728	6.03	12933.87	2092.57	0.23
Mountain	4737	500-Year	48780.00	518.43	543.47	538.13	543.73	0.000777	6.60	16141.90	2193.79	0.24
Mountain	4737	100-Year_Ult	38800.00	518.43	542.17	537.00	542.41	0.000743	6.21	13976.13	2116.34	0.23
Mountain	4803	2-Year	8760.00	517.65	536.40	528.10	536.57	0.000535	4.13	4503.76	1673.00	0.19
Mountain	4803	5-Year	14300.00	517.65	538.25	530.44	538.41	0.000550	4.52	7318.24	1818.14	0.19
Mountain	4803	10-Year	18460.00	517.65	538.95	532.90	539.14	0.000654	5.06	8422.62	1860.54	0.21
Mountain	4803	25-Year	24030.00	517.65	540.01	533.55	540.21	0.000697	5.44	10116.36	1956.04	0.22
Mountain	4803	50-Year	29150.00	517.65	540.82	536.57	541.03	0.000740	5.76	11442.04	1996.08	0.23
Mountain	4803	100-Year	34440.00	517.65	541.57	537.08	541.80	0.000775	6.04	12692.99	2029.96	0.24
Mountain	4803	500-Year	48780.00	517.65	543.51	538.27	543.76	0.000810	6.56	15922.07	2103.34	0.24
Mountain	4803	100-Year_Ult	38800.00	517.65	542.21	537.37	542.44	0.000784	6.21	13748.48	2059.65	0.24
Mountain	5912 5912	2-Year	8760.00	519.39	537.13		537.52	0.001678	6.69	3377.76	1352.46	0.31
Mountain	5912 5912	5-Year	14300.00	519.39	538.96		539.18	0.001145	5.99	5903.68	1412.55	0.26
Mountain	5912 5912	10-Year	18460.00	519.39	539.76		539.99	0.001171	6.26	7046.57	1433.48	0.27
Mountain	5912 5912	25-Year	24030.00	519.39	540.84		541.05	0.001121	6.38	8603.19	1507.47	0.27
Mountain	5912 5912	50-Year	29150.00	519.39	541.67		541.89	0.001112	6.55	9900.94	1616.51	0.27
Mountain	5912 5912	100-Year	34440.00	519.39	542.45		542.67	0.001108	6.72	11184.17	1684.83	0.27
Mountain	5912 5912	500-Year	48780.00	519.39	544.39		544.63	0.001059	7.00	14590.42	1826.11	0.27
Mountain	5912 5912	100-Year_Ult	38800.00	519.39	543.08		543.31	0.001088	6.80	12267.09	1727.03	0.27
Mountain	8400 8400	2-Year	9230.00	520.61	539.98	532.97	540.27	0.000942	5.60	4372.72	2470.93	0.25
Mountain	8400 8400	5-Year	14650.00	520.61	541.13	537.32	541.37	0.000930	5.82	6852.70	2685.81	0.25
Mountain	8400 8400	10-Year	18870.00	520.61	541.91	540.22	542.11	0.000888	5.86	8523.96	2754.02	0.24
Mountain	8400 8400	25-Year	24490.00	520.61	542.85	540.66	543.03	0.000829	5.86	10581.32	2813.97	0.24
Mountain	8400 8400	50-Year	29700.00	520.61	543.63	541.02	543.80	0.000796	5.89	12299.37	2846.23	0.23
Mountain	8400 8400	100-Year	35050.00	520.61	544.36	541.31	544.53	0.000768	5.93	13919.76	2872.98	0.23
Mountain	8400 8400	500-Year	49580.00	520.61	546.18	541.95	546.35	0.000706	6.02	17942.44	2925.74	0.22
Mountain	8400 8400	100-Year_Ult	39300.00	520.61	544.94	541.54	545.11	0.000739	5.93	15202.45	2896.87	0.23
Mountain	10133	2-Year	9230.00	522.89	542.03	537.67	542.58	0.002091	8.05	2361.08	2735.83	0.35
Mountain	10133	5-Year	14650.00	522.89	543.23	539.87	543.84	0.002548	9.31	3606.68	2834.58	0.39
Mountain	10133	10-Year	18870.00	522.89	543.96	542.70	544.58	0.002776	9.98	4352.48	2892.51	0.41
Mountain	10133	25-Year	24490.00	522.89	544.80	543.37	545.46	0.002964	10.62	5224.05	2960.93	0.42

HEC-RAS Plan: Mountain_Multi River: Mountain Reach: Mountain (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mountain	10133	50-Year	29700.00	522.89	545.51	543.88	546.19	0.003060	11.05	5960.57	2977.73	0.43
Mountain	10133	100-Year	35050.00	522.89	546.18	544.33	546.89	0.003132	11.42	6653.12	2985.90	0.44
Mountain	10133	500-Year	49580.00	522.89	547.83	545.32	548.61	0.003202	12.15	8362.72	3023.24	0.45
Mountain	10133	100-Year_Ult	39300.00	522.89	546.69	544.65	547.42	0.003158	11.66	7182.43	2999.84	0.44
Mountain	10396	2-Year	9230.00	523.94	542.62	538.06	543.12	0.001834	7.16	2328.82	2523.10	0.33
Mountain	10396	5-Year	14650.00	523.94	543.88	540.05	544.58	0.002619	9.04	3040.95	2782.75	0.40
Mountain	10396	10-Year	18870.00	523.94	544.64	540.74	545.46	0.003012	10.01	3483.95	2837.14	0.43
Mountain	10396	25-Year	24490.00	523.94	545.51	543.87	546.48	0.003469	11.11	3988.37	2871.15	0.47
Mountain	10396	50-Year	29700.00	523.94	546.23	544.46	547.33	0.003827	11.98	4403.76	2896.27	0.49
Mountain	10396	100-Year	35050.00	523.94	546.89	545.01	548.13	0.004157	12.79	4789.69	2914.21	0.52
Mountain	10396	500-Year	49580.00	523.94	548.49	546.33	550.08	0.004862	14.61	5718.56	2976.71	0.57
Mountain	10396	100-Year_Ult	39300.00	523.94	547.39	545.43	548.73	0.004383	13.36	5079.30	2925.05	0.53
Mountain	10720 US HWY 287		Bridge									
Mountain	10907	2-Year	9230.00	523.84	543.66	538.56	543.94	0.001036	5.49	2892.59	667.08	0.25
Mountain	10907	5-Year	14650.00	523.84	545.48	540.39	545.81	0.001160	6.27	3870.62	922.79	0.27
Mountain	10907	10-Year	18870.00	523.84	546.64	541.43	547.03	0.001235	6.77	4499.94	988.03	0.28
Mountain	10907	25-Year	24490.00	523.84	548.02	542.49	548.47	0.001309	7.32	5243.43	1052.65	0.29
Mountain	10907	50-Year	29700.00	523.84	549.18	544.13	549.69	0.001359	7.75	5868.99	1150.83	0.30
Mountain	10907	100-Year	35050.00	523.84	550.28	544.71	550.85	0.001400	8.15	6462.51	1338.73	0.31
Mountain	10907	500-Year	49580.00	523.84	553.53	546.07	554.21	0.001303	8.63	8221.86	1610.86	0.31
Mountain	10907	100-Year_Ult	39300.00	523.84	551.11	545.14	551.73	0.001423	8.43	6911.81	1414.28	0.31
Mountain	10995	2-Year	9230.00	524.31	543.89	539.03	544.06	0.000662	4.58	3652.23	843.53	0.20
Mountain	10995	5-Year	14650.00	524.31	545.74	540.54	545.95	0.000757	5.26	4797.66	1268.52	0.22
Mountain	10995	10-Year	18870.00	524.31	546.93	541.90	547.17	0.000814	5.68	5537.36	1455.34	0.23
Mountain	10995	25-Year	24490.00	524.31	548.34	542.70	548.63	0.000870	6.15	6412.11	1588.01	0.24
Mountain	10995	50-Year	29700.00	524.31	549.53	543.49	549.86	0.000910	6.52	7148.47	1764.44	0.24
Mountain	10995	100-Year	35050.00	524.31	550.66	544.01	551.03	0.000942	6.86	7847.75	1772.24	0.25
Mountain	10995	500-Year	49580.00	524.31	554.33	545.26	554.43	0.000304	4.29	20320.52	1843.82	0.15
Mountain	10995	100-Year_Ult	39300.00	524.31	551.51	544.41	551.91	0.000961	7.10	8376.78	1783.24	0.25
Mountain	13175 13175	2-Year	9230.00	526.95	545.38		545.64	0.000942	5.56	4008.48	1590.95	0.24
Mountain	13175 13175	5-Year	14650.00	526.95	547.18		547.33	0.000671	5.03	6906.62	1631.97	0.21
Mountain	13175 13175	10-Year	18870.00	526.95	548.35		548.48	0.000566	4.82	8841.11	1660.25	0.19
Mountain	13175 13175	25-Year	24490.00	526.95	549.75		549.86	0.000483	4.67	11171.60	1683.19	0.18
Mountain	13175 13175	50-Year	29700.00	526.95	550.93		551.04	0.000434	4.59	13175.08	1706.44	0.17
Mountain	13175 13175	100-Year	35050.00	526.95	552.05		552.16	0.000396	4.54	15103.84	1718.96	0.17
Mountain	13175 13175	500-Year	49580.00	526.95	554.91		555.02	0.000327	4.46	20076.92	1761.05	0.15
Mountain	13175 13175	100-Year_Ult	39300.00	526.95	552.91		553.02	0.000373	4.51	16574.68	1728.33	0.16
Mountain	14220 14220	2-Year	9320.00	527.75	546.51		547.01	0.001931	7.59	2728.51	1303.32	0.33
Mountain	14220 14220	5-Year	14720.00	527.75	548.02		548.36	0.001589	7.30	5239.80	1982.78	0.31
Mountain	14220 14220	10-Year	19020.00	527.75	549.06		549.28	0.001171	6.51	7370.74	2083.51	0.27
Mountain	14220 14220	25-Year	24660.00	527.75	550.32		550.48	0.000835	5.74	10035.00	2127.42	0.23
Mountain	14220 14220	50-Year	29950.00	527.75	551.43		551.56	0.000669	5.33	12422.53	2200.44	0.20
Mountain	14220 14220	100-Year	35370.00	527.75	552.50		552.61	0.000555	5.01	14806.96	2260.58	0.19
Mountain	14220 14220	500-Year	50480.00	527.75	555.26		555.36	0.000379	4.48	21232.37	2383.13	0.16
Mountain	14220 14220	100-Year_Ult	39610.00	527.75	553.32		553.42	0.000487	4.81	16673.58	2298.06	0.18
Mountain	16326 16326	2-Year	9320.00	531.18	550.05		550.59	0.001602	7.29	2691.86	1187.26	0.31
Mountain	16326 16326	5-Year	14720.00	531.18	551.22		551.74	0.001791	8.07	4570.90	1984.49	0.34
Mountain	16326 16326	10-Year	19020.00	531.18	551.77		552.30	0.002000	8.70	5728.56	2216.90	0.36
Mountain	16326 16326	25-Year	24660.00	531.18	552.46		552.94	0.002003	8.92	7278.64	2308.09	0.36
Mountain	16326 16326	50-Year	29950.00	531.18	553.18		553.58	0.001770	8.60	9006.22	2409.00	0.34
Mountain	16326 16326	100-Year	35370.00	531.18	553.96		554.27	0.001468	8.03	10894.62	2478.12	0.31
Mountain	16326 16326	500-Year	50480.00	531.18	556.21		556.41	0.000862	6.60	16652.18	2624.66	0.24
Mountain	16326 16326	100-Year_Ult	39610.00	531.18	554.59		554.86	0.001250	7.56	12462.81	2512.37	0.29
Mountain	19232 19232	2-Year	9120.00	532.83	553.66	548.17	553.97	0.001251	5.95	3457.31	1119.61	0.26
Mountain	19232 19232	5-Year	14410.00	532.83	554.94	553.08	555.26	0.001423	6.69	5152.64	1532.96	0.29
Mountain	19232 19232	10-Year	18580.00	532.83	555.68	553.67	556.00	0.001519	7.11	6314.92	1589.28	0.30
Mountain	19232 19232	25-Year	24060.00	532.83	556.33	554.23	556.68	0.001675	7.64	7364.42	1612.74	0.31
Mountain	19232 19232	50-Year	29200.00	532.83	556.81	554.88	557.19	0.001869	8.21	8129.95	1630.54	0.33
Mountain	19232 19232	100-Year	34450.00	532.83	557.22	555.50	557.65	0.002068	8.77	8811.04	1728.21	0.35
Mountain	19232 19232	500-Year	49130.00	532.83	558.45	556.24	558.95	0.002287	9.61	10859.11	1974.56	0.37
Mountain	19232 19232	100-Year_Ult	38680.00	532.83	557.55	555.73	558.01	0.002199	9.14	9354.11	1791.73	0.36
Mountain	20749 20749	2-Year	9130.00	535.74	556.08		557.04	0.003281	9.21	1990.47	841.29	0.43
Mountain	20749 20749	5-Year	14420.00	535.74	557.60		558.25	0.002765	9.05	4491.84	2054.98	0.40
Mountain	20749 20749	10-Year	18590.00	535.74	558.35		558.84	0.002351	8.62	6130.27	2209.68	0.38
Mountain	20749 20749	25-Year	24060.00	535.74	559.10		559.49	0.002116	8.42	7790.65	2267.14	0.36
Mountain	20749 20749	50-Year	29200.00	535.74	559.71		560.07	0.001994	8.37	9202.36	2334.63	0.35
Mountain	20749 20749	100-Year	34430.00	535.74	560.27		560.61	0.001895	8.33	10526.73	2371.14	0.34
Mountain	20749 20749	500-Year	49130.00	535.74	561.64		561.95	0.001785	8.48	13880.10	2534.04	0.34
Mountain	20749 20749	100-Year_Ult	38670.00	535.74	560.69		561.02	0.001850	8.36	11536.65	2422.27	0.34
Mountain	24384 24384	2-Year	6570.00	543.21	562.56		562.84	0.000951	5.48	3155.12	1608.85	0.24
Mountain	24384 24384	5-Year	10490.00	543.21	563.43		563.72	0.001140	6.22	4664.39	1820.26	0.26
Mountain	24384 24384	10-Year	13470.00	543.21	563.83		564.14	0.001347	6.86	5401.06	1880.16	0.29
Mountain	24384 24384	25-Year	17560.00	543.21	564.34		564.67	0.001538	7.47	6378.94	1956.21	0.31
Mountain	24384 24384	50-Year	21320.00	543.21	564.78		565.12	0.001630	7.82	7258.60	2000.31	0.32
Mountain	24384 24384	100-Year	25100.00	543.21	565.19		565.54	0.001689	8.07	8091.91	2034.18	0.33
Mountain	24384 24384	500-Year	35540.00	543.21	566.30		566.63	0.001704	8.42	10380.35	2120.95	0.33
Mountain	24384 24384	100-Year_Ult	28590.00	543.21	565.55		565.90	0.001733	8.28	8821.58	2063.87	0.33

HEC-RAS Plan: Newton_Multi River: Soap Creek Reach: Newton Branch

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Newton Branch	894	10-Year	2600.00	531.19	540.56	539.75	540.79	0.003004	5.55	1431.16	894.64	0.40
Newton Branch	894	50-Year	6100.00	531.19	542.09	540.89	542.31	0.003001	6.46	3130.13	1274.56	0.42
Newton Branch	894	100-Year	7800.00	531.19	542.58	541.32	542.79	0.003001	6.74	3763.56	1305.87	0.42
Newton Branch	894	500-Year	12300.00	531.19	543.62	542.00	543.84	0.003004	7.32	5184.85	1397.66	0.43
Newton Branch	894	100-Year_Ult	10500.00	531.19	543.24	541.79	543.45	0.003001	7.11	4647.90	1385.06	0.43
Newton Branch	1388	10-Year	2600.00	532.68	541.40		541.51	0.000974	3.34	1598.14	747.52	0.24
Newton Branch	1388	50-Year	6100.00	532.68	542.97		543.12	0.001294	4.50	3090.42	1080.54	0.29
Newton Branch	1388	100-Year	7800.00	532.68	543.47		543.62	0.001366	4.82	3630.79	1108.44	0.30
Newton Branch	1388	500-Year	12300.00	532.68	544.52		544.71	0.001515	5.51	4828.29	1158.09	0.32
Newton Branch	1388	100-Year_Ult	10500.00	532.68	544.13		544.31	0.001460	5.25	4378.11	1139.09	0.31
Newton Branch	1471	10-Year	2600.00	532.32	541.48	538.39	541.59	0.001048	3.46	1593.75	805.00	0.25
Newton Branch	1471	50-Year	6100.00	532.32	543.09	541.09	543.22	0.001228	4.38	3179.63	1086.76	0.28
Newton Branch	1471	100-Year	7800.00	532.32	543.58	541.56	543.73	0.001302	4.70	3728.56	1113.22	0.29
Newton Branch	1471	500-Year	12300.00	532.32	544.65	542.54	544.83	0.001439	5.36	4937.58	1137.97	0.31
Newton Branch	1471	100-Year_Ult	10500.00	532.32	544.26	542.16	544.42	0.001393	5.12	4486.84	1133.26	0.30
Newton Branch	1520		Culvert									
Newton Branch	1567	10-Year	2600.00	533.66	541.36	540.71	541.61	0.003460	5.64	1106.69	718.79	0.43
Newton Branch	1567	50-Year	6100.00	533.66	543.07	541.84	543.24	0.002393	5.64	2708.17	1042.55	0.38
Newton Branch	1567	100-Year	7800.00	533.66	543.61	541.93	543.77	0.002219	5.71	3271.35	1054.47	0.37
Newton Branch	1567	500-Year	12300.00	533.66	544.70	542.89	544.88	0.002157	6.16	4437.83	1085.49	0.37
Newton Branch	1567	100-Year_Ult	10500.00	533.66	544.26	542.69	544.43	0.002238	6.06	3959.66	1073.32	0.37
Newton Branch	1617	10-Year	2600.00	535.12	541.59		541.79	0.002971	4.88	1166.58	729.65	0.40
Newton Branch	1617	50-Year	6100.00	535.12	543.19		543.36	0.002433	5.40	2682.13	1075.99	0.38
Newton Branch	1617	100-Year	7800.00	535.12	543.72		543.89	0.002245	5.48	3252.90	1085.60	0.37
Newton Branch	1617	500-Year	12300.00	535.12	544.80		544.99	0.002145	5.92	4446.41	1106.52	0.38
Newton Branch	1617	100-Year_Ult	10500.00	535.12	544.36		544.55	0.002237	5.82	3962.02	1101.27	0.38
Newton Branch	2323	10-Year	2600.00	536.30	543.41		543.53	0.002454	4.31	1251.90	886.05	0.36
Newton Branch	2323	50-Year	6100.00	536.30	544.65		544.78	0.002094	4.68	2416.32	972.18	0.34
Newton Branch	2323	100-Year	7800.00	536.30	545.09		545.24	0.002075	4.90	2845.63	985.13	0.35
Newton Branch	2323	500-Year	12300.00	536.30	546.10		546.28	0.002019	5.34	3863.31	1027.35	0.35
Newton Branch	2323	100-Year_Ult	10500.00	536.30	545.71		545.88	0.002059	5.20	3470.45	1010.90	0.35
Newton Branch	3088	10-Year	2600.00	538.22	545.32		545.57	0.003794	5.83	1028.89	637.78	0.46
Newton Branch	3088	50-Year	6100.00	538.22	546.46		546.79	0.004833	7.54	1848.29	787.82	0.53
Newton Branch	3088	100-Year	7800.00	538.22	546.91		547.26	0.005076	8.09	2213.02	844.72	0.55
Newton Branch	3088	500-Year	12300.00	538.22	547.86		548.27	0.005142	8.91	3066.70	929.41	0.57
Newton Branch	3088	100-Year_Ult	10500.00	538.22	547.51		547.90	0.005120	8.61	2739.72	903.01	0.56
Newton Branch	3851	10-Year	2600.00	539.21	547.09		547.18	0.001563	3.77	1588.47	817.64	0.30
Newton Branch	3851	50-Year	6100.00	539.21	548.51		548.63	0.001716	4.66	2803.75	891.52	0.32
Newton Branch	3851	100-Year	7800.00	539.21	549.03		549.16	0.001762	4.96	3266.85	904.30	0.33
Newton Branch	3851	500-Year	12300.00	539.21	550.13		550.31	0.001985	5.81	4287.38	959.93	0.36
Newton Branch	3851	100-Year_Ult	10500.00	539.21	549.71		549.87	0.001892	5.47	3894.97	929.18	0.35
Newton Branch	4919	10-Year	1500.00	541.25	548.57		548.65	0.001511	3.94	1188.97	990.02	0.29
Newton Branch	4919	50-Year	3600.00	541.25	549.89		549.94	0.001004	3.69	2577.89	1085.79	0.24
Newton Branch	4919	100-Year	4700.00	541.25	550.39		550.45	0.000943	3.74	3128.87	1097.91	0.24
Newton Branch	4919	500-Year	7600.00	541.25	551.54		551.60	0.000847	3.90	4404.06	1122.46	0.23
Newton Branch	4919	100-Year_Ult	6600.00	541.25	551.12		551.18	0.000912	3.91	3930.35	1113.12	0.24
Newton Branch	5603	10-Year	1500.00	543.16	549.64		549.92	0.004815	5.96	616.80	537.59	0.49
Newton Branch	5603	50-Year	3600.00	543.16	550.58		550.88	0.005840	7.45	1281.87	847.93	0.56
Newton Branch	5603	100-Year	4700.00	543.16	551.02		551.29	0.005268	7.45	1682.86	942.82	0.54
Newton Branch	5603	500-Year	7600.00	543.16	552.05		552.25	0.003532	6.80	2680.07	986.27	0.46
Newton Branch	5603	100-Year_Ult	6600.00	543.16	551.69		551.91	0.004095	7.06	2321.27	969.17	0.49
Newton Branch	6135	10-Year	1500.00	545.04	551.27		551.36	0.002077	3.74	823.92	577.34	0.32
Newton Branch	6135	50-Year	3600.00	545.04	552.51		552.63	0.002630	5.00	1867.46	981.95	0.38
Newton Branch	6135	100-Year	4700.00	545.04	552.87		553.01	0.002774	5.36	2232.07	1006.31	0.39
Newton Branch	6135	500-Year	7600.00	545.04	553.60		553.77	0.003193	6.23	2980.44	1036.17	0.43
Newton Branch	6135	100-Year_Ult	6600.00	545.04	553.36		553.52	0.003104	5.99	2730.24	1029.34	0.42
Newton Branch	7199	10-Year	1500.00	547.81	554.01		554.36	0.005031	6.17	469.13	350.73	0.51
Newton Branch	7199	50-Year	3600.00	547.81	555.42		555.71	0.004290	6.84	1246.13	744.68	0.50
Newton Branch	7199	100-Year	4700.00	547.81	555.81		556.09	0.004131	7.01	1544.80	781.96	0.49
Newton Branch	7199	500-Year	7600.00	547.81	556.66		556.94	0.003863	7.38	2244.55	857.11	0.49
Newton Branch	7199	100-Year_Ult	6600.00	547.81	556.40		556.68	0.003905	7.23	2022.51	836.24	0.49
Newton Branch	7926	10-Year	1500.00	549.69	555.47		555.52	0.001171	2.73	961.06	600.00	0.24
Newton Branch	7926	50-Year	3600.00	549.69	556.75		556.83	0.001369	3.56	1824.15	722.83	0.28
Newton Branch	7926	100-Year	4700.00	549.69	557.15		557.25	0.001542	3.97	2121.44	753.26	0.30
Newton Branch	7926	500-Year	7600.00	549.69	558.03		558.17	0.001881	4.84	2836.00	855.16	0.34
Newton Branch	7926	100-Year_Ult	6600.00	549.69	557.75		557.88	0.001790	4.59	2603.52	827.04	0.33

HEC-RAS Plan: Newton_Multi River: Soap Creek Reach: Newton Branch (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Newton Branch	8505	10-Year	1500.00	550.69	556.56	556.56	557.43	0.010439	8.27	267.84	202.47	0.72
Newton Branch	8505	50-Year	3600.00	550.69	557.89		558.59	0.008510	9.00	795.65	487.64	0.68
Newton Branch	8505	100-Year	4700.00	550.69	558.43		559.02	0.007173	8.80	1071.58	534.46	0.63
Newton Branch	8505	500-Year	7600.00	550.69	559.49		560.02	0.005974	8.95	1665.16	588.67	0.59
Newton Branch	8505	100-Year_Ult	6600.00	550.69	559.17		559.70	0.006156	8.81	1479.87	568.32	0.60
Newton Branch	8631	10-Year	1500.00	551.05	557.91	555.88	558.04	0.001472	3.62	766.97	450.33	0.29
Newton Branch	8631	50-Year	3600.00	551.05	558.99	557.83	559.26	0.002623	5.52	1292.82	515.01	0.40
Newton Branch	8631	100-Year	4700.00	551.05	559.33	558.25	559.67	0.003286	6.40	1468.81	530.75	0.45
Newton Branch	8631	500-Year	7600.00	551.05	560.16	558.88	560.65	0.004283	7.94	1924.98	557.85	0.52
Newton Branch	8631	100-Year_Ult	6600.00	551.05	559.89	558.80	560.33	0.003977	7.45	1774.33	547.17	0.50
Newton Branch	8676		Culvert									
Newton Branch	8718	10-Year	1500.00	553.44	561.63	557.92	561.65	0.000196	1.67	1740.03	776.36	0.11
Newton Branch	8718	50-Year	3600.00	553.44	562.71	560.00	562.74	0.000265	2.13	3485.41	868.44	0.13
Newton Branch	8718	100-Year	4700.00	553.44	563.14	560.00	563.18	0.000342	2.50	3864.95	903.74	0.15
Newton Branch	8718	500-Year	7600.00	553.44	563.83	560.18	563.90	0.000583	3.44	4507.25	949.22	0.20
Newton Branch	8718	100-Year_Ult	6600.00	553.44	563.60	560.06	563.65	0.000505	3.15	4287.34	942.11	0.18
Newton Branch	8783	10-Year	1500.00	553.64	561.66		561.67	0.000083	1.06	2592.00	685.34	0.07
Newton Branch	8783	50-Year	3600.00	553.64	562.73		562.75	0.000239	1.98	3398.74	806.97	0.13
Newton Branch	8783	100-Year	4700.00	553.64	563.16		563.20	0.000316	2.36	3760.84	861.07	0.15
Newton Branch	8783	500-Year	7600.00	553.64	563.87		563.94	0.000559	3.32	4391.44	929.49	0.20
Newton Branch	8783	100-Year_Ult	6600.00	553.64	563.63		563.69	0.000483	3.03	4175.44	899.60	0.18
Newton Branch	9227	10-Year	1500.00	553.91	561.70		561.71	0.000143	1.31	2601.30	1014.93	0.09
Newton Branch	9227	50-Year	3600.00	553.91	562.84		562.87	0.000272	2.01	3792.13	1067.68	0.13
Newton Branch	9227	100-Year	4700.00	553.91	563.31		563.34	0.000321	2.27	4297.37	1101.21	0.14
Newton Branch	9227	500-Year	7600.00	553.91	564.12		564.16	0.000471	2.94	5209.95	1156.42	0.17
Newton Branch	9227	100-Year_Ult	6600.00	553.91	563.85		563.89	0.000426	2.74	4901.76	1138.09	0.17
Newton Branch	9918	10-Year	1500.00	557.00	561.87		561.93	0.001310	3.10	1226.31	935.83	0.26
Newton Branch	9918	50-Year	3600.00	557.00	563.12		563.17	0.001059	3.31	2422.55	986.57	0.25
Newton Branch	9918	100-Year	4700.00	557.00	563.61		563.67	0.001027	3.45	2917.23	1002.15	0.25
Newton Branch	9918	500-Year	7600.00	557.00	564.52		564.60	0.001154	4.02	3844.53	1033.37	0.27
Newton Branch	9918	100-Year_Ult	6600.00	557.00	564.23		564.30	0.001123	3.85	3538.81	1023.97	0.26

HEC-RAS Plan: N_Hanger_Multi River: North_Hanger Reach: North_Hanger

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
North_Hanger	812	10-Year	480.00	517.99	520.33	519.53	520.45	0.008002	2.75	174.67	125.91	0.41
North_Hanger	812	50-Year	710.00	517.99	520.74	519.83	520.89	0.008001	3.11	228.14	136.33	0.42
North_Hanger	812	100-Year	810.00	517.99	520.88	519.94	521.04	0.008001	3.27	247.56	137.21	0.43
North_Hanger	812	500-Year	1070.00	517.99	521.21	520.23	521.41	0.008002	3.66	292.86	138.88	0.44
North_Hanger	812	100-Year Ult	1090.00	517.99	521.23	520.25	521.44	0.008002	3.68	296.16	139.00	0.44
North_Hanger	1151	10-Year	480.00	520.63	523.41		523.68	0.012394	4.85	141.42	99.73	0.56
North_Hanger	1151	50-Year	710.00	520.63	523.84		524.17	0.012858	5.53	185.95	106.66	0.58
North_Hanger	1151	100-Year	810.00	520.63	524.00		524.36	0.013087	5.79	202.98	108.45	0.59
North_Hanger	1151	500-Year	1070.00	520.63	524.38		524.80	0.013642	6.41	245.04	115.27	0.62
North_Hanger	1151	100-Year Ult	1090.00	520.63	524.41		524.83	0.013679	6.45	248.04	115.57	0.62
North_Hanger	1392	10-Year	480.00	523.77	526.71		526.85	0.014848	3.46	160.52	110.49	0.44
North_Hanger	1392	50-Year	710.00	523.77	527.15		527.34	0.014178	3.88	211.76	117.69	0.45
North_Hanger	1392	100-Year	810.00	523.77	527.32		527.52	0.013974	4.04	231.75	119.72	0.45
North_Hanger	1392	500-Year	1070.00	523.77	527.72		527.95	0.013243	4.33	285.92	144.35	0.45
North_Hanger	1392	100-Year Ult	1090.00	523.77	527.75		527.98	0.013204	4.36	289.96	145.03	0.45
North_Hanger	1552	10-Year	350.00	524.71	528.21		528.28	0.005220	2.52	177.98	126.09	0.27
North_Hanger	1552	50-Year	520.00	524.71	528.66		528.74	0.005304	2.82	238.50	145.65	0.28
North_Hanger	1552	100-Year	600.00	524.71	528.84		528.92	0.005376	2.94	264.77	151.90	0.29
North_Hanger	1552	500-Year	780.00	524.71	529.22		529.31	0.005318	3.15	325.61	168.14	0.29
North_Hanger	1552	100-Year Ult	830.00	524.71	529.27		529.37	0.005636	3.27	333.92	169.45	0.30
North_Hanger	2003	10-Year	350.00	527.28	530.74		530.81	0.007567	2.71	196.98	166.33	0.32
North_Hanger	2003	50-Year	520.00	527.28	531.15		531.23	0.007177	2.95	270.81	197.16	0.32
North_Hanger	2003	100-Year	600.00	527.28	531.36		531.44	0.007205	3.11	314.33	216.48	0.32
North_Hanger	2003	500-Year	780.00	527.28	531.67		531.76	0.006834	3.25	383.61	220.27	0.32
North_Hanger	2003	100-Year Ult	830.00	527.28	531.77		531.86	0.006609	3.26	404.73	221.43	0.32
North_Hanger	2239	10-Year	350.00	528.80	532.31		532.42	0.008164	3.14	163.45	123.33	0.34
North_Hanger	2239	50-Year	520.00	528.80	532.76		532.89	0.008814	3.62	230.52	168.52	0.36
North_Hanger	2239	100-Year	600.00	528.80	532.95		533.09	0.008470	3.70	264.48	179.47	0.36
North_Hanger	2239	500-Year	780.00	528.80	533.27		533.42	0.008833	4.02	325.43	202.45	0.37
North_Hanger	2239	100-Year Ult	830.00	528.80	533.34		533.50	0.008912	4.09	340.27	204.93	0.38

HEC-RAS Plan: Penwell_Multi River: PENWELL Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	264	10-Year	980.00	534.00	541.78	539.62	542.13	0.003047	5.20	247.88	99.34	0.38
1	264	50-Year	1450.00	534.00	542.63	540.59	543.12	0.003728	6.28	305.59	170.83	0.42
1	264	100-Year	1650.00	534.00	542.98	541.02	543.52	0.003891	6.64	329.36	182.30	0.44
1	264	500-Year	2160.00	534.00	543.76	541.74	544.42	0.004297	7.47	382.32	206.75	0.47
1	264	100-Year_Ult	2080.00	534.00	543.76	541.65	544.38	0.003985	7.20	382.32	206.75	0.45
1	297		Bridge									
1	330	10-Year	980.00	536.00	542.20	539.76	542.40	0.001855	3.99	304.21	247.73	0.30
1	330	50-Year	1450.00	536.00	543.20	540.41	543.48	0.002164	4.80	371.93	296.92	0.33
1	330	100-Year	1650.00	536.00	543.59	540.64	543.91	0.002244	5.09	398.93	321.77	0.34
1	330	500-Year	2160.00	536.00	544.50	541.21	544.90	0.002438	5.75	460.24	448.53	0.36
1	330	100-Year_Ult	2080.00	536.00	544.44	541.12	544.82	0.002324	5.59	456.31	445.70	0.35
1	453	10-Year	980.00	536.00	542.51	540.43	542.64	0.001789	3.11	396.94	203.08	0.28
1	453	50-Year	1450.00	536.00	543.61	540.94	543.73	0.001308	3.14	640.68	329.53	0.25
1	453	100-Year	1650.00	536.00	544.05	541.12	544.17	0.001150	3.11	745.11	374.89	0.23
1	453	500-Year	2160.00	536.00	545.05	541.58	545.16	0.000914	3.10	984.53	459.68	0.21
1	453	100-Year_Ult	2080.00	536.00	544.97	541.52	545.07	0.000901	3.05	963.57	452.31	0.21
1	692	10-Year	980.00	540.00	543.16		543.33	0.005229	3.33	294.39	152.06	0.42
1	692	50-Year	1450.00	540.00	544.04		544.21	0.003298	3.34	440.42	179.53	0.36
1	692	100-Year	1650.00	540.00	544.41		544.58	0.002773	3.34	509.85	194.26	0.33
1	692	500-Year	2160.00	540.00	545.32		545.48	0.001950	3.31	702.03	229.92	0.29
1	692	100-Year_Ult	2080.00	540.00	545.23		545.39	0.001959	3.27	681.63	226.39	0.29
1	1125	10-Year	660.00	542.00	545.34		545.57	0.005137	3.90	196.60	120.68	0.44
1	1125	50-Year	970.00	542.00	545.72		546.05	0.006428	4.79	245.48	136.58	0.50
1	1125	100-Year	1110.00	542.00	545.89		546.25	0.006770	5.11	268.45	143.46	0.52
1	1125	500-Year	1450.00	542.00	546.37		546.77	0.006414	5.49	342.99	165.36	0.52
1	1125	100-Year_Ult	1410.00	542.00	546.30		546.70	0.006622	5.49	330.64	161.99	0.52
1	1381	10-Year	660.00	545.96	547.48		547.83	0.018142	4.75	138.92	107.26	0.74
1	1381	50-Year	970.00	545.96	547.97		548.36	0.013651	5.01	202.00	168.75	0.67
1	1381	100-Year	1110.00	545.96	548.15	547.68	548.55	0.012622	5.11	238.58	212.91	0.65
1	1381	500-Year	1450.00	545.96	548.48	548.12	548.91	0.011684	5.42	310.19	217.96	0.64
1	1381	100-Year_Ult	1410.00	545.96	548.45	548.08	548.87	0.011690	5.37	303.13	217.47	0.64
1	1708	10-Year	660.00	548.00	550.75		550.93	0.005761	3.51	202.02	133.08	0.44
1	1708	50-Year	970.00	548.00	551.12		551.38	0.006645	4.23	253.84	146.28	0.49
1	1708	100-Year	1110.00	548.00	551.26		551.56	0.006999	4.52	275.09	151.38	0.51
1	1708	500-Year	1450.00	548.00	551.58		551.95	0.007651	5.12	324.71	162.23	0.54
1	1708	100-Year_Ult	1410.00	548.00	551.54		551.91	0.007574	5.06	319.19	161.09	0.54
1	2487	10-Year	660.00	552.00	554.26		554.36	0.003516	2.63	253.26	154.72	0.34
1	2487	50-Year	970.00	552.00	554.75		554.89	0.003334	3.00	337.60	186.11	0.35
1	2487	100-Year	1110.00	552.00	554.95		555.10	0.003289	3.15	374.98	198.28	0.35
1	2487	500-Year	1450.00	552.00	555.36		555.54	0.003235	3.45	462.49	222.32	0.36
1	2487	100-Year_Ult	1410.00	552.00	555.32		555.49	0.003235	3.42	452.62	219.77	0.36
1	2956	10-Year	660.00	553.44	556.06	555.05	556.12	0.002400	1.99	394.70	344.57	0.28
1	2956	50-Year	970.00	553.44	556.27	555.37	556.36	0.003263	2.52	466.96	348.03	0.33
1	2956	100-Year	1110.00	553.44	556.43	555.51	556.52	0.003132	2.60	520.92	350.58	0.33
1	2956	500-Year	1450.00	553.44	556.77	555.81	556.87	0.002904	2.79	642.34	356.37	0.32
1	2956	100-Year_Ult	1410.00	553.44	556.73	555.77	556.83	0.002930	2.77	628.35	355.71	0.32
1	3612	10-Year	660.00	559.34	560.87	560.87	561.32	0.038833	5.39	122.47	138.69	1.01
1	3612	50-Year	970.00	559.34	561.15	561.15	561.69	0.036777	5.90	164.37	155.92	1.01
1	3612	100-Year	1110.00	559.34	561.27	561.27	561.84	0.035880	6.08	182.46	162.32	1.01
1	3612	500-Year	1450.00	559.34	561.52	561.52	562.16	0.034420	6.45	224.95	177.88	1.01
1	3612	100-Year_Ult	1410.00	559.34	561.49	561.49	562.13	0.034399	6.39	220.55	176.47	1.01
1	4112	10-Year	220.00	562.00	565.42	563.89	565.47	0.001196	1.92	174.37	160.11	0.21
1	4112	50-Year	320.00	562.00	565.83		565.88	0.001227	2.15	248.58	203.35	0.22
1	4112	100-Year	370.00	562.00	565.98		566.03	0.001266	2.26	280.65	217.50	0.22
1	4112	500-Year	470.00	562.00	566.27		566.33	0.001236	2.37	346.31	229.13	0.23
1	4112	100-Year_Ult	470.00	562.00	566.25		566.31	0.001287	2.40	340.71	228.29	0.23
1	4600	10-Year	220.00	566.00	567.51	567.51	568.04	0.036784	5.84	37.65	36.06	1.01
1	4600	50-Year	320.00	566.00	567.84	567.84	568.47	0.034791	6.34	50.48	41.03	1.01
1	4600	100-Year	370.00	566.00	567.99	567.99	568.65	0.034183	6.55	56.52	43.19	1.01
1	4600	500-Year	470.00	566.00	568.23	568.23	568.99	0.030894	6.97	68.42	52.93	0.99
1	4600	100-Year_Ult	470.00	566.00	568.23	568.23	568.99	0.030894	6.97	68.42	52.93	0.99
1	4877	10-Year	220.00	570.00	571.96	571.32	572.11	0.007716	3.02	72.87	117.74	0.48
1	4877	50-Year	320.00	570.00	572.28	571.62	572.46	0.007716	3.46	96.61	155.79	0.49

HEC-RAS Plan: Penwell_Multi River: PENWELL Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	4877	100-Year	370.00	570.00	572.41	571.75	572.61	0.007686	3.65	108.40	169.29	0.50
1	4877	500-Year	470.00	570.00	572.63	571.98	572.87	0.007835	4.01	131.21	205.37	0.51
1	4877	100-Year_Ult	470.00	570.00	572.63	571.98	572.87	0.007835	4.01	131.21	205.37	0.51
1	5263	10-Year	220.00	574.00	575.86		576.12	0.014427	4.02	54.69	45.50	0.65
1	5263	50-Year	320.00	574.00	576.18	575.80	576.51	0.014635	4.60	69.91	52.04	0.67
1	5263	100-Year	370.00	574.00	576.30	575.94	576.67	0.014777	4.89	76.67	55.04	0.68
1	5263	500-Year	470.00	574.00	576.54	576.16	576.99	0.014798	5.37	90.38	60.78	0.70
1	5263	100-Year_Ult	470.00	574.00	576.54	576.16	576.99	0.014798	5.37	90.38	60.78	0.70
1	5600	10-Year	80.00	578.00	579.36		579.41	0.004373	1.93	41.97	46.27	0.34
1	5600	50-Year	120.00	578.00	579.65		579.73	0.004103	2.18	56.90	53.79	0.35
1	5600	100-Year	130.00	578.00	579.76		579.83	0.003658	2.17	62.52	56.58	0.33
1	5600	500-Year	170.00	578.00	579.99		580.08	0.003550	2.38	76.41	62.11	0.34
1	5600	100-Year_Ult	170.00	578.00	579.99		580.08	0.003550	2.38	76.41	62.11	0.34
1	5949	10-Year	80.00	586.00	586.47	586.47	586.68	0.049440	3.66	21.88	53.13	1.00
1	5949	50-Year	120.00	586.00	586.60	586.60	586.86	0.045948	4.09	29.32	56.88	1.00
1	5949	100-Year	130.00	586.00	586.63	586.63	586.91	0.045401	4.19	31.05	57.72	1.01
1	5949	500-Year	170.00	586.00	586.75	586.75	587.06	0.043348	4.50	37.78	60.86	1.01
1	5949	100-Year_Ult	170.00	586.00	586.75	586.75	587.06	0.043348	4.50	37.78	60.86	1.01
1	6257	10-Year	80.00	591.99	592.56		592.62	0.010133	1.92	41.74	81.27	0.47
1	6257	50-Year	120.00	591.99	592.70		592.78	0.010422	2.26	53.17	82.73	0.50
1	6257	100-Year	130.00	591.99	592.73		592.81	0.010455	2.33	55.84	83.12	0.50
1	6257	500-Year	170.00	591.99	592.85		592.95	0.010648	2.59	65.65	84.45	0.52
1	6257	100-Year_Ult	170.00	591.99	592.85		592.95	0.010648	2.59	65.65	84.45	0.52
1	6287	10-Year	80.00	597.96	599.55	599.55	600.02	0.039990	5.53	14.48	15.37	1.00
1	6287	50-Year	120.00	597.96	600.15	600.15	600.31	0.014524	3.59	59.63	247.25	0.62
1	6287	100-Year	130.00	597.96	600.18	600.18	600.33	0.013857	3.53	67.87	249.33	0.61
1	6287	500-Year	170.00	597.96	600.24	600.24	600.41	0.016402	3.91	82.56	253.24	0.66
1	6287	100-Year_Ult	170.00	597.96	600.24	600.24	600.41	0.016402	3.91	82.56	253.24	0.66

HEC-RAS Plan: Plains_Multi River: Plains Reach: Plains

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Plains	190	10-Year	1300.00	539.14	547.99	547.23	548.16	0.002001	4.51	677.44	787.36	0.32
Plains	190	50-Year	2500.00	539.14	549.00	548.00	549.15	0.002000	4.99	1098.80	1041.64	0.33
Plains	190	100-Year	3100.00	539.14	549.41	548.20	549.57	0.002001	5.18	1271.61	1084.95	0.33
Plains	190	500-Year	4700.00	539.14	550.36	548.66	550.54	0.002001	5.60	1670.79	1160.72	0.34
Plains	190	100-Year_Ult	4000.00	539.14	549.96	548.48	550.14	0.002002	5.43	1504.68	1142.14	0.33
Plains	267	10-Year	1300.00	541.10	548.07	547.84	548.55	0.005164	6.57	387.94	460.15	0.52
Plains	267	50-Year	2500.00	541.10	549.10	548.64	549.51	0.004712	7.12	738.60	723.10	0.51
Plains	267	100-Year	3100.00	541.10	549.51	548.95	549.91	0.004429	7.22	885.23	915.02	0.50
Plains	267	500-Year	4700.00	541.10	550.47	549.49	550.86	0.004029	7.56	1218.61	1012.16	0.49
Plains	267	100-Year_Ult	4000.00	541.10	550.07	549.27	550.46	0.004169	7.41	1080.34	958.01	0.50
Plains	400		Bridge									
Plains	501	10-Year	1300.00	542.93	549.20	547.36	549.29	0.001103	3.33	596.99	250.96	0.25
Plains	501	50-Year	2500.00	542.93	550.47	548.16	550.62	0.001344	4.22	861.21	433.72	0.29
Plains	501	100-Year	3100.00	542.93	550.98	548.40	551.16	0.001417	4.55	973.47	482.61	0.30
Plains	501	500-Year	4700.00	542.93	552.15	549.06	552.40	0.001570	5.30	1236.30	626.37	0.32
Plains	501	100-Year_Ult	4000.00	542.93	551.67	548.79	551.89	0.001511	4.99	1126.48	538.72	0.31
Plains	593	10-Year	1300.00	542.54	549.28	547.90	549.45	0.001617	4.14	621.33	426.22	0.31
Plains	593	50-Year	2500.00	542.54	550.57	548.99	550.78	0.001778	4.98	991.05	508.21	0.33
Plains	593	100-Year	3100.00	542.54	551.10	549.30	551.32	0.001825	5.30	1145.41	523.18	0.34
Plains	593	500-Year	4700.00	542.54	552.29	549.96	552.55	0.001923	6.00	1504.28	659.56	0.36
Plains	593	100-Year_Ult	4000.00	542.54	551.80	549.68	552.04	0.001884	5.71	1355.35	585.04	0.35
Plains	1546	10-Year	1300.00	544.40	550.92		551.03	0.001979	4.03	790.38	498.56	0.32
Plains	1546	50-Year	2500.00	544.40	552.11		552.20	0.001488	4.05	1438.49	582.97	0.29
Plains	1546	100-Year	3100.00	544.40	552.60		552.69	0.001356	4.08	1733.88	617.99	0.28
Plains	1546	500-Year	4700.00	544.40	553.74		553.82	0.001140	4.16	2473.51	682.53	0.27
Plains	1546	100-Year_Ult	4000.00	544.40	553.26		553.35	0.001213	4.11	2154.84	657.59	0.27
Plains	2309	10-Year	1300.00	546.60	552.80		553.11	0.004996	6.18	546.35	635.45	0.50
Plains	2309	50-Year	2500.00	546.60	553.53		553.73	0.003928	6.03	1060.50	718.71	0.45
Plains	2309	100-Year	3100.00	546.60	553.86		554.03	0.003376	5.81	1298.53	725.56	0.42
Plains	2309	500-Year	4700.00	546.60	554.73		554.86	0.002325	5.29	1932.23	734.40	0.36
Plains	2309	100-Year_Ult	4000.00	546.60	554.35		554.50	0.002710	5.50	1655.84	730.99	0.39
Plains	2501	10-Year	1300.00	546.68	553.56		553.79	0.002701	4.92	676.75	804.89	0.38
Plains	2501	50-Year	2700.00	546.68	554.17		554.40	0.003258	5.83	1179.75	821.04	0.43
Plains	2501	100-Year	3500.00	546.68	554.45		554.68	0.003411	6.16	1406.17	823.96	0.44
Plains	2501	500-Year	5500.00	546.68	555.17		555.38	0.003041	6.27	2002.80	831.46	0.43
Plains	2501	100-Year_Ult	4800.00	546.68	554.86		555.10	0.003467	6.49	1746.27	828.08	0.45
Plains	2640	10-Year	1300.00	547.17	554.05	554.05	554.52	0.006032	6.97	424.90	558.44	0.56
Plains	2640	50-Year	2700.00	547.17	554.58		555.27	0.010010	9.63	784.87	768.81	0.73
Plains	2640	100-Year	3500.00	547.17	554.96		555.42	0.007594	8.77	1077.34	794.74	0.65
Plains	2640	500-Year	5500.00	547.17	555.64		555.99	0.005931	8.36	1629.63	822.61	0.58
Plains	2640	100-Year_Ult	4800.00	547.17	555.39		555.78	0.006565	8.57	1429.43	809.45	0.61
Plains	2989	10-Year	1300.00	547.95	555.44	553.66	555.77	0.003299	5.78	475.11	405.46	0.43
Plains	2989	50-Year	2700.00	547.95	556.47	554.79	556.86	0.004193	7.29	923.20	717.23	0.50
Plains	2989	100-Year	3500.00	547.95	556.55	556.39	557.15	0.006363	9.05	962.37	722.06	0.61
Plains	2989	500-Year	5500.00	547.95	556.97	556.97	557.86	0.009623	11.59	1165.70	746.99	0.76
Plains	2989	100-Year_Ult	4800.00	547.95	556.84	556.81	557.62	0.008465	10.74	1104.42	743.41	0.71
Plains	3561	10-Year	1300.00	550.33	557.19	556.87	557.63	0.004602	6.78	419.03	698.70	0.50
Plains	3561	50-Year	2700.00	550.33	558.40	557.78	558.91	0.005278	8.25	701.40	709.50	0.55
Plains	3561	100-Year	3500.00	550.33	559.04	558.17	559.55	0.005120	8.61	851.36	714.27	0.55
Plains	3561	500-Year	5500.00	550.33	560.18	558.94	560.82	0.005601	9.90	1125.72	732.87	0.59
Plains	3561	100-Year_Ult	4800.00	550.33	559.81	558.70	560.41	0.005437	9.48	1036.52	726.37	0.58
Plains	3698	10-Year	1300.00	551.00	557.77	556.09	558.35	0.004824	7.08	318.15	137.53	0.52
Plains	3698	50-Year	2700.00	551.00	559.01	558.51	559.99	0.007284	9.92	494.56	163.81	0.66
Plains	3698	100-Year	3500.00	551.00	559.59	559.10	560.74	0.008096	11.04	580.45	172.74	0.71
Plains	3698	500-Year	5500.00	551.00	560.71	560.27	562.31	0.010071	13.50	752.47	201.03	0.81
Plains	3698	100-Year_Ult	4800.00	551.00	560.35	559.88	561.79	0.009388	12.67	696.50	191.48	0.78
Plains	4177	10-Year	1300.00	552.94	559.13	558.04	559.19	0.000983	3.13	886.18	451.97	0.24
Plains	4177	50-Year	2700.00	552.94	560.72	558.61	560.78	0.000745	3.24	1588.64	502.61	0.22
Plains	4177	100-Year	3500.00	552.94	561.46	558.85	561.52	0.000696	3.35	1925.92	555.42	0.21
Plains	4177	500-Year	5500.00	552.94	563.02	559.32	563.10	0.000625	3.59	2661.93	609.88	0.21
Plains	4177	100-Year_Ult	4800.00	552.94	562.50	559.18	562.58	0.000645	3.51	2414.96	598.08	0.21
Plains	4869	10-Year	1300.00	553.01	559.68	558.67	559.73	0.001130	3.18	1079.20	661.45	0.25
Plains	4869	50-Year	2700.00	553.01	561.12	559.18	561.17	0.000847	3.24	1985.00	743.95	0.22

HEC-RAS Plan: Plains_Multi River: Plains Reach: Plains (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Plains	4869	100-Year	3500.00	553.01	561.83	559.38	561.87	0.000762	3.29	2437.87	822.19	0.21
Plains	4869	500-Year	5500.00	553.01	563.35	559.82	563.40	0.000651	3.45	3445.83	870.30	0.20
Plains	4869	100-Year_Ult	4800.00	553.01	562.84	559.68	562.89	0.000685	3.40	3105.22	856.44	0.21
Plains	5034	10-Year	1300.00	553.06	559.82	558.87	559.91	0.001426	3.61	880.90	629.18	0.28
Plains	5034	50-Year	2700.00	553.06	561.23	559.59	561.30	0.001092	3.70	1704.72	777.64	0.25
Plains	5034	100-Year	3500.00	553.06	561.92	559.85	562.00	0.000979	3.74	2112.95	862.42	0.24
Plains	5034	500-Year	5500.00	553.06	563.43	560.33	563.51	0.000832	3.90	2998.36	941.35	0.23
Plains	5034	100-Year_Ult	4800.00	553.06	562.93	560.17	563.00	0.000874	3.84	2702.67	908.56	0.23
Plains	5078		Culvert									
Plains	5128	10-Year	1300.00	554.49	562.54	559.80	562.57	0.000425	2.37	1478.79	976.79	0.16
Plains	5128	50-Year	2700.00	554.49	563.24	561.20	563.31	0.000953	3.79	1840.76	1001.07	0.24
Plains	5128	100-Year	3500.00	554.49	563.56	561.49	563.65	0.001230	4.42	2005.87	1008.35	0.28
Plains	5128	500-Year	5500.00	554.49	564.22	562.04	564.37	0.001853	5.72	2349.50	1028.04	0.34
Plains	5128	100-Year_Ult	4800.00	554.49	564.04	561.87	564.17	0.001603	5.25	2256.54	1022.37	0.32
Plains	5209	10-Year	1300.00	553.80	562.56	558.53	562.60	0.000302	2.01	1463.80	856.14	0.14
Plains	5209	50-Year	2700.00	553.80	563.28	560.83	563.37	0.000725	3.32	1839.69	912.86	0.21
Plains	5209	100-Year	3500.00	553.80	563.61	561.32	563.73	0.000948	3.91	2016.56	923.45	0.25
Plains	5209	500-Year	5500.00	553.80	564.30	562.02	564.49	0.001458	5.13	2386.47	972.16	0.31
Plains	5209	100-Year_Ult	4800.00	553.80	564.11	561.79	564.27	0.001257	4.69	2284.16	951.88	0.29
Plains	5715	10-Year	1300.00	556.18	562.77	561.31	562.92	0.001812	3.64	753.65	557.98	0.31
Plains	5715	50-Year	2700.00	556.18	563.75	562.67	563.95	0.002381	4.79	1239.22	611.03	0.37
Plains	5715	100-Year	3500.00	556.18	564.20	562.98	564.42	0.002552	5.24	1470.04	627.09	0.39
Plains	5715	500-Year	5500.00	556.18	565.12	563.60	565.40	0.002862	6.14	1955.01	652.01	0.42
Plains	5715	100-Year_Ult	4800.00	556.18	564.84	563.39	565.10	0.002725	5.82	1805.58	642.70	0.41
Plains	6237	10-Year	1300.00	557.47	563.51		563.61	0.001934	3.45	895.84	572.42	0.31
Plains	6237	50-Year	2700.00	557.47	564.55		564.67	0.002042	4.17	1515.07	612.40	0.33
Plains	6237	100-Year	3500.00	557.47	565.02		565.14	0.002101	4.49	1805.94	634.44	0.34
Plains	6237	500-Year	5500.00	557.47	565.98		566.14	0.002195	5.13	2437.70	673.93	0.36
Plains	6237	100-Year_Ult	4800.00	557.47	565.68		565.82	0.002156	4.92	2232.75	662.25	0.35
Plains	7571	10-Year	1300.00	560.13	565.91		566.04	0.002746	4.22	810.38	565.98	0.38
Plains	7571	50-Year	2700.00	560.13	566.88		567.03	0.002859	4.99	1391.25	618.99	0.40
Plains	7571	100-Year	3500.00	560.13	567.33		567.50	0.002854	5.29	1677.91	640.56	0.40
Plains	7571	500-Year	5500.00	560.13	568.29		568.47	0.002853	5.90	2311.84	691.63	0.41
Plains	7571	100-Year_Ult	4800.00	560.13	567.98		568.15	0.002857	5.71	2101.14	675.10	0.41
Plains	8629	10-Year	1300.00	563.09	568.20		568.38	0.002461	4.06	675.10	454.55	0.36
Plains	8629	50-Year	2700.00	563.09	569.23		569.45	0.002836	5.09	1166.60	506.21	0.40
Plains	8629	100-Year	3500.00	563.09	569.69		569.93	0.002985	5.53	1404.18	559.06	0.42
Plains	8629	500-Year	5500.00	563.09	570.63		570.91	0.003158	6.33	1959.43	610.99	0.44
Plains	8629	100-Year_Ult	4800.00	563.09	570.33		570.60	0.003127	6.10	1779.54	603.66	0.44
Plains	9558	10-Year	1400.00	566.06	570.31		570.46	0.003259	4.35	759.85	593.95	0.41
Plains	9558	50-Year	2700.00	566.06	571.22		571.36	0.002845	4.72	1314.34	630.26	0.39
Plains	9558	100-Year	3500.00	566.06	571.65		571.80	0.002746	4.94	1591.05	640.84	0.39
Plains	9558	500-Year	5400.00	566.06	572.56		572.72	0.002629	5.41	2182.65	679.70	0.40
Plains	9558	100-Year_Ult	4800.00	566.06	572.28		572.44	0.002659	5.27	1996.47	660.58	0.40
Plains	10027	10-Year	1400.00	566.74	571.45		571.52	0.001729	3.35	761.14	412.23	0.30
Plains	10027	50-Year	2700.00	566.74	572.36		572.46	0.002095	4.24	1181.49	506.12	0.34
Plains	10027	100-Year	3500.00	566.74	572.78		572.89	0.002143	4.53	1397.43	527.20	0.35
Plains	10027	500-Year	5400.00	566.74	573.66		573.81	0.002213	5.10	1891.00	590.75	0.36
Plains	10027	100-Year_Ult	4800.00	566.74	573.39		573.53	0.002207	4.95	1732.88	572.52	0.36

HEC-RAS Plan: Small_Multi River: Small_Branch Reach: Reach_1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	449	10-Year	620.00	544.00	546.40	546.01	546.75	0.011647	4.72	131.69	90.17	0.67
Reach_1	449	50-Year	950.00	544.00	547.19	546.42	547.52	0.006555	4.67	216.21	130.59	0.54
Reach_1	449	100-Year	1110.00	544.00	547.51	546.61	547.84	0.005582	4.70	262.53	158.93	0.51
Reach_1	449	500-Year	1500.00	544.00	548.22	547.04	548.52	0.003950	4.63	395.06	207.65	0.45
Reach_1	449	100-Year_Ult	1590.00	544.00	548.22	547.12	548.56	0.004438	4.91	395.06	207.65	0.47
Reach_1	722	10-Year	610.00	546.00	548.32		548.42	0.003678	2.52	242.68	173.02	0.37
Reach_1	722	50-Year	950.00	546.00	548.76		548.89	0.003891	2.96	321.87	188.63	0.40
Reach_1	722	100-Year	1100.00	546.00	548.94		549.09	0.003775	3.10	356.22	194.42	0.40
Reach_1	722	500-Year	1470.00	546.00	549.35		549.52	0.003494	3.40	438.18	207.20	0.39
Reach_1	722	100-Year_Ult	1570.00	546.00	549.44		549.62	0.003505	3.49	456.71	209.92	0.40
Reach_1	1348	10-Year	610.00	550.00	551.77		551.96	0.009629	3.47	175.62	158.15	0.58
Reach_1	1348	50-Year	950.00	550.00	552.21		552.43	0.008817	3.74	253.99	191.58	0.57
Reach_1	1348	100-Year	1100.00	550.00	552.33		552.58	0.008923	3.96	277.73	193.95	0.58
Reach_1	1348	500-Year	1470.00	550.00	552.60		552.91	0.009238	4.45	330.52	199.06	0.61
Reach_1	1348	100-Year_Ult	1570.00	550.00	552.68		553.00	0.009121	4.54	346.18	200.55	0.61
Reach_1	1619	10-Year	610.00	552.00	553.97		554.13	0.006777	3.16	193.24	154.01	0.50
Reach_1	1619	50-Year	950.00	552.00	554.33		554.54	0.006972	3.75	267.02	220.13	0.52
Reach_1	1619	100-Year	1100.00	552.00	554.46		554.70	0.006983	3.96	297.13	226.25	0.53
Reach_1	1619	500-Year	1470.00	552.00	554.76		555.05	0.006940	4.39	367.05	239.84	0.54
Reach_1	1619	100-Year_Ult	1570.00	552.00	554.83		555.13	0.006994	4.50	383.69	242.97	0.55
Reach_1	2190	10-Year	450.00	556.00	557.64	557.04	557.76	0.005853	2.82	159.64	252.32	0.46
Reach_1	2190	50-Year	670.00	556.00	558.08	557.33	558.12	0.001728	1.72	390.43	278.84	0.26
Reach_1	2190	100-Year	770.00	556.00	557.44	557.44	557.96	0.028912	5.79	133.07	229.85	1.00
Reach_1	2190	500-Year	1010.00	556.00	558.06	557.66	558.17	0.004081	2.62	385.80	278.58	0.39
Reach_1	2190	100-Year_Ult	1090.00	556.00	558.13	557.75	558.24	0.004045	2.69	405.58	279.67	0.39
Reach_1	2760	10-Year	450.00	560.00	562.19	561.75	562.43	0.012043	4.00	112.54	96.87	0.65
Reach_1	2760	50-Year	670.00	560.00	562.15	562.15	562.74	0.028411	6.14	109.15	94.01	1.00
Reach_1	2760	100-Year	770.00	560.00	563.14	562.31	563.31	0.004553	3.31	245.63	181.86	0.43
Reach_1	2760	500-Year	1010.00	560.00	562.59	562.59	563.22	0.027305	6.37	158.90	132.11	1.00
Reach_1	2760	100-Year_Ult	1090.00	560.00	562.66	562.66	563.32	0.026386	6.49	168.71	138.88	0.99
Reach_1	3139	10-Year	450.00	562.00	565.37		565.50	0.005753	2.80	160.65	137.29	0.45
Reach_1	3139	50-Year	670.00	562.00	565.87	565.05	566.00	0.004016	2.92	232.71	154.13	0.40
Reach_1	3139	100-Year	770.00	562.00	565.57		565.83	0.010403	4.11	187.92	144.63	0.62
Reach_1	3139	500-Year	1010.00	562.00	566.31		566.49	0.004089	3.45	303.25	168.81	0.42
Reach_1	3139	100-Year_Ult	1090.00	562.00	566.39		566.59	0.004142	3.56	317.91	171.82	0.43
Reach_1	4026	10-Year	450.00	568.97	570.56		570.67	0.005945	2.71	166.11	154.49	0.46
Reach_1	4026	50-Year	670.00	568.97	570.73		570.92	0.008141	3.48	193.98	164.56	0.55
Reach_1	4026	100-Year	770.00	568.97	571.15		571.29	0.004072	2.97	267.57	187.56	0.40
Reach_1	4026	500-Year	1010.00	568.97	571.10		571.35	0.007792	4.02	258.13	184.78	0.56
Reach_1	4026	100-Year_Ult	1090.00	568.97	571.18	570.63	571.44	0.007660	4.12	273.38	189.25	0.56
Reach_1	4669	10-Year	450.00	574.00	574.96		575.06	0.007913	2.61	172.09	204.68	0.50
Reach_1	4669	50-Year	670.00	574.00	575.30		575.41	0.006062	2.74	244.74	222.45	0.46
Reach_1	4669	100-Year	770.00	574.00	575.18		575.37	0.011160	3.51	219.07	216.34	0.62
Reach_1	4669	500-Year	1010.00	574.00	575.63		575.78	0.006139	3.14	321.42	239.79	0.48
Reach_1	4669	100-Year_Ult	1090.00	574.00	575.70		575.86	0.006187	3.23	337.64	243.30	0.48
Reach_1	4938	10-Year	450.00	577.16	578.39	578.33	578.68	0.026583	4.35	103.51	142.60	0.90
Reach_1	4938	50-Year	670.00	577.16	578.55	578.55	578.98	0.032056	5.26	127.31	151.53	1.01
Reach_1	4938	100-Year	770.00	577.16	578.83	578.65	579.14	0.017729	4.50	171.02	164.98	0.78
Reach_1	4938	500-Year	1010.00	577.16	578.84	578.84	579.37	0.029768	5.86	172.46	165.41	1.01
Reach_1	4938	100-Year_Ult	1090.00	577.16	578.90	578.90	579.45	0.029313	5.98	182.41	168.22	1.01
Reach_1	5359	10-Year	140.00	584.52	585.49		585.55	0.005616	1.90	73.74	109.66	0.41
Reach_1	5359	50-Year	200.00	584.52	585.75		585.81	0.004148	1.93	103.77	120.20	0.37
Reach_1	5359	100-Year	230.00	584.52	585.58		585.70	0.010530	2.76	83.33	113.28	0.57
Reach_1	5359	500-Year	300.00	584.52	586.00		586.07	0.004330	2.24	134.28	130.76	0.39
Reach_1	5359	100-Year_Ult	360.00	584.52	586.08		586.17	0.004899	2.49	145.09	133.67	0.41
Reach_1	5865	10-Year	140.00	592.65	593.24	593.24	593.44	0.041916	3.55	39.43	103.58	1.01
Reach_1	5865	50-Year	200.00	592.65	593.35	593.35	593.59	0.039048	3.92	50.96	109.24	1.01
Reach_1	5865	100-Year	230.00	592.65	593.46	593.40	593.66	0.025876	3.59	64.04	115.14	0.85
Reach_1	5865	500-Year	300.00	592.65	593.50	593.50	593.80	0.035646	4.37	68.70	117.14	1.00
Reach_1	5865	100-Year_Ult	360.00	592.65	593.58	593.58	593.91	0.034823	4.60	78.21	121.11	1.01
Reach_1	6355	10-Year	140.00	604.38	605.63	605.44	605.82	0.016875	3.56	39.30	51.86	0.72
Reach_1	6355	50-Year	200.00	604.38	605.81	605.64	606.07	0.017890	4.05	49.41	56.21	0.76
Reach_1	6355	100-Year	230.00	604.38	605.80	605.72	606.15	0.024910	4.74	48.52	55.84	0.90
Reach_1	6355	500-Year	300.00	604.38	606.05	605.90	606.40	0.019379	4.71	63.68	61.24	0.81

HEC-RAS Plan: Small_Multi River: Small_Branch Reach: Reach_1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	6355	100-Year_Ult	360.00	604.38	606.18	606.03	606.57	0.019870	5.06	71.19	62.73	0.84
Reach_1	6610	10-Year	140.00	613.97	614.95	614.95	615.38	0.031906	5.25	26.69	31.56	1.01
Reach_1	6610	50-Year	200.00	613.97	615.19	615.19	615.71	0.029649	5.78	34.58	33.38	1.00
Reach_1	6610	100-Year	230.00	613.97	615.30	615.30	615.86	0.029011	6.02	38.22	34.18	1.00
Reach_1	6610	500-Year	300.00	613.97	615.53	615.53	616.18	0.027907	6.48	46.27	35.90	1.01
Reach_1	6610	100-Year_Ult	360.00	613.97	615.71	615.71	616.43	0.027070	6.81	52.88	37.25	1.01
Reach_1	6840	10-Year	140.00	625.99	626.24	626.24	626.37	0.048215	2.85	49.14	199.44	1.01
Reach_1	6840	50-Year	200.00	625.99	626.31	626.31	626.47	0.043548	3.18	62.86	200.31	1.00
Reach_1	6840	100-Year	230.00	625.99	626.34	626.34	626.52	0.042020	3.33	69.15	200.71	1.00
Reach_1	6840	500-Year	300.00	625.99	626.41	626.41	626.62	0.040343	3.65	82.24	201.53	1.01
Reach_1	6840	100-Year_Ult	360.00	625.99	626.46	626.46	626.69	0.038604	3.87	93.09	202.21	1.00
Reach_1	6904	10-Year	140.00	626.00	627.29		627.38	0.007764	2.45	57.24	74.16	0.49
Reach_1	6904	50-Year	200.00	626.00	627.46		627.58	0.009173	2.85	70.23	82.10	0.54
Reach_1	6904	100-Year	230.00	626.00	627.52		627.66	0.009969	3.04	75.59	85.16	0.57
Reach_1	6904	500-Year	300.00	626.00	627.67	627.32	627.84	0.011158	3.39	88.42	92.07	0.61
Reach_1	6904	100-Year_Ult	360.00	626.00	627.77		627.98	0.012164	3.67	98.14	96.97	0.64
Reach_1	7355	10-Year	140.00	632.45	633.13	633.07	633.27	0.026132	3.04	45.99	106.79	0.82
Reach_1	7355	50-Year	200.00	632.45	633.29	633.18	633.44	0.019788	3.12	64.18	116.77	0.74
Reach_1	7355	100-Year	230.00	632.45	633.37	633.22	633.52	0.017600	3.12	73.71	122.57	0.71
Reach_1	7355	500-Year	300.00	632.45	633.52		633.68	0.015185	3.23	93.01	131.76	0.68
Reach_1	7355	100-Year_Ult	360.00	632.45	633.64		633.81	0.013774	3.30	109.21	139.18	0.66
Reach_1	7560	10-Year	140.00	636.00	636.64		636.73	0.011788	2.43	57.64	103.31	0.57
Reach_1	7560	50-Year	200.00	636.00	636.74		636.88	0.014393	2.93	68.35	107.65	0.65
Reach_1	7560	100-Year	230.00	636.00	636.78		636.94	0.015891	3.17	72.61	109.32	0.69
Reach_1	7560	500-Year	300.00	636.00	636.88		637.08	0.018092	3.61	83.10	113.34	0.74
Reach_1	7560	100-Year_Ult	360.00	636.00	636.95		637.19	0.019809	3.95	91.17	116.34	0.79
Reach_1	7814	10-Year	140.00	640.00	641.30	641.30	641.82	0.029983	5.79	24.19	23.39	1.00
Reach_1	7814	50-Year	200.00	640.00	641.60	641.60	642.23	0.028578	6.34	31.54	25.60	1.01
Reach_1	7814	100-Year	230.00	640.00	641.74	641.74	642.41	0.027952	6.56	35.07	26.59	1.01
Reach_1	7814	500-Year	300.00	640.00	642.05	642.05	642.78	0.024941	6.85	44.20	37.98	0.97
Reach_1	7814	100-Year_Ult	360.00	640.00	642.32	642.32	643.04	0.020210	6.87	56.15	50.68	0.90

HEC-RAS Plan: Soap_Multi River: Soap Creek Reach: Main

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	4312	10-Year	9900.00	521.95	535.64	533.46	535.84	0.001400	5.93	4661.73	1084.12	0.31
Main	4312	50-Year	19500.00	521.95	538.21	534.74	538.43	0.001401	6.80	7631.53	1213.90	0.32
Main	4312	100-Year	24300.00	521.95	539.25	535.20	539.48	0.001400	7.13	8920.24	1264.23	0.33
Main	4312	500-Year	36700.00	521.95	541.52	536.20	541.78	0.001400	7.84	11908.09	1392.09	0.33
Main	4312	100-Year_Ult	33500.00	521.95	540.96	535.96	541.22	0.001401	7.67	11156.12	1336.10	0.33
Main	5382	10-Year	9700.00	521.61	536.61		536.84	0.001296	5.75	4390.31	1083.44	0.30
Main	5382	50-Year	19200.00	521.61	539.14		539.39	0.001312	6.62	7268.31	1182.36	0.31
Main	5382	100-Year	23900.00	521.61	540.17		540.43	0.001305	6.92	8507.12	1214.96	0.32
Main	5382	500-Year	36000.00	521.61	542.45		542.75	0.001361	7.77	11381.99	1338.57	0.33
Main	5382	100-Year_Ult	33100.00	521.61	541.89		542.17	0.001333	7.53	10642.74	1286.36	0.33
Main	6193	10-Year	9700.00	523.85	537.63		537.95	0.001902	7.07	3977.14	880.66	0.37
Main	6193	50-Year	19200.00	523.85	540.16		540.54	0.002129	8.53	6321.65	967.31	0.40
Main	6193	100-Year	23900.00	523.85	541.17		541.59	0.002208	9.09	7333.40	1015.90	0.41
Main	6193	500-Year	36000.00	523.85	543.46		543.92	0.002251	10.08	9738.84	1097.36	0.43
Main	6193	100-Year_Ult	33100.00	523.85	542.89		543.35	0.002278	9.92	9122.69	1070.35	0.43
Main	7067	10-Year	9700.00	523.29	538.97		539.25	0.001565	6.52	4373.03	1056.76	0.33
Main	7067	50-Year	19200.00	523.29	541.58		541.87	0.001571	7.46	7284.80	1168.15	0.35
Main	7067	100-Year	23900.00	523.29	542.63		542.93	0.001559	7.79	8540.43	1219.27	0.35
Main	7067	500-Year	36000.00	523.29	544.94		545.26	0.001555	8.53	11527.88	1335.85	0.36
Main	7067	100-Year_Ult	33100.00	523.29	544.39		544.71	0.001589	8.45	10798.98	1321.72	0.36
Main	7587	10-Year	9700.00	524.31	539.63		539.83	0.001006	5.10	5127.57	1184.57	0.26
Main	7587	50-Year	19200.00	524.31	542.24		542.47	0.001086	6.06	8451.16	1334.68	0.28
Main	7587	100-Year	23900.00	524.31	543.29		543.53	0.001106	6.42	9899.83	1410.72	0.29
Main	7587	500-Year	36000.00	524.31	545.60		545.86	0.001110	7.06	13253.92	1498.93	0.30
Main	7587	100-Year_Ult	33100.00	524.31	545.06		545.32	0.001117	6.93	12457.23	1476.33	0.30
Main	8501	10-Year	9700.00	526.62	540.63		540.78	0.001090	5.14	5811.17	1789.00	0.28
Main	8501	50-Year	19200.00	526.62	543.19		543.30	0.000784	5.02	10626.33	1961.80	0.24
Main	8501	100-Year	23900.00	526.62	544.22		544.33	0.000719	5.06	12679.21	2012.74	0.23
Main	8501	500-Year	36000.00	526.62	546.49		546.60	0.000625	5.20	17412.85	2163.72	0.22
Main	8501	100-Year_Ult	33100.00	526.62	545.97		546.08	0.000650	5.19	16294.02	2137.68	0.23
Main	9153	10-Year	10100.00	528.18	541.33		541.55	0.001833	6.43	5100.33	1754.22	0.35
Main	9153	50-Year	19800.00	528.18	543.67		543.81	0.001243	6.07	9537.45	2010.30	0.30
Main	9153	100-Year	24600.00	528.18	544.65		544.78	0.001098	5.99	11553.39	2099.22	0.29
Main	9153	500-Year	37000.00	528.18	546.85		546.97	0.000882	5.93	16293.63	2217.34	0.26
Main	9153	100-Year_Ult	34400.00	528.18	546.34		546.47	0.000944	6.00	15186.82	2190.82	0.27
Main	9681	10-Year	10100.00	529.40	542.23		542.40	0.001461	5.39	5243.52	1856.14	0.31
Main	9681	50-Year	19800.00	529.40	544.30		544.43	0.001138	5.45	9419.49	2186.96	0.29
Main	9681	100-Year	24600.00	529.40	545.20		545.33	0.000997	5.37	11441.29	2260.29	0.27
Main	9681	500-Year	37000.00	529.40	547.28		547.41	0.000769	5.24	16258.78	2358.22	0.24
Main	9681	100-Year_Ult	34400.00	529.40	546.81		546.94	0.000829	5.32	15154.06	2344.35	0.25
Main	9814	10-Year	8200.00	529.81	542.45		542.56	0.000878	4.45	5380.60	1846.88	0.24
Main	9814	50-Year	14000.00	529.81	544.48		544.55	0.000558	4.00	9464.42	2128.26	0.20
Main	9814	100-Year	16800.00	529.81	545.37		545.43	0.000468	3.84	11384.70	2208.61	0.19
Main	9814	500-Year	24700.00	529.81	547.43		547.49	0.000354	3.67	16111.73	2390.69	0.17
Main	9814	100-Year_Ult	24200.00	529.81	546.96		547.03	0.000422	3.93	15007.45	2341.45	0.18
Main	9924	10-Year	8200.00	529.46	542.54	540.22	542.67	0.001040	4.72	5261.66	2068.54	0.27
Main	9924	50-Year	14000.00	529.46	544.57	541.29	544.61	0.000433	3.45	11163.17	2201.72	0.18
Main	9924	100-Year	16800.00	529.46	545.44	541.70	545.49	0.000387	3.42	13122.96	2250.97	0.17
Main	9924	500-Year	24700.00	529.46	547.48	542.54	547.53	0.000331	3.50	17835.51	2361.15	0.16
Main	9924	100-Year_Ult	24200.00	529.46	547.03	542.49	547.08	0.000384	3.69	16763.32	2342.87	0.17
Main	10649	10-Year	8200.00	531.32	543.55	542.60	544.02	0.003056	8.08	3008.16	1200.16	0.45
Main	10649	50-Year	14000.00	531.32	544.96	543.70	545.16	0.001658	6.50	5968.56	1353.14	0.34
Main	10649	100-Year	16800.00	531.32	545.79	544.05	545.98	0.001503	6.48	7047.81	1433.51	0.33
Main	10649	500-Year	24700.00	531.32	547.77	544.36	547.94	0.001244	6.51	9689.49	1496.17	0.30
Main	10649	100-Year_Ult	24200.00	531.32	547.36	544.36	547.56	0.001431	6.85	9139.71	1488.71	0.32
Main	10938	10-Year	8200.00	530.49	544.30	542.10	544.70	0.001948	7.00	3317.21	904.13	0.37
Main	10938	50-Year	14000.00	530.49	545.25	543.59	545.95	0.003357	9.70	4180.56	1048.27	0.49
Main	10938	100-Year	16800.00	530.49	546.04	544.46	546.73	0.003316	10.05	4955.35	1137.22	0.49
Main	10938	500-Year	24700.00	530.49	547.97	545.62	548.57	0.002811	10.14	7016.59	1251.35	0.46
Main	10938	100-Year_Ult	24200.00	530.49	547.60	545.56	548.27	0.003183	10.61	6611.03	1228.43	0.49
Main	11143	10-Year	8200.00	530.08	544.70	542.96	545.15	0.002487	7.78	3062.40	999.52	0.41
Main	11143	50-Year	14000.00	530.08	545.99	544.17	546.63	0.003575	10.02	4133.33	1110.16	0.50
Main	11143	100-Year	16800.00	530.08	546.76	544.99	547.40	0.003498	10.32	4822.12	1158.04	0.50
Main	11143	500-Year	24700.00	530.08	548.53	546.00	549.18	0.003437	11.11	6478.60	1237.68	0.50

HEC-RAS Plan: Soap_Multi River: Soap Creek Reach: Main (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	11143	100-Year_Ult	24200.00	530.08	548.25	545.99	548.94	0.003711	11.39	6201.58	1232.42	0.52
Main	11670	10-Year	8200.00	530.73	545.92	544.01	546.54	0.002653	8.50	2243.46	984.61	0.43
Main	11670	50-Year	14000.00	530.73	547.68	545.58	548.56	0.003567	10.76	3003.57	1078.80	0.50
Main	11670	100-Year	16800.00	530.73	548.43	546.22	549.41	0.003850	11.58	3335.19	1108.10	0.53
Main	11670	500-Year	24700.00	530.73	550.15	547.66	551.43	0.004613	13.63	4114.62	1181.23	0.59
Main	11670	100-Year_Ult	24200.00	530.73	549.99	547.58	551.27	0.004666	13.62	4040.49	1175.33	0.59
Main	11799	10-Year	8200.00	530.61	546.45	543.86	546.84	0.001690	7.06	2762.44	1144.33	0.34
Main	11799	50-Year	14000.00	530.61	548.41	545.30	548.96	0.002213	8.87	3724.77	1242.67	0.40
Main	11799	100-Year	16800.00	530.61	549.23	545.85	549.85	0.002385	9.54	4135.75	1281.00	0.42
Main	11799	500-Year	24700.00	530.61	551.16	547.25	551.95	0.002784	11.13	5134.52	1350.66	0.47
Main	11799	100-Year_Ult	24200.00	530.61	551.01	547.17	551.80	0.002793	11.08	5055.87	1346.16	0.47
Main	11913	10-Year	8900.00	531.03	546.55	544.25	547.18	0.002166	8.20	2255.30	1239.64	0.40
Main	11913	50-Year	15100.00	531.03	548.52	545.96	549.44	0.002906	10.41	2985.59	1430.00	0.47
Main	11913	100-Year	18300.00	531.03	549.33	546.66	550.40	0.003254	11.40	3283.37	1460.52	0.50
Main	11913	500-Year	26300.00	531.03	551.25	548.15	552.62	0.003783	13.25	3993.69	1552.98	0.55
Main	11913	100-Year_Ult	26900.00	531.03	551.05	548.26	552.55	0.004178	13.82	3921.59	1546.05	0.58
Main	12060		Bridge									
Main	12200	10-Year	8900.00	530.85	548.05	544.36	548.36	0.001221	6.23	3081.46	1213.78	0.30
Main	12200	50-Year	15100.00	530.85	549.80	545.84	550.32	0.001879	8.37	3816.13	1258.12	0.38
Main	12200	100-Year	18300.00	530.85	549.81	546.49	550.56	0.002756	10.14	3818.00	1258.19	0.46
Main	12200	500-Year	26300.00	530.85	553.05	547.83	553.80	0.002247	10.41	5181.77	1347.27	0.43
Main	12200	100-Year_Ult	26900.00	530.85	552.92	547.93	553.72	0.002431	10.78	5126.35	1338.05	0.44
Main	12331	10-Year	8900.00	532.03	548.20	546.14	548.60	0.001852	7.44	3079.86	1205.11	0.36
Main	12331	50-Year	15100.00	532.03	550.12	547.54	550.59	0.002132	8.73	4289.95	1338.87	0.39
Main	12331	100-Year	18300.00	532.03	550.32	548.08	550.96	0.002873	10.22	4419.19	1344.71	0.46
Main	12331	500-Year	26300.00	532.03	553.67	549.15	554.14	0.001830	9.29	6528.29	1610.46	0.38
Main	12331	100-Year_Ult	26900.00	532.03	553.59	549.20	554.09	0.001962	9.59	6476.42	1609.77	0.39
Main	12709	10-Year	8900.00	531.59	549.00		549.21	0.001051	5.50	3570.88	754.81	0.26
Main	12709	50-Year	15100.00	531.59	551.04		551.27	0.001093	6.15	5182.71	817.09	0.27
Main	12709	100-Year	18300.00	531.59	551.55		551.83	0.001282	6.80	5603.08	826.86	0.30
Main	12709	500-Year	26300.00	531.59	554.49		554.72	0.000884	6.31	8107.38	870.86	0.25
Main	12709	100-Year_Ult	26900.00	531.59	554.47		554.71	0.000932	6.48	8085.49	870.63	0.26
Main	13427	10-Year	8900.00	535.66	549.40	542.10	549.43	0.000137	1.94	7033.86	1110.35	0.10
Main	13427	50-Year	15100.00	535.66	551.47	542.88	551.52	0.000188	2.52	9066.13	1157.10	0.12
Main	13427	100-Year	18300.00	535.66	552.06	543.23	552.13	0.000229	2.87	9658.54	1172.92	0.13
Main	13427	500-Year	26300.00	535.66	554.88	544.07	554.96	0.000216	3.13	12558.90	1216.41	0.13
Main	13427	100-Year_Ult	26900.00	535.66	554.88	544.14	554.96	0.000226	3.20	12554.18	1216.35	0.13
Main	13940	10-Year	8900.00	534.75	549.47		549.50	0.000170	2.10	6611.38	885.27	0.11
Main	13940	50-Year	15100.00	534.75	551.57		551.63	0.000228	2.72	8483.51	898.04	0.13
Main	13940	100-Year	18300.00	534.75	552.18		552.25	0.000275	3.08	9033.57	902.08	0.14
Main	13940	500-Year	26300.00	534.75	554.99		555.08	0.000263	3.40	11598.98	926.29	0.14
Main	13940	100-Year_Ult	26900.00	534.75	554.99		555.09	0.000275	3.47	11599.55	926.30	0.15
Main	14559	10-Year	8900.00	536.98	549.60		549.69	0.000586	3.53	4154.71	840.83	0.20
Main	14559	50-Year	15100.00	536.98	551.73		551.85	0.000579	4.00	6062.31	953.06	0.20
Main	14559	100-Year	18300.00	536.98	552.37		552.51	0.000646	4.37	6687.79	996.41	0.22
Main	14559	500-Year	26300.00	536.98	555.17		555.30	0.000477	4.29	9649.61	1124.66	0.19
Main	14559	100-Year_Ult	26900.00	536.98	555.17		555.32	0.000497	4.38	9659.22	1124.82	0.20
Main	14995	10-Year	8900.00	536.01	549.86		549.93	0.000558	3.42	4423.76	891.18	0.19
Main	14995	50-Year	15100.00	536.01	551.99		552.09	0.000547	3.87	6429.69	1017.90	0.20
Main	14995	100-Year	18300.00	536.01	552.66		552.78	0.000597	4.19	7123.55	1057.49	0.21
Main	14995	500-Year	26300.00	536.01	555.38		555.50	0.000451	4.15	10372.35	1294.40	0.19
Main	14995	100-Year_Ult	26900.00	536.01	555.40		555.53	0.000469	4.24	10395.50	1295.07	0.19
Main	15484	10-Year	8900.00	537.15	550.14	547.47	550.34	0.001359	5.24	2914.08	809.52	0.30
Main	15484	50-Year	15100.00	537.15	552.24	548.80	552.48	0.001182	5.59	4415.71	852.53	0.29
Main	15484	100-Year	18300.00	537.15	552.93	549.17	553.20	0.001257	5.99	4919.26	861.46	0.30
Main	15484	500-Year	26300.00	537.15	555.59	550.11	555.77	0.000697	5.09	8115.49	905.91	0.23
Main	15484	100-Year_Ult	26900.00	537.15	555.61	550.18	555.81	0.000723	5.18	8138.82	906.07	0.24
Main	16134	10-Year	8900.00	539.67	550.81	550.44	552.14	0.007159	12.03	1209.70	535.38	0.70
Main	16134	50-Year	15100.00	539.67	552.54	551.90	554.24	0.007723	14.01	1710.97	556.70	0.75
Main	16134	100-Year	18300.00	539.67	553.12	552.52	555.14	0.008587	15.30	1886.59	569.23	0.79
Main	16134	500-Year	26300.00	539.67	555.94	554.00	556.41	0.001839	8.19	5171.03	617.77	0.38
Main	16134	100-Year_Ult	26900.00	539.67	555.97	554.00	556.47	0.001899	8.34	5194.64	618.47	0.39

HEC-RAS Plan: Soap_Multi River: Soap Creek Reach: Main (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	16196	10-Year	8900.00	539.50	551.83	549.93	552.43	0.003191	8.53	1658.44	510.66	0.47
Main	16196	50-Year	15100.00	539.50	553.65	551.31	554.56	0.003917	10.53	2205.23	538.77	0.53
Main	16196	100-Year	18300.00	539.50	554.42	551.88	555.49	0.004238	11.42	2445.63	554.76	0.56
Main	16196	500-Year	26300.00	539.50	555.98	553.27	556.49	0.002021	8.51	4953.30	582.16	0.39
Main	16196	100-Year_Ult	26900.00	539.50	556.02	553.36	556.55	0.002088	8.67	4976.25	583.81	0.40
Main	16284	10-Year	8900.00	539.20	552.18	549.75	552.71	0.002461	7.59	1806.61	484.84	0.42
Main	16284	50-Year	15100.00	539.20	554.16	551.23	554.91	0.002844	9.18	2437.69	539.31	0.46
Main	16284	100-Year	18300.00	539.20	555.00	552.06	555.87	0.003005	9.87	2708.48	559.31	0.48
Main	16284	500-Year	26300.00	539.20	556.12	553.36	556.78	0.002496	9.50	4621.03	616.66	0.45
Main	16284	100-Year_Ult	26900.00	539.20	556.16	553.46	556.84	0.002569	9.66	4648.42	617.81	0.45
Main	16420		Bridge									
Main	16550	10-Year	8900.00	539.18	553.33	548.43	553.71	0.001193	5.59	2270.47	1009.97	0.30
Main	16550	50-Year	15100.00	539.18	555.88	551.24	556.40	0.001331	6.78	3185.71	1273.40	0.33
Main	16550	100-Year	18300.00	539.18	557.00	552.12	557.58	0.001375	7.27	3589.82	1342.21	0.34
Main	16550	500-Year	26300.00	539.18	559.65	553.57	559.81	0.000477	4.79	11653.09	1670.67	0.20
Main	16550	100-Year_Ult	26900.00	539.18	560.83	553.69	560.94	0.000329	4.15	13652.95	1722.56	0.17
Main	16644	10-Year	8900.00	540.69	553.44	551.71	553.92	0.002754	8.12	2270.54	861.73	0.44
Main	16644	50-Year	15100.00	540.69	556.18	552.96	556.57	0.001871	7.80	3680.53	1187.08	0.38
Main	16644	100-Year	18300.00	540.69	557.38	553.68	557.78	0.001690	7.85	4300.17	1295.43	0.36
Main	16644	500-Year	26300.00	540.69	559.71	554.68	559.86	0.000813	6.01	10523.44	1530.67	0.26
Main	16644	100-Year_Ult	26900.00	540.69	560.87	554.75	560.98	0.000543	5.13	12330.26	1610.34	0.21
Main	17107	10-Year	8900.00	540.65	554.63		554.91	0.001684	6.72	3114.17	796.66	0.34
Main	17107	50-Year	15100.00	540.65	557.06		557.28	0.001237	6.52	5165.27	898.18	0.30
Main	17107	100-Year	18300.00	540.65	558.20		558.41	0.001079	6.40	6217.24	939.78	0.29
Main	17107	500-Year	26300.00	540.65	560.08		560.32	0.001082	6.92	8054.42	1026.29	0.29
Main	17107	100-Year_Ult	26900.00	540.65	561.11		561.30	0.000787	6.13	9124.09	1051.88	0.25
Main	17945	10-Year	8900.00	541.54	555.77		555.97	0.001415	5.64	3736.80	1163.78	0.31
Main	17945	50-Year	15300.00	541.54	557.87		558.03	0.001072	5.55	6401.09	1357.29	0.28
Main	17945	100-Year	18500.00	541.54	558.91		559.05	0.000927	5.44	7864.76	1490.05	0.26
Main	17945	500-Year	27000.00	541.54	560.77		560.91	0.000819	5.57	10797.69	1652.92	0.25
Main	17945	100-Year_Ult	28000.00	541.54	561.62		561.73	0.000617	5.01	12227.73	1708.41	0.22
Main	19009	10-Year	8900.00	544.15	556.96		557.12	0.001435	5.31	3841.29	1190.05	0.31
Main	19009	50-Year	15300.00	544.15	558.74		558.89	0.001185	5.42	6085.34	1316.47	0.29
Main	19009	100-Year	18500.00	544.15	559.64		559.78	0.001023	5.31	7290.01	1362.00	0.27
Main	19009	500-Year	27000.00	544.15	561.40		561.55	0.000920	5.52	9762.68	1555.45	0.26
Main	19009	100-Year_Ult	28000.00	544.15	562.11		562.24	0.000775	5.24	10929.99	1682.37	0.24
Main	19483	10-Year	8900.00	543.20	557.66		557.94	0.001915	6.81	3307.05	958.78	0.36
Main	19483	50-Year	15300.00	543.20	559.34		559.62	0.001850	7.36	5008.08	1051.61	0.36
Main	19483	100-Year	18500.00	543.20	560.16		560.43	0.001689	7.33	5883.21	1083.48	0.35
Main	19483	500-Year	27000.00	543.20	561.86		562.14	0.001560	7.62	7767.92	1135.15	0.34
Main	19483	100-Year_Ult	28000.00	543.20	562.49		562.73	0.001282	7.09	8489.51	1153.42	0.31
Main	20107	10-Year	8900.00	547.77	558.80		559.06	0.001754	5.96	3042.63	903.66	0.34
Main	20107	50-Year	15300.00	547.77	560.44		560.73	0.001765	6.66	4633.04	1032.14	0.35
Main	20107	100-Year	18500.00	547.77	561.18		561.47	0.001705	6.84	5424.95	1091.94	0.35
Main	20107	500-Year	27000.00	547.77	562.81		563.13	0.001648	7.33	7360.09	1273.59	0.35
Main	20107	100-Year_Ult	28000.00	547.77	563.29		563.57	0.001435	7.00	7987.94	1354.45	0.33
Main	20698	10-Year	8900.00	547.28	559.93		560.27	0.002367	7.08	3002.03	1053.00	0.40
Main	20698	50-Year	15300.00	547.28	561.54		561.85	0.002147	7.46	4847.37	1207.78	0.39
Main	20698	100-Year	18500.00	547.28	562.23		562.53	0.002010	7.50	5698.64	1266.49	0.38
Main	20698	500-Year	27000.00	547.28	563.81		564.10	0.001838	7.78	7862.68	1472.66	0.37
Main	20698	100-Year_Ult	28000.00	547.28	564.16		564.44	0.001710	7.64	8392.48	1513.55	0.36
Main	21296	10-Year	9100.00	547.01	560.87		561.13	0.001640	6.31	3531.09	1003.23	0.34
Main	21296	50-Year	15700.00	547.01	562.38		562.66	0.001815	7.23	5155.41	1144.36	0.36
Main	21296	100-Year	18600.00	547.01	563.01		563.30	0.001771	7.38	5900.41	1200.91	0.36
Main	21296	500-Year	27600.00	547.01	564.52		564.84	0.001793	7.99	7778.80	1289.42	0.37
Main	21296	100-Year_Ult	28600.00	547.01	564.82		565.12	0.001665	7.80	8172.89	1303.93	0.36
Main	22193	10-Year	9100.00	549.95	562.26		562.53	0.002325	6.47	3099.01	973.48	0.38
Main	22193	50-Year	15700.00	549.95	563.79		564.08	0.002260	7.10	4648.08	1055.71	0.39
Main	22193	100-Year	18600.00	549.95	564.37		564.67	0.002208	7.28	5267.90	1074.63	0.39
Main	22193	500-Year	27600.00	549.95	565.85		566.19	0.002183	7.88	6904.29	1137.63	0.39
Main	22193	100-Year_Ult	28600.00	549.95	566.07		566.41	0.002104	7.82	7154.27	1147.58	0.39
Main	22806	10-Year	9000.00	551.00	563.50		563.79	0.002023	6.32	2992.87	857.34	0.36
Main	22806	50-Year	15400.00	551.00	565.02		565.35	0.002166	7.22	4343.22	927.71	0.39

HEC-RAS Plan: Soap_Multi River: Soap Creek Reach: Main (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	22806	100-Year	18300.00	551.00	565.59		565.94	0.002210	7.55	4873.36	947.21	0.39
Main	22806	500-Year	27000.00	551.00	567.06		567.49	0.002333	8.41	6321.65	1017.71	0.41
Main	22806	100-Year_Ult	28300.00	551.00	567.25		567.69	0.002350	8.53	6515.31	1027.12	0.42
Main	23476	10-Year	9000.00	553.25	564.87		565.16	0.002157	6.54	2910.55	820.97	0.37
Main	23476	50-Year	15400.00	553.25	566.49		566.83	0.002321	7.54	4354.39	970.13	0.40
Main	23476	100-Year	18300.00	553.25	567.10		567.46	0.002393	7.93	4963.02	1030.34	0.41
Main	23476	500-Year	27000.00	553.25	568.67		569.07	0.002440	8.71	6661.17	1162.36	0.42
Main	23476	100-Year_Ult	28300.00	553.25	568.87		569.27	0.002437	8.79	6894.06	1169.25	0.42
Main	24145	10-Year	9200.00	552.42	566.25		566.52	0.001976	6.68	3221.46	981.56	0.36
Main	24145	50-Year	15500.00	552.42	567.92		568.18	0.001830	7.09	5007.38	1134.91	0.36
Main	24145	100-Year	18800.00	552.42	568.57		568.84	0.001857	7.39	5757.07	1193.35	0.36
Main	24145	500-Year	26800.00	552.42	570.13		570.41	0.001720	7.68	7691.65	1287.07	0.36
Main	24145	100-Year_Ult	29000.00	552.42	570.35		570.65	0.001823	7.99	7975.92	1301.56	0.37
Main	24631	10-Year	9200.00	552.43	567.05		567.27	0.001464	5.95	3227.42	793.28	0.31
Main	24631	50-Year	15500.00	552.43	568.67		568.93	0.001608	6.82	4689.05	966.11	0.34
Main	24631	100-Year	18800.00	552.43	569.33		569.62	0.001685	7.22	5351.62	1031.31	0.35
Main	24631	500-Year	26800.00	552.43	570.84		571.16	0.001689	7.76	7008.17	1147.23	0.35
Main	24631	100-Year_Ult	29000.00	552.43	571.10		571.44	0.001772	8.04	7308.19	1168.01	0.36
Main	26180	10-Year	8900.00	555.46	569.15		569.38	0.001958	6.56	3302.42	944.17	0.35
Main	26180	50-Year	14800.00	555.46	570.78		571.01	0.001808	6.92	4904.49	1024.18	0.35
Main	26180	100-Year	18100.00	555.46	571.49		571.73	0.001802	7.18	5640.95	1051.64	0.35
Main	26180	500-Year	25900.00	555.46	572.97		573.24	0.001783	7.67	7238.76	1109.06	0.36
Main	26180	100-Year_Ult	28100.00	555.46	573.30		573.58	0.001808	7.84	7605.29	1118.45	0.36
Main	27382	10-Year	8900.00	557.33	570.81		571.00	0.001929	6.03	3080.59	874.54	0.34
Main	27382	50-Year	14800.00	557.33	572.26		572.49	0.001914	6.59	4407.21	955.94	0.35
Main	27382	100-Year	18100.00	557.33	572.94		573.19	0.001910	6.84	5069.50	987.69	0.35
Main	27382	500-Year	25900.00	557.33	574.35		574.64	0.001857	7.27	6498.29	1034.34	0.35
Main	27382	100-Year_Ult	28100.00	557.33	574.69		575.00	0.001868	7.41	6848.99	1048.80	0.35
Main	27885	10-Year	9100.00	559.10	571.43		571.66	0.001843	6.06	3090.10	835.42	0.35
Main	27885	50-Year	15200.00	559.10	572.86		573.15	0.002014	6.97	4324.32	876.44	0.37
Main	27885	100-Year	18000.00	559.10	573.53		573.82	0.001956	7.15	4919.52	916.32	0.37
Main	27885	500-Year	26100.00	559.10	574.93		575.29	0.002102	8.00	6264.11	984.41	0.39
Main	27885	100-Year_Ult	28700.00	559.10	575.27		575.66	0.002192	8.31	6602.97	998.77	0.40
Main	28320	10-Year	9100.00	559.82	572.30		572.75	0.003473	8.43	2513.33	605.35	0.48
Main	28320	50-Year	15200.00	559.82	573.82		574.38	0.004019	9.99	3470.78	657.58	0.52
Main	28320	100-Year	18000.00	559.82	574.45		575.06	0.004148	10.52	3901.90	687.85	0.54
Main	28320	500-Year	26100.00	559.82	575.90		576.63	0.004511	11.85	4922.96	725.69	0.57
Main	28320	100-Year_Ult	28700.00	559.82	576.28		577.06	0.004664	12.27	5197.31	733.99	0.58
Main	29260	10-Year	8700.00	560.22	574.38		574.52	0.001380	5.35	3666.51	730.72	0.29
Main	29260	50-Year	14600.00	560.22	576.17		576.36	0.001518	6.23	5014.29	774.49	0.31
Main	29260	100-Year	17400.00	560.22	576.88		577.09	0.001556	6.55	5573.51	806.78	0.32
Main	29260	500-Year	25000.00	560.22	578.54		578.80	0.001644	7.29	6971.43	870.80	0.34
Main	29260	100-Year_Ult	28100.00	560.22	579.03		579.31	0.001743	7.68	7400.42	891.49	0.35
Main	29876	10-Year	8700.00	561.43	575.08		575.30	0.001723	6.35	3317.61	796.16	0.34
Main	29876	50-Year	14600.00	561.43	576.91		577.15	0.001719	7.02	4870.12	891.43	0.34
Main	29876	100-Year	17400.00	561.43	577.64		577.89	0.001736	7.32	5535.03	938.73	0.35
Main	29876	500-Year	25000.00	561.43	579.33		579.61	0.001731	7.90	7191.92	1017.77	0.36
Main	29876	100-Year_Ult	28100.00	561.43	579.86		580.16	0.001797	8.23	7739.96	1052.50	0.36
Main	30837	10-Year	8700.00	563.39	576.39		576.62	0.001519	5.99	3127.21	654.52	0.32
Main	30837	50-Year	14600.00	563.39	578.23		578.53	0.001675	7.00	4395.41	714.80	0.35
Main	30837	100-Year	17400.00	563.39	578.97		579.30	0.001730	7.39	4938.35	745.50	0.36
Main	30837	500-Year	25000.00	563.39	580.67		581.05	0.001839	8.26	6256.06	802.14	0.38
Main	30837	100-Year_Ult	28100.00	563.39	581.24		581.65	0.001890	8.59	6714.97	812.76	0.39
Main	31869	10-Year	8900.00	565.06	577.75		577.87	0.001114	4.85	4180.21	841.96	0.27
Main	31869	50-Year	15000.00	565.06	579.71		579.86	0.001176	5.62	5967.95	1002.48	0.29
Main	31869	100-Year	17800.00	565.06	580.51		580.68	0.001220	5.98	6830.60	1194.08	0.30
Main	31869	500-Year	25000.00	565.06	582.28		582.46	0.001197	6.47	9156.62	1390.99	0.30
Main	31869	100-Year_Ult	28900.00	565.06	582.91		583.10	0.001253	6.81	10047.17	1433.04	0.31
Main	32649	10-Year	8900.00	567.72	578.60		578.83	0.002238	6.44	3101.26	751.34	0.38
Main	32649	50-Year	15000.00	567.72	580.54		580.78	0.001945	6.84	4639.67	823.96	0.37
Main	32649	100-Year	17800.00	567.72	581.33		581.58	0.001834	6.96	5311.49	864.10	0.36
Main	32649	500-Year	25000.00	567.72	583.04		583.32	0.001687	7.31	6916.17	1006.23	0.35
Main	32649	100-Year_Ult	28900.00	567.72	583.69		583.99	0.001729	7.64	7579.31	1047.26	0.36

HEC-RAS Plan: Soap_Multi River: Soap Creek Reach: Main (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	33434	10-Year	6600.00	569.27	580.01		580.20	0.001600	5.33	2855.37	672.32	0.32
Main	33434	50-Year	10700.00	569.27	581.79		582.00	0.001506	5.88	4180.33	805.66	0.33
Main	33434	100-Year	12600.00	569.27	582.52		582.73	0.001438	6.02	4778.59	826.40	0.32
Main	33434	500-Year	17600.00	569.27	584.15		584.38	0.001353	6.40	6163.67	887.72	0.32
Main	33434	100-Year_Ult	20700.00	569.27	584.83		585.09	0.001429	6.82	6776.55	920.31	0.33
Main	34413	10-Year	6600.00	571.13	581.59		581.80	0.001929	6.00	2861.53	642.60	0.36
Main	34413	50-Year	10700.00	571.13	583.31		583.55	0.001961	6.82	4028.34	711.14	0.37
Main	34413	100-Year	12600.00	571.13	583.99		584.25	0.001962	7.11	4520.46	733.98	0.37
Main	34413	500-Year	17600.00	571.13	585.56		585.85	0.001990	7.81	5728.01	803.10	0.39
Main	34413	100-Year_Ult	20700.00	571.13	586.31		586.63	0.002057	8.25	6338.15	823.04	0.40
Main	35123	10-Year	6700.00	572.94	583.10		583.44	0.002628	7.14	1974.00	568.77	0.42
Main	35123	50-Year	10700.00	572.94	584.76		585.10	0.002320	7.50	3002.65	667.02	0.40
Main	35123	100-Year	12600.00	572.94	585.42		585.76	0.002224	7.64	3449.98	693.43	0.40
Main	35123	500-Year	17800.00	572.94	586.98		587.34	0.002132	8.14	4594.03	771.19	0.40
Main	35123	100-Year_Ult	21300.00	572.94	587.77		588.16	0.002197	8.60	5220.97	815.58	0.41
Main	35463	10-Year	6700.00	573.35	583.99		584.29	0.002359	6.84	2426.63	660.26	0.39
Main	35463	50-Year	10700.00	573.35	585.56		585.86	0.002152	7.25	3518.40	720.05	0.38
Main	35463	100-Year	12600.00	573.35	586.19		586.50	0.002112	7.45	3978.75	740.94	0.38
Main	35463	500-Year	17800.00	573.35	587.73		588.05	0.002062	7.99	5220.30	868.08	0.39
Main	35463	100-Year_Ult	21300.00	573.35	588.54		588.89	0.002090	8.38	5951.67	925.56	0.39
Main	36318	10-Year	6500.00	576.15	585.92		586.22	0.002267	6.57	2326.04	693.30	0.39
Main	36318	50-Year	10400.00	576.15	587.36		587.67	0.002193	7.15	3381.01	789.91	0.39
Main	36318	100-Year	12300.00	576.15	587.96		588.28	0.002180	7.40	3873.68	835.54	0.40
Main	36318	500-Year	17400.00	576.15	589.40		589.71	0.001958	7.62	5169.66	940.56	0.38
Main	36318	100-Year_Ult	20900.00	576.15	590.22		590.54	0.001897	7.83	5964.83	1012.29	0.38
Main	37022	10-Year	6500.00	575.40	587.28		587.49	0.001513	5.79	2660.81	716.44	0.32
Main	37022	50-Year	10400.00	575.40	588.70		588.92	0.001505	6.30	3688.18	735.95	0.32
Main	37022	100-Year	12300.00	575.40	589.30		589.53	0.001515	6.53	4132.41	750.35	0.33
Main	37022	500-Year	17400.00	575.40	590.65		590.91	0.001567	7.12	5170.76	781.01	0.34
Main	37022	100-Year_Ult	20900.00	575.40	591.44		591.73	0.001594	7.45	5795.52	801.86	0.35
Main	37680	10-Year	6500.00	575.39	588.17		588.35	0.001188	5.25	2642.03	645.19	0.28
Main	37680	50-Year	10400.00	575.39	589.60		589.81	0.001295	5.96	3598.49	695.19	0.30
Main	37680	100-Year	12300.00	575.39	590.20		590.43	0.001314	6.20	4026.47	719.95	0.31
Main	37680	500-Year	17400.00	575.39	591.59		591.87	0.001412	6.90	5078.29	796.89	0.32
Main	37680	100-Year_Ult	20900.00	575.39	592.40		592.71	0.001462	7.29	5743.93	839.99	0.33
Main	38447	10-Year	6900.00	580.23	589.52		590.01	0.004149	8.31	1950.02	637.78	0.52
Main	38447	50-Year	10900.00	580.23	590.97		591.41	0.003442	8.46	2908.02	679.80	0.49
Main	38447	100-Year	12700.00	580.23	591.57		591.99	0.003219	8.52	3316.05	697.63	0.47
Main	38447	500-Year	17500.00	580.23	592.97		593.40	0.002834	8.73	4316.63	730.89	0.46
Main	38447	100-Year_Ult	22300.00	580.23	593.85		594.34	0.003042	9.50	4965.85	754.28	0.48
Main	39317	10-Year	6900.00	580.91	591.98		592.19	0.001745	5.92	2903.00	905.04	0.34
Main	39317	50-Year	10900.00	580.91	593.20		593.43	0.001752	6.43	4041.19	955.36	0.35
Main	39317	100-Year	12700.00	580.91	593.70		593.92	0.001713	6.56	4517.71	963.77	0.35
Main	39317	500-Year	17500.00	580.91	594.93		595.17	0.001621	6.84	5737.43	1017.93	0.34
Main	39317	100-Year_Ult	22300.00	580.91	595.93		596.19	0.001665	7.30	6783.62	1070.97	0.35
Main	40329	10-Year	4900.00	583.54	593.98	592.70	594.45	0.002925	7.16	1557.23	523.24	0.43
Main	40329	50-Year	8000.00	583.54	595.26	593.99	595.78	0.003149	8.16	2255.95	558.87	0.46
Main	40329	100-Year	9400.00	583.54	595.73	594.31	596.27	0.003218	8.52	2520.66	562.39	0.47
Main	40329	500-Year	12800.00	583.54	596.86	595.07	597.42	0.003156	9.04	3160.76	569.23	0.47
Main	40329	100-Year_Ult	17100.00	583.54	597.93	595.76	598.57	0.003365	9.92	3775.54	628.71	0.50
Main	41331	10-Year	4700.00	587.13	596.47		596.75	0.001955	5.47	1801.96	882.33	0.35
Main	41331	50-Year	7300.00	587.13	597.62		597.84	0.001531	5.33	2857.60	923.68	0.32
Main	41331	100-Year	8600.00	587.13	598.07		598.28	0.001449	5.37	3271.93	927.08	0.31
Main	41331	500-Year	11700.00	587.13	599.07		599.27	0.001287	5.42	4201.94	939.53	0.30
Main	41331	100-Year_Ult	16000.00	587.13	600.18		600.39	0.001218	5.66	5257.28	951.69	0.30

HEC-RAS Plan: Stuart-Multi River: Stuart_Branch Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	1258	10-Year	270.00	529.02	530.08	529.78	530.14	0.009003	2.00	135.13	226.52	0.46
1	1258	50-Year	390.00	529.02	530.24	529.91	530.32	0.009007	2.27	171.94	238.41	0.47
1	1258	100-Year	440.00	529.02	530.30	529.95	530.38	0.009008	2.36	186.22	242.87	0.48
1	1258	500-Year	570.00	529.02	530.43	530.05	530.54	0.009004	2.59	220.40	252.71	0.49
1	1258	100-Year_Ult	560.00	529.02	530.42	530.05	530.53	0.009003	2.57	217.92	252.04	0.49
1	1569	10-Year	270.00	532.00	533.96	533.76	534.46	0.022351	5.64	47.89	33.03	0.83
1	1569	50-Year	390.00	532.00	534.28	534.16	534.96	0.026385	6.64	58.71	35.82	0.91
1	1569	100-Year	440.00	532.00	534.38	534.31	535.15	0.028055	7.02	62.64	36.79	0.95
1	1569	500-Year	570.00	532.00	534.66	534.66	535.60	0.030675	7.80	73.12	39.25	1.01
1	1569	100-Year_Ult	560.00	532.00	534.63	534.63	535.57	0.030757	7.76	72.12	39.02	1.01
1	1854	10-Year	270.00	534.00	536.70		536.82	0.004186	2.99	116.49	127.93	0.38
1	1854	50-Year	390.00	534.00	537.11		537.24	0.003667	3.18	178.78	170.20	0.36
1	1854	100-Year	440.00	534.00	537.27		537.40	0.003480	3.23	206.13	186.90	0.36
1	1854	500-Year	570.00	534.00	537.62		537.74	0.003125	3.34	279.24	230.38	0.35
1	1854	100-Year_Ult	560.00	534.00	537.59		537.72	0.003146	3.33	273.94	228.40	0.35
1	2152	10-Year	270.00	536.00	538.03		538.16	0.004804	2.90	93.05	55.94	0.39
1	2152	50-Year	390.00	536.00	538.37		538.56	0.005325	3.46	114.45	67.47	0.43
1	2152	100-Year	440.00	536.00	538.50		538.71	0.005547	3.68	122.95	71.37	0.44
1	2152	500-Year	570.00	536.00	538.77		539.04	0.006101	4.18	144.56	83.28	0.47
1	2152	100-Year_Ult	560.00	536.00	538.76		539.02	0.006055	4.14	142.99	82.64	0.47
1	2532	10-Year	60.00	538.77	540.12	540.12	540.61	0.039567	5.62	10.67	10.92	1.00
1	2532	50-Year	90.00	538.77	540.68		541.11	0.022284	5.26	17.12	12.28	0.78
1	2532	100-Year	100.00	538.77	540.87		541.28	0.018803	5.12	19.54	12.75	0.73
1	2532	500-Year	120.00	538.77	541.31		541.66	0.012956	4.74	25.31	13.81	0.62
1	2532	100-Year_Ult	130.00	538.77	541.31		541.72	0.015220	5.14	25.30	13.81	0.67
1	2795	10-Year	60.00	543.00	545.07	544.60	545.18	0.009551	2.66	22.52	25.28	0.50
1	2795	50-Year	90.00	543.00	545.26	544.85	545.43	0.012423	3.23	27.83	28.47	0.58
1	2795	100-Year	100.00	543.00	545.31		545.49	0.013649	3.43	29.12	29.21	0.61
1	2795	500-Year	120.00	543.00	545.35		545.60	0.017492	3.94	30.46	29.96	0.69
1	2795	100-Year_Ult	130.00	543.00	545.48		545.70	0.014979	3.78	34.40	32.06	0.64
1	3153	10-Year	60.00	548.00	549.17		549.30	0.014121	2.86	21.01	28.75	0.59
1	3153	50-Year	90.00	548.00	549.49		549.62	0.011032	2.89	31.15	34.81	0.54
1	3153	100-Year	100.00	548.00	549.59		549.72	0.010288	2.90	34.51	36.43	0.52
1	3153	500-Year	120.00	548.00	549.78		549.91	0.008767	2.87	41.77	39.60	0.49
1	3153	100-Year_Ult	130.00	548.00	549.80		549.95	0.009603	3.03	42.84	40.05	0.52
1	3442	10-Year	60.00	552.00	552.75		552.83	0.010613	2.25	26.67	42.27	0.50
1	3442	50-Year	90.00	552.00	552.90		553.02	0.012499	2.71	33.21	44.97	0.56
1	3442	100-Year	100.00	552.00	552.94		553.07	0.013171	2.85	35.05	45.71	0.57
1	3442	500-Year	120.00	552.00	553.01		553.16	0.014841	3.15	38.12	46.90	0.62
1	3442	100-Year_Ult	130.00	552.00	553.08		553.23	0.013579	3.13	41.59	48.38	0.59
1	3740	10-Year	60.00	557.97	558.63	558.62	558.78	0.050191	3.14	19.11	58.98	0.97
1	3740	50-Year	90.00	557.97	558.77	558.72	558.93	0.036217	3.22	27.97	65.13	0.87
1	3740	100-Year	100.00	557.97	558.82	558.76	558.98	0.033104	3.22	31.02	67.35	0.84
1	3740	500-Year	120.00	557.97	558.92	558.82	559.07	0.027751	3.18	37.78	73.45	0.78
1	3740	100-Year_Ult	130.00	557.97	558.92		559.10	0.031090	3.39	38.37	73.75	0.83
1	3931	10-Year	60.00	562.47	563.28	563.10	563.33	0.013686	1.91	31.44	92.03	0.53
1	3931	50-Year	90.00	562.47	563.36	563.21	563.45	0.016523	2.35	38.22	99.21	0.60
1	3931	100-Year	100.00	562.47	563.39	563.24	563.48	0.017537	2.50	39.99	100.52	0.62
1	3931	500-Year	120.00	562.47	563.42	563.30	563.55	0.020013	2.80	42.88	102.66	0.67
1	3931	100-Year_Ult	130.00	562.47	563.47	563.32	563.59	0.018212	2.81	46.28	105.54	0.65
1	3965		Culvert									
1	4020	10-Year	60.00	562.73	566.40	563.53	566.40	0.000031	0.35	172.32	120.05	0.04
1	4020	50-Year	90.00	562.73	567.19	563.69	567.20	0.000030	0.34	265.23	154.56	0.03
1	4020	100-Year	100.00	562.73	567.31	563.74	567.31	0.000032	0.37	277.36	163.28	0.04
1	4020	500-Year	120.00	562.73	567.48	563.81	567.48	0.000039	0.42	296.31	177.45	0.04
1	4020	100-Year_Ult	130.00	562.73	567.53	563.86	567.53	0.000043	0.44	302.40	181.82	0.04
1	4252	10-Year	60.00	567.91	568.62	568.62	568.87	0.029827	4.02	14.94	30.10	1.00
1	4252	50-Year	90.00	567.91	568.79	568.79	569.10	0.028055	4.42	20.37	33.94	1.01
1	4252	100-Year	100.00	567.91	568.84	568.84	569.16	0.028094	4.55	21.99	35.14	1.01
1	4252	500-Year	120.00	567.91	568.94	568.94	569.28	0.027063	4.70	25.55	37.79	1.01
1	4252	100-Year_Ult	130.00	567.91	568.98	568.98	569.33	0.026892	4.78	27.18	38.95	1.01
1	4333	10-Year	60.00	574.07	575.62	575.62	576.02	0.040908	5.11	11.73	14.50	1.00
1	4333	50-Year	90.00	574.07	575.93	575.93	576.36	0.039781	5.28	17.05	19.81	1.00

HEC-RAS Plan: Stuart-Multi River: Stuart_Branch Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	4333	100-Year	100.00	574.07	576.01	576.01	576.45	0.038795	5.31	18.82	21.28	1.00
1	4333	500-Year	120.00	574.07	576.16	576.16	576.62	0.037965	5.44	22.07	23.75	0.99
1	4333	100-Year_Ult	130.00	574.07	576.21	576.21	576.69	0.038419	5.55	23.44	24.71	1.00
1	4560	10-Year	60.00	576.00	577.21		577.23	0.001900	0.98	61.38	93.41	0.21
1	4560	50-Year	90.00	576.00	577.58		577.59	0.001964	0.83	108.90	219.83	0.21
1	4560	100-Year	100.00	576.00	577.62		577.63	0.001880	0.85	117.64	220.46	0.20
1	4560	500-Year	120.00	576.00	577.70		577.71	0.001716	0.89	135.17	221.73	0.20
1	4560	100-Year_Ult	130.00	576.00	577.74		577.76	0.001627	0.90	144.27	222.39	0.20
1	4716	10-Year	60.00	576.00	577.29		577.30	0.000186	0.42	141.66	132.59	0.07
1	4716	50-Year	90.00	576.00	577.65		577.66	0.000168	0.47	191.58	145.34	0.07
1	4716	100-Year	100.00	576.00	577.70		577.70	0.000187	0.51	198.09	146.86	0.08
1	4716	500-Year	120.00	576.00	577.78		577.79	0.000223	0.57	210.98	149.76	0.08
1	4716	100-Year_Ult	130.00	576.00	577.83		577.83	0.000238	0.60	217.52	151.16	0.09

HEC-RAS Plan: Swadley-Multi River: Swadley_River Reach: Reach_1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	492	10-Year	470.00	524.00	526.56	526.03	526.88	0.013003	4.57	102.86	65.14	0.64
Reach_1	492	50-Year	680.00	524.00	527.03	526.46	527.42	0.013018	5.01	135.61	74.75	0.66
Reach_1	492	100-Year	740.00	524.00	527.14	526.56	527.55	0.013013	5.12	144.51	77.16	0.66
Reach_1	492	500-Year	920.00	524.00	527.46	526.84	527.92	0.013006	5.41	170.16	83.70	0.67
Reach_1	492	100-Year_Ult	830.00	524.00	527.31	526.71	527.74	0.013010	5.27	157.51	80.54	0.66
Reach_1	636	10-Year	470.00	526.00	528.78	528.41	529.23	0.019095	5.40	87.09	60.15	0.77
Reach_1	636	50-Year	660.00	526.00	529.17	528.86	529.73	0.017794	6.01	109.91	89.17	0.77
Reach_1	636	100-Year	730.00	526.00	529.28	528.98	529.89	0.017874	6.26	116.70	102.58	0.78
Reach_1	636	500-Year	900.00	526.00	529.56	529.23	530.27	0.017555	6.77	133.46	115.42	0.79
Reach_1	636	100-Year_Ult	810.00	526.00	529.42	529.11	530.08	0.017524	6.49	125.13	109.29	0.78
Reach_1	689		Culvert									
Reach_1	769	10-Year	470.00	525.61	533.25	528.88	533.27	0.000130	0.97	485.81	234.72	0.08
Reach_1	769	50-Year	660.00	525.61	535.23	529.19	535.24	0.000083	0.97	682.27	322.65	0.07
Reach_1	769	100-Year	730.00	525.61	535.97	529.30	535.98	0.000072	0.97	756.28	346.00	0.06
Reach_1	769	500-Year	900.00	525.61	537.93	529.53	537.94	0.000051	0.95	951.34	406.27	0.05
Reach_1	769	100-Year_Ult	810.00	525.61	536.84	529.41	536.86	0.000061	0.96	843.26	372.02	0.06
Reach_1	1226	10-Year	470.00	528.90	533.38		533.42	0.001182	1.55	302.30	160.43	0.20
Reach_1	1226	50-Year	660.00	528.90	535.28		535.30	0.000219	1.01	670.16	222.38	0.10
Reach_1	1226	100-Year	730.00	528.90	536.02		536.03	0.000139	0.92	840.63	242.64	0.08
Reach_1	1226	500-Year	900.00	528.90	537.96		537.97	0.000055	0.74	1366.44	297.58	0.05
Reach_1	1226	100-Year_Ult	810.00	528.90	536.88		536.89	0.000089	0.83	1061.58	267.17	0.06
Reach_1	1671	10-Year	470.00	532.00	534.35		534.51	0.005803	3.25	158.83	129.58	0.44
Reach_1	1671	50-Year	660.00	532.00	535.48		535.56	0.001767	2.44	328.38	170.90	0.26
Reach_1	1671	100-Year	730.00	532.00	536.13		536.19	0.000964	2.07	449.65	200.77	0.20
Reach_1	1671	500-Year	900.00	532.00	538.00		538.03	0.000247	1.40	882.64	258.30	0.11
Reach_1	1671	100-Year_Ult	810.00	532.00	536.95		536.99	0.000499	1.72	626.07	229.13	0.15
Reach_1	1957	10-Year	310.00	534.00	536.17		536.34	0.007600	3.28	94.60	66.16	0.48
Reach_1	1957	50-Year	460.00	534.00	536.23		536.57	0.014949	4.66	98.67	67.55	0.68
Reach_1	1957	100-Year	520.00	534.00	536.51		536.81	0.011763	4.39	118.41	74.08	0.61
Reach_1	1957	500-Year	700.00	534.00	538.08		538.19	0.002463	2.66	263.47	111.38	0.30
Reach_1	1957	100-Year_Ult	680.00	534.00	537.12		537.38	0.007928	4.04	168.18	88.58	0.52
Reach_1	2505	10-Year	310.00	538.00	539.51		539.59	0.004751	2.29	135.49	114.54	0.37
Reach_1	2505	50-Year	460.00	538.00	540.00		540.09	0.003523	2.36	195.17	126.06	0.33
Reach_1	2505	100-Year	520.00	538.00	540.10		540.20	0.003775	2.51	207.46	128.66	0.35
Reach_1	2505	500-Year	700.00	538.00	540.12		540.29	0.006608	3.33	209.98	129.22	0.46
Reach_1	2505	100-Year_Ult	680.00	538.00	540.35		540.47	0.004214	2.82	240.98	135.86	0.37
Reach_1	2764	10-Year	310.00	539.52	541.46	541.20	541.91	0.019709	5.36	57.81	39.28	0.78
Reach_1	2764	50-Year	460.00	539.52	541.62	541.62	542.42	0.032181	7.16	64.20	40.79	1.01
Reach_1	2764	100-Year	520.00	539.52	541.78	541.78	542.62	0.031525	7.37	70.53	42.25	1.01
Reach_1	2764	500-Year	700.00	539.52	542.49	542.19	543.21	0.019808	6.80	102.91	49.02	0.83
Reach_1	2764	100-Year_Ult	680.00	539.52	542.14	542.14	543.10	0.030239	7.86	86.55	45.65	1.01
Reach_1	2904	10-Year	310.00	539.96	543.03		543.20	0.005120	3.31	93.65	47.71	0.42
Reach_1	2904	50-Year	460.00	539.96	543.68		543.89	0.004828	3.62	127.16	54.22	0.42
Reach_1	2904	100-Year	520.00	539.96	543.88		544.10	0.004921	3.77	137.93	56.05	0.42
Reach_1	2904	500-Year	700.00	539.96	544.30		544.59	0.005658	4.31	162.48	59.96	0.46
Reach_1	2904	100-Year_Ult	680.00	539.96	544.34		544.61	0.005118	4.12	164.99	60.35	0.44
Reach_1	3138	10-Year	310.00	541.84	544.40		544.60	0.007003	3.55	87.22	50.68	0.48
Reach_1	3138	50-Year	460.00	541.84	544.98		545.21	0.006629	3.89	118.30	57.60	0.48
Reach_1	3138	100-Year	520.00	541.84	545.18		545.43	0.006527	3.98	130.49	60.53	0.48
Reach_1	3138	500-Year	700.00	541.84	545.74		546.02	0.006499	4.19	166.93	71.52	0.48
Reach_1	3138	100-Year_Ult	680.00	541.84	545.69		545.96	0.006449	4.18	162.86	69.82	0.48
Reach_1	3251	10-Year	310.00	542.35	545.03		545.15	0.003523	2.79	111.17	55.44	0.35
Reach_1	3251	50-Year	460.00	542.35	545.60		545.76	0.003607	3.20	143.92	59.39	0.36
Reach_1	3251	100-Year	520.00	542.35	545.80		545.97	0.003636	3.33	156.17	60.94	0.37
Reach_1	3251	500-Year	700.00	542.35	546.35		546.56	0.003706	3.66	191.14	65.52	0.38
Reach_1	3251	100-Year_Ult	680.00	542.35	546.29		546.50	0.003703	3.63	187.27	64.98	0.38
Reach_1	3465	10-Year	310.00	547.58	548.78	548.78	549.13	0.042773	4.80	64.62	93.42	1.02
Reach_1	3465	50-Year	460.00	547.58	549.00	549.00	549.44	0.038550	5.38	85.52	96.25	1.01
Reach_1	3465	100-Year	520.00	547.58	549.08	549.08	549.56	0.037794	5.52	94.14	100.31	1.00
Reach_1	3465	500-Year	700.00	547.58	549.34	549.34	549.85	0.036083	5.71	122.53	119.87	1.00
Reach_1	3465	100-Year_Ult	680.00	547.58	549.31	549.31	549.82	0.037748	5.73	118.59	119.36	1.01
Reach_1	3978	10-Year	310.00	551.65	555.38	554.52	555.55	0.005837	3.31	97.63	69.20	0.43
Reach_1	3978	50-Year	460.00	551.65	555.78	554.89	556.02	0.006276	3.93	128.89	84.51	0.46

HEC-RAS Plan: Swadley-Multi River: Swadley_River Reach: Reach_1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	3978	100-Year	520.00	551.65	555.93	555.04	556.18	0.006401	4.13	141.23	90.02	0.47
Reach_1	3978	500-Year	700.00	551.65	556.29	555.41	556.61	0.006728	4.66	177.10	104.62	0.50
Reach_1	3978	100-Year_Ult	680.00	551.65	556.27	555.37	556.57	0.006590	4.58	174.35	103.57	0.49
Reach_1	4458	10-Year	310.00	556.00	558.32		558.49	0.006500	3.31	94.56	64.78	0.46
Reach_1	4458	50-Year	460.00	556.00	558.77		558.99	0.006225	3.81	126.49	77.43	0.47
Reach_1	4458	100-Year	520.00	556.00	558.92		559.16	0.006192	3.99	139.34	88.16	0.47
Reach_1	4458	500-Year	700.00	556.00	559.33		559.62	0.006097	4.42	179.07	106.44	0.48
Reach_1	4458	100-Year_Ult	680.00	556.00	559.28		559.57	0.006175	4.39	173.88	104.86	0.48
Reach_1	4907	10-Year	80.00	560.00	561.56		561.73	0.011888	3.32	24.06	22.82	0.57
Reach_1	4907	50-Year	120.00	560.00	561.91		562.12	0.011714	3.69	32.54	26.10	0.58
Reach_1	4907	100-Year	140.00	560.00	562.05		562.28	0.011520	3.85	38.12	65.75	0.58
Reach_1	4907	500-Year	180.00	560.00	562.33		562.54	0.008846	3.82	57.68	73.48	0.53
Reach_1	4907	100-Year_Ult	180.00	560.00	562.32		562.54	0.009021	3.85	57.13	73.27	0.53
Reach_1	5185	10-Year	80.00	564.00	565.21		565.36	0.014318	3.04	26.31	33.09	0.60
Reach_1	5185	50-Year	120.00	564.00	565.48		565.65	0.013819	3.34	35.92	38.19	0.61
Reach_1	5185	100-Year	140.00	564.00	565.59		565.78	0.013821	3.48	40.24	40.27	0.61
Reach_1	5185	500-Year	180.00	564.00	565.68		565.94	0.018284	4.12	43.70	41.86	0.71
Reach_1	5185	100-Year_Ult	180.00	564.00	565.68		565.94	0.018006	4.10	43.94	41.98	0.71
Reach_1	5585	10-Year	80.00	569.51	570.89		571.01	0.013982	2.84	28.18	38.64	0.59
Reach_1	5585	50-Year	120.00	569.51	571.11		571.27	0.014250	3.24	37.05	42.24	0.61
Reach_1	5585	100-Year	140.00	569.51	571.20		571.38	0.014176	3.41	41.00	42.99	0.62
Reach_1	5585	500-Year	180.00	569.51	571.45		571.63	0.011357	3.47	51.94	45.02	0.57
Reach_1	5585	100-Year_Ult	180.00	569.51	571.44		571.63	0.011478	3.48	51.75	44.99	0.57
Reach_1	5850	10-Year	80.00	574.00	574.78		574.90	0.015544	2.83	28.22	42.04	0.61
Reach_1	5850	50-Year	120.00	574.00	574.99		575.15	0.015133	3.21	37.33	45.12	0.62
Reach_1	5850	100-Year	140.00	574.00	575.08		575.25	0.015136	3.38	41.43	46.43	0.63
Reach_1	5850	500-Year	180.00	574.00	575.17	574.94	575.41	0.018318	3.91	46.06	47.88	0.70
Reach_1	5850	100-Year_Ult	180.00	574.00	575.18	574.94	575.41	0.018128	3.89	46.22	47.93	0.70
Reach_1	6280	10-Year	80.00	583.91	584.77	584.74	584.97	0.038680	3.55	22.54	47.61	0.91
Reach_1	6280	50-Year	120.00	583.91	584.97	584.93	585.16	0.039998	3.49	34.39	76.36	0.92
Reach_1	6280	100-Year	140.00	583.91	585.04	585.00	585.23	0.039667	3.48	40.19	88.94	0.91
Reach_1	6280	500-Year	180.00	583.91	585.21	585.10	585.36	0.029888	3.10	57.98	123.34	0.80
Reach_1	6280	100-Year_Ult	180.00	583.91	585.21	585.10	585.36	0.030338	3.13	57.58	122.56	0.80

HEC-RAS Plan: Taaffe-Multi River: Taaffe_Reach Reach: Reach_1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	1629	10-Year	1010.00	524.00	528.54	525.81	528.62	0.001000	2.30	438.40	133.09	0.22
Reach_1	1629	50-Year	1520.00	524.00	529.64	526.35	529.74	0.001001	2.55	596.65	155.78	0.23
Reach_1	1629	100-Year	1750.00	524.00	530.04	526.56	530.15	0.001001	2.65	661.56	164.00	0.23
Reach_1	1629	500-Year	2330.00	524.00	530.80	527.06	530.94	0.001000	2.96	790.43	176.22	0.24
Reach_1	1629	100-Year_Ult	2210.00	524.00	530.65	526.96	530.78	0.001000	2.90	764.34	173.82	0.24
Reach_1	2109	10-Year	970.00	524.00	529.18		529.38	0.002561	3.53	274.63	87.19	0.35
Reach_1	2109	50-Year	1450.00	524.00	530.25		530.48	0.002401	3.89	372.78	97.42	0.35
Reach_1	2109	100-Year	1670.00	524.00	530.64		530.90	0.002395	4.05	412.11	101.04	0.35
Reach_1	2109	500-Year	2230.00	524.00	531.40		531.72	0.002606	4.54	490.85	107.93	0.38
Reach_1	2109	100-Year_Ult	2090.00	524.00	531.24		531.55	0.002516	4.40	474.63	106.55	0.37
Reach_1	2402	10-Year	970.00	524.00	529.94		530.23	0.003104	4.28	226.40	61.11	0.39
Reach_1	2402	50-Year	1450.00	524.00	531.02		531.38	0.003655	4.83	300.44	77.20	0.43
Reach_1	2402	100-Year	1670.00	524.00	531.42		531.81	0.003807	5.02	332.90	83.37	0.44
Reach_1	2402	500-Year	2230.00	524.00	532.25		532.71	0.004168	5.48	406.92	95.82	0.47
Reach_1	2402	100-Year_Ult	2090.00	524.00	532.07		532.51	0.004064	5.36	389.98	93.12	0.46
Reach_1	2664	10-Year	970.00	524.00	530.47		530.54	0.000568	2.12	457.98	101.21	0.18
Reach_1	2664	50-Year	1450.00	524.00	531.67		531.76	0.000713	2.44	594.98	126.87	0.20
Reach_1	2664	100-Year	1670.00	524.00	532.12		532.22	0.000771	2.55	654.61	138.35	0.21
Reach_1	2664	500-Year	2230.00	524.00	533.05		533.17	0.000854	2.82	789.66	154.88	0.22
Reach_1	2664	100-Year_Ult	2090.00	524.00	532.84		532.96	0.000828	2.76	757.99	150.55	0.22
Reach_1	2702	10-Year	970.00	524.00	530.31	527.07	530.64	0.000607	4.66	208.32	36.20	0.33
Reach_1	2702	50-Year	1450.00	524.00	531.38	528.00	531.93	0.000795	5.93	244.59	37.09	0.39
Reach_1	2702	100-Year	1670.00	524.00	531.77	528.37	532.42	0.000887	6.48	257.60	37.40	0.41
Reach_1	2702	500-Year	2230.00	524.00	532.49	529.27	533.46	0.001169	7.91	282.03	38.00	0.48
Reach_1	2702	100-Year_Ult	2090.00	524.00	532.34	529.06	533.22	0.001092	7.55	276.86	37.88	0.46
Reach_1	2703		Culvert									
Reach_1	2744	10-Year	970.00	530.40	535.05	533.35	535.65	0.002764	6.22	155.90	94.74	0.51
Reach_1	2744	50-Year	1450.00	530.40	537.15	534.27	537.48	0.001432	4.60	325.43	135.60	0.36
Reach_1	2744	100-Year	1670.00	530.40	537.76	534.66	537.93	0.000809	3.32	537.22	154.51	0.27
Reach_1	2744	500-Year	2230.00	530.40	538.44	535.57	538.66	0.000881	3.79	701.61	296.06	0.29
Reach_1	2744	100-Year_Ult	2090.00	530.40	538.29	535.34	538.50	0.000865	3.68	657.39	289.43	0.28
Reach_1	2766	10-Year	970.00	530.00	535.39		535.78	0.008569	4.99	194.43	78.73	0.56
Reach_1	2766	50-Year	1450.00	530.00	537.34		537.54	0.003238	3.60	402.66	128.50	0.36
Reach_1	2766	100-Year	1670.00	530.00	537.77		537.97	0.003068	3.63	460.55	139.75	0.35
Reach_1	2766	500-Year	2230.00	530.00	538.46		538.70	0.003085	3.96	564.32	159.50	0.36
Reach_1	2766	100-Year_Ult	2090.00	530.00	538.31		538.54	0.003110	3.87	540.44	156.25	0.36
Reach_1	2933	10-Year	970.00	532.00	536.73		536.92	0.005470	3.49	278.09	138.13	0.43
Reach_1	2933	50-Year	1450.00	532.00	537.89		538.05	0.002889	3.26	444.53	151.12	0.34
Reach_1	2933	100-Year	1670.00	532.00	538.27		538.44	0.002562	3.32	503.82	156.25	0.32
Reach_1	2933	500-Year	2230.00	532.00	538.95		539.16	0.002436	3.67	613.55	165.71	0.32
Reach_1	2933	100-Year_Ult	2090.00	532.00	538.80		539.00	0.002435	3.57	588.82	163.75	0.32
Reach_1	3366	10-Year	970.00	534.00	539.12		539.42	0.005901	4.77	280.04	160.87	0.48
Reach_1	3366	50-Year	1450.00	534.00	539.59		540.00	0.007126	5.76	355.73	165.82	0.54
Reach_1	3366	100-Year	1670.00	534.00	539.82		540.26	0.007127	6.01	395.36	168.27	0.55
Reach_1	3366	500-Year	2230.00	534.00	540.42		540.90	0.006822	6.48	497.88	179.97	0.55
Reach_1	3366	100-Year_Ult	2090.00	534.00	540.27		540.75	0.006902	6.38	472.46	176.58	0.55
Reach_1	3797	10-Year	970.00	538.23	542.63		543.12	0.013293	5.56	174.32	83.66	0.68
Reach_1	3797	50-Year	1450.00	538.23	543.36		543.94	0.012108	6.06	239.17	94.08	0.67
Reach_1	3797	100-Year	1670.00	538.23	543.61		544.24	0.012341	6.36	262.66	97.57	0.68
Reach_1	3797	500-Year	2230.00	538.23	544.13		544.90	0.013152	7.08	315.24	109.07	0.72
Reach_1	3797	100-Year_Ult	2090.00	538.23	544.02		544.75	0.012987	6.87	304.11	105.23	0.71
Reach_1	4113	10-Year	630.00	542.00	545.92		546.13	0.006135	3.67	171.45	85.77	0.46
Reach_1	4113	50-Year	920.00	542.00	546.55		546.80	0.006015	4.00	229.75	99.58	0.46
Reach_1	4113	100-Year	1060.00	542.00	546.85		547.10	0.005879	4.06	260.79	108.69	0.46
Reach_1	4113	500-Year	1410.00	542.00	547.54		547.80	0.005578	4.07	346.72	138.97	0.45
Reach_1	4113	100-Year_Ult	1440.00	542.00	547.47		547.75	0.006286	4.28	336.64	136.79	0.48
Reach_1	4561	10-Year	630.00	546.00	548.59		548.75	0.005579	3.23	195.32	111.13	0.43
Reach_1	4561	50-Year	920.00	546.00	549.13		549.33	0.005298	3.57	257.39	120.74	0.43
Reach_1	4561	100-Year	1060.00	546.00	549.37		549.58	0.005186	3.69	287.08	126.23	0.43
Reach_1	4561	500-Year	1410.00	546.00	549.90		550.14	0.004902	3.96	356.12	135.14	0.43
Reach_1	4561	100-Year_Ult	1440.00	546.00	549.96		550.20	0.004779	3.95	364.52	136.18	0.43
Reach_1	4758	10-Year	630.00	546.00	549.81		550.18	0.008761	4.88	129.02	76.89	0.66
Reach_1	4758	50-Year	920.00	546.00	550.26		550.73	0.008859	5.55	167.14	93.93	0.69

HEC-RAS Plan: Taaffe-Multi River: Taaffe_Reach Reach: Reach_1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	4758	100-Year	1060.00	546.00	550.45		550.97	0.008650	5.83	185.95	103.40	0.69
Reach_1	4758	500-Year	1410.00	546.00	550.86		551.49	0.008384	6.43	232.96	123.12	0.70
Reach_1	4758	100-Year_Ult	1440.00	546.00	550.90		551.54	0.008320	6.47	237.53	124.90	0.70
Reach_1	4919	10-Year	630.00	542.90	550.31		550.37	0.000370	1.95	328.70	81.69	0.16
Reach_1	4919	50-Year	920.00	542.90	550.89		550.99	0.000525	2.51	378.71	90.41	0.19
Reach_1	4919	100-Year	1060.00	542.90	551.14		551.25	0.000596	2.76	404.07	119.82	0.21
Reach_1	4919	500-Year	1410.00	542.90	551.66		551.83	0.000752	3.30	477.01	157.67	0.24
Reach_1	4919	100-Year_Ult	1440.00	542.90	551.70		551.87	0.000763	3.34	483.70	160.70	0.24
Reach_1	5007	10-Year	630.00	543.20	550.35		550.41	0.000412	1.94	325.31	85.00	0.17
Reach_1	5007	50-Year	920.00	543.20	550.94		551.04	0.000562	2.48	380.42	99.63	0.20
Reach_1	5007	100-Year	1060.00	543.20	551.19		551.31	0.000626	2.71	406.17	105.58	0.21
Reach_1	5007	500-Year	1410.00	543.20	551.74		551.89	0.000775	3.22	466.75	118.30	0.24
Reach_1	5007	100-Year_Ult	1440.00	543.20	551.78		551.94	0.000786	3.26	471.86	119.31	0.24
Reach_1	5391	10-Year	630.00	544.35	550.54		550.63	0.000814	2.41	261.64	74.77	0.23
Reach_1	5391	50-Year	920.00	544.35	551.20		551.34	0.001037	2.94	312.55	79.17	0.26
Reach_1	5391	100-Year	1060.00	544.35	551.48		551.64	0.001130	3.17	334.83	81.02	0.27
Reach_1	5391	500-Year	1410.00	544.35	552.08		552.29	0.001330	3.66	385.24	93.59	0.30
Reach_1	5391	100-Year_Ult	1440.00	544.35	552.13		552.34	0.001340	3.70	389.77	98.71	0.30
Reach_1	5795	10-Year	630.00	545.50	550.95		551.09	0.001538	3.02	208.27	68.12	0.30
Reach_1	5795	50-Year	920.00	545.50	551.69		551.88	0.001695	3.53	260.56	72.55	0.33
Reach_1	5795	100-Year	1060.00	545.50	552.00		552.22	0.001760	3.74	283.43	74.40	0.34
Reach_1	5795	500-Year	1410.00	545.50	552.68		552.95	0.001916	4.21	335.10	78.43	0.36
Reach_1	5795	100-Year_Ult	1440.00	545.50	552.73		553.01	0.001930	4.25	339.15	78.73	0.36
Reach_1	6084	10-Year	630.00	546.40	551.46		551.66	0.002488	3.57	176.69	64.89	0.38
Reach_1	6084	50-Year	920.00	546.40	552.24		552.49	0.002477	4.03	228.50	69.54	0.39
Reach_1	6084	100-Year	1060.00	546.40	552.56		552.84	0.002486	4.22	251.34	71.50	0.40
Reach_1	6084	500-Year	1410.00	546.40	553.27		553.60	0.002539	4.64	303.59	75.78	0.41
Reach_1	6084	100-Year_Ult	1440.00	546.40	553.32		553.66	0.002546	4.68	307.76	76.11	0.41
Reach_1	6337	10-Year	630.00	547.20	552.11		552.31	0.002656	3.59	175.32	66.95	0.39
Reach_1	6337	50-Year	920.00	547.20	552.88		553.13	0.002595	4.03	228.41	72.10	0.40
Reach_1	6337	100-Year	1060.00	547.20	553.20		553.48	0.002578	4.20	252.22	74.29	0.40
Reach_1	6337	500-Year	1410.00	547.20	553.93		554.25	0.002575	4.58	307.76	79.47	0.41
Reach_1	6337	100-Year_Ult	1440.00	547.20	553.99		554.32	0.002597	4.61	312.55	80.56	0.41
Reach_1	6745	10-Year	630.00	548.40	553.24		553.46	0.002926	3.77	167.18	63.90	0.41
Reach_1	6745	50-Year	920.00	548.40	553.98		554.26	0.002950	4.24	216.99	69.86	0.42
Reach_1	6745	100-Year	1060.00	548.40	554.31		554.61	0.002967	4.42	240.09	73.06	0.43
Reach_1	6745	500-Year	1410.00	548.40	555.03		555.38	0.002962	4.77	297.23	137.00	0.44
Reach_1	6745	100-Year_Ult	1440.00	548.40	555.09		555.44	0.002926	4.79	305.37	140.10	0.44
Reach_1	6888	10-Year	630.00	549.55	553.78		554.16	0.008249	4.94	127.62	59.77	0.60
Reach_1	6888	50-Year	920.00	549.55	554.52		554.95	0.007655	5.22	176.10	71.64	0.59
Reach_1	6888	100-Year	1060.00	549.55	554.85		555.28	0.007309	5.30	200.04	76.96	0.58
Reach_1	6888	500-Year	1410.00	549.55	555.55		556.01	0.006308	5.50	256.52	83.50	0.55
Reach_1	6888	100-Year_Ult	1440.00	549.55	555.60		556.07	0.006261	5.52	260.85	83.88	0.55

HEC-RAS Plan: Tarrell-Multi River: Tarrell_Branch Reach: Tarrell_Reach

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Tarrell_Reach	1787	10-Year	175.00	536.00	537.91	537.73	538.31	0.019018	5.07	34.50	29.01	0.82
Tarrell_Reach	1787	50-Year	235.00	536.00	538.18	538.18	538.59	0.016158	5.27	53.78	93.12	0.78
Tarrell_Reach	1787	100-Year	260.00	536.00	538.25	538.25	538.68	0.015833	5.39	60.69	94.28	0.78
Tarrell_Reach	1787	500-Year	320.00	536.00	538.41	538.41	538.85	0.015375	5.67	75.38	96.69	0.78
Tarrell_Reach	1787	100-Year_Ult	280.00	536.00	538.31	538.31	538.74	0.015771	5.51	65.56	95.09	0.78
Tarrell_Reach	2080	10-Year	175.00	540.00	543.34	543.08	543.94	0.019033	6.23	28.10	16.11	0.83
Tarrell_Reach	2080	50-Year	235.00	540.00	543.58	543.48	544.41	0.023987	7.31	32.15	17.23	0.94
Tarrell_Reach	2080	100-Year	260.00	540.00	543.69	543.63	544.60	0.025416	7.66	33.94	17.71	0.98
Tarrell_Reach	2080	500-Year	320.00	540.00	543.97	543.97	545.01	0.026329	8.17	39.15	19.04	1.00
Tarrell_Reach	2080	100-Year_Ult	280.00	540.00	543.77	543.75	544.74	0.026195	7.89	35.48	18.11	0.99
Tarrell_Reach	2297	10-Year	75.00	546.00	547.78	547.60	548.21	0.020948	5.29	14.17	11.23	0.83
Tarrell_Reach	2297	50-Year	85.00	546.00	548.24		548.53	0.010703	4.29	19.83	12.95	0.61
Tarrell_Reach	2297	100-Year	90.00	546.00	548.41		548.67	0.009060	4.09	21.99	13.54	0.57
Tarrell_Reach	2297	500-Year	100.00	546.00	548.69		548.92	0.007089	3.85	26.01	14.59	0.51
Tarrell_Reach	2297	100-Year_Ult	100.00	546.00	548.55		548.82	0.008825	4.17	23.99	14.07	0.56
Tarrell_Reach	2503	10-Year	75.00	550.00	551.62		551.93	0.015681	4.47	16.79	14.30	0.73
Tarrell_Reach	2503	50-Year	85.00	550.00	551.48	551.45	551.99	0.028646	5.75	14.79	13.60	0.97
Tarrell_Reach	2503	100-Year	90.00	550.00	551.50	551.50	552.05	0.030767	5.99	15.02	13.69	1.01
Tarrell_Reach	2503	500-Year	100.00	550.00	551.59	551.59	552.17	0.030282	6.14	16.29	14.13	1.01
Tarrell_Reach	2503	100-Year_Ult	100.00	550.00	551.59	551.59	552.17	0.030282	6.14	16.29	14.13	1.01
Tarrell_Reach	2736	10-Year	75.00	552.00	554.72		554.90	0.010398	3.33	22.55	16.02	0.49
Tarrell_Reach	2736	50-Year	85.00	552.00	555.02		555.17	0.007828	3.09	27.52	17.65	0.44
Tarrell_Reach	2736	100-Year	90.00	552.00	555.11		555.25	0.007586	3.10	29.06	18.12	0.43
Tarrell_Reach	2736	500-Year	100.00	552.00	555.23		555.39	0.007668	3.19	31.31	18.79	0.44
Tarrell_Reach	2736	100-Year_Ult	100.00	552.00	555.23		555.39	0.007688	3.20	31.28	18.79	0.44
Tarrell_Reach	2850	10-Year	75.00	554.00	555.96		556.11	0.010935	3.08	24.36	20.95	0.50
Tarrell_Reach	2850	50-Year	85.00	554.00	556.07		556.23	0.011095	3.18	26.72	22.12	0.51
Tarrell_Reach	2850	100-Year	90.00	554.00	556.13		556.29	0.010953	3.20	28.10	22.79	0.51
Tarrell_Reach	2850	500-Year	100.00	554.00	556.25		556.41	0.010636	3.24	30.87	24.10	0.50
Tarrell_Reach	2850	100-Year_Ult	100.00	554.00	556.25		556.41	0.010635	3.24	30.87	24.10	0.50
Tarrell_Reach	2897	10-Year	180.00	556.00	556.37		556.38	0.004772	0.89	209.01	524.41	0.27
Tarrell_Reach	2897	50-Year	250.00	556.00	556.47		556.48	0.004419	0.99	261.00	527.22	0.27
Tarrell_Reach	2897	100-Year	280.00	556.00	556.51		556.53	0.004123	1.01	285.49	528.54	0.27
Tarrell_Reach	2897	500-Year	350.00	556.00	556.61		556.63	0.003757	1.06	336.27	531.26	0.26
Tarrell_Reach	2897	100-Year_Ult	320.00	556.00	556.60		556.61	0.003360	0.99	329.43	530.89	0.25
Tarrell_Reach	2960	10-Year	180.00	555.61	556.56	556.03	556.56	0.000568	0.50	362.14	533.81	0.11
Tarrell_Reach	2960	50-Year	250.00	555.61	556.67	556.06	556.68	0.000644	0.59	425.43	536.34	0.12
Tarrell_Reach	2960	100-Year	280.00	555.61	556.72	556.08	556.73	0.000672	0.62	450.04	537.33	0.12
Tarrell_Reach	2960	500-Year	350.00	555.61	556.82	556.11	556.83	0.000724	0.69	503.83	539.49	0.13
Tarrell_Reach	2960	100-Year_Ult	320.00	555.61	556.79	556.09	556.80	0.000676	0.66	487.21	538.83	0.12
Tarrell_Reach	3360	10-Year	180.00	555.62	556.78	556.10	556.79	0.000569	0.57	313.26	371.91	0.11
Tarrell_Reach	3360	50-Year	250.00	555.62	556.93	556.14	556.94	0.000650	0.68	369.45	379.32	0.12
Tarrell_Reach	3360	100-Year	280.00	555.62	556.99	556.16	557.00	0.000680	0.72	391.24	382.16	0.12
Tarrell_Reach	3360	500-Year	350.00	555.62	557.11	556.21	557.12	0.000738	0.80	439.26	388.34	0.13
Tarrell_Reach	3360	100-Year_Ult	320.00	555.62	557.07	556.19	557.07	0.000706	0.76	420.76	385.97	0.13
Tarrell_Reach	3595	10-Year	90.00	556.00	556.94		556.96	0.001227	0.84	107.00	127.65	0.16
Tarrell_Reach	3595	50-Year	120.00	556.00	557.11		557.13	0.001255	0.93	128.73	133.87	0.17
Tarrell_Reach	3595	100-Year	140.00	556.00	557.18		557.20	0.001385	1.01	137.97	136.00	0.18
Tarrell_Reach	3595	500-Year	170.00	556.00	557.32		557.34	0.001409	1.08	156.91	141.99	0.18
Tarrell_Reach	3595	100-Year_Ult	160.00	556.00	557.26		557.28	0.001424	1.07	149.40	138.71	0.18
Tarrell_Reach	3913	10-Year	90.00	558.00	558.72	558.72	558.98	0.054742	4.10	21.97	42.05	1.00
Tarrell_Reach	3913	50-Year	120.00	558.00	558.84	558.84	559.14	0.053404	4.40	27.29	46.12	1.01
Tarrell_Reach	3913	100-Year	140.00	558.00	558.91	558.91	559.23	0.052189	4.55	30.79	48.64	1.01
Tarrell_Reach	3913	500-Year	170.00	558.00	559.01	559.01	559.36	0.050782	4.74	35.85	52.07	1.01
Tarrell_Reach	3913	100-Year_Ult	160.00	558.00	558.98	558.98	559.32	0.051271	4.68	34.17	50.96	1.01
Tarrell_Reach	4132	10-Year	90.00	562.00	563.11	562.70	563.20	0.009661	2.35	38.34	46.02	0.45
Tarrell_Reach	4132	50-Year	120.00	562.00	563.29	562.83	563.39	0.009866	2.57	46.70	49.72	0.47
Tarrell_Reach	4132	100-Year	140.00	562.00	563.39	562.91	563.50	0.010006	2.70	51.76	51.56	0.48
Tarrell_Reach	4132	500-Year	170.00	562.00	563.52	563.01	563.65	0.010199	2.88	58.94	54.06	0.49
Tarrell_Reach	4132	100-Year_Ult	160.00	562.00	563.48	562.98	563.60	0.010137	2.83	56.59	53.26	0.48
Tarrell_Reach	4296	10-Year	90.00	564.00	565.21		565.38	0.019043	3.37	26.74	30.99	0.64
Tarrell_Reach	4296	50-Year	120.00	564.00	565.40		565.60	0.019000	3.64	32.96	33.88	0.65
Tarrell_Reach	4296	100-Year	140.00	564.00	565.51		565.74	0.018807	3.78	37.01	35.64	0.65
Tarrell_Reach	4296	500-Year	170.00	564.00	565.67		565.91	0.018846	3.99	42.61	37.94	0.66
Tarrell_Reach	4296	100-Year_Ult	160.00	564.00	565.62		565.86	0.018819	3.92	40.79	37.20	0.66
Tarrell_Reach	4527	10-Year	90.00	570.00	571.22	571.14	571.46	0.038425	3.92	22.99	36.07	0.86

HEC-RAS Plan: Tarrell-Multi River: Tarrell_Branch Reach: Tarrell_Reach (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Tarrell_Reach	4527	50-Year	120.00	570.00	571.37	571.29	571.64	0.037826	4.18	28.68	40.26	0.87
Tarrell_Reach	4527	100-Year	140.00	570.00	571.45	571.37	571.75	0.038140	4.37	32.07	42.48	0.89
Tarrell_Reach	4527	500-Year	170.00	570.00	571.57	571.49	571.89	0.037449	4.56	37.30	45.71	0.89
Tarrell_Reach	4527	100-Year_Ult	160.00	570.00	571.53	571.45	571.85	0.037693	4.50	35.57	44.67	0.89
Tarrell_Reach	4846	10-Year	90.00	580.00	580.74	580.58	580.88	0.023355	2.94	30.66	51.11	0.67
Tarrell_Reach	4846	50-Year	120.00	580.00	580.87	580.69	581.03	0.023539	3.22	37.29	54.46	0.69
Tarrell_Reach	4846	100-Year	140.00	580.00	580.95	580.76	581.12	0.023287	3.36	41.67	56.58	0.69
Tarrell_Reach	4846	500-Year	170.00	580.00	581.05	580.85	581.25	0.023536	3.57	47.56	59.30	0.70
Tarrell_Reach	4846	100-Year_Ult	160.00	580.00	581.02	580.82	581.21	0.023430	3.50	45.65	58.43	0.70
Tarrell_Reach	4970	10-Year	90.00	584.00	584.87	584.87	585.18	0.052883	4.47	20.15	32.97	1.01
Tarrell_Reach	4970	50-Year	120.00	584.00	585.01	585.01	585.37	0.050728	4.77	25.14	36.10	1.01
Tarrell_Reach	4970	100-Year	140.00	584.00	585.10	585.10	585.48	0.049663	4.94	28.32	37.96	1.01
Tarrell_Reach	4970	500-Year	170.00	584.00	585.22	585.22	585.63	0.048294	5.16	32.93	40.50	1.01
Tarrell_Reach	4970	100-Year_Ult	160.00	584.00	585.18	585.18	585.58	0.048592	5.09	31.44	39.70	1.01

HEC-RAS Plan: Ten_Multi River: Ten Branch Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	1702	10-Year	440.00	525.66	530.83	529.07	531.06	0.005008	3.91	112.60	36.52	0.39
1	1702	50-Year	750.00	525.66	531.97	529.94	532.31	0.005007	4.75	173.28	75.20	0.41
1	1702	100-Year	880.00	525.66	532.34	530.28	532.72	0.005008	5.03	203.06	85.40	0.42
1	1702	500-Year	1150.00	525.66	533.00	530.87	533.44	0.005007	5.52	265.08	101.80	0.43
1	1702	100-Year Ult	1080.00	525.66	532.84	530.72	533.27	0.005007	5.40	249.03	97.84	0.43
1	1810	10-Year	440.00	528.00	531.46		531.90	0.011210	5.30	83.01	31.40	0.57
1	1810	50-Year	750.00	528.00	532.53		533.13	0.010163	6.31	130.36	51.29	0.58
1	1810	100-Year	880.00	528.00	532.88		533.55	0.010153	6.69	148.62	54.81	0.58
1	1810	500-Year	1150.00	528.00	533.49		534.30	0.010354	7.42	184.72	62.59	0.60
1	1810	100-Year Ult	1080.00	528.00	533.34		534.12	0.010291	7.24	175.58	60.78	0.60
1	1993	10-Year	440.00	527.00	533.13		533.62	0.007911	5.59	81.74	28.82	0.49
1	1993	50-Year	750.00	527.00	534.21		534.96	0.009481	7.16	131.46	59.92	0.56
1	1993	100-Year	880.00	527.00	534.57		535.40	0.009766	7.61	153.84	63.95	0.57
1	1993	500-Year	1150.00	527.00	535.24		536.18	0.010075	8.34	199.18	71.65	0.59
1	1993	100-Year Ult	1080.00	527.00	535.07		535.99	0.010032	8.18	187.65	70.42	0.59
1	2124	10-Year	520.00	528.00	534.07		534.27	0.003409	3.66	146.25	48.01	0.34
1	2124	50-Year	740.00	528.00	535.36		535.57	0.002370	3.74	228.04	76.07	0.30
1	2124	100-Year	770.00	528.00	535.78		535.96	0.001892	3.52	261.15	82.26	0.27
1	2124	500-Year	970.00	528.00	536.54		536.74	0.001798	3.75	327.88	92.25	0.27
1	2124	100-Year Ult	960.00	528.00	536.36		536.57	0.001980	3.86	311.39	90.06	0.28
1	2348	10-Year	520.00	530.39	535.12		536.05	0.021248	7.73	67.30	21.77	0.77
1	2348	50-Year	740.00	530.39	535.89		537.07	0.022089	8.74	84.71	23.85	0.81
1	2348	100-Year	770.00	530.39	536.10		537.24	0.019790	8.59	89.95	26.98	0.77
1	2348	500-Year	970.00	530.39	536.70	536.03	538.03	0.019060	9.29	111.44	44.63	0.78
1	2348	100-Year Ult	960.00	530.39	536.58	536.00	537.96	0.020611	9.48	106.20	41.04	0.80
1	2482	10-Year	520.00	532.00	537.47		537.90	0.009229	5.27	99.23	34.99	0.53
1	2482	50-Year	740.00	532.00	538.31		538.84	0.008181	5.83	131.37	40.93	0.52
1	2482	100-Year	770.00	532.00	538.39		538.94	0.008272	5.94	134.62	41.49	0.52
1	2482	500-Year	970.00	532.00	539.03		539.66	0.007856	6.40	162.61	46.96	0.52
1	2482	100-Year Ult	960.00	532.00	539.02		539.64	0.007746	6.34	162.18	46.75	0.52
1	2724	10-Year	520.00	536.00	540.89	540.89	541.64	0.018828	7.64	106.81	78.28	0.74
1	2724	50-Year	740.00	536.00	541.35	541.35	542.21	0.019759	8.54	145.86	109.36	0.77
1	2724	100-Year	770.00	536.00	541.42	541.42	542.28	0.019608	8.60	152.01	119.35	0.77
1	2724	500-Year	970.00	536.00	541.92	541.92	542.63	0.015542	8.30	238.12	195.45	0.70
1	2724	100-Year Ult	960.00	536.00	541.90	541.90	542.61	0.015642	8.30	234.42	194.47	0.70
1	2892	10-Year	520.00	537.00	542.45		542.57	0.002346	2.74	193.52	77.61	0.27
1	2892	50-Year	740.00	537.00	543.06		543.22	0.002568	3.23	258.44	189.69	0.30
1	2892	100-Year	770.00	537.00	543.13		543.29	0.002606	3.30	274.47	279.87	0.30
1	2892	500-Year	970.00	537.00	543.42		543.62	0.002928	3.67	371.38	334.26	0.32
1	2892	100-Year Ult	960.00	537.00	543.41		543.61	0.002914	3.66	366.89	333.59	0.32
1	3340	10-Year	520.00	539.00	543.77	542.08	544.02	0.004587	4.06	157.12	89.20	0.39
1	3340	50-Year	740.00	539.00	544.43	542.72	544.72	0.004624	4.58	227.88	158.29	0.40
1	3340	100-Year	770.00	539.00	544.51	542.81	544.81	0.004638	4.65	238.41	172.45	0.40
1	3340	500-Year	970.00	539.00	544.90	543.39	545.24	0.004836	5.04	328.46	226.13	0.42
1	3340	100-Year Ult	960.00	539.00	544.89	543.38	545.22	0.004830	5.03	324.63	224.80	0.41
1	3675	10-Year	520.00	542.00	546.26	546.26	546.97	0.019497	7.31	113.68	149.84	0.77
1	3675	50-Year	740.00	542.00	546.75	546.75	547.45	0.017606	7.73	176.73	222.40	0.75
1	3675	100-Year	770.00	542.00	546.82	546.80	547.51	0.017141	7.73	186.58	231.99	0.74
1	3675	500-Year	970.00	542.00	547.13	547.09	547.61	0.013150	7.18	317.15	262.39	0.66
1	3675	100-Year Ult	960.00	542.00	547.11	547.09	547.60	0.013229	7.18	313.37	261.91	0.66
1	3850	10-Year	520.00	543.00	547.54		547.61	0.001485	2.34	327.57	237.59	0.22
1	3850	50-Year	740.00	543.00	547.99		548.06	0.001523	2.57	436.67	252.02	0.23
1	3850	100-Year	770.00	543.00	548.04		548.11	0.001540	2.61	449.31	254.47	0.23
1	3850	500-Year	970.00	543.00	548.17		548.27	0.002063	3.08	482.01	261.20	0.27
1	3850	100-Year Ult	960.00	543.00	548.15		548.26	0.002049	3.07	479.20	260.63	0.27
1	4116	10-Year	520.00	544.00	548.07		548.26	0.007296	4.54	190.44	157.16	0.47
1	4116	50-Year	740.00	544.00	548.47		548.67	0.006646	4.73	256.28	167.95	0.46
1	4116	100-Year	770.00	544.00	548.52		548.72	0.006591	4.76	264.60	169.16	0.46
1	4116	500-Year	970.00	544.00	548.77		548.99	0.006911	5.11	307.42	175.88	0.47
1	4116	100-Year Ult	960.00	544.00	548.76		548.98	0.006909	5.09	305.15	175.48	0.47
1	4285	10-Year	520.00	548.97	549.93	549.86	550.28	0.036758	4.72	110.18	126.54	0.89
1	4285	50-Year	740.00	548.97	550.11	550.08	550.59	0.040692	5.58	132.71	129.60	0.97
1	4285	100-Year	770.00	548.97	550.13	550.11	550.63	0.041383	5.70	135.26	129.91	0.98
1	4285	500-Year	970.00	548.97	550.33	550.29	550.89	0.036596	6.02	161.81	133.09	0.95
1	4285	100-Year Ult	960.00	548.97	550.32	550.28	550.88	0.036691	6.00	160.65	132.95	0.95
1	4829	10-Year	520.00	541.45	550.36		550.37	0.000026	0.48	1123.90	169.79	0.03

HEC-RAS Plan: Ten_Multi River: Ten Branch Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	4829	50-Year	740.00	541.45	550.73		550.73	0.000045	0.65	1185.61	171.57	0.04
1	4829	100-Year	770.00	541.45	550.77		550.78	0.000048	0.68	1193.72	171.80	0.04
1	4829	500-Year	970.00	541.45	551.07		551.08	0.000067	0.82	1245.21	173.27	0.05
1	4829	100-Year Ult	960.00	541.45	551.06		551.07	0.000066	0.81	1242.71	173.20	0.05
1	4955	10-Year	350.00	542.76	550.37		550.37	0.000045	0.55	670.14	125.23	0.04
1	4955	50-Year	490.00	542.76	550.73		550.74	0.000072	0.72	715.96	126.52	0.05
1	4955	100-Year	550.00	542.76	550.78		550.79	0.000088	0.80	721.91	126.68	0.06
1	4955	500-Year	690.00	542.76	551.08		551.09	0.000119	0.96	760.16	127.70	0.06
1	4955	100-Year Ult	660.00	542.76	551.06		551.08	0.000110	0.92	758.35	127.66	0.06
1	5088	10-Year	350.00	544.00	550.37		550.38	0.000158	0.84	414.43	91.77	0.07
1	5088	50-Year	490.00	544.00	550.74		550.76	0.000240	1.09	448.33	93.06	0.09
1	5088	100-Year	550.00	544.00	550.79		550.81	0.000292	1.22	452.89	93.24	0.10
1	5088	500-Year	690.00	544.00	551.09		551.12	0.000378	1.44	481.36	94.31	0.11
1	5088	100-Year Ult	660.00	544.00	551.08		551.11	0.000349	1.38	479.92	94.25	0.11
1	5152	10-Year	350.00	546.00	550.38		550.40	0.000428	1.17	299.83	87.08	0.11
1	5152	50-Year	490.00	546.00	550.75		550.79	0.000599	1.48	332.35	88.44	0.13
1	5152	100-Year	550.00	546.00	550.80		550.85	0.000722	1.64	336.91	88.63	0.15
1	5152	500-Year	690.00	546.00	551.11		551.17	0.000883	1.90	364.30	89.72	0.16
1	5152	100-Year Ult	660.00	546.00	551.09		551.15	0.000819	1.83	362.81	89.67	0.16
1	5286	10-Year	350.00	548.00	551.17	551.17	552.21	0.044887	8.15	43.04	22.11	1.01
1	5286	50-Year	490.00	548.00	551.73	551.73	552.96	0.039073	8.93	56.18	25.27	0.98
1	5286	100-Year	550.00	548.00	551.94	551.94	553.25	0.037547	9.22	61.71	26.46	0.97
1	5286	500-Year	690.00	548.00	552.41	552.41	553.88	0.034616	9.82	74.77	29.39	0.96
1	5286	100-Year Ult	660.00	548.00	552.31	552.31	553.75	0.035224	9.71	71.91	28.68	0.96
1	5350	10-Year	350.00	549.00	552.75		552.89	0.003983	3.01	116.16	42.02	0.32
1	5350	50-Year	490.00	549.00	553.45		553.62	0.003764	3.36	146.05	44.16	0.32
1	5350	100-Year	550.00	549.00	553.72		553.91	0.003673	3.49	158.11	45.00	0.32
1	5350	500-Year	690.00	549.00	554.30		554.52	0.003523	3.78	184.97	46.84	0.32
1	5350	100-Year Ult	660.00	549.00	554.18		554.40	0.003549	3.72	179.36	46.46	0.32
1	5362	10-Year	350.00	549.00	552.82		552.94	0.003189	2.78	125.79	43.21	0.29
1	5362	50-Year	490.00	549.00	553.51		553.67	0.003101	3.14	156.53	45.37	0.29
1	5362	100-Year	550.00	549.00	553.78		553.95	0.003059	3.27	168.92	46.22	0.29
1	5362	500-Year	690.00	549.00	554.37		554.57	0.002989	3.56	196.49	47.90	0.30
1	5362	100-Year Ult	660.00	549.00	554.25		554.44	0.003001	3.50	190.74	47.57	0.30

HEC-RAS Plan: Unid-Multi River: Unidentified Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	485	10-Year	340.00	522.17	523.34	523.18	523.58	0.020005	3.97	89.12	124.43	0.73
1	485	50-Year	480.00	522.17	523.53	523.39	523.84	0.020002	4.51	115.34	147.48	0.75
1	485	100-Year	540.00	522.17	523.60	523.49	523.93	0.020005	4.71	126.71	162.11	0.76
1	485	500-Year	670.00	522.17	523.75	523.63	524.12	0.020006	5.08	151.47	184.58	0.78
1	485	100-Year Ult	580.00	522.17	523.65	523.53	523.99	0.020007	4.83	134.39	171.46	0.77
1	648	10-Year	340.00	523.16	525.18	524.67	525.28	0.006301	2.66	133.60	125.98	0.43
1	648	50-Year	480.00	523.16	525.43		525.57	0.006493	3.06	167.51	148.73	0.45
1	648	100-Year	540.00	523.16	525.53		525.68	0.006621	3.23	183.24	176.51	0.46
1	648	500-Year	670.00	523.16	525.71		525.89	0.006763	3.51	217.72	201.44	0.47
1	648	100-Year Ult	580.00	523.16	525.58		525.75	0.006677	3.32	193.70	186.57	0.46
1	863	10-Year	340.00	524.58	527.30	527.12	527.54	0.019913	3.90	88.18	103.71	0.72
1	863	50-Year	480.00	524.58	527.53		527.82	0.018751	4.39	112.23	111.48	0.73
1	863	100-Year	540.00	524.58	527.62		527.94	0.018145	4.55	122.56	113.32	0.73
1	863	500-Year	670.00	524.58	527.79		528.16	0.017740	4.91	142.84	121.64	0.73
1	863	100-Year Ult	580.00	524.58	527.67		528.01	0.017972	4.66	128.92	115.75	0.73
1	1139	10-Year	340.00	529.97	532.18		532.58	0.016635	5.16	73.72	67.99	0.72
1	1139	50-Year	480.00	529.97	532.45		532.97	0.018397	6.03	92.89	75.45	0.78
1	1139	100-Year	540.00	529.97	532.54		533.12	0.019289	6.37	99.99	77.71	0.81
1	1139	500-Year	670.00	529.97	532.75	532.57	533.44	0.020436	7.02	117.55	92.63	0.85
1	1139	100-Year Ult	580.00	529.97	532.61	532.50	533.22	0.019657	6.58	105.17	80.58	0.82
1	1310	10-Year	340.00	531.78	533.73		533.81	0.003856	2.35	158.33	133.84	0.35
1	1310	50-Year	480.00	531.78	534.08		534.18	0.003558	2.61	207.81	152.93	0.34
1	1310	100-Year	540.00	531.78	534.23		534.33	0.003410	2.69	230.38	159.87	0.34
1	1310	500-Year	670.00	531.78	534.50		534.62	0.003184	2.85	275.83	169.99	0.34
1	1310	100-Year Ult	580.00	531.78	534.31		534.42	0.003343	2.75	244.22	161.61	0.34
1	1488	10-Year	240.00	532.79	535.30	535.30	535.78	0.026323	5.76	48.66	90.72	0.88
1	1488	50-Year	320.00	532.79	535.51	535.51	536.08	0.026690	6.37	59.76	93.18	0.91
1	1488	100-Year	360.00	532.79	535.61	535.61	536.22	0.026372	6.61	65.19	95.56	0.91
1	1488	500-Year	440.00	532.79	535.79	535.79	536.47	0.026248	7.07	75.03	103.90	0.93
1	1488	100-Year Ult	390.00	532.79	535.68	535.68	536.31	0.026456	6.80	68.85	100.71	0.92
1	1541	10-Year	240.00	533.64	536.26	535.80	536.72	0.012712	5.50	47.31	73.95	0.66
1	1541	50-Year	320.00	533.64	536.51	536.18	537.14	0.015177	6.47	56.76	94.13	0.73
1	1541	100-Year	360.00	533.64	536.63	536.37	537.32	0.016028	6.85	61.82	96.35	0.76
1	1541	500-Year	440.00	533.64	536.82	536.41	537.64	0.017665	7.56	70.99	100.53	0.81
1	1541	100-Year Ult	390.00	533.64	536.70	536.41	537.44	0.016660	7.12	65.37	97.96	0.78
1	1583	10-Year	240.00	534.85	537.10	537.10	537.69	0.034358	6.14	39.09	51.31	0.99
1	1583	50-Year	320.00	534.85	537.38	537.37	538.05	0.032084	6.56	48.84	59.06	0.98
1	1583	100-Year	360.00	534.85	537.52	537.48	538.22	0.029720	6.72	53.89	62.94	0.96
1	1583	500-Year	440.00	534.85	537.80	537.70	538.54	0.025239	6.92	64.90	80.96	0.91
1	1583	100-Year Ult	390.00	534.85	537.62	537.58	538.34	0.027845	6.80	57.96	68.85	0.94
1	1679	10-Year	240.00	536.95	539.03	538.56	539.21	0.008877	3.60	74.89	106.45	0.52
1	1679	50-Year	320.00	536.95	539.30	538.75	539.52	0.008595	3.97	90.88	114.83	0.53
1	1679	100-Year	360.00	536.95	539.42	538.84	539.65	0.008635	4.15	97.78	116.00	0.54
1	1679	500-Year	440.00	536.95	539.63	539.01	539.91	0.008792	4.51	110.42	118.02	0.55
1	1679	100-Year Ult	390.00	536.95	539.50	538.90	539.75	0.008702	4.29	102.62	116.82	0.54
1	1765	10-Year	240.00	537.49	539.87	539.75	540.09	0.011972	4.45	87.38	120.27	0.61
1	1765	50-Year	320.00	537.49	540.11	539.90	540.33	0.010523	4.57	113.74	124.21	0.59
1	1765	100-Year	360.00	537.49	540.23	539.97	540.44	0.009759	4.59	127.07	126.45	0.57
1	1765	500-Year	440.00	537.49	540.46	540.09	540.67	0.008598	4.63	152.54	128.44	0.55
1	1765	100-Year Ult	390.00	537.49	540.32	540.01	540.53	0.009271	4.60	136.81	127.25	0.56
1	2054	10-Year	240.00	544.31	547.63	547.63	548.67	0.026058	8.33	31.09	16.44	0.94
1	2054	50-Year	320.00	544.31	548.11	548.11	549.31	0.024181	9.04	39.40	18.33	0.93
1	2054	100-Year	360.00	544.31	548.34	548.34	549.60	0.023152	9.31	43.69	19.18	0.93
1	2054	500-Year	440.00	544.31	548.74	548.74	550.12	0.022148	9.85	51.57	20.54	0.92
1	2054	100-Year Ult	390.00	544.31	548.51	548.51	549.80	0.022350	9.47	46.98	19.76	0.92
1	2209	10-Year	240.00	544.97	549.19	546.43	549.21	0.000479	1.11	231.92	278.39	0.10
1	2209	50-Year	320.00	544.97	549.86	546.63	549.88	0.000443	1.19	289.15	295.41	0.10
1	2209	100-Year	360.00	544.97	550.15	546.73	550.17	0.000430	1.22	315.38	308.30	0.10
1	2209	500-Year	440.00	544.97	550.70	546.88	550.73	0.000414	1.29	366.05	323.28	0.10
1	2209	100-Year Ult	390.00	544.97	550.36	546.79	550.38	0.000424	1.25	334.25	314.17	0.10
1	2281	10-Year	240.00	545.41	549.21	545.99	549.22	0.000047	0.35	667.98	403.71	0.03
1	2281	50-Year	320.00	545.41	549.88	546.09	549.89	0.000046	0.38	802.64	413.37	0.03
1	2281	100-Year	360.00	545.41	550.18	546.12	550.18	0.000046	0.40	863.05	417.79	0.03
1	2281	500-Year	440.00	545.41	550.73	546.19	550.73	0.000046	0.43	977.57	423.26	0.03
1	2281	100-Year Ult	390.00	545.41	550.39	546.15	550.39	0.000046	0.42	906.23	420.13	0.03
1	2330	10-Year	150.00	544.51	549.22		549.22	0.000015	0.21	736.67	208.51	0.02

HEC-RAS Plan: Unid-Multi River: Unidentified Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	2330	50-Year	200.00	544.51	549.89		549.89	0.000015	0.24	880.01	218.57	0.02
1	2330	100-Year	220.00	544.51	550.19		550.19	0.000015	0.24	944.99	221.19	0.02
1	2330	500-Year	270.00	544.51	550.74		550.74	0.000015	0.26	1068.89	227.83	0.02
1	2330	100-Year Ult	240.00	544.51	550.39		550.40	0.000015	0.25	991.45	223.42	0.02
1	2475	10-Year	150.00	544.65	549.22		549.22	0.000069	0.45	364.47	128.02	0.04
1	2475	50-Year	200.00	544.65	549.89		549.90	0.000065	0.49	453.79	139.72	0.04
1	2475	100-Year	220.00	544.65	550.19		550.19	0.000061	0.49	495.47	142.65	0.04
1	2475	500-Year	270.00	544.65	550.74		550.74	0.000059	0.52	576.21	150.95	0.04
1	2475	100-Year Ult	240.00	544.65	550.40		550.40	0.000060	0.50	525.49	144.61	0.04
1	2697	10-Year	150.00	545.89	549.24		549.27	0.000814	1.55	110.83	62.74	0.17
1	2697	50-Year	200.00	545.89	549.90		549.94	0.000567	1.52	155.57	71.19	0.15
1	2697	100-Year	220.00	545.89	550.20		550.23	0.000488	1.49	177.66	82.73	0.14
1	2697	500-Year	270.00	545.89	550.75		550.78	0.000401	1.49	235.51	115.77	0.13
1	2697	100-Year Ult	240.00	545.89	550.41		550.44	0.000455	1.50	197.39	102.98	0.14
1	2796	10-Year	150.00	551.45	552.65	552.65	552.91	0.027434	4.29	40.50	76.41	0.84
1	2796	50-Year	200.00	551.45	552.76	552.76	553.07	0.028548	4.77	49.44	81.34	0.87
1	2796	100-Year	220.00	551.45	552.81	552.81	553.13	0.028362	4.91	53.12	82.71	0.88
1	2796	500-Year	270.00	551.45	552.91	552.91	553.26	0.028496	5.25	61.34	84.96	0.89
1	2796	100-Year Ult	240.00	551.45	552.84	552.84	553.18	0.029066	5.09	56.02	83.35	0.89
1	3054	10-Year	150.00	558.34	559.28		559.53	0.024166	4.07	38.33	52.37	0.79
1	3054	50-Year	200.00	558.34	559.44		559.74	0.023602	4.51	46.79	56.22	0.80
1	3054	100-Year	220.00	558.34	559.49		559.82	0.023903	4.70	49.65	56.80	0.81
1	3054	500-Year	270.00	558.34	559.61		559.99	0.024080	5.08	56.79	58.53	0.83
1	3054	100-Year Ult	240.00	558.34	559.54		559.89	0.023480	4.83	52.92	57.47	0.81
1	3252	10-Year	30.00	561.57	563.07		563.13	0.006520	2.01	15.10	22.51	0.40
1	3252	50-Year	40.00	561.57	563.21		563.29	0.006532	2.25	18.48	25.35	0.41
1	3252	100-Year	50.00	561.57	563.30		563.40	0.007181	2.52	20.94	26.38	0.44
1	3252	500-Year	60.00	561.57	563.43		563.54	0.006658	2.63	24.49	27.79	0.43
1	3252	100-Year Ult	50.00	561.57	563.32		563.42	0.006681	2.46	21.48	26.60	0.43
1	3441	10-Year	30.00	569.09	569.58	569.58	569.74	0.055025	3.19	9.41	30.36	1.01
1	3441	50-Year	40.00	569.09	569.65	569.65	569.83	0.049789	3.45	11.62	32.28	0.99
1	3441	100-Year	50.00	569.09	569.71	569.71	569.92	0.047406	3.71	13.61	34.84	0.99
1	3441	500-Year	60.00	569.09	569.78	569.78	570.00	0.040336	3.79	16.35	40.74	0.94
1	3441	100-Year Ult	50.00	569.09	569.71	569.71	569.92	0.047406	3.71	13.61	34.84	0.99
1	3582	10-Year	30.00	572.06	573.59	573.37	573.83	0.017559	3.93	7.99	9.41	0.68
1	3582	50-Year	40.00	572.06	573.74	573.55	574.05	0.019421	4.51	9.46	10.17	0.73
1	3582	100-Year	50.00	572.06	573.87	573.71	574.25	0.020925	5.02	10.82	10.82	0.77
1	3582	500-Year	60.00	572.06	573.96	573.86	574.42	0.024138	5.61	11.73	11.24	0.83
1	3582	100-Year Ult	50.00	572.06	573.87	573.71	574.25	0.020925	5.02	10.82	10.82	0.77
1	3771	10-Year	30.00	584.26	584.98	584.98	585.21	0.049223	3.84	7.81	17.61	1.01
1	3771	50-Year	40.00	584.26	585.08	585.08	585.35	0.045832	4.16	9.68	19.82	1.00
1	3771	100-Year	50.00	584.26	585.19	585.19	585.48	0.039422	4.34	11.88	23.37	0.96
1	3771	500-Year	60.00	584.26	585.27	585.27	585.59	0.036731	4.55	13.90	24.87	0.95
1	3771	100-Year Ult	50.00	584.26	585.19	585.19	585.48	0.039422	4.34	11.88	23.37	0.96

HEC-RAS Plan: Webb_Multi River: Webb Reach: Webb

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Webb	1405	10-Year	790.00	518.96	521.47	520.83	521.72	0.008010	4.01	210.39	134.20	0.52
Webb	1405	50-Year	1160.00	518.96	521.93	521.20	522.25	0.008013	4.65	275.06	144.46	0.54
Webb	1405	100-Year	1350.00	518.96	522.15	521.37	522.52	0.008004	4.94	308.91	170.48	0.55
Webb	1405	500-Year	1790.00	518.96	522.58	521.72	523.02	0.008013	5.49	388.21	193.10	0.56
Webb	1405	100-Year Ult	1600.00	518.96	522.41	521.55	522.82	0.008001	5.27	355.02	187.65	0.56
Webb	1719	10-Year	790.00	521.48	524.27		524.53	0.010184	4.65	245.57	169.10	0.59
Webb	1719	50-Year	1160.00	521.48	524.72		525.05	0.010034	5.30	324.67	182.90	0.60
Webb	1719	100-Year	1350.00	521.48	524.93		525.28	0.009839	5.55	363.24	186.53	0.61
Webb	1719	500-Year	1790.00	521.48	525.35		525.77	0.009730	6.11	444.77	196.70	0.62
Webb	1719	100-Year Ult	1600.00	521.48	525.18		525.56	0.009725	5.87	410.17	190.80	0.61
Webb	2033	10-Year	460.00	522.76	526.42		526.53	0.003494	3.37	194.63	115.21	0.36
Webb	2033	50-Year	700.00	522.76	526.92		527.07	0.003678	3.87	254.89	125.13	0.38
Webb	2033	100-Year	820.00	522.76	527.15		527.31	0.003777	4.11	283.71	132.12	0.39
Webb	2033	500-Year	1090.00	522.76	527.62		527.81	0.003859	4.52	349.38	148.19	0.40
Webb	2033	100-Year Ult	930.00	522.76	527.40		527.56	0.003594	4.20	317.24	138.48	0.39
Webb	2065	10-Year	460.00	522.80	526.41		526.79	0.009871	5.13	102.30	70.45	0.59
Webb	2065	50-Year	700.00	522.80	526.84		527.38	0.011571	6.22	139.48	97.34	0.66
Webb	2065	100-Year	820.00	522.80	527.06		527.63	0.011309	6.48	161.75	106.77	0.66
Webb	2065	500-Year	1090.00	522.80	527.55		528.12	0.010093	6.76	217.27	119.25	0.64
Webb	2065	100-Year Ult	930.00	522.80	527.31		527.86	0.010314	6.52	189.29	116.49	0.64
Webb	2243	10-Year	460.00	523.80	527.61		527.77	0.003409	3.26	141.15	53.98	0.36
Webb	2243	50-Year	700.00	523.80	528.32		528.55	0.004022	3.82	189.18	108.36	0.39
Webb	2243	100-Year	820.00	523.80	528.55		528.81	0.004221	4.11	215.64	119.11	0.41
Webb	2243	500-Year	1090.00	523.80	528.99		529.32	0.004651	4.70	269.68	132.33	0.44
Webb	2243	100-Year Ult	930.00	523.80	528.74		529.03	0.004393	4.36	238.38	122.84	0.42
Webb	2259	10-Year	460.00	523.88	527.71		527.83	0.002998	2.75	167.36	75.07	0.32
Webb	2259	50-Year	700.00	523.88	528.46		528.61	0.002747	3.08	232.15	100.49	0.32
Webb	2259	100-Year	820.00	523.88	528.71		528.88	0.002836	3.31	258.44	123.61	0.33
Webb	2259	500-Year	1090.00	523.88	529.17		529.39	0.003032	3.76	321.21	139.94	0.35
Webb	2259	100-Year Ult	930.00	523.88	528.91		529.10	0.002918	3.50	284.78	134.59	0.34
Webb	2607	10-Year	460.00	527.48	529.77		530.09	0.021212	4.67	110.35	93.09	0.68
Webb	2607	50-Year	700.00	527.48	530.25		530.63	0.017693	5.15	156.70	97.80	0.65
Webb	2607	100-Year	820.00	527.48	530.49		530.89	0.016094	5.30	180.41	100.47	0.63
Webb	2607	500-Year	1090.00	527.48	530.97		531.42	0.014113	5.66	230.17	107.31	0.61
Webb	2607	100-Year Ult	930.00	527.48	530.70		531.12	0.015096	5.45	201.26	103.42	0.62
Webb	2722	10-Year	290.00	528.11	531.31		531.44	0.005744	3.08	124.46	89.57	0.37
Webb	2722	50-Year	470.00	528.11	531.78		531.97	0.006775	3.82	169.40	101.95	0.42
Webb	2722	100-Year	560.00	528.11	531.98		532.19	0.007136	4.12	190.00	105.90	0.43
Webb	2722	500-Year	760.00	528.11	532.40		532.66	0.007480	4.63	239.02	125.60	0.46
Webb	2722	100-Year Ult	670.00	528.11	532.17		532.42	0.007846	4.52	210.79	116.32	0.46
Webb	2911	10-Year	290.00	528.72	532.00		532.07	0.002115	2.06	141.02	57.84	0.23
Webb	2911	50-Year	470.00	528.72	532.62		532.73	0.002635	2.65	178.56	62.68	0.27
Webb	2911	100-Year	560.00	528.72	532.88		533.01	0.002844	2.91	194.95	64.48	0.28
Webb	2911	500-Year	760.00	528.72	533.39		533.56	0.003232	3.40	228.31	68.11	0.31
Webb	2911	100-Year Ult	670.00	528.72	533.16		533.32	0.003092	3.20	213.21	66.42	0.30
Webb	3045	10-Year	290.00	529.82	532.32		532.39	0.002710	2.01	144.18	73.63	0.25
Webb	3045	50-Year	470.00	529.82	533.00		533.09	0.002654	2.42	195.23	77.55	0.26
Webb	3045	100-Year	560.00	529.82	533.28		533.38	0.002675	2.60	217.31	79.31	0.27
Webb	3045	500-Year	760.00	529.82	533.83		533.97	0.002738	2.95	262.02	83.21	0.28
Webb	3045	100-Year Ult	670.00	529.82	533.59		533.71	0.002722	2.80	242.11	81.23	0.28

HEC-RAS Plan: WSoapMultiP River: West_Soap Reach: West_Soap

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
West_Soap	437	2Year	570.00	569.70	575.09	573.37	575.36	0.003005	4.40	197.97	181.51	0.39
West_Soap	437	5-Year	1610.00	569.70	576.68	575.98	576.95	0.003005	5.50	707.27	502.20	0.41
West_Soap	437	10-Year	2400.00	569.70	577.27	576.62	577.53	0.003001	5.88	1022.81	558.11	0.42
West_Soap	437	25-Year	3420.00	569.70	577.83	577.07	578.09	0.003000	6.23	1343.42	576.21	0.42
West_Soap	437	50-Year	4300.00	569.70	578.26	577.35	578.52	0.003001	6.49	1598.90	611.81	0.43
West_Soap	437	100-Year	5200.00	569.70	578.64	577.59	578.90	0.003002	6.72	1834.12	634.41	0.43
West_Soap	437	500-Year	7400.00	569.70	579.44	578.04	579.71	0.003002	7.19	2356.99	678.84	0.44
West_Soap	437	100-Year_Ult	8200.00	569.70	579.70	578.16	579.98	0.003000	7.33	2535.74	700.99	0.44
West_Soap	1304	2Year	570.00	570.50	576.63		576.71	0.001015	2.53	317.41	156.99	0.23
West_Soap	1304	5-Year	1610.00	570.50	578.37		578.56	0.001640	4.11	648.12	233.05	0.31
West_Soap	1304	10-Year	2400.00	570.50	579.05		579.31	0.002117	5.04	823.38	277.02	0.35
West_Soap	1304	25-Year	3420.00	570.50	579.70		580.05	0.002599	5.97	1018.88	318.19	0.40
West_Soap	1304	50-Year	4300.00	570.50	580.17		580.58	0.002895	6.58	1170.74	328.02	0.42
West_Soap	1304	100-Year	5200.00	570.50	580.59		581.05	0.003177	7.14	1310.86	343.14	0.45
West_Soap	1304	500-Year	7400.00	570.50	581.44		582.03	0.003758	8.32	1620.41	378.55	0.50
West_Soap	1304	100-Year_Ult	8200.00	570.50	581.72		582.35	0.003945	8.70	1726.55	395.55	0.51
West_Soap	2047	2Year	570.00	571.67	577.29		577.34	0.000949	2.29	421.77	269.43	0.22
West_Soap	2047	5-Year	1610.00	571.67	579.11		579.17	0.000747	2.70	1001.22	353.62	0.21
West_Soap	2047	10-Year	2400.00	571.67	579.92		579.99	0.000798	3.06	1293.17	369.54	0.22
West_Soap	2047	25-Year	3420.00	571.67	580.72		580.81	0.000886	3.50	1593.04	383.83	0.24
West_Soap	2047	50-Year	4300.00	571.67	581.28		581.39	0.000961	3.85	1813.82	396.20	0.25
West_Soap	2047	100-Year	5200.00	571.67	581.79		581.92	0.001032	4.16	2018.08	405.04	0.26
West_Soap	2047	500-Year	7400.00	571.67	582.84		583.01	0.001173	4.82	2453.31	421.79	0.28
West_Soap	2047	100-Year_Ult	8200.00	571.67	583.18		583.37	0.001217	5.03	2597.36	430.35	0.29
West_Soap	2976	2Year	570.00	573.44	578.44		578.60	0.004298	4.08	262.00	294.74	0.43
West_Soap	2976	5-Year	1610.00	573.44	579.81		579.93	0.002631	4.16	749.16	401.18	0.36
West_Soap	2976	10-Year	2400.00	573.44	580.58		580.69	0.002155	4.22	1066.76	424.62	0.33
West_Soap	2976	25-Year	3420.00	573.44	581.38		581.50	0.001952	4.44	1425.01	465.30	0.33
West_Soap	2976	50-Year	4300.00	573.44	581.96		582.09	0.001844	4.60	1698.99	483.18	0.32
West_Soap	2976	100-Year	5200.00	573.44	582.49		582.62	0.001765	4.75	1954.72	493.04	0.32
West_Soap	2976	500-Year	7400.00	573.44	583.58		583.75	0.001720	5.18	2517.77	529.86	0.32
West_Soap	2976	100-Year_Ult	8200.00	573.44	583.94		584.11	0.001697	5.29	2704.88	535.61	0.32
West_Soap	3876	2Year	570.00	575.91	580.41		580.50	0.001813	3.30	380.37	224.78	0.30
West_Soap	3876	5-Year	1610.00	575.91	581.63		581.82	0.003363	5.42	682.04	307.65	0.43
West_Soap	3876	10-Year	2400.00	575.91	582.26		582.53	0.004226	6.58	890.43	336.36	0.49
West_Soap	3876	25-Year	3420.00	575.91	582.95		583.26	0.004516	7.35	1125.24	353.37	0.52
West_Soap	3876	50-Year	4300.00	575.91	583.46		583.82	0.004787	7.97	1313.23	386.10	0.54
West_Soap	3876	100-Year	5200.00	575.91	583.94		584.32	0.005018	8.54	1500.87	405.67	0.56
West_Soap	3876	500-Year	7400.00	575.91	584.98		585.43	0.005174	9.48	1973.55	475.68	0.58
West_Soap	3876	100-Year_Ult	8200.00	575.91	585.31		585.76	0.005122	9.68	2129.51	487.56	0.58
West_Soap	5788	2Year	570.00	577.96	582.29		582.34	0.001692	2.99	499.90	330.13	0.28
West_Soap	5788	5-Year	1610.00	577.96	583.82		583.88	0.001621	3.73	1048.35	378.97	0.29
West_Soap	5788	10-Year	2400.00	577.96	584.63		584.71	0.001615	4.11	1358.48	393.56	0.30
West_Soap	5788	25-Year	3420.00	577.96	585.41		585.50	0.001747	4.65	1683.52	433.08	0.32
West_Soap	5788	50-Year	4300.00	577.96	586.00		586.10	0.001808	5.01	1952.15	476.45	0.33
West_Soap	5788	100-Year	5200.00	577.96	586.53		586.65	0.001852	5.31	2211.07	501.66	0.34
West_Soap	5788	500-Year	7400.00	577.96	587.62		587.77	0.001934	5.93	2794.51	553.13	0.35
West_Soap	5788	100-Year_Ult	8200.00	577.96	587.95		588.10	0.001986	6.16	2978.50	588.02	0.36
West_Soap	6601	2Year	570.00	577.00	583.35		583.42	0.001514	2.65	341.07	158.88	0.26
West_Soap	6601	5-Year	1610.00	577.00	584.84		584.96	0.001853	3.79	938.14	587.49	0.31
West_Soap	6601	10-Year	2400.00	577.00	585.55		585.65	0.001627	3.90	1373.86	646.59	0.30
West_Soap	6601	25-Year	3420.00	577.00	586.29		586.39	0.001478	4.05	1878.04	714.87	0.29
West_Soap	6601	50-Year	4300.00	577.00	586.84		586.94	0.001342	4.09	2283.85	747.29	0.28
West_Soap	6601	100-Year	5200.00	577.00	587.35		587.44	0.001241	4.13	2666.22	769.41	0.27
West_Soap	6601	500-Year	7400.00	577.00	588.41		588.51	0.001118	4.30	3508.05	811.00	0.26
West_Soap	6601	100-Year_Ult	8200.00	577.00	588.73		588.84	0.001101	4.38	3775.81	825.52	0.26
West_Soap	6685	2Year	700.00	578.20	583.50		583.55	0.001323	2.38	548.65	288.25	0.25
West_Soap	6685	5-Year	1720.00	578.20	585.03		585.10	0.001374	3.22	1060.79	427.25	0.27
West_Soap	6685	10-Year	2400.00	578.20	585.69		585.78	0.001431	3.61	1372.51	534.00	0.28
West_Soap	6685	25-Year	3400.00	578.20	586.41		586.51	0.001545	4.09	1784.07	625.32	0.30
West_Soap	6685	50-Year	4100.00	578.20	586.95		587.06	0.001450	4.20	2147.95	694.23	0.29
West_Soap	6685	100-Year	4700.00	578.20	587.45		587.55	0.001299	4.18	2500.63	722.69	0.28
West_Soap	6685	500-Year	6500.00	578.20	588.50		588.60	0.001261	4.53	3288.06	771.47	0.28
West_Soap	6685	100-Year_Ult	7500.00	578.20	588.82		588.94	0.001357	4.83	3541.68	785.63	0.30
West_Soap	6727		Culvert									
West_Soap	6756	2Year	700.00	578.20	583.92	583.32	583.99	0.002956	3.43	514.15	423.58	0.35
West_Soap	6756	5-Year	1720.00	578.20	585.03	583.81	585.11	0.002642	4.02	1010.90	460.76	0.35
West_Soap	6756	10-Year	2400.00	578.20	585.73	584.13	585.81	0.002262	4.14	1342.06	488.41	0.34
West_Soap	6756	25-Year	3400.00	578.20	586.47	584.44	586.56	0.002209	4.50	1704.91	506.71	0.34
West_Soap	6756	50-Year	4100.00	578.20	587.01	584.62	587.10	0.002061	4.63	1983.66	525.08	0.33
West_Soap	6756	100-Year	4700.00	578.20	587.50	584.76	587.59	0.001848	4.62	2242.94	532.15	0.32
West_Soap	6756	500-Year	6500.00	578.20	588.54	585.16	588.65	0.001856	5.11	2825.54	603.31	0.33

HEC-RAS Plan: WSoapMultiP River: West_Soap Reach: West_Soap (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
West_Soap	6756	100-Year_Ult	7500.00	578.20	588.92	585.36	589.05	0.001950	5.41	3056.81	616.43	0.34
West_Soap	6806	2Year	700.00	580.16	584.09		584.13	0.002397	2.64	638.55	525.85	0.31
West_Soap	6806	5-Year	1720.00	580.16	585.18		585.22	0.001890	3.06	1216.65	536.37	0.30
West_Soap	6806	10-Year	2400.00	580.16	585.86		585.91	0.001585	3.18	1587.98	547.50	0.28
West_Soap	6806	25-Year	3400.00	580.16	586.60		586.65	0.001542	3.51	1991.02	554.90	0.29
West_Soap	6806	50-Year	4100.00	580.16	587.13		587.19	0.001441	3.65	2288.28	561.35	0.28
West_Soap	6806	100-Year	4700.00	580.16	587.61		587.67	0.001331	3.72	2558.89	568.06	0.27
West_Soap	6806	500-Year	6500.00	580.16	588.66		588.74	0.001311	4.13	3165.15	585.07	0.28
West_Soap	6806	100-Year_Ult	7500.00	580.16	589.04		589.13	0.001407	4.44	3390.87	591.59	0.29
West_Soap	7690	2Year	700.00	582.71	585.71		585.74	0.002112	2.80	596.23	383.85	0.31
West_Soap	7690	5-Year	1720.00	582.71	586.73		586.80	0.002587	3.88	1002.23	417.02	0.36
West_Soap	7690	10-Year	2400.00	582.71	587.31		587.39	0.002767	4.44	1252.76	454.68	0.39
West_Soap	7690	25-Year	3400.00	582.71	588.00		588.10	0.002737	4.90	1573.64	468.40	0.39
West_Soap	7690	50-Year	4100.00	582.71	588.47		588.57	0.002715	5.19	1796.47	488.53	0.40
West_Soap	7690	100-Year	4700.00	582.71	588.86		588.97	0.002594	5.32	1987.63	493.43	0.39
West_Soap	7690	500-Year	6500.00	582.71	589.87		590.00	0.002495	5.82	2502.36	531.17	0.40
West_Soap	7690	100-Year_Ult	7500.00	582.71	590.33		590.48	0.002620	6.23	2754.21	556.04	0.41
West_Soap	8050	2Year	700.00	585.67	587.00		587.05	0.007781	2.99	397.95	464.08	0.52
West_Soap	8050	5-Year	1720.00	585.67	587.93		588.00	0.004621	3.53	867.00	509.24	0.44
West_Soap	8050	10-Year	2400.00	585.67	588.46		588.54	0.003825	3.75	1133.82	512.81	0.42
West_Soap	8050	25-Year	3400.00	585.67	589.09		589.18	0.003419	4.12	1458.27	516.40	0.41
West_Soap	8050	50-Year	4100.00	585.67	589.51		589.62	0.003159	4.32	1678.52	518.81	0.40
West_Soap	8050	100-Year	4700.00	585.67	589.85		589.97	0.003020	4.48	1856.63	526.39	0.40
West_Soap	8050	500-Year	6500.00	585.67	590.80		590.93	0.002731	4.93	2365.24	545.09	0.39
West_Soap	8050	100-Year_Ult	7500.00	585.67	591.27		591.41	0.002626	5.14	2623.54	551.36	0.39
West_Soap	9617	2Year	700.00	588.37	590.06		590.08	0.002243	1.84	590.44	382.84	0.29
West_Soap	9617	5-Year	1720.00	588.37	590.97		591.03	0.003091	3.09	970.65	444.61	0.37
West_Soap	9617	10-Year	2400.00	588.37	591.42		591.50	0.003489	3.72	1181.26	484.34	0.40
West_Soap	9617	25-Year	3400.00	588.37	591.98		592.09	0.003721	4.36	1466.78	543.66	0.43
West_Soap	9617	50-Year	4100.00	588.37	592.33		592.46	0.003854	4.76	1673.31	604.26	0.45
West_Soap	9617	100-Year	4700.00	588.37	592.60		592.73	0.003842	4.99	1836.42	629.53	0.45
West_Soap	9617	500-Year	6500.00	588.37	593.40		593.57	0.003868	5.69	2370.64	698.68	0.47
West_Soap	9617	100-Year_Ult	7500.00	588.37	593.78		593.95	0.003740	5.89	2635.36	719.54	0.46
West_Soap	10740	2Year	700.00	589.18	591.90		591.93	0.002805	2.71	631.29	554.53	0.34
West_Soap	10740	5-Year	1720.00	589.18	592.92		592.96	0.002257	3.19	1240.08	629.88	0.32
West_Soap	10740	10-Year	2400.00	589.18	593.43		593.48	0.002129	3.45	1568.27	645.48	0.32
West_Soap	10740	25-Year	3400.00	589.18	594.07		594.12	0.002127	3.84	1991.22	685.82	0.33
West_Soap	10740	50-Year	4100.00	589.18	594.45		594.52	0.002117	4.07	2261.74	722.44	0.34
West_Soap	10740	100-Year	4700.00	589.18	594.73		594.80	0.002141	4.25	2468.16	751.90	0.34
West_Soap	10740	500-Year	6500.00	589.18	595.56		595.64	0.002136	4.72	3109.33	797.38	0.35
West_Soap	10740	100-Year_Ult	7500.00	589.18	595.93		596.02	0.002197	4.99	3413.74	834.24	0.36
West_Soap	11782	2Year	700.00	591.35	593.42		593.45	0.004534	2.72	517.18	533.70	0.40
West_Soap	11782	5-Year	1720.00	591.35	594.18		594.23	0.004221	3.47	1001.20	686.72	0.41
West_Soap	11782	10-Year	2400.00	591.35	594.59		594.65	0.003794	3.69	1296.01	750.62	0.40
West_Soap	11782	25-Year	3400.00	591.35	595.14		595.20	0.003194	3.84	1717.63	787.07	0.38
West_Soap	11782	50-Year	4100.00	591.35	595.48		595.55	0.002950	3.95	1995.96	832.01	0.37
West_Soap	11782	100-Year	4700.00	591.35	595.74		595.82	0.002806	4.04	2216.11	857.84	0.37
West_Soap	11782	500-Year	6500.00	591.35	596.49		596.58	0.002397	4.21	2890.41	944.77	0.35
West_Soap	11782	100-Year_Ult	7500.00	591.35	596.85		596.94	0.002253	4.30	3236.60	975.95	0.34
West_Soap	11991	2Year	700.00	591.22	594.02		594.05	0.002289	2.38	666.84	702.38	0.30
West_Soap	11991	5-Year	1720.00	591.22	594.77		594.81	0.002310	2.99	1224.80	770.92	0.32
West_Soap	11991	10-Year	2400.00	591.22	595.16		595.20	0.002290	3.26	1525.38	793.66	0.33
West_Soap	11991	25-Year	3400.00	591.22	595.65		595.70	0.002218	3.55	1927.27	834.04	0.33
West_Soap	11991	50-Year	4100.00	591.22	595.97		596.03	0.002139	3.69	2195.20	869.19	0.33
West_Soap	11991	100-Year	4700.00	591.22	596.22		596.29	0.002177	3.88	2423.47	926.17	0.34
West_Soap	11991	500-Year	6500.00	591.22	596.92		596.99	0.002021	4.15	3099.13	1002.62	0.33
West_Soap	11991	100-Year_Ult	7500.00	591.22	597.26		597.34	0.001946	4.27	3446.15	1031.18	0.33
West_Soap	12090	2Year	700.00	591.03	594.20		594.21	0.001162	1.95	792.65	565.98	0.22
West_Soap	12090	5-Year	1720.00	591.03	594.98		595.01	0.001654	2.82	1300.21	742.52	0.28
West_Soap	12090	10-Year	2400.00	591.03	595.37		595.41	0.001783	3.16	1599.54	786.54	0.30
West_Soap	12090	25-Year	3400.00	591.03	595.86		595.92	0.001876	3.54	1998.43	832.45	0.31
West_Soap	12090	50-Year	4100.00	591.03	596.18		596.24	0.001886	3.73	2261.67	855.84	0.32
West_Soap	12090	100-Year	4700.00	591.03	596.43		596.49	0.001860	3.85	2480.54	866.77	0.32
West_Soap	12090	500-Year	6500.00	591.03	597.12		597.19	0.001828	4.19	3101.60	929.34	0.32
West_Soap	12090	100-Year_Ult	7500.00	591.03	597.45		597.54	0.001816	4.35	3415.75	948.58	0.32
West_Soap	12117		Culvert									
West_Soap	12169	2Year	700.00	591.66	595.70	593.52	595.70	0.000147	0.91	1412.32	696.47	0.09
West_Soap	12169	5-Year	1720.00	591.66	596.40	594.02	596.42	0.000348	1.58	1917.36	737.27	0.14
West_Soap	12169	10-Year	2400.00	591.66	596.78	594.19	596.80	0.000449	1.90	2199.47	762.21	0.16
West_Soap	12169	25-Year	3400.00	591.66	597.23	594.47	597.26	0.000563	2.27	2549.70	774.47	0.18
West_Soap	12169	50-Year	4100.00	591.66	597.49	594.64	597.53	0.000650	2.52	2750.05	787.55	0.19

HEC-RAS Plan: WSoapMultiP River: West_Soap Reach: West_Soap (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
West_Soap	12169	100-Year	4700.00	591.66	597.66	594.76	597.71	0.000738	2.75	2886.90	797.49	0.21
West_Soap	12169	500-Year	6500.00	591.66	598.21	595.14	598.27	0.000935	3.29	3335.39	848.42	0.24
West_Soap	12169	100-Year_Ult	7500.00	591.66	598.45	595.25	598.53	0.001050	3.59	3548.25	874.91	0.25
West_Soap	12230	2Year	700.00	590.48	595.71		595.71	0.000145	0.91	1410.80	689.95	0.08
West_Soap	12230	5-Year	1720.00	590.48	596.42		596.44	0.000335	1.56	1916.87	717.06	0.13
West_Soap	12230	10-Year	2400.00	590.48	596.81		596.83	0.000427	1.86	2192.24	728.80	0.15
West_Soap	12230	25-Year	3400.00	590.48	597.27		597.30	0.000544	2.24	2532.68	746.87	0.17
West_Soap	12230	50-Year	4100.00	590.48	597.53		597.57	0.000629	2.49	2730.63	759.05	0.19
West_Soap	12230	100-Year	4700.00	590.48	597.71		597.75	0.000711	2.70	2866.02	764.41	0.20
West_Soap	12230	500-Year	6500.00	590.48	598.26		598.33	0.000881	3.20	3294.52	781.86	0.23
West_Soap	12230	100-Year_Ult	7500.00	590.48	598.52		598.59	0.000986	3.48	3494.84	795.45	0.24
West_Soap	13150	2Year	700.00	591.27	595.80		595.80	0.000072	0.57	1584.62	703.01	0.06
West_Soap	13150	5-Year	1720.00	591.27	596.64		596.65	0.000156	0.99	2182.05	724.73	0.09
West_Soap	13150	10-Year	2400.00	591.27	597.07		597.09	0.000196	1.19	2500.03	730.26	0.10
West_Soap	13150	25-Year	3400.00	591.27	597.61		597.63	0.000247	1.44	2892.94	740.55	0.12
West_Soap	13150	50-Year	4100.00	591.27	597.92		597.95	0.000281	1.60	3125.25	747.34	0.12
West_Soap	13150	100-Year	4700.00	591.27	598.14		598.18	0.000312	1.74	3293.91	750.96	0.13
West_Soap	13150	500-Year	6500.00	591.27	598.80		598.85	0.000381	2.07	3790.69	761.53	0.15
West_Soap	13150	100-Year_Ult	7500.00	591.27	599.11		599.17	0.000418	2.24	4029.02	765.27	0.16
West_Soap	13860	2Year	700.00	592.55	595.80		596.05	0.011483	5.44	228.09	324.03	0.68
West_Soap	13860	5-Year	1720.00	592.55	596.84		597.00	0.004518	4.54	607.97	394.95	0.46
West_Soap	13860	10-Year	2400.00	592.55	597.33		597.49	0.003825	4.62	807.09	418.64	0.43
West_Soap	13860	25-Year	3400.00	592.55	597.92		598.10	0.003476	4.88	1065.72	455.64	0.43
West_Soap	13860	50-Year	4100.00	592.55	598.27		598.46	0.003294	5.02	1225.40	465.18	0.42
West_Soap	13860	100-Year	4700.00	592.55	598.53		598.73	0.003243	5.17	1345.36	477.42	0.42
West_Soap	13860	500-Year	6500.00	592.55	599.25		599.49	0.003113	5.57	1720.13	569.08	0.42
West_Soap	13860	100-Year_Ult	7500.00	592.55	599.59		599.84	0.003041	5.74	1923.13	605.22	0.42
West_Soap	14620	2Year	700.00	591.74	598.74	597.96	598.85	0.001742	3.71	448.99	456.36	0.29
West_Soap	14620	5-Year	1720.00	591.74	599.49	598.92	599.65	0.002717	5.09	853.90	575.83	0.38
West_Soap	14620	10-Year	2400.00	591.74	599.86	599.20	600.02	0.002865	5.45	1069.93	593.00	0.39
West_Soap	14620	25-Year	3400.00	591.74	600.36	599.55	600.53	0.002879	5.76	1377.19	628.43	0.40
West_Soap	14620	50-Year	4100.00	591.74	600.66	599.67	600.83	0.002895	5.95	1569.67	652.93	0.40
West_Soap	14620	100-Year	4700.00	591.74	600.91	599.82	601.08	0.002883	6.08	1729.92	663.38	0.40
West_Soap	14620	500-Year	6500.00	591.74	601.59		601.78	0.002850	6.42	2196.82	716.43	0.41
West_Soap	14620	100-Year_Ult	7500.00	591.74	601.90		602.10	0.002822	6.56	2422.74	725.65	0.41
West_Soap	15315	2Year	700.00	593.05	599.92		600.10	0.001873	4.11	311.41	261.80	0.32
West_Soap	15315	5-Year	1720.00	593.05	601.09		601.27	0.002133	5.02	697.97	396.48	0.35
West_Soap	15315	10-Year	2400.00	593.05	601.57		601.77	0.002332	5.51	899.79	441.80	0.37
West_Soap	15315	25-Year	3400.00	593.05	602.12		602.34	0.002495	6.01	1157.89	492.00	0.39
West_Soap	15315	50-Year	4100.00	593.05	602.44		602.67	0.002549	6.24	1319.00	514.85	0.40
West_Soap	15315	100-Year	4700.00	593.05	602.69		602.94	0.002595	6.44	1452.68	542.80	0.40
West_Soap	15315	500-Year	6500.00	593.05	603.41		603.68	0.002767	7.04	1873.79	632.34	0.42
West_Soap	15315	100-Year_Ult	7500.00	593.05	603.72		604.01	0.002813	7.27	2077.77	661.79	0.43

Existing vs. Ultimate 100-Year Water Surface Elevation Comparisons

HEC-RAS Plan: WSComp River: Bedford_Reach Reach: Main_Reach

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Main_Reach	4353	100YR	537.21	
Main_Reach	4353	100YR ULT	538.01	0.79
Main_Reach	5404	100YR	539.09	
Main_Reach	5404	100YR ULT	539.92	0.82
Main_Reach	6026	100YR	540.42	
Main_Reach	6026	100YR ULT	541.27	0.85
Main_Reach	6731	100YR	541.78	
Main_Reach	6731	100YR ULT	542.52	0.75
Main_Reach	7347	100YR	543.09	
Main_Reach	7347	100YR ULT	543.81	0.72
Main_Reach	8034	100YR	545.12	
Main_Reach	8034	100YR ULT	545.90	0.78
Main_Reach	8255	100YR	546.53	
Main_Reach	8255	100YR ULT	547.21	0.68
Main_Reach	8815	100YR	547.23	
Main_Reach	8815	100YR ULT	547.91	0.68
Main_Reach	9057	100YR	547.58	
Main_Reach	9057	100YR ULT	548.28	0.69
Main_Reach	9488	100YR	548.39	
Main_Reach	9488	100YR ULT	549.08	0.70
Main_Reach	9860	100YR	551.22	
Main_Reach	9860	100YR ULT	551.90	0.68
Main_Reach	10589	100YR	552.80	
Main_Reach	10589	100YR ULT	553.49	0.69
Main_Reach	11199	100YR	554.35	
Main_Reach	11199	100YR ULT	555.06	0.71
Main_Reach	11327	100YR	555.15	
Main_Reach	11327	100YR ULT	555.66	0.51
Main_Reach	11518	100YR	557.08	
Main_Reach	11518	100YR ULT	557.69	0.61
Main_Reach	12006	100YR	558.52	
Main_Reach	12006	100YR ULT	559.34	0.82
Main_Reach	12423	100YR	559.27	
Main_Reach	12423	100YR ULT	560.12	0.84

HEC-RAS Plan: WSComp River: Bedford_Reach Reach: Main_Reach (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Main_Reach	12715	100YR	560.14	
Main_Reach	12715	100YR ULT	560.96	0.82
Main_Reach	14280	100YR	564.74	
Main_Reach	14280	100YR ULT	565.56	0.82
Main_Reach	14411	100YR	565.00	
Main_Reach	14411	100YR ULT	565.75	0.75
Main_Reach	14443		Bridge	
Main_Reach	14475	100YR	566.89	
Main_Reach	14475	100YR ULT	568.25	1.36
Main_Reach	15286	100YR	568.52	
Main_Reach	15286	100YR ULT	569.62	1.10

HEC-RAS Plan: WSComp River: Davis Reach: 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	6974	100YR	598.42	
1	6974	100YR ULT	598.59	0.17
1	6752	100YR	597.06	
1	6752	100YR ULT	597.25	0.19
1	6468	100YR	595.31	
1	6468	100YR ULT	595.47	0.17
1	6230	100YR	594.11	
1	6230	100YR ULT	594.28	0.16
1	6053	100YR	592.50	
1	6053	100YR ULT	592.72	0.22
1	5708	100YR	589.16	
1	5708	100YR ULT	589.30	0.14
1	5531	100YR	586.80	
1	5531	100YR ULT	587.02	0.22
1	5275	100YR	585.86	
1	5275	100YR ULT	586.08	0.22
1	4867	100YR	584.15	
1	4867	100YR ULT	584.39	0.23
1	4587	100YR	582.52	
1	4587	100YR ULT	582.72	0.21
1	4306	100YR	581.36	
1	4306	100YR ULT	581.56	0.20
1	4121	100YR	579.83	
1	4121	100YR ULT	579.99	0.17
1	3695	100YR	576.29	
1	3695	100YR ULT	576.48	0.19
1	3453	100YR	574.24	
1	3453	100YR ULT	574.38	0.14
1	3222	100YR	572.29	
1	3222	100YR ULT	572.48	0.19
1	2762	100YR	568.11	
1	2762	100YR ULT	568.40	0.29
1	2457.	100YR	566.07	
1	2457.	100YR ULT	566.29	0.22

HEC-RAS Plan: WSComp River: Davis Reach: 1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	2234	100YR	564.12	
1	2234	100YR ULT	564.32	0.20
1	1873	100YR	562.23	
1	1873	100YR ULT	562.43	0.21
1	1365	100YR	558.80	
1	1365	100YR ULT	559.06	0.25
1	956	100YR	556.14	
1	956	100YR ULT	556.38	0.25
1	731	100YR	554.16	
1	731	100YR ULT	554.68	0.51
1	638	100YR	552.71	
1	638	100YR ULT	552.77	0.06
1	481	100YR	551.42	
1	481	100YR ULT	551.88	0.46
1	357	100YR	550.97	
1	357	100YR ULT	551.40	0.43
1	265	100YR	550.52	
1	265	100YR ULT	550.95	0.44

HEC-RAS Plan: WSComp River: East_Soap Reach: East_Soap

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
East_Soap	6027	100YR	617.02	
East_Soap	6027	100YR ULT	618.14	1.13
East_Soap	5930	100YR	616.71	
East_Soap	5930	100YR ULT	617.83	1.11
East_Soap	5749	100YR	616.03	
East_Soap	5749	100YR ULT	617.23	1.20
East_Soap	5135	100YR	614.07	
East_Soap	5135	100YR ULT	615.39	1.32
East_Soap	4765	100YR	613.49	
East_Soap	4765	100YR ULT	614.66	1.17
East_Soap	4363	100YR	612.64	
East_Soap	4363	100YR ULT	613.72	1.08
East_Soap	4094	100YR	612.22	
East_Soap	4094	100YR ULT	613.30	1.08
East_Soap	4016	100YR	611.81	
East_Soap	4016	100YR ULT	612.90	1.09
East_Soap	3932	100YR	611.21	
East_Soap	3932	100YR ULT	612.12	0.90
East_Soap	3895	100YR	611.19	
East_Soap	3895	100YR ULT	612.01	0.82
East_Soap	3843	100YR	611.31	
East_Soap	3843	100YR ULT	612.12	0.82
East_Soap	3816		Culvert	
East_Soap	3765	100YR	606.78	
East_Soap	3765	100YR ULT	608.27	1.49
East_Soap	3633	100YR	606.48	
East_Soap	3633	100YR ULT	607.55	1.06
East_Soap	3588	100YR	606.53	
East_Soap	3588	100YR ULT	607.65	1.12
East_Soap	3347	100YR	606.41	
East_Soap	3347	100YR ULT	607.42	1.01
East_Soap	2820	100YR	606.28	
East_Soap	2820	100YR ULT	607.24	0.96
East_Soap	2780	100YR	606.16	

HEC-RAS Plan: WSComp River: East_Soap Reach: East_Soap (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
East_Soap	2780	100YR ULT	607.13	0.97
East_Soap	2740		Bridge	
East_Soap	2716	100YR	602.86	
East_Soap	2716	100YR ULT	604.52	1.67
East_Soap	2692	100YR	602.41	
East_Soap	2692	100YR ULT	604.03	1.61
East_Soap	2629	100YR	601.98	
East_Soap	2629	100YR ULT	603.15	1.17
East_Soap	2588	100YR	601.89	
East_Soap	2588	100YR ULT	603.05	1.17
East_Soap	2360	100YR	600.64	
East_Soap	2360	100YR ULT	601.89	1.25
East_Soap	2029	100YR	599.28	
East_Soap	2029	100YR ULT	600.37	1.09
East_Soap	1539	100YR	596.90	
East_Soap	1539	100YR ULT	597.87	0.98
East_Soap	766	100YR	593.47	
East_Soap	766	100YR ULT	594.39	0.93

HEC-RAS Plan: WSComp River: Edge_Creek_River Reach: Reach_1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach_1	958	100YR	533.84	
Reach_1	958	100YR ULT	534.42	0.58
Reach_1	1475	100YR	538.82	
Reach_1	1475	100YR ULT	539.36	0.54
Reach_1	1654	100YR	550.36	
Reach_1	1654	100YR ULT	550.78	0.43
Reach_1	1877	100YR	559.32	
Reach_1	1877	100YR ULT	559.75	0.43
Reach_1	1960	100YR	559.83	
Reach_1	1960	100YR ULT	560.52	0.69
Reach_1	2060	100YR	559.73	
Reach_1	2060	100YR ULT	560.40	0.67
Reach_1	3803	100YR	560.48	
Reach_1	3803	100YR ULT	561.29	0.80
Reach_1	4220	100YR	560.49	
Reach_1	4220	100YR ULT	561.29	0.81
Reach_1	4613	100YR	560.50	
Reach_1	4613	100YR ULT	561.31	0.81
Reach_1	5024	100YR	560.52	
Reach_1	5024	100YR ULT	561.34	0.82
Reach_1	5531	100YR	562.58	
Reach_1	5531	100YR ULT	562.71	0.13
Reach_1	6259	100YR	567.79	
Reach_1	6259	100YR ULT	568.03	0.24
Reach_1	6443	100YR	568.70	
Reach_1	6443	100YR ULT	568.95	0.24
Reach_1	6773	100YR	571.23	
Reach_1	6773	100YR ULT	571.48	0.25
Reach_1	7326	100YR	576.58	
Reach_1	7326	100YR ULT	576.79	0.22
Reach_1	7826	100YR	580.84	
Reach_1	7826	100YR ULT	581.07	0.23
Reach_1	8322	100YR	584.48	
Reach_1	8322	100YR ULT	584.71	0.23

HEC-RAS Plan: WSComp River: Edge_Creek_River Reach: Reach_1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach_1	8857	100YR	589.75	
Reach_1	8857	100YR ULT	589.98	0.23
Reach_1	9573	100YR	597.56	
Reach_1	9573	100YR ULT	597.76	0.20
Reach_1	10009	100YR	603.35	
Reach_1	10009	100YR ULT	603.43	0.08
Reach_1	10238	100YR	609.52	
Reach_1	10238	100YR ULT	609.75	0.23
Reach_1	10645	100YR	621.99	
Reach_1	10645	100YR ULT	622.12	0.13
Reach_1	10814	100YR	628.18	
Reach_1	10814	100YR ULT	628.47	0.29

HEC-RAS Plan: WSComp River: Edge Tributary 1 Reach: Reach_1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach_1	887	100YR	559.19	
Reach_1	887	100YR ULT	559.55	0.36
Reach_1	1212	100YR	562.27	
Reach_1	1212	100YR ULT	562.74	0.47
Reach_1	1555	100YR	564.74	
Reach_1	1555	100YR ULT	564.94	0.20
Reach_1	1824	100YR	567.31	
Reach_1	1824	100YR ULT	567.78	0.47
Reach_1	2475	100YR	570.06	
Reach_1	2475	100YR ULT	570.64	0.58
Reach_1	2955	100YR	573.22	
Reach_1	2955	100YR ULT	573.63	0.41
Reach_1	3356	100YR	578.01	
Reach_1	3356	100YR ULT	578.33	0.31
Reach_1	3684	100YR	580.65	
Reach_1	3684	100YR ULT	581.07	0.43
Reach_1	3907	100YR	582.09	
Reach_1	3907	100YR ULT	582.51	0.42
Reach_1	4147	100YR	583.89	
Reach_1	4147	100YR ULT	584.28	0.39
Reach_1	4483	100YR	586.08	
Reach_1	4483	100YR ULT	586.52	0.44
Reach_1	4750	100YR	588.19	
Reach_1	4750	100YR ULT	588.55	0.36
Reach_1	4921	100YR	590.67	
Reach_1	4921	100YR ULT	591.09	0.43
Reach_1	5446	100YR	595.85	
Reach_1	5446	100YR ULT	596.51	0.66
Reach_1	5675	100YR	598.50	
Reach_1	5675	100YR ULT	599.02	0.52
Reach_1	5897	100YR	602.59	
Reach_1	5897	100YR ULT	603.04	0.45

HEC-RAS Plan: WSComp River: Foster Reach: Foster

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Foster	1941	100YR	531.34	
Foster	1941	100YR ULT	531.47	0.13
Foster	1807	100YR	530.51	
Foster	1807	100YR ULT	530.57	0.06
Foster	1516	100YR	527.14	
Foster	1516	100YR ULT	527.29	0.15
Foster	1259	100YR	525.54	
Foster	1259	100YR ULT	525.63	0.09
Foster	1039	100YR	523.11	
Foster	1039	100YR ULT	523.19	0.08
Foster	938	100YR	520.90	
Foster	938	100YR ULT	520.96	0.06

HEC-RAS Plan: WSComp River: Foster_Trib Reach: Foster_Trib

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Foster_Trib	1121	100YR	535.96	
Foster_Trib	1121	100YR ULT	536.11	0.15
Foster_Trib	988	100YR	533.44	
Foster_Trib	988	100YR ULT	533.68	0.24
Foster_Trib	761	100YR	529.79	
Foster_Trib	761	100YR ULT	529.94	0.15
Foster_Trib	563	100YR	525.86	
Foster_Trib	563	100YR ULT	525.95	0.09
Foster_Trib	442	100YR	523.76	
Foster_Trib	442	100YR ULT	523.83	0.08
Foster_Trib	282	100YR	521.25	
Foster_Trib	282	100YR ULT	521.31	0.06

HEC-RAS Plan: WSComp River: Gifco_Trib 1 Reach: 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	323	100 YR	550.71	
1	323	100 YR ULT	550.82	0.11
1	616	100 YR	551.53	
1	616	100 YR ULT	551.65	0.12
1	913	100 YR	555.64	
1	913	100 YR ULT	555.74	0.11
1	1218	100 YR	561.39	
1	1218	100 YR ULT	561.48	0.10
1	1516	100 YR	567.34	
1	1516	100 YR ULT	567.45	0.11
1	1835	100 YR	570.77	
1	1835	100 YR ULT	570.93	0.16
1	2147	100 YR	574.98	
1	2147	100 YR ULT	575.08	0.10
1	2490	100 YR	578.77	
1	2490	100 YR ULT	578.94	0.17
1	2823	100 YR	584.23	
1	2823	100 YR ULT	584.35	0.12

HEC-RAS Plan: WSComp River: Gifco_Trib 2 Reach: 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	471	100 YR	550.90	
1	471	100 YR ULT	551.02	0.12
1	731	100 YR	552.18	
1	731	100 YR ULT	552.40	0.21
1	948	100 YR	558.45	
1	948	100 YR ULT	558.61	0.16
1	1175	100 YR	560.63	
1	1175	100 YR ULT	560.79	0.16
1	1647	100 YR	560.80	
1	1647	100 YR ULT	560.98	0.18
1	1954	100 YR	561.08	
1	1954	100 YR ULT	561.23	0.15
1	2257	100 YR	563.06	
1	2257	100 YR ULT	563.33	0.27
1	2432	100 YR	563.47	
1	2432	100 YR ULT	563.74	0.27
1	2707	100 YR	566.03	
1	2707	100 YR ULT	566.34	0.31
1	3014	100 YR	567.86	
1	3014	100 YR ULT	568.19	0.33
1	3299	100 YR	569.81	
1	3299	100 YR ULT	570.56	0.75
1	3591	100 YR	573.60	
1	3591	100 YR ULT	573.68	0.07
1	3928	100 YR	575.43	
1	3928	100 YR ULT	575.72	0.29
1	4277	100 YR	578.27	
1	4277	100 YR ULT	578.42	0.15
1	4571	100 YR	581.23	
1	4571	100 YR ULT	581.56	0.33
1	4874	100 YR	586.27	
1	4874	100 YR ULT	586.46	0.19
1	5176	100 YR	589.80	
1	5176	100 YR ULT	589.99	0.19

HEC-RAS Plan: WSComp River: Gifco_Trib 2 Reach: 1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	5499	100 YR	597.56	
1	5499	100 YR ULT	597.72	0.16
1	5824	100 YR	604.50	
1	5824	100 YR ULT	604.63	0.13
1	6065	100 YR	616.81	
1	6065	100 YR ULT	617.15	0.34

HEC-RAS Plan: WSComp River: Gifco_Trib 3 Reach: 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	122	100 YR	548.00	
1	122	100 YR ULT	548.00	0.00
1	349	100 YR	549.38	
1	349	100 YR ULT	549.60	0.22
1	523	100 YR	553.38	
1	523	100 YR ULT	553.61	0.23
1	812	100 YR	556.66	
1	812	100 YR ULT	556.97	0.32
1	1121	100 YR	560.67	
1	1121	100 YR ULT	561.02	0.34
1	1410	100 YR	564.37	
1	1410	100 YR ULT	564.75	0.38
1	1671	100 YR	570.82	
1	1671	100 YR ULT	571.27	0.44
1	1809	100 YR	578.09	
1	1809	100 YR ULT	578.69	0.61

HEC-RAS Plan: WSComp River: Grassy Reach: Grassy

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Grassy	32281	100YR	625.79	
Grassy	32281	100YR ULT	626.39	0.60
Grassy	31785	100YR	625.48	
Grassy	31785	100YR ULT	626.08	0.60
Grassy	31757	100YR	625.43	
Grassy	31757	100YR ULT	626.04	0.60
Grassy	31737		Bridge	
Grassy	31701	100YR	625.20	
Grassy	31701	100YR ULT	625.84	0.64
Grassy	31661	100YR	625.19	
Grassy	31661	100YR ULT	625.83	0.64
Grassy	31511	100YR	624.93	
Grassy	31511	100YR ULT	625.58	0.65
Grassy	31019	100YR	624.56	
Grassy	31019	100YR ULT	625.21	0.65
Grassy	30518	100YR	624.08	
Grassy	30518	100YR ULT	624.73	0.65
Grassy	29809	100YR	623.16	
Grassy	29809	100YR ULT	623.81	0.65
Grassy	29011	100YR	621.55	
Grassy	29011	100YR ULT	622.17	0.62
Grassy	28572	100YR	620.64	
Grassy	28572	100YR ULT	621.25	0.62
Grassy	27444	100YR	617.44	
Grassy	27444	100YR ULT	618.13	0.70
Grassy	26572	100YR	614.89	
Grassy	26572	100YR ULT	615.54	0.65
Grassy	25478	100YR	613.42	
Grassy	25478	100YR ULT	613.99	0.57
Grassy	24985	100YR	612.75	
Grassy	24985	100YR ULT	613.29	0.54
Grassy	24543	100YR	612.20	
Grassy	24543	100YR ULT	612.68	0.48
Grassy	24088	100YR	611.47	

HEC-RAS Plan: WSComp River: Grassy Reach: Grassy (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Grassy	24088	100YR ULT	611.94	0.47
Grassy	23390	100YR	611.01	
Grassy	23390	100YR ULT	611.44	0.43
Grassy	23268	100YR	610.95	
Grassy	23268	100YR ULT	611.38	0.43
Grassy	23244		Bridge	
Grassy	23223	100YR	610.52	
Grassy	23223	100YR ULT	611.00	0.48
Grassy	23089	100YR	610.29	
Grassy	23089	100YR ULT	610.75	0.47
Grassy	22435	100YR	608.76	
Grassy	22435	100YR ULT	609.21	0.45
Grassy	21576	100YR	607.82	
Grassy	21576	100YR ULT	608.30	0.48
Grassy	20530	100YR	606.48	
Grassy	20530	100YR ULT	606.97	0.49
Grassy	19713	100YR	605.04	
Grassy	19713	100YR ULT	605.49	0.45
Grassy	19361	100YR	604.70	
Grassy	19361	100YR ULT	605.14	0.44
Grassy	19132	100YR	604.28	
Grassy	19132	100YR ULT	604.71	0.42
Grassy	18576	100YR	602.86	
Grassy	18576	100YR ULT	603.23	0.37
Grassy	18564	100YR	602.83	
Grassy	18564	100YR ULT	603.19	0.36
Grassy	18546		Culvert	
Grassy	18523	100YR	602.60	
Grassy	18523	100YR ULT	603.06	0.45
Grassy	18499	100YR	602.57	
Grassy	18499	100YR ULT	603.02	0.45
Grassy	17784	100YR	600.53	
Grassy	17784	100YR ULT	601.02	0.49

HEC-RAS Plan: WSComp River: Grassy Reach: Grassy (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Grassy	17236	100YR	599.41	
Grassy	17236	100YR ULT	599.86	0.45
Grassy	16509	100YR	598.09	
Grassy	16509	100YR ULT	598.51	0.42
Grassy	15758	100YR	596.11	
Grassy	15758	100YR ULT	596.56	0.45
Grassy	15035	100YR	594.13	
Grassy	15035	100YR ULT	594.59	0.46
Grassy	14296	100YR	592.87	
Grassy	14296	100YR ULT	593.34	0.46
Grassy	13434	100YR	591.26	
Grassy	13434	100YR ULT	591.68	0.42
Grassy	12533	100YR	589.20	
Grassy	12533	100YR ULT	589.62	0.42
Grassy	11910	100YR	587.61	
Grassy	11910	100YR ULT	587.99	0.38
Grassy	11190	100YR	584.91	
Grassy	11190	100YR ULT	585.28	0.38
Grassy	9963	100YR	582.61	
Grassy	9963	100YR ULT	583.01	0.39
Grassy	8993	100YR	581.57	
Grassy	8993	100YR ULT	581.99	0.42
Grassy	8633	100YR	581.01	
Grassy	8633	100YR ULT	581.43	0.41
Grassy	7362	100YR	578.41	
Grassy	7362	100YR ULT	578.81	0.39
Grassy	6339	100YR	575.90	
Grassy	6339	100YR ULT	576.34	0.44
Grassy	5653	100YR	574.09	
Grassy	5653	100YR ULT	574.52	0.44
Grassy	4899	100YR	571.41	
Grassy	4899	100YR ULT	571.82	0.41
Grassy	3907	100YR	569.31	
Grassy	3907	100YR ULT	569.70	0.39

HEC-RAS Plan: WSComp River: Grassy Reach: Grassy (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Grassy	1996	100YR	564.97	
Grassy	1996	100YR ULT	565.32	0.34
Grassy	863	100YR	564.44	
Grassy	863	100YR ULT	564.57	0.13

HEC-RAS Plan: WSComp River: Grassy_Trib Reach: Grassy_Trib

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Grassy_Trib	5191	100YR	629.32	
Grassy_Trib	5191	100YR ULT	629.85	0.53
Grassy_Trib	4560	100YR	626.40	
Grassy_Trib	4560	100YR ULT	626.95	0.55
Grassy_Trib	4121	100YR	624.24	
Grassy_Trib	4121	100YR ULT	625.00	0.76
Grassy_Trib	3821	100YR	623.31	
Grassy_Trib	3821	100YR ULT	624.13	0.81
Grassy_Trib	3497	100YR	621.60	
Grassy_Trib	3497	100YR ULT	622.27	0.67
Grassy_Trib	3026	100YR	619.62	
Grassy_Trib	3026	100YR ULT	620.29	0.67
Grassy_Trib	2654	100YR	618.15	
Grassy_Trib	2654	100YR ULT	618.76	0.61
Grassy_Trib	1685	100YR	617.46	
Grassy_Trib	1685	100YR ULT	617.92	0.46
Grassy_Trib	1217	100YR	616.20	
Grassy_Trib	1217	100YR ULT	616.47	0.27
Grassy_Trib	786	100YR	614.57	
Grassy_Trib	786	100YR ULT	615.72	1.16
Grassy_Trib	696	100YR	610.32	
Grassy_Trib	696	100YR ULT	612.40	2.09

HEC-RAS Plan: WSComp River: Hanger Reach: Hanger

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Hanger	2302	100YR	539.38	
Hanger	2302	100YR ULT	539.59	0.20
Hanger	2167	100YR	539.11	
Hanger	2167	100YR ULT	539.17	0.05
Hanger	2058	100YR	538.52	
Hanger	2058	100YR ULT	538.56	0.04
Hanger	1520	100YR	534.81	
Hanger	1520	100YR ULT	534.81	0.00
Hanger	1505	100YR	534.65	
Hanger	1505	100YR ULT	534.65	0.00
Hanger	1332	100YR	531.68	
Hanger	1332	100YR ULT	531.68	0.00
Hanger	1241	100YR	531.30	
Hanger	1241	100YR ULT	531.30	0.00
Hanger	957	100YR	527.36	
Hanger	957	100YR ULT	527.36	0.00
Hanger	772	100YR	525.49	
Hanger	772	100YR ULT	525.49	0.00
Hanger	489	100YR	522.20	
Hanger	489	100YR ULT	522.20	0.00

HEC-RAS Plan: WSComp River: Hight Reach: 1 Profile: 100 YR ULT

Reach	River Sta	Profile	W.S. Elev
			(ft)
1	128.738	100 YR ULT	534.91
1	417.319	100 YR ULT	535.12
1	659.292	100 YR ULT	535.33
1	1654.411	100 YR ULT	538.17
1	1915.028	100 YR ULT	539.53
1	1925.038		Bridge
1	1935.028	100 YR ULT	539.66
1	3292.698	100 YR ULT	545.41
1	3635.905	100 YR ULT	548.68
1	3796.160	100 YR ULT	549.37
1	3810		Culvert
1	3825.907	100 YR ULT	549.52
1	3929.943	100 YR ULT	549.59
1	4402.184	100 YR ULT	553.63
1	4699.184	100 YR ULT	556.38
1	4825.182	100 YR ULT	556.77
1	4877		Culvert
1	4972.713	100 YR ULT	558.74
1	5062.229	100 YR ULT	558.83
1	5077		Culvert
1	5093.429	100 YR ULT	561.36
1	5299.095	100 YR ULT	562.33
1	5605.017	100 YR ULT	564.41
1	6011.242	100 YR ULT	567.52
1	6285.351	100 YR ULT	567.68
1	6298.5		Culvert
1	6311.123	100 YR ULT	570.27
1	6602.296	100 YR ULT	570.14
1	6845.274	100 YR ULT	572.30

HEC-RAS Plan: WSComp River: Hollings Reach: 2 Profile: 100 YR ULT

Reach	River Sta	Profile	W.S. Elev
			(ft)
2	1514.253	100 YR ULT	535.01
2	1881.656	100 YR ULT	535.42
2	2165.267	100 YR ULT	535.90
2	2494.865	100 YR ULT	536.68
2	2880.744	100 YR ULT	538.21
2	3273.453	100 YR ULT	540.66
2	3685.615	100 YR ULT	543.03
2	4348.646	100 YR ULT	545.88
2	4775.156	100 YR ULT	547.70
2	5057.791	100 YR ULT	548.47
2	5122.010	100 YR ULT	549.85
2	5192.494	100 YR ULT	551.60
2	5595.119	100 YR ULT	552.91
2	5782.378	100 YR ULT	553.40
2	6219.829	100 YR ULT	554.72
2	7050.407	100 YR ULT	558.67
2	7689.822	100 YR ULT	562.09
2	8413.969	100 YR ULT	565.67
2	8920.227	100 YR ULT	566.58
2	9229.300	100 YR ULT	567.06
2	9737.502	100 YR ULT	572.00
2	10398.79	100 YR ULT	574.60
2	10790.00	100 YR ULT	576.88
2	11287.76	100 YR ULT	579.81
2	11521.86	100 YR ULT	580.39
2	12035.21	100 YR ULT	581.93
2	12496.07	100 YR ULT	585.53
2	13194.17	100 YR ULT	589.70
2	13456.56	100 YR ULT	591.19

HEC-RAS Plan: WSComp River: Loyd Reach: Loyd

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Loyd	6554	100YR	569.90	
Loyd	6554	100YR ULT	570.03	0.14
Loyd	6114	100YR	565.76	
Loyd	6114	100YR ULT	565.91	0.15
Loyd	5858	100YR	563.49	
Loyd	5858	100YR ULT	563.70	0.21
Loyd	5605	100YR	561.63	
Loyd	5605	100YR ULT	561.83	0.19
Loyd	5488	100YR	561.44	
Loyd	5488	100YR ULT	561.63	0.19
Loyd	5310	100YR	559.83	
Loyd	5310	100YR ULT	560.12	0.29
Loyd	5224	100YR	559.25	
Loyd	5224	100YR ULT	559.44	0.19
Loyd	4937	100YR	557.40	
Loyd	4937	100YR ULT	557.75	0.35
Loyd	4891	100YR	557.15	
Loyd	4891	100YR ULT	557.52	0.37
Loyd	4747	100YR	555.93	
Loyd	4747	100YR ULT	556.30	0.37
Loyd	4707	100YR	555.81	
Loyd	4707	100YR ULT	556.23	0.42
Loyd	4288	100YR	552.84	
Loyd	4288	100YR ULT	553.09	0.25
Loyd	3798	100YR	551.05	
Loyd	3798	100YR ULT	551.18	0.13
Loyd	3635	100YR	550.53	
Loyd	3635	100YR ULT	550.63	0.11
Loyd	3553	100YR	549.31	
Loyd	3553	100YR ULT	549.53	0.22
Loyd	3491	100YR	547.80	
Loyd	3491	100YR ULT	548.20	0.39
Loyd	3445	100YR	547.43	
Loyd	3445	100YR ULT	547.83	0.40

HEC-RAS Plan: WSComp River: Loyd Reach: Loyd (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Loyd	3211	100YR	545.37	
Loyd	3211	100YR ULT	545.79	0.42
Loyd	2943	100YR	544.60	
Loyd	2943	100YR ULT	544.96	0.36
Loyd	2285	100YR	538.64	
Loyd	2285	100YR ULT	538.76	0.12
Loyd	1811	100YR	536.82	
Loyd	1811	100YR ULT	537.00	0.18

HEC-RAS Plan: WSComp River: Lynn Reach: 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	1177	100YR	568.70	
1	1177	100YR ULT	568.69	-0.01
1	1031	100YR	565.77	
1	1031	100YR ULT	565.82	0.05
1	893	100YR	562.87	
1	893	100YR ULT	562.87	0.00
1	751	100YR	560.44	
1	751	100YR ULT	560.48	0.04
1	603	100YR	557.32	
1	603	100YR ULT	557.33	0.01
1	462	100YR	544.71	
1	462	100YR ULT	544.75	0.04
1	358	100YR	543.83	
1	358	100YR ULT	543.87	0.05
1	235	100YR	541.61	
1	235	100YR ULT	541.64	0.03
1	157	100YR	537.94	
1	157	100YR ULT	537.98	0.04

HEC-RAS Plan: WSComp River: Mills_Branch Reach: Reach 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach 1	631	100YR	534.67	
Reach 1	631	100YR ULT	534.79	0.12
Reach 1	1085	100YR	539.66	
Reach 1	1085	100YR ULT	539.78	0.12
Reach 1	1232	100YR	542.33	
Reach 1	1232	100YR ULT	542.44	0.10
Reach 1	1579	100YR	545.09	
Reach 1	1579	100YR ULT	545.03	-0.05
Reach 1	1807	100YR	546.27	
Reach 1	1807	100YR ULT	546.28	0.02
Reach 1	1954	100YR	546.43	
Reach 1	1954	100YR ULT	546.47	0.04
Reach 1	2354	100YR	546.53	
Reach 1	2354	100YR ULT	546.60	0.07
Reach 1	2715	100YR	549.40	
Reach 1	2715	100YR ULT	549.57	0.17
Reach 1	3199	100YR	559.08	
Reach 1	3199	100YR ULT	559.20	0.12
Reach 1	3480	100YR	563.05	
Reach 1	3480	100YR ULT	563.19	0.14
Reach 1	3679	100YR	570.33	
Reach 1	3679	100YR ULT	570.43	0.10
Reach 1	3912	100YR	579.18	
Reach 1	3912	100YR ULT	579.33	0.15

HEC-RAS Plan: WSComp River: Mountain Reach: Mountain

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Mountain	24384 24384	100YR	565.19	
Mountain	24384 24384	100YR ULT	565.55	0.36
Mountain	20749 20749	100YR	560.27	
Mountain	20749 20749	100YR ULT	560.69	0.42
Mountain	19232 19232	100YR	557.22	
Mountain	19232 19232	100YR ULT	557.55	0.33
Mountain	16326 16326	100YR	553.96	
Mountain	16326 16326	100YR ULT	554.59	0.63
Mountain	14220 14220	100YR	552.50	
Mountain	14220 14220	100YR ULT	553.32	0.82
Mountain	13175 13175	100YR	552.05	
Mountain	13175 13175	100YR ULT	552.91	0.85
Mountain	10995	100YR	550.66	
Mountain	10995	100YR ULT	551.51	0.85
Mountain	10907	100YR	550.28	
Mountain	10907	100YR ULT	551.11	0.83
Mountain	10720 US HWY 287		Bridge	
Mountain	10396	100YR	546.89	
Mountain	10396	100YR ULT	547.39	0.50
Mountain	10133	100YR	546.18	
Mountain	10133	100YR ULT	546.69	0.51
Mountain	8400 8400	100YR	544.36	
Mountain	8400 8400	100YR ULT	544.94	0.58
Mountain	5912 5912	100YR	542.45	
Mountain	5912 5912	100YR ULT	543.08	0.63
Mountain	4803	100YR	541.57	
Mountain	4803	100YR ULT	542.21	0.63
Mountain	4737	100YR	541.54	
Mountain	4737	100YR ULT	542.17	0.63
Mountain	4672 FM 661		Bridge	
Mountain	4550	100YR	541.31	
Mountain	4550	100YR ULT	541.98	0.67
Mountain	4451	100YR	541.25	
Mountain	4451	100YR ULT	541.91	0.67

HEC-RAS Plan: WSComp River: Mountain Reach: Mountain (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Mountain	3718 3718	100YR	539.59	
Mountain	3718 3718	100YR ULT	540.22	0.64
Mountain	1888 1888	100YR	536.73	
Mountain	1888 1888	100YR ULT	537.47	0.74
Mountain	374 374	100YR	535.18	
Mountain	374 374	100YR ULT	535.94	0.76

HEC-RAS Plan: WSComp River: Soap Creek Reach: Newton Branch

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Newton Branch	9918	100YR	563.61	
Newton Branch	9918	100YR ULT	564.23	0.61
Newton Branch	9227	100YR	563.31	
Newton Branch	9227	100YR ULT	563.85	0.54
Newton Branch	8783	100YR	563.16	
Newton Branch	8783	100YR ULT	563.63	0.47
Newton Branch	8718	100YR	563.14	
Newton Branch	8718	100YR ULT	563.60	0.46
Newton Branch	8676		Culvert	
Newton Branch	8631	100YR	559.33	
Newton Branch	8631	100YR ULT	559.89	0.57
Newton Branch	8505	100YR	558.43	
Newton Branch	8505	100YR ULT	559.17	0.74
Newton Branch	7926	100YR	557.15	
Newton Branch	7926	100YR ULT	557.75	0.61
Newton Branch	7199	100YR	555.81	
Newton Branch	7199	100YR ULT	556.40	0.59
Newton Branch	6135	100YR	552.87	
Newton Branch	6135	100YR ULT	553.36	0.49
Newton Branch	5603	100YR	551.02	
Newton Branch	5603	100YR ULT	551.69	0.67
Newton Branch	4919	100YR	550.39	
Newton Branch	4919	100YR ULT	551.12	0.73
Newton Branch	3851	100YR	549.03	
Newton Branch	3851	100YR ULT	549.71	0.68
Newton Branch	3088	100YR	546.91	
Newton Branch	3088	100YR ULT	547.51	0.60
Newton Branch	2323	100YR	545.09	
Newton Branch	2323	100YR ULT	545.71	0.62
Newton Branch	1617	100YR	543.72	
Newton Branch	1617	100YR ULT	544.36	0.65
Newton Branch	1567	100YR	543.61	
Newton Branch	1567	100YR ULT	544.26	0.65
Newton Branch	1520		Culvert	

HEC-RAS Plan: WSComp River: Soap Creek Reach: Newton Branch (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Newton Branch	1471	100YR	543.58	
Newton Branch	1471	100YR ULT	544.26	0.67
Newton Branch	1388	100YR	543.47	
Newton Branch	1388	100YR ULT	544.13	0.67
Newton Branch	894	100YR	542.58	
Newton Branch	894	100YR ULT	543.24	0.66

HEC-RAS Plan: WSComp River: North_Hanger Reach: North_Hanger

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
North_Hanger	2239	100YR	532.95	
North_Hanger	2239	100YR ULT	533.34	0.39
North_Hanger	2003	100YR	531.36	
North_Hanger	2003	100YR ULT	531.77	0.41
North_Hanger	1552	100YR	528.84	
North_Hanger	1552	100YR ULT	529.27	0.43
North_Hanger	1392	100YR	527.32	
North_Hanger	1392	100YR ULT	527.75	0.43
North_Hanger	1151	100YR	524.00	
North_Hanger	1151	100YR ULT	524.41	0.40
North_Hanger	812	100YR	520.88	
North_Hanger	812	100YR ULT	521.23	0.35

HEC-RAS Plan: WSComp River: PENWELL Reach: 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	264	100 YR	541.02	
1	264	100 YR ULT	541.65	0.63
1	297		Bridge	
1	330	100 YR	543.09	
1	330	100 YR ULT	543.83	0.74
1	453	100 YR	543.65	
1	453	100 YR ULT	544.49	0.84
1	692	100 YR	544.17	
1	692	100 YR ULT	544.87	0.70
1	1125	100 YR	545.96	
1	1125	100 YR ULT	546.30	0.34
1	1381	100 YR	548.12	
1	1381	100 YR ULT	548.45	0.33
1	1708	100 YR	551.27	
1	1708	100 YR ULT	551.54	0.27
1	2487	100 YR	554.94	
1	2487	100 YR ULT	555.32	0.38
1	2956	100 YR	556.43	
1	2956	100 YR ULT	556.73	0.30
1	3612	100 YR	561.27	
1	3612	100 YR ULT	561.49	0.22
1	4112	100 YR	565.98	
1	4112	100 YR ULT	566.25	0.27
1	4600	100 YR	567.99	
1	4600	100 YR ULT	568.23	0.25
1	4877	100 YR	572.41	
1	4877	100 YR ULT	572.63	0.22
1	5263	100 YR	576.30	
1	5263	100 YR ULT	576.54	0.24
1	5600	100 YR	579.76	
1	5600	100 YR ULT	579.99	0.23
1	5949	100 YR	586.63	
1	5949	100 YR ULT	586.75	0.11
1	6257	100 YR	592.73	

HEC-RAS Plan: WSComp River: PENWELL Reach: 1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	6257	100 YR ULT	592.85	0.12
1	6287	100 YR	600.18	
1	6287	100 YR ULT	600.24	0.06

HEC-RAS Plan: WSComp River: Plains Reach: Plains

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Plains	190	100 YR	549.41	
Plains	190	100 YR ULT	549.96	0.55
Plains	267	100 YR	549.51	
Plains	267	100 YR ULT	550.07	0.56
Plains	400		Bridge	
Plains	501	100 YR	550.98	
Plains	501	100 YR ULT	551.67	0.69
Plains	593	100 YR	551.10	
Plains	593	100 YR ULT	551.80	0.70
Plains	1546	100 YR	552.60	
Plains	1546	100 YR ULT	553.26	0.66
Plains	2309	100 YR	553.86	
Plains	2309	100 YR ULT	554.35	0.49
Plains	2501	100 YR	554.45	
Plains	2501	100 YR ULT	554.86	0.41
Plains	2640	100 YR	554.96	
Plains	2640	100 YR ULT	555.39	0.44
Plains	2989	100 YR	556.55	
Plains	2989	100 YR ULT	556.84	0.29
Plains	3561	100 YR	559.04	
Plains	3561	100 YR ULT	559.81	0.77
Plains	3698	100 YR	559.59	
Plains	3698	100 YR ULT	560.35	0.76
Plains	4177	100 YR	561.46	
Plains	4177	100 YR ULT	562.50	1.04
Plains	4869	100 YR	561.83	
Plains	4869	100 YR ULT	562.84	1.01
Plains	5034	100 YR	561.92	
Plains	5034	100 YR ULT	562.93	1.00
Plains	5078		Culvert	
Plains	5128	100 YR	563.56	
Plains	5128	100 YR ULT	564.04	0.48
Plains	5209	100 YR	563.61	
Plains	5209	100 YR ULT	564.11	0.50

HEC-RAS Plan: WSComp River: Plains Reach: Plains (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Plains	5715	100 YR	564.20	
Plains	5715	100 YR ULT	564.84	0.64
Plains	6237	100 YR	565.02	
Plains	6237	100 YR ULT	565.68	0.66
Plains	7571	100 YR	567.33	
Plains	7571	100 YR ULT	567.98	0.64
Plains	8629	100 YR	569.69	
Plains	8629	100 YR ULT	570.33	0.64
Plains	9558	100 YR	571.65	
Plains	9558	100 YR ULT	572.28	0.63
Plains	10027	100 YR	572.78	
Plains	10027	100 YR ULT	573.39	0.61

HEC-RAS Plan: WSComp River: Small_Branch Reach: Reach_1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach_1	449	100 YR	546.61	
Reach_1	449	100 YR ULT	547.12	0.50
Reach_1	722	100 YR	549.12	
Reach_1	722	100 YR ULT	549.63	0.51
Reach_1	1348	100 YR	552.19	
Reach_1	1348	100 YR ULT	552.55	0.35
Reach_1	1619	100 YR	554.53	
Reach_1	1619	100 YR ULT	554.89	0.36
Reach_1	2190	100 YR	557.44	
Reach_1	2190	100 YR ULT	558.10	0.66
Reach_1	2760	100 YR	563.14	
Reach_1	2760	100 YR ULT	562.69	-0.46
Reach_1	3139	100 YR	565.57	
Reach_1	3139	100 YR ULT	566.38	0.81
Reach_1	4026	100 YR	571.15	
Reach_1	4026	100 YR ULT	571.20	0.04
Reach_1	4669	100 YR	575.18	
Reach_1	4669	100 YR ULT	575.69	0.51
Reach_1	4938	100 YR	578.83	
Reach_1	4938	100 YR ULT	578.90	0.07
Reach_1	5359	100 YR	585.58	
Reach_1	5359	100 YR ULT	586.08	0.50
Reach_1	5865	100 YR	593.46	
Reach_1	5865	100 YR ULT	593.58	0.12
Reach_1	6355	100 YR	605.80	
Reach_1	6355	100 YR ULT	606.18	0.38
Reach_1	6610	100 YR	615.30	
Reach_1	6610	100 YR ULT	615.71	0.41
Reach_1	6840	100 YR	626.34	
Reach_1	6840	100 YR ULT	626.46	0.12
Reach_1	6904	100 YR	627.52	
Reach_1	6904	100 YR ULT	627.77	0.25
Reach_1	7355	100 YR	633.37	
Reach_1	7355	100 YR ULT	633.64	0.27

HEC-RAS Plan: WSComp River: Small_Branch Reach: Reach_1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach_1	7560	100 YR	636.78	
Reach_1	7560	100 YR ULT	636.95	0.16
Reach_1	7814	100 YR	641.74	
Reach_1	7814	100 YR ULT	642.32	0.58

HEC-RAS Plan: WSComp River: Soap Creek Reach: Main

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Main	4312	100 YR	539.25	
Main	4312	100 YR ULT	540.96	1.71
Main	5382	100 YR	540.17	
Main	5382	100 YR ULT	541.89	1.72
Main	6193	100 YR	541.17	
Main	6193	100 YR ULT	542.89	1.72
Main	7067	100 YR	542.63	
Main	7067	100 YR ULT	544.39	1.76
Main	7587	100 YR	543.29	
Main	7587	100 YR ULT	545.06	1.77
Main	8501	100 YR	544.22	
Main	8501	100 YR ULT	545.97	1.75
Main	9153	100 YR	544.65	
Main	9153	100 YR ULT	546.34	1.70
Main	9681	100 YR	545.20	
Main	9681	100 YR ULT	546.81	1.61
Main	9814	100 YR	545.37	
Main	9814	100 YR ULT	546.96	1.59
Main	9924	100 YR	545.44	
Main	9924	100 YR ULT	547.03	1.58
Main	10649	100 YR	545.79	
Main	10649	100 YR ULT	547.36	1.57
Main	10938	100 YR	546.04	
Main	10938	100 YR ULT	547.60	1.56
Main	11143	100 YR	546.76	
Main	11143	100 YR ULT	548.25	1.48
Main	11670	100 YR	548.43	
Main	11670	100 YR ULT	549.99	1.56
Main	11799	100 YR	549.23	
Main	11799	100 YR ULT	551.01	1.78
Main	11913	100 YR	549.33	
Main	11913	100 YR ULT	551.05	1.72
Main	12060		Bridge	
Main	12200	100 YR	549.81	

HEC-RAS Plan: WSComp River: Soap Creek Reach: Main (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Main	12200	100 YR ULT	552.92	3.12
Main	12331	100 YR	550.32	
Main	12331	100 YR ULT	553.59	3.27
Main	12709	100 YR	551.55	
Main	12709	100 YR ULT	554.47	2.92
Main	13427	100 YR	552.06	
Main	13427	100 YR ULT	554.88	2.82
Main	13940	100 YR	552.18	
Main	13940	100 YR ULT	554.99	2.81
Main	14559	100 YR	552.37	
Main	14559	100 YR ULT	555.17	2.80
Main	14995	100 YR	552.66	
Main	14995	100 YR ULT	555.40	2.74
Main	15484	100 YR	552.93	
Main	15484	100 YR ULT	555.61	2.68
Main	16134	100 YR	553.12	
Main	16134	100 YR ULT	555.97	2.85
Main	16196	100 YR	554.42	
Main	16196	100 YR ULT	556.02	1.61
Main	16284	100 YR	555.00	
Main	16284	100 YR ULT	556.16	1.16
Main	16420		Bridge	
Main	16550	100 YR	557.00	
Main	16550	100 YR ULT	560.83	3.83
Main	16644	100 YR	557.38	
Main	16644	100 YR ULT	560.87	3.48
Main	17107	100 YR	558.20	
Main	17107	100 YR ULT	561.11	2.91
Main	17945	100 YR	558.91	
Main	17945	100 YR ULT	561.62	2.71
Main	19009	100 YR	559.64	
Main	19009	100 YR ULT	562.11	2.47
Main	19483	100 YR	560.16	
Main	19483	100 YR ULT	562.49	2.33

HEC-RAS Plan: WSComp River: Soap Creek Reach: Main (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Main	20107	100 YR	561.18	
Main	20107	100 YR ULT	563.29	2.11
Main	20698	100 YR	562.23	
Main	20698	100 YR ULT	564.16	1.93
Main	21296	100 YR	563.01	
Main	21296	100 YR ULT	564.82	1.81
Main	22193	100 YR	564.37	
Main	22193	100 YR ULT	566.07	1.70
Main	22806	100 YR	565.59	
Main	22806	100 YR ULT	567.25	1.67
Main	23476	100 YR	567.10	
Main	23476	100 YR ULT	568.87	1.76
Main	24145	100 YR	568.57	
Main	24145	100 YR ULT	570.35	1.78
Main	24631	100 YR	569.33	
Main	24631	100 YR ULT	571.10	1.77
Main	26180	100 YR	571.49	
Main	26180	100 YR ULT	573.30	1.81
Main	27382	100 YR	572.94	
Main	27382	100 YR ULT	574.69	1.75
Main	27885	100 YR	573.53	
Main	27885	100 YR ULT	575.27	1.74
Main	28320	100 YR	574.45	
Main	28320	100 YR ULT	576.28	1.82
Main	29260	100 YR	576.88	
Main	29260	100 YR ULT	579.03	2.15
Main	29876	100 YR	577.64	
Main	29876	100 YR ULT	579.86	2.22
Main	30837	100 YR	578.97	
Main	30837	100 YR ULT	581.24	2.26
Main	31869	100 YR	580.51	
Main	31869	100 YR ULT	582.91	2.40
Main	32649	100 YR	581.33	
Main	32649	100 YR ULT	583.69	2.36

HEC-RAS Plan: WSComp River: Soap Creek Reach: Main (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Main	33434	100 YR	582.52	
Main	33434	100 YR ULT	584.83	2.31
Main	34413	100 YR	583.99	
Main	34413	100 YR ULT	586.31	2.32
Main	35123	100 YR	585.42	
Main	35123	100 YR ULT	587.77	2.35
Main	35463	100 YR	586.19	
Main	35463	100 YR ULT	588.54	2.35
Main	36318	100 YR	587.96	
Main	36318	100 YR ULT	590.22	2.25
Main	37022	100 YR	589.30	
Main	37022	100 YR ULT	591.44	2.14
Main	37680	100 YR	590.20	
Main	37680	100 YR ULT	592.40	2.20
Main	38447	100 YR	591.57	
Main	38447	100 YR ULT	593.85	2.28
Main	39317	100 YR	593.70	
Main	39317	100 YR ULT	595.93	2.23
Main	40329	100 YR	595.73	
Main	40329	100 YR ULT	597.93	2.20
Main	41331	100 YR	598.07	
Main	41331	100 YR ULT	600.18	2.11

HEC-RAS Plan: WSComp River: Stuart_Branch Reach: 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	1258	100 YR	530.30	
1	1258	100 YR ULT	530.42	0.13
1	1569	100 YR	534.38	
1	1569	100 YR ULT	534.63	0.25
1	1854	100 YR	537.27	
1	1854	100 YR ULT	537.59	0.33
1	2152	100 YR	538.50	
1	2152	100 YR ULT	538.76	0.26
1	2532	100 YR	540.87	
1	2532	100 YR ULT	541.31	0.43
1	2795	100 YR	545.31	
1	2795	100 YR ULT	545.48	0.17
1	3153	100 YR	549.59	
1	3153	100 YR ULT	549.80	0.22
1	3442	100 YR	552.94	
1	3442	100 YR ULT	553.08	0.14
1	3740	100 YR	558.82	
1	3740	100 YR ULT	558.92	0.10
1	3931	100 YR	563.39	
1	3931	100 YR ULT	563.47	0.08
1	3965		Culvert	
1	4020	100 YR	567.31	
1	4020	100 YR ULT	567.53	0.22
1	4252	100 YR	568.84	
1	4252	100 YR ULT	568.98	0.14
1	4333	100 YR	576.01	
1	4333	100 YR ULT	576.21	0.20
1	4560	100 YR	577.62	
1	4560	100 YR ULT	577.74	0.12
1	4716	100 YR	577.70	
1	4716	100 YR ULT	577.83	0.13

HEC-RAS Plan: WSComp River: Swadley_River Reach: Reach_1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach_1	492	100 YR	527.14	
Reach_1	492	100 YR ULT	527.31	0.16
Reach_1	636	100 YR	529.28	
Reach_1	636	100 YR ULT	529.42	0.14
Reach_1	689		Culvert	
Reach_1	769	100 YR	535.97	
Reach_1	769	100 YR ULT	536.84	0.87
Reach_1	1226	100 YR	536.02	
Reach_1	1226	100 YR ULT	536.88	0.87
Reach_1	1671	100 YR	536.13	
Reach_1	1671	100 YR ULT	536.95	0.82
Reach_1	1957	100 YR	536.51	
Reach_1	1957	100 YR ULT	537.12	0.61
Reach_1	2505	100 YR	540.10	
Reach_1	2505	100 YR ULT	540.35	0.25
Reach_1	2764	100 YR	541.78	
Reach_1	2764	100 YR ULT	542.14	0.36
Reach_1	2904	100 YR	543.88	
Reach_1	2904	100 YR ULT	544.34	0.47
Reach_1	3138	100 YR	545.18	
Reach_1	3138	100 YR ULT	545.69	0.50
Reach_1	3251	100 YR	545.80	
Reach_1	3251	100 YR ULT	546.29	0.49
Reach_1	3465	100 YR	549.08	
Reach_1	3465	100 YR ULT	549.31	0.23
Reach_1	3978	100 YR	555.92	
Reach_1	3978	100 YR ULT	556.27	0.34
Reach_1	4458	100 YR	558.92	
Reach_1	4458	100 YR ULT	559.28	0.36
Reach_1	4907	100 YR	562.05	
Reach_1	4907	100 YR ULT	562.32	0.27
Reach_1	5185	100 YR	565.59	
Reach_1	5185	100 YR ULT	565.68	0.09
Reach_1	5585	100 YR	571.20	

HEC-RAS Plan: WSComp River: Swadley_River Reach: Reach_1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach_1	5585	100 YR ULT	571.44	0.24
Reach_1	5850	100 YR	575.08	
Reach_1	5850	100 YR ULT	575.18	0.10
Reach_1	6280	100 YR	585.04	
Reach_1	6280	100 YR ULT	585.21	0.17

HEC-RAS Plan: WSComp River: Taaffe_Reach Reach: Reach_1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach_1	1629	100 YR	530.04	
Reach_1	1629	100 YR ULT	530.65	0.61
Reach_1	2109	100 YR	530.64	
Reach_1	2109	100 YR ULT	531.24	0.60
Reach_1	2402	100 YR	531.42	
Reach_1	2402	100 YR ULT	532.07	0.65
Reach_1	2664	100 YR	532.12	
Reach_1	2664	100 YR ULT	532.84	0.72
Reach_1	2702	100 YR	531.77	
Reach_1	2702	100 YR ULT	532.34	0.57
Reach_1	2703		Culvert	
Reach_1	2744	100 YR	537.76	
Reach_1	2744	100 YR ULT	538.29	0.53
Reach_1	2766	100 YR	537.77	
Reach_1	2766	100 YR ULT	538.31	0.54
Reach_1	2933	100 YR	538.27	
Reach_1	2933	100 YR ULT	538.80	0.53
Reach_1	3366	100 YR	539.82	
Reach_1	3366	100 YR ULT	540.27	0.45
Reach_1	3797	100 YR	543.61	
Reach_1	3797	100 YR ULT	544.02	0.41
Reach_1	4113	100 YR	546.85	
Reach_1	4113	100 YR ULT	547.47	0.62
Reach_1	4561	100 YR	549.37	
Reach_1	4561	100 YR ULT	549.96	0.59
Reach_1	4758	100 YR	550.45	
Reach_1	4758	100 YR ULT	550.90	0.45
Reach_1	4919	100 YR	551.14	
Reach_1	4919	100 YR ULT	551.70	0.57
Reach_1	5007	100 YR	551.19	
Reach_1	5007	100 YR ULT	551.78	0.58
Reach_1	5391	100 YR	551.48	
Reach_1	5391	100 YR ULT	552.13	0.65
Reach_1	5795	100 YR	552.00	

HEC-RAS Plan: WSComp River: Taaffe_Reach Reach: Reach_1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Reach_1	5795	100 YR ULT	552.73	0.73
Reach_1	6084	100 YR	552.56	
Reach_1	6084	100 YR ULT	553.32	0.76
Reach_1	6337	100 YR	553.20	
Reach_1	6337	100 YR ULT	553.99	0.78
Reach_1	6745	100 YR	554.31	
Reach_1	6745	100 YR ULT	555.09	0.78
Reach_1	6888	100 YR	554.85	
Reach_1	6888	100 YR ULT	555.60	0.75

HEC-RAS Plan: WSComp River: Tarrell_Branch Reach: Tarrell_Reach

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Tarrell_Reach	1787	100 YR	538.25	
Tarrell_Reach	1787	100 YR ULT	538.31	0.06
Tarrell_Reach	2080	100 YR	543.69	
Tarrell_Reach	2080	100 YR ULT	543.75	0.06
Tarrell_Reach	2297	100 YR	548.41	
Tarrell_Reach	2297	100 YR ULT	548.58	0.17
Tarrell_Reach	2503	100 YR	551.50	
Tarrell_Reach	2503	100 YR ULT	551.59	0.09
Tarrell_Reach	2736	100 YR	555.11	
Tarrell_Reach	2736	100 YR ULT	555.23	0.12
Tarrell_Reach	2850	100 YR	556.13	
Tarrell_Reach	2850	100 YR ULT	556.25	0.12
Tarrell_Reach	2897	100 YR	556.51	
Tarrell_Reach	2897	100 YR ULT	556.60	0.08
Tarrell_Reach	2960	100 YR	556.72	
Tarrell_Reach	2960	100 YR ULT	556.79	0.07
Tarrell_Reach	3360	100 YR	556.99	
Tarrell_Reach	3360	100 YR ULT	557.07	0.08
Tarrell_Reach	3595	100 YR	557.18	
Tarrell_Reach	3595	100 YR ULT	557.26	0.08
Tarrell_Reach	3913	100 YR	558.91	
Tarrell_Reach	3913	100 YR ULT	558.98	0.07
Tarrell_Reach	4132	100 YR	563.39	
Tarrell_Reach	4132	100 YR ULT	563.48	0.09
Tarrell_Reach	4296	100 YR	565.51	
Tarrell_Reach	4296	100 YR ULT	565.62	0.10
Tarrell_Reach	4527	100 YR	571.45	
Tarrell_Reach	4527	100 YR ULT	571.53	0.08
Tarrell_Reach	4846	100 YR	580.95	
Tarrell_Reach	4846	100 YR ULT	581.02	0.07
Tarrell_Reach	4970	100 YR	585.10	
Tarrell_Reach	4970	100 YR ULT	585.18	0.08

HEC-RAS Plan: WSComp River: Ten Branch Reach: 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	1702	100 YR	532.34	
1	1702	100 YR ULT	532.84	0.50
1	1810	100 YR	532.88	
1	1810	100 YR ULT	533.34	0.47
1	1993	100 YR	534.57	
1	1993	100 YR ULT	535.07	0.50
1	2124	100 YR	535.78	
1	2124	100 YR ULT	536.36	0.58
1	2348	100 YR	536.10	
1	2348	100 YR ULT	536.58	0.48
1	2482	100 YR	538.39	
1	2482	100 YR ULT	539.02	0.63
1	2724	100 YR	541.42	
1	2724	100 YR ULT	541.90	0.48
1	2892	100 YR	543.13	
1	2892	100 YR ULT	543.41	0.28
1	3340	100 YR	544.51	
1	3340	100 YR ULT	544.89	0.38
1	3675	100 YR	546.82	
1	3675	100 YR ULT	547.11	0.30
1	3850	100 YR	548.04	
1	3850	100 YR ULT	548.15	0.12
1	4116	100 YR	548.52	
1	4116	100 YR ULT	548.76	0.24
1	4285	100 YR	550.13	
1	4285	100 YR ULT	550.32	0.19
1	4829	100 YR	550.77	
1	4829	100 YR ULT	551.06	0.28
1	4955	100 YR	550.78	
1	4955	100 YR ULT	551.06	0.29
1	5088	100 YR	550.79	
1	5088	100 YR ULT	551.08	0.29
1	5152	100 YR	550.80	
1	5152	100 YR ULT	551.09	0.29

HEC-RAS Plan: WSComp River: Ten Branch Reach: 1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	5286	100 YR	551.94	
1	5286	100 YR ULT	552.31	0.37
1	5350	100 YR	553.72	
1	5350	100 YR ULT	554.18	0.46
1	5362	100 YR	553.78	
1	5362	100 YR ULT	554.25	0.47

HEC-RAS Plan: WSComp River: Unidentified Reach: 1

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	485	100 YR	523.60	
1	485	100 YR ULT	523.65	0.05
1	648	100 YR	525.53	
1	648	100 YR ULT	525.59	0.06
1	863	100 YR	527.62	
1	863	100 YR ULT	527.67	0.05
1	1139	100 YR	532.54	
1	1139	100 YR ULT	532.61	0.07
1	1310	100 YR	534.23	
1	1310	100 YR ULT	534.31	0.09
1	1488	100 YR	535.61	
1	1488	100 YR ULT	535.68	0.07
1	1541	100 YR	536.63	
1	1541	100 YR ULT	536.70	0.08
1	1583	100 YR	537.52	
1	1583	100 YR ULT	537.62	0.11
1	1679	100 YR	539.42	
1	1679	100 YR ULT	539.50	0.08
1	1765	100 YR	540.23	
1	1765	100 YR ULT	540.32	0.09
1	2054	100 YR	548.34	
1	2054	100 YR ULT	548.51	0.17
1	2209	100 YR	550.15	
1	2209	100 YR ULT	550.36	0.21
1	2281	100 YR	550.18	
1	2281	100 YR ULT	550.39	0.21
1	2330	100 YR	550.19	
1	2330	100 YR ULT	550.39	0.21
1	2475	100 YR	550.19	
1	2475	100 YR ULT	550.40	0.21
1	2697	100 YR	550.20	
1	2697	100 YR ULT	550.41	0.21
1	2796	100 YR	552.81	
1	2796	100 YR ULT	552.84	0.03

HEC-RAS Plan: WSComp River: Unidentified Reach: 1 (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
1	3054	100 YR	559.49	
1	3054	100 YR ULT	559.54	0.06
1	3252	100 YR	563.30	
1	3252	100 YR ULT	563.32	0.02
1	3441	100 YR	569.71	
1	3441	100 YR ULT	569.71	0.00
1	3582	100 YR	573.87	
1	3582	100 YR ULT	573.87	0.00
1	3771	100 YR	585.19	
1	3771	100 YR ULT	585.19	0.00

HEC-RAS Plan: WSComp River: Webb Reach: Webb

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
Webb	1405	100 YR	522.15	
Webb	1405	100 YR ULT	522.41	0.25
Webb	1719	100 YR	524.93	
Webb	1719	100 YR ULT	525.18	0.25
Webb	2033	100 YR	527.15	
Webb	2033	100 YR ULT	527.40	0.25
Webb	2065	100 YR	527.06	
Webb	2065	100 YR ULT	527.31	0.24
Webb	2243	100 YR	528.55	
Webb	2243	100 YR ULT	528.74	0.19
Webb	2259	100 YR	528.71	
Webb	2259	100 YR ULT	528.91	0.20
Webb	2607	100 YR	530.49	
Webb	2607	100 YR ULT	530.70	0.20
Webb	2722	100 YR	531.98	
Webb	2722	100 YR ULT	532.17	0.19
Webb	2911	100 YR	532.88	
Webb	2911	100 YR ULT	533.16	0.28
Webb	3045	100 YR	533.28	
Webb	3045	100 YR ULT	533.59	0.31

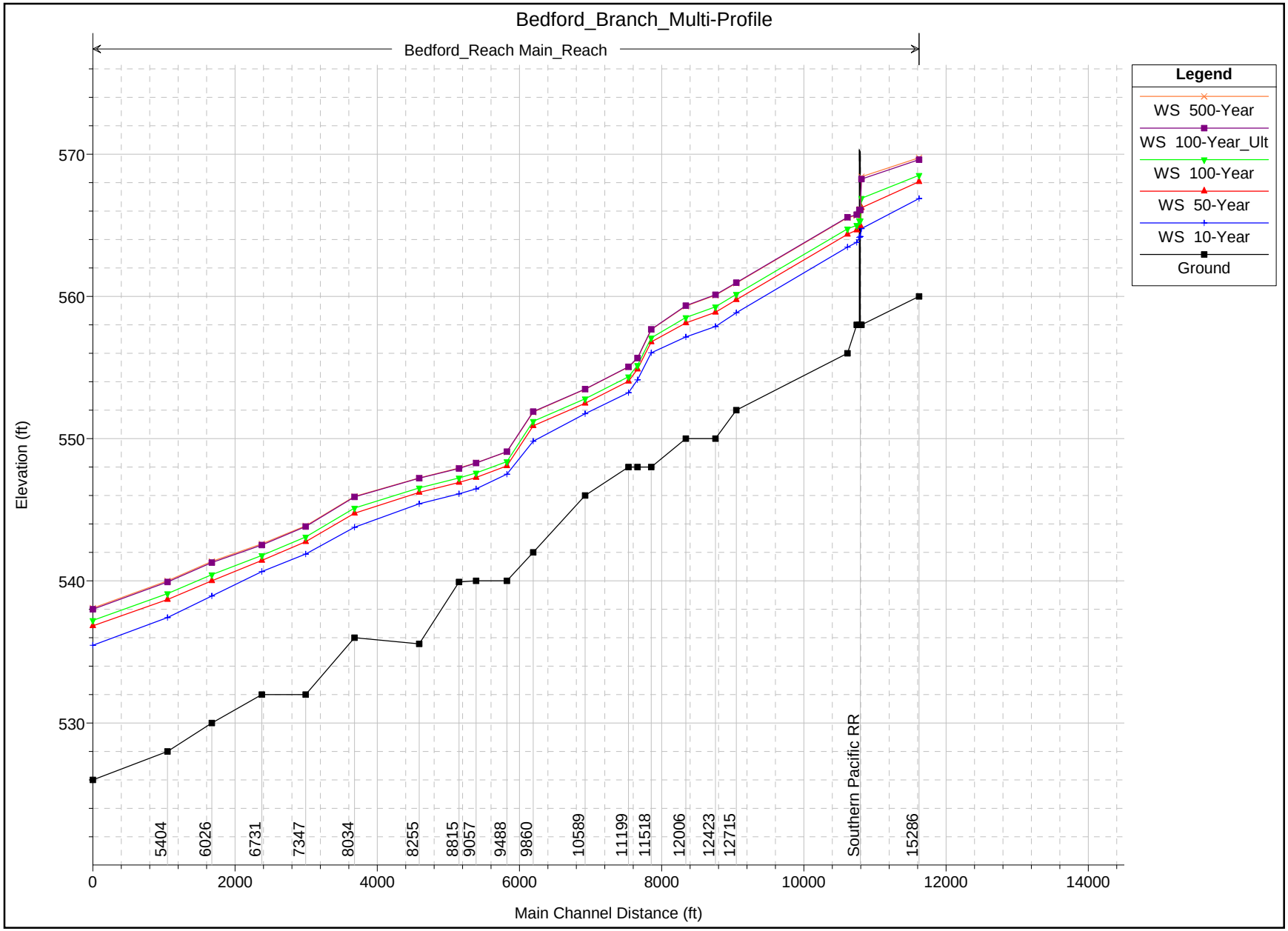
HEC-RAS Plan: WSComp River: West_Soap Reach: West_Soap

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
West_Soap	437	100 YR	578.64	
West_Soap	437	100 YR ULT	579.70	1.06
West_Soap	1304	100 YR	580.59	
West_Soap	1304	100 YR ULT	581.72	1.13
West_Soap	2047	100 YR	581.79	
West_Soap	2047	100 YR ULT	583.18	1.39
West_Soap	2976	100 YR	582.49	
West_Soap	2976	100 YR ULT	583.94	1.45
West_Soap	3876	100 YR	583.94	
West_Soap	3876	100 YR ULT	585.31	1.37
West_Soap	5788	100 YR	586.53	
West_Soap	5788	100 YR ULT	587.95	1.42
West_Soap	6601	100 YR	587.35	
West_Soap	6601	100 YR ULT	588.73	1.39
West_Soap	6685	100 YR	587.45	
West_Soap	6685	100 YR ULT	588.82	1.38
West_Soap	6727		Culvert	
West_Soap	6756	100 YR	587.50	
West_Soap	6756	100 YR ULT	588.92	1.42
West_Soap	6806	100 YR	587.61	
West_Soap	6806	100 YR ULT	589.04	1.43
West_Soap	7690	100 YR	588.86	
West_Soap	7690	100 YR ULT	590.33	1.47
West_Soap	8050	100 YR	589.85	
West_Soap	8050	100 YR ULT	591.27	1.42
West_Soap	9617	100 YR	592.60	
West_Soap	9617	100 YR ULT	593.78	1.18
West_Soap	10740	100 YR	594.73	
West_Soap	10740	100 YR ULT	595.93	1.20
West_Soap	11782	100 YR	595.74	
West_Soap	11782	100 YR ULT	596.85	1.11
West_Soap	11991	100 YR	596.22	
West_Soap	11991	100 YR ULT	597.26	1.04
West_Soap	12090	100 YR	596.43	

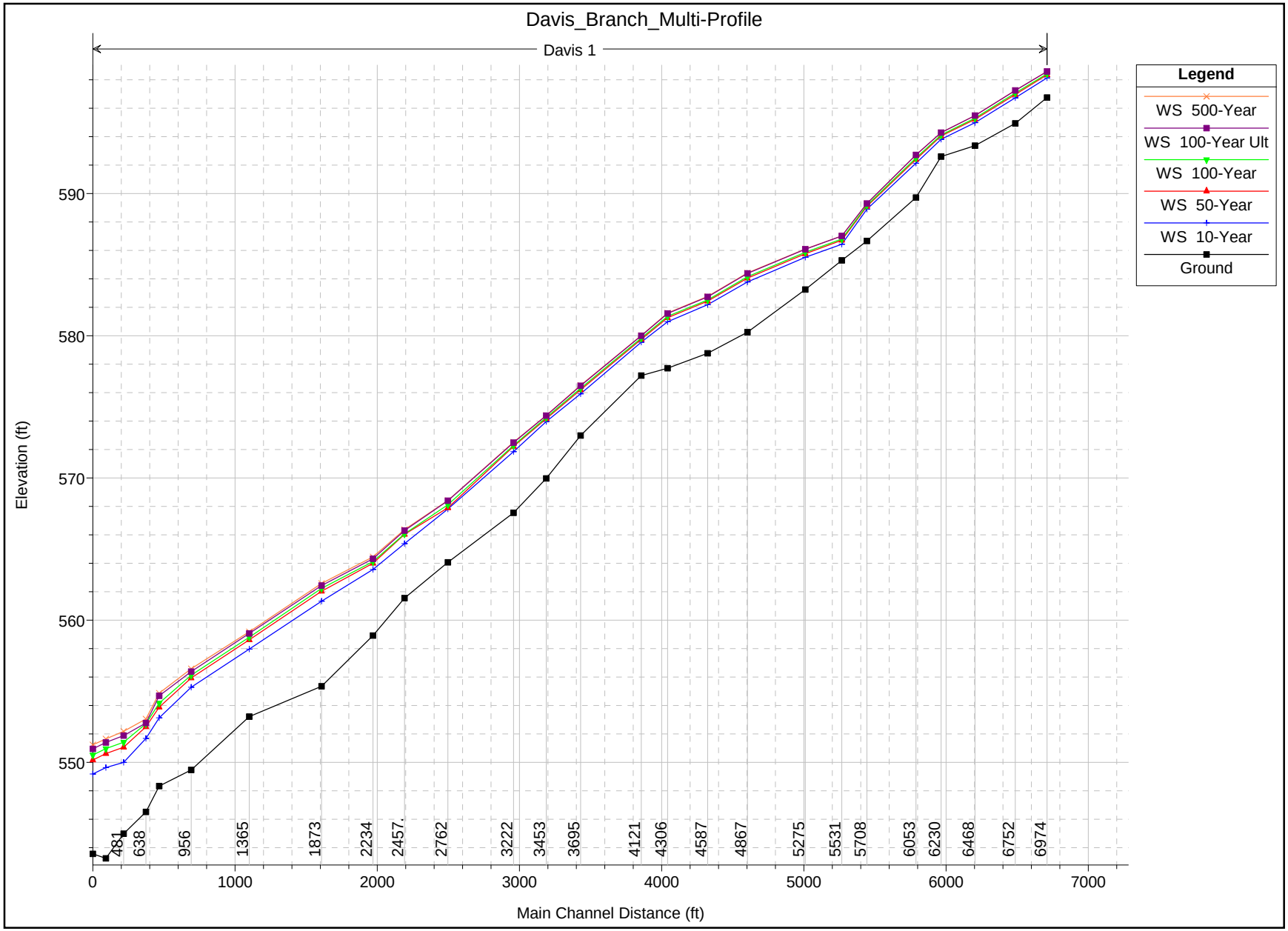
HEC-RAS Plan: WSComp River: West_Soap Reach: West_Soap (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS
			(ft)	(ft)
West_Soap	12090	100 YR ULT	597.45	1.02
West_Soap	12117		Culvert	
West_Soap	12169	100 YR	597.66	
West_Soap	12169	100 YR ULT	598.45	0.79
West_Soap	12230	100 YR	597.71	
West_Soap	12230	100 YR ULT	598.52	0.81
West_Soap	13150	100 YR	598.14	
West_Soap	13150	100 YR ULT	599.11	0.97
West_Soap	13860	100 YR	598.53	
West_Soap	13860	100 YR ULT	599.59	1.06
West_Soap	14620	100 YR	600.91	
West_Soap	14620	100 YR ULT	601.90	0.99
West_Soap	15315	100 YR	602.69	
West_Soap	15315	100 YR ULT	603.72	1.03

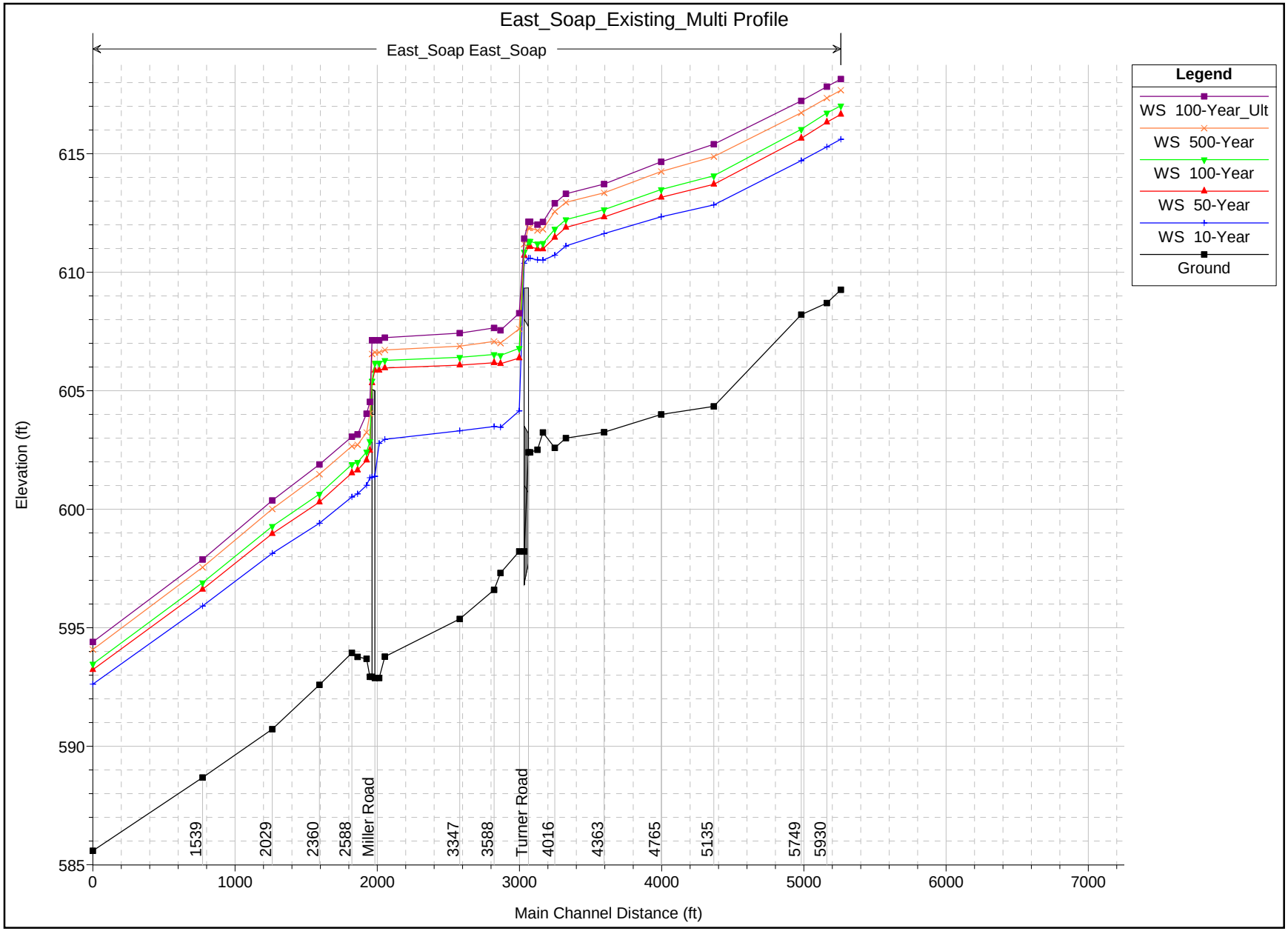
Profiles



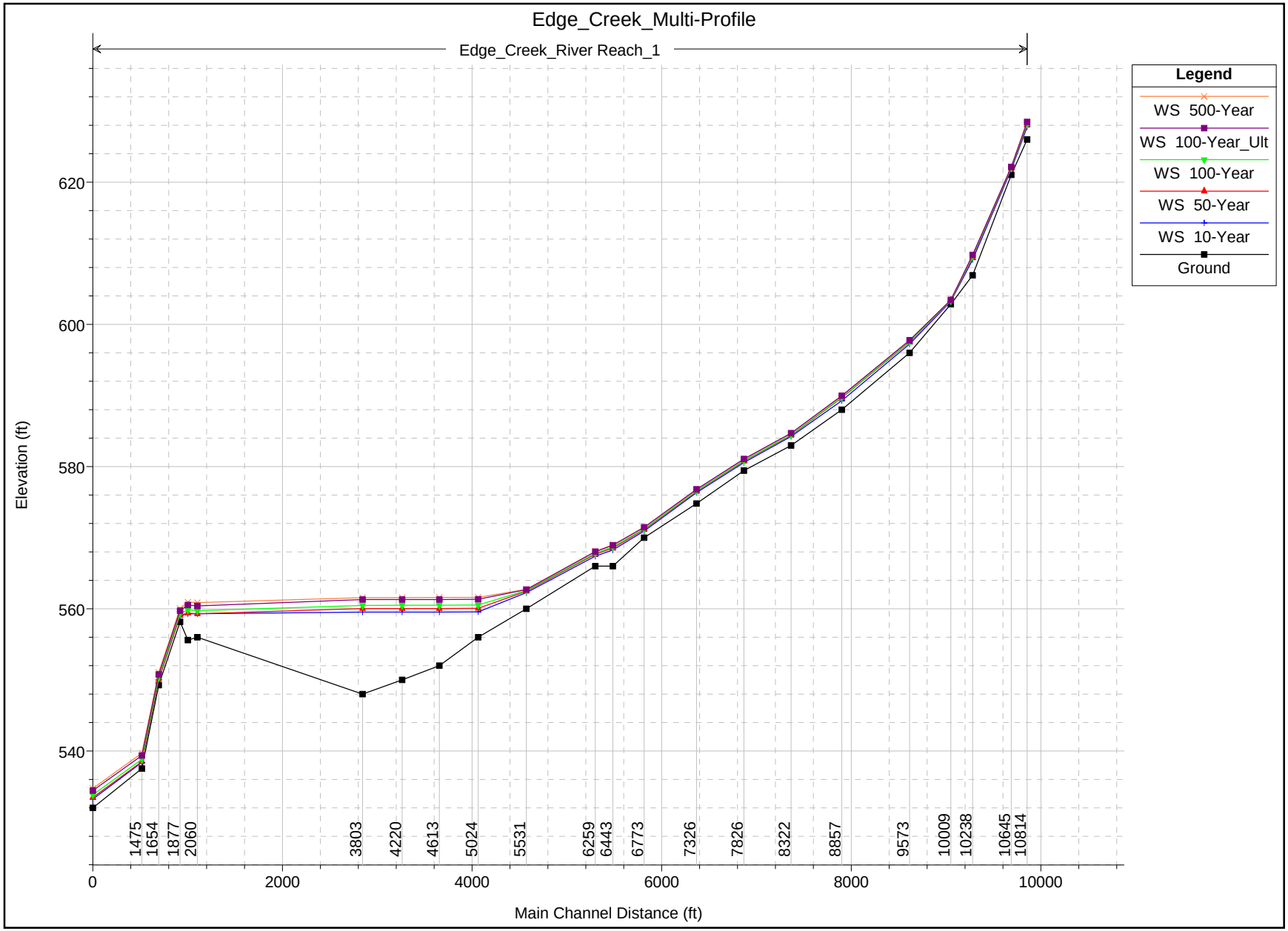
1 in Horiz. = 2000 ft 1 in Vert. = 10 ft



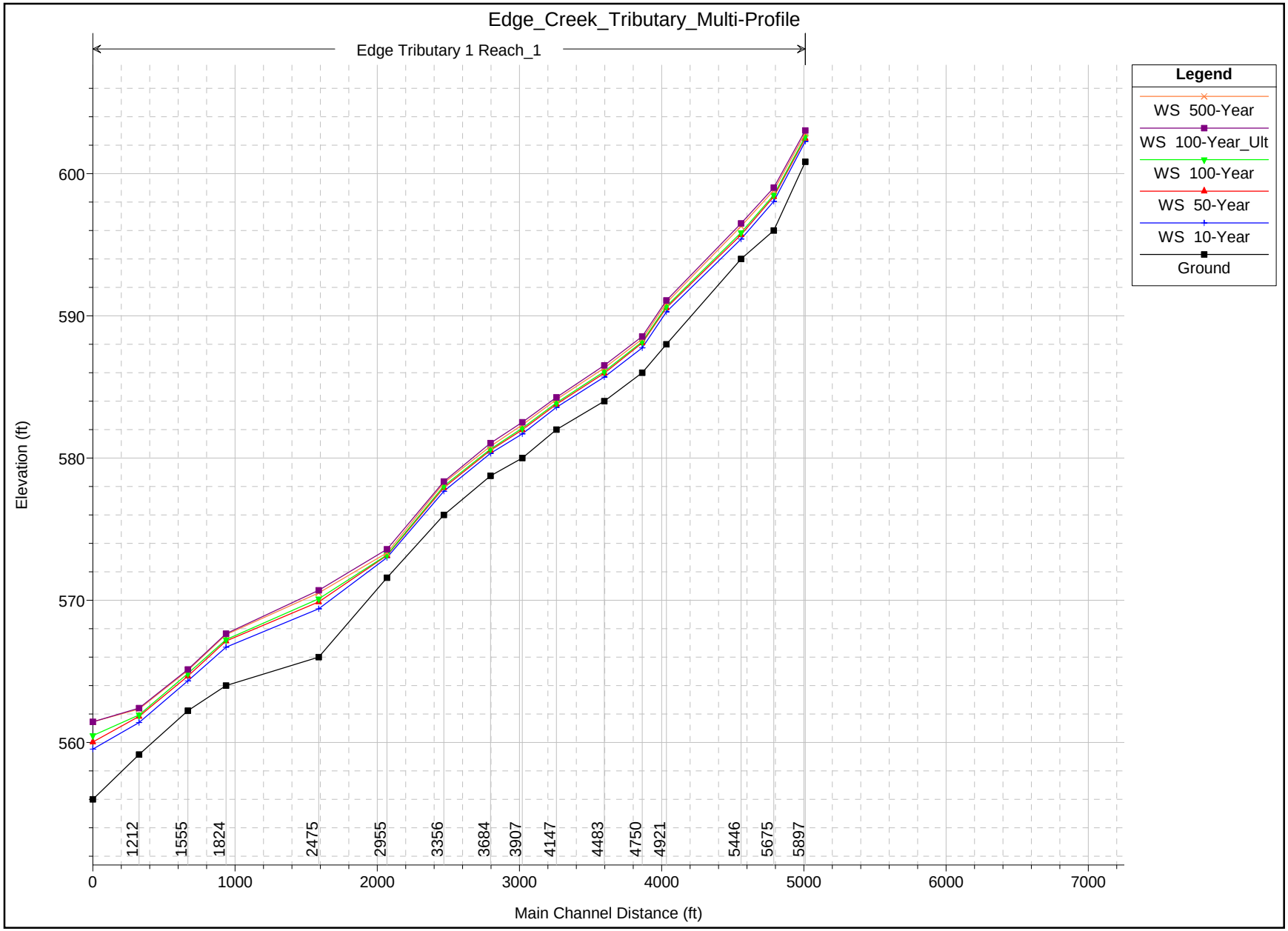
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



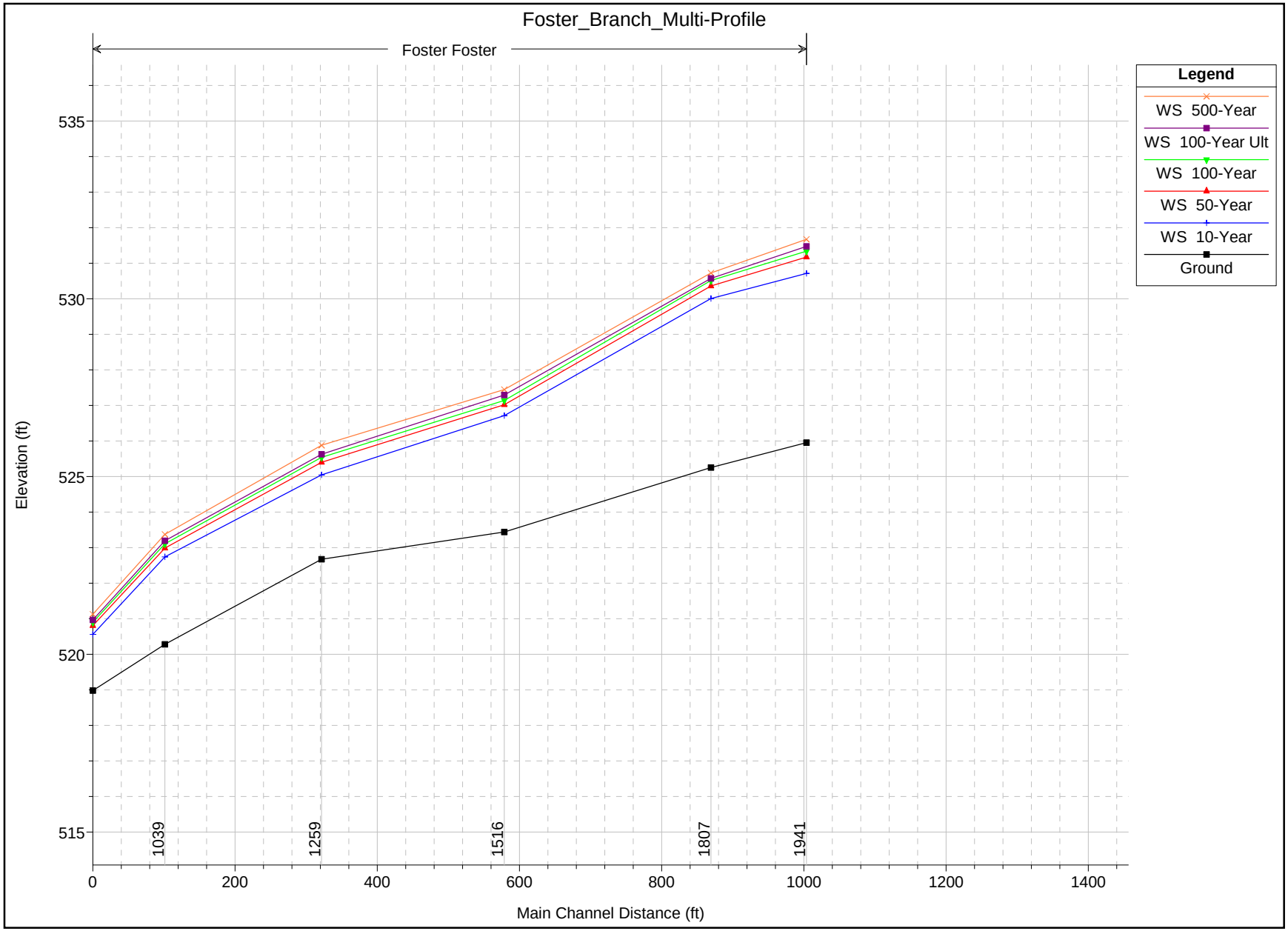
1 in Horiz. = 1000 ft 1 in Vert. = 6 ft



1 in Horiz. = 1500 ft 1 in Vert. = 20 ft



1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



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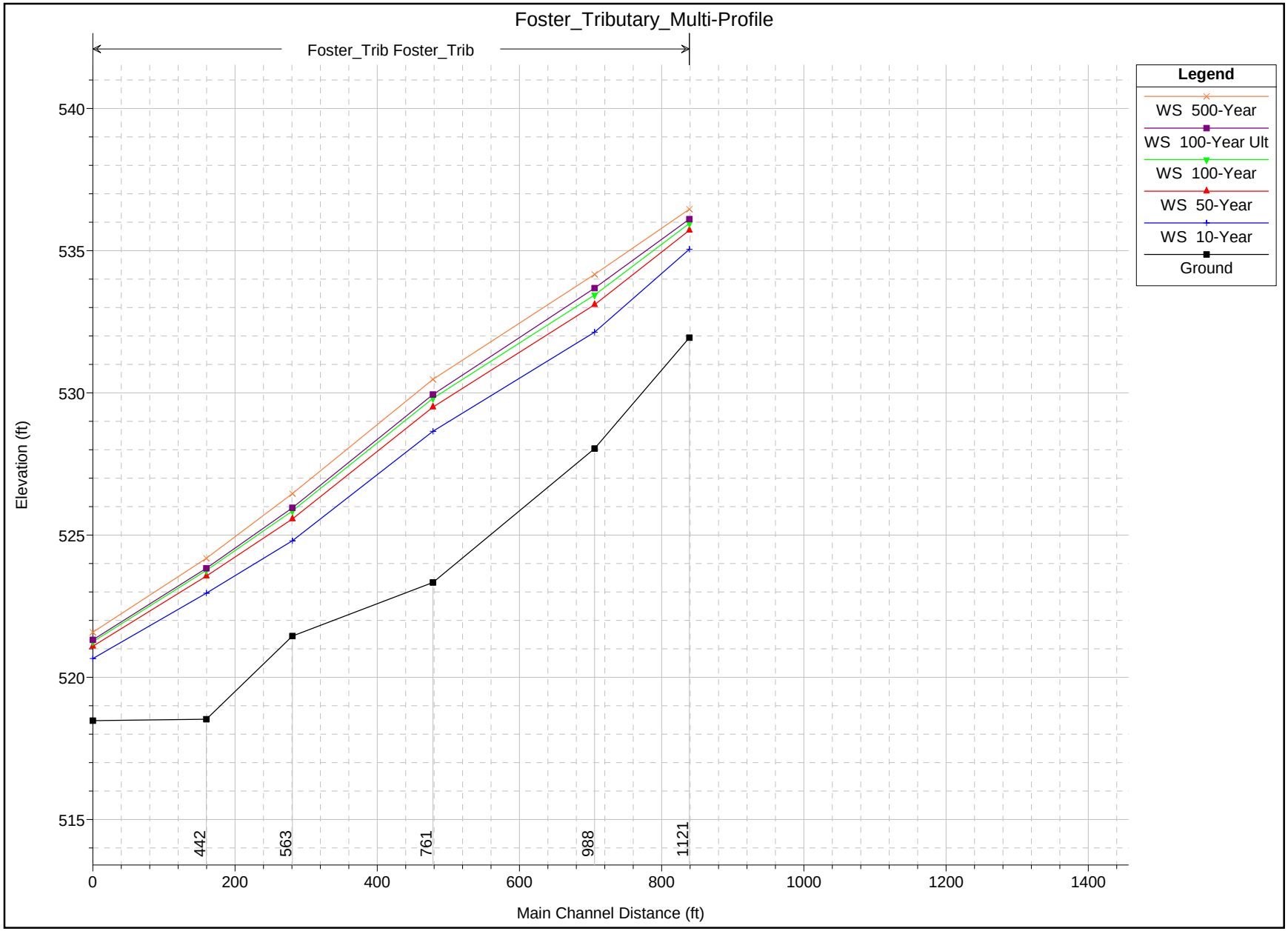

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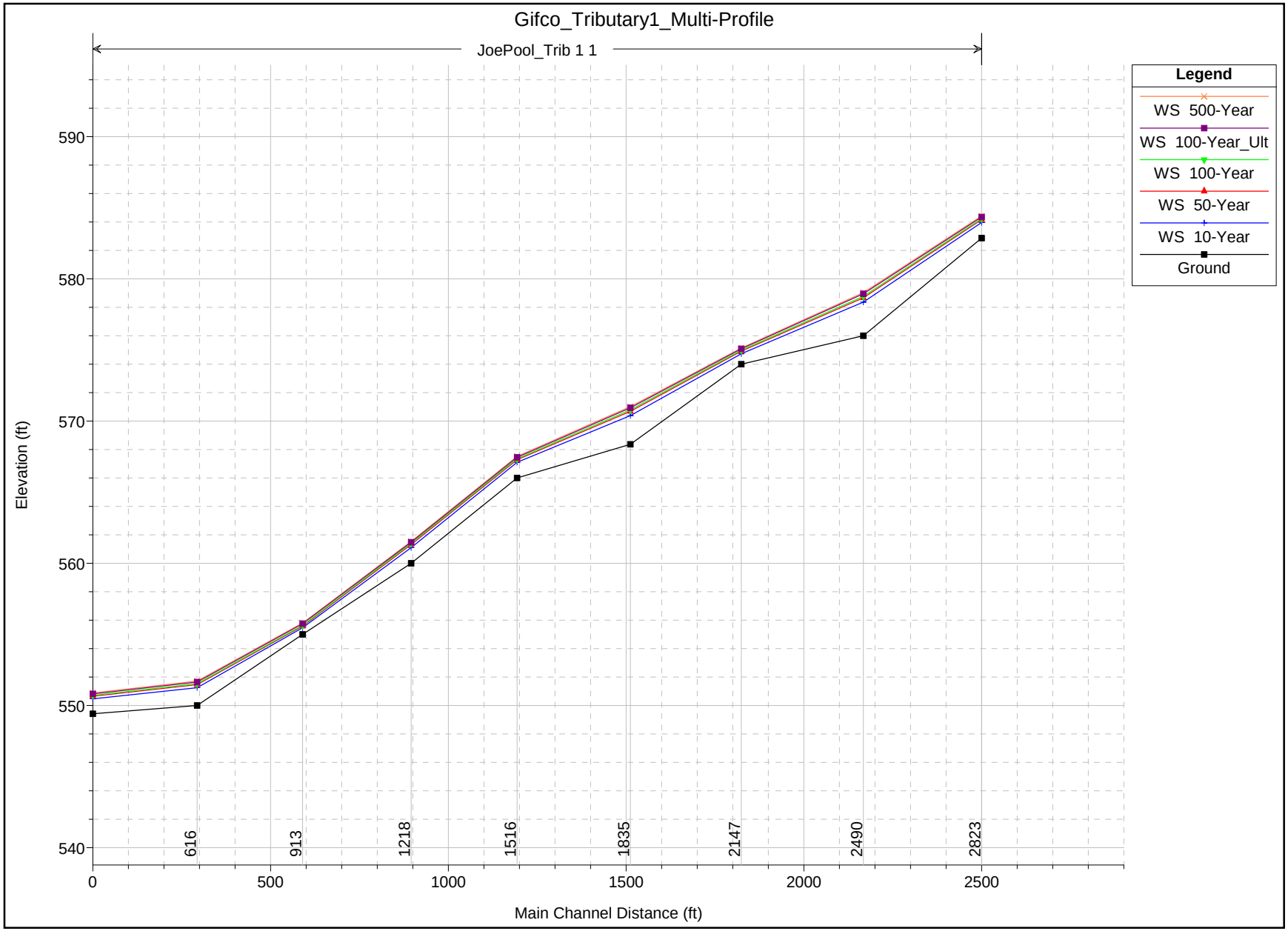

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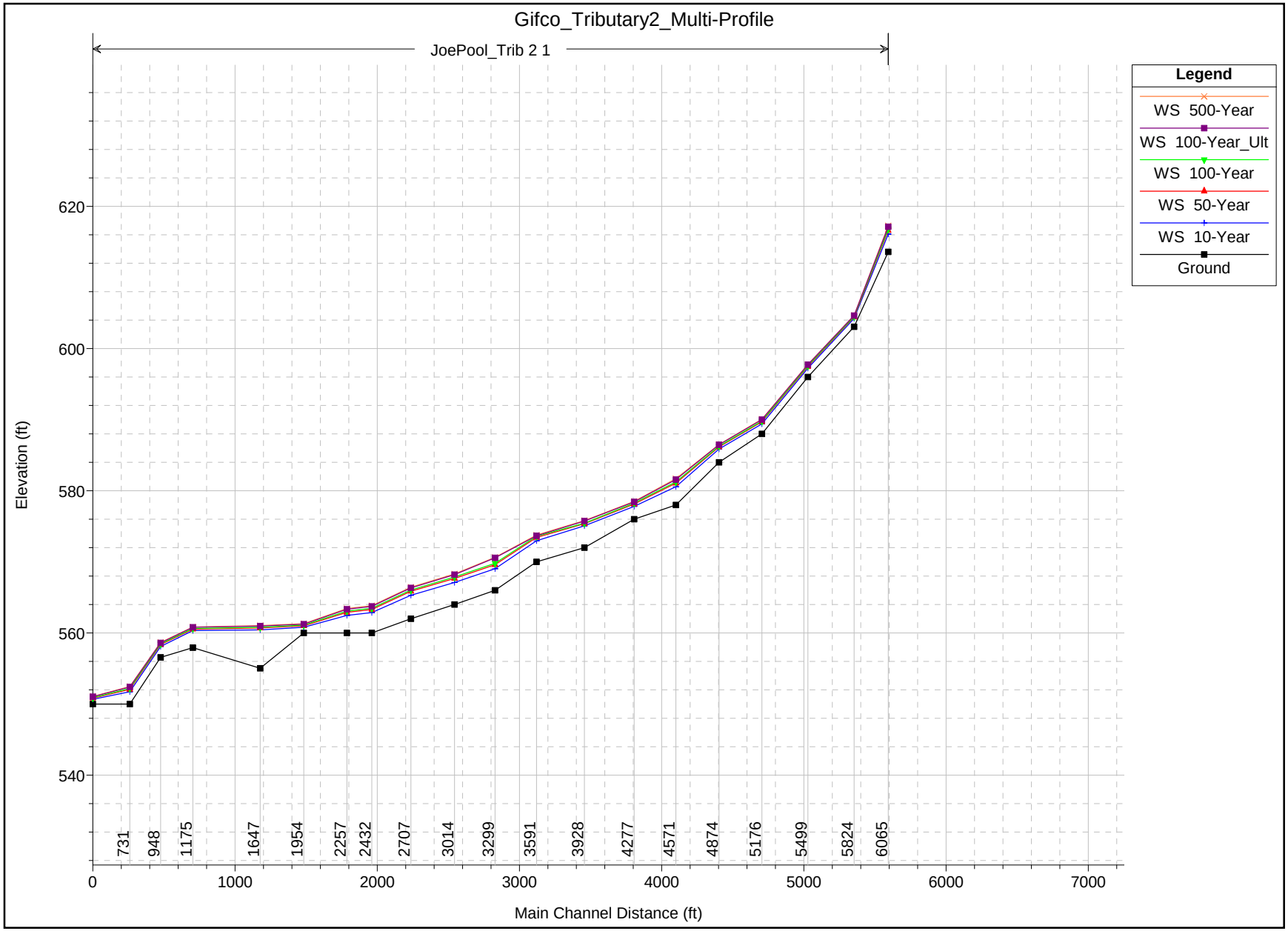

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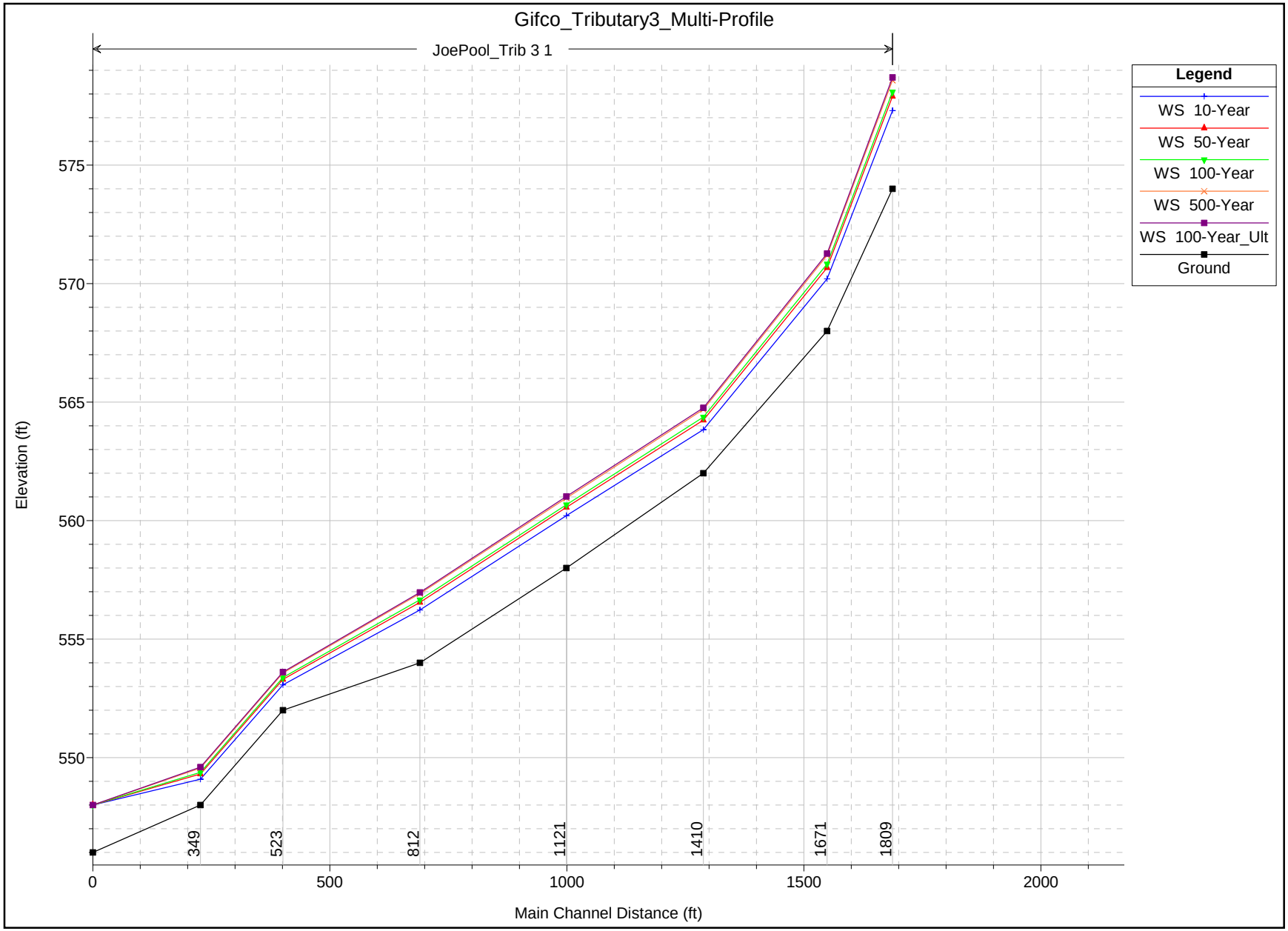

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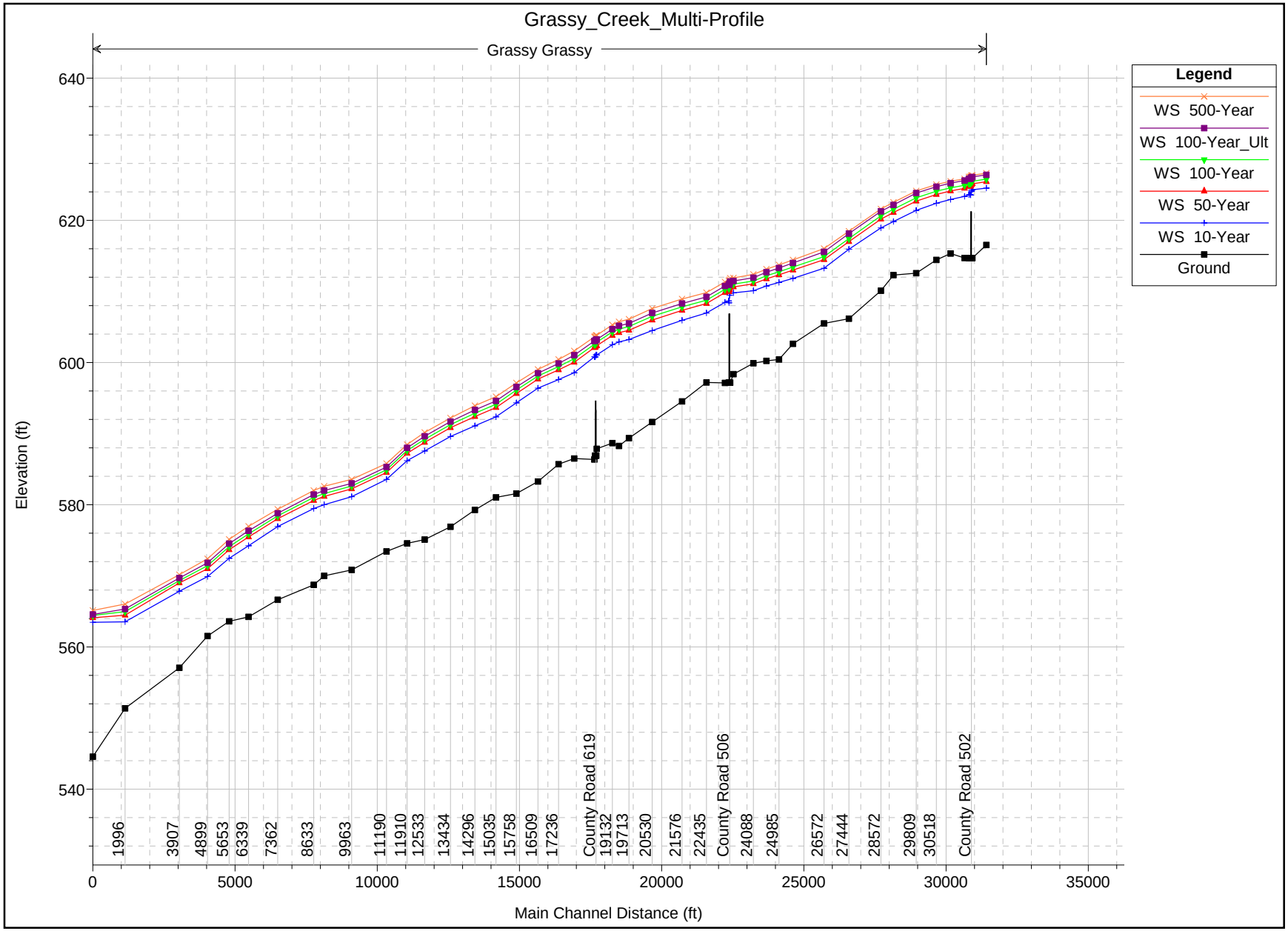

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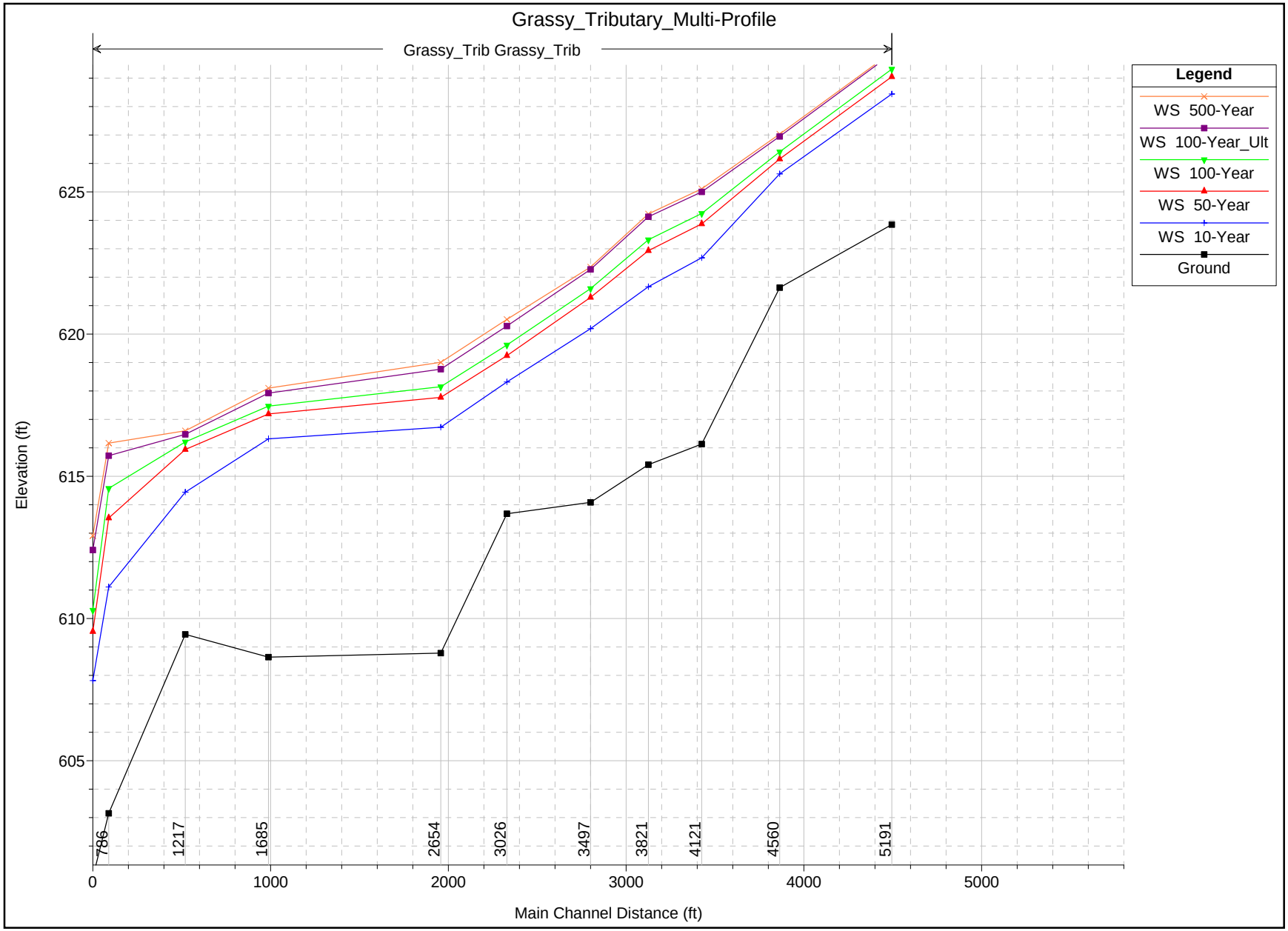

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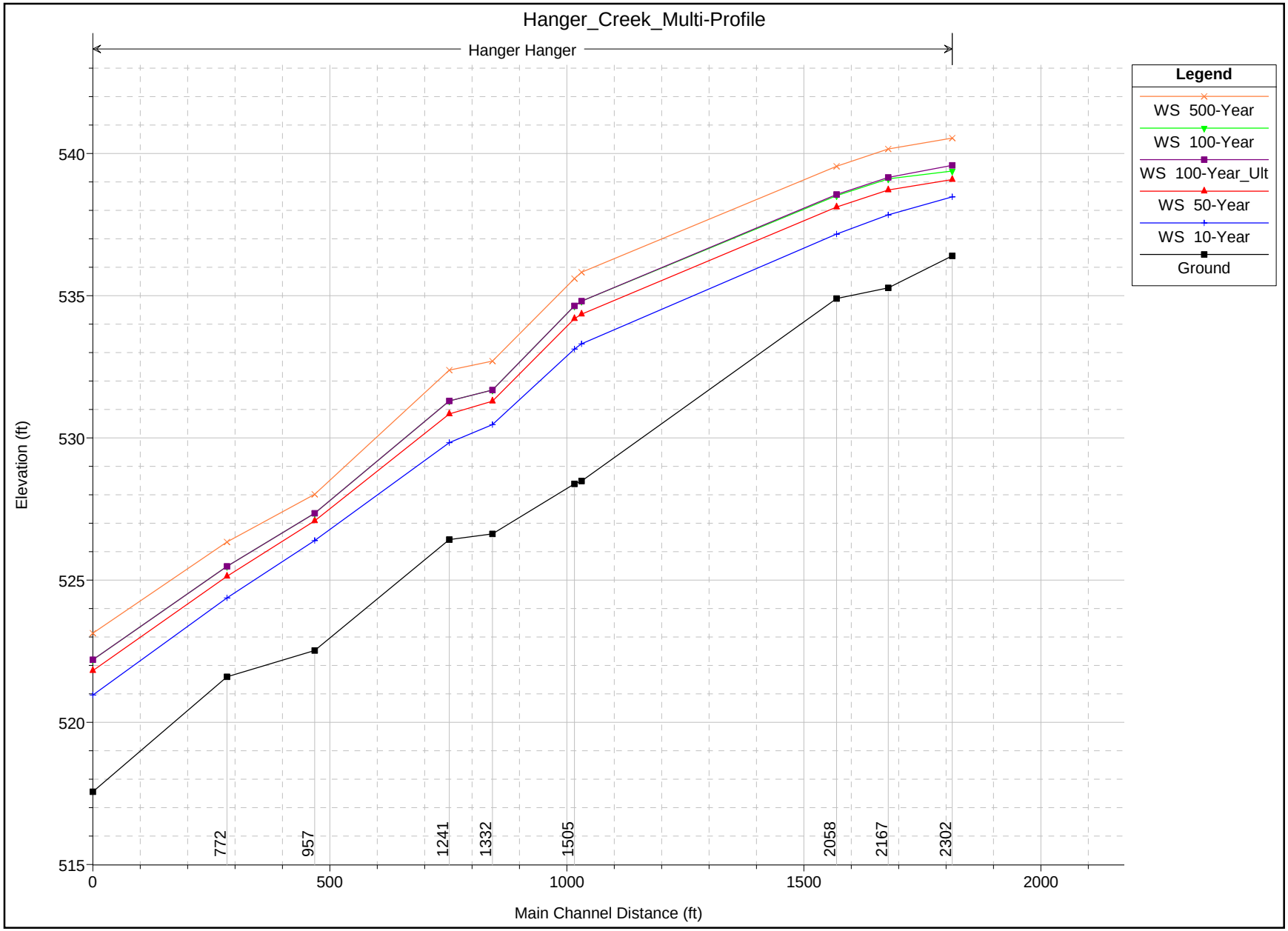

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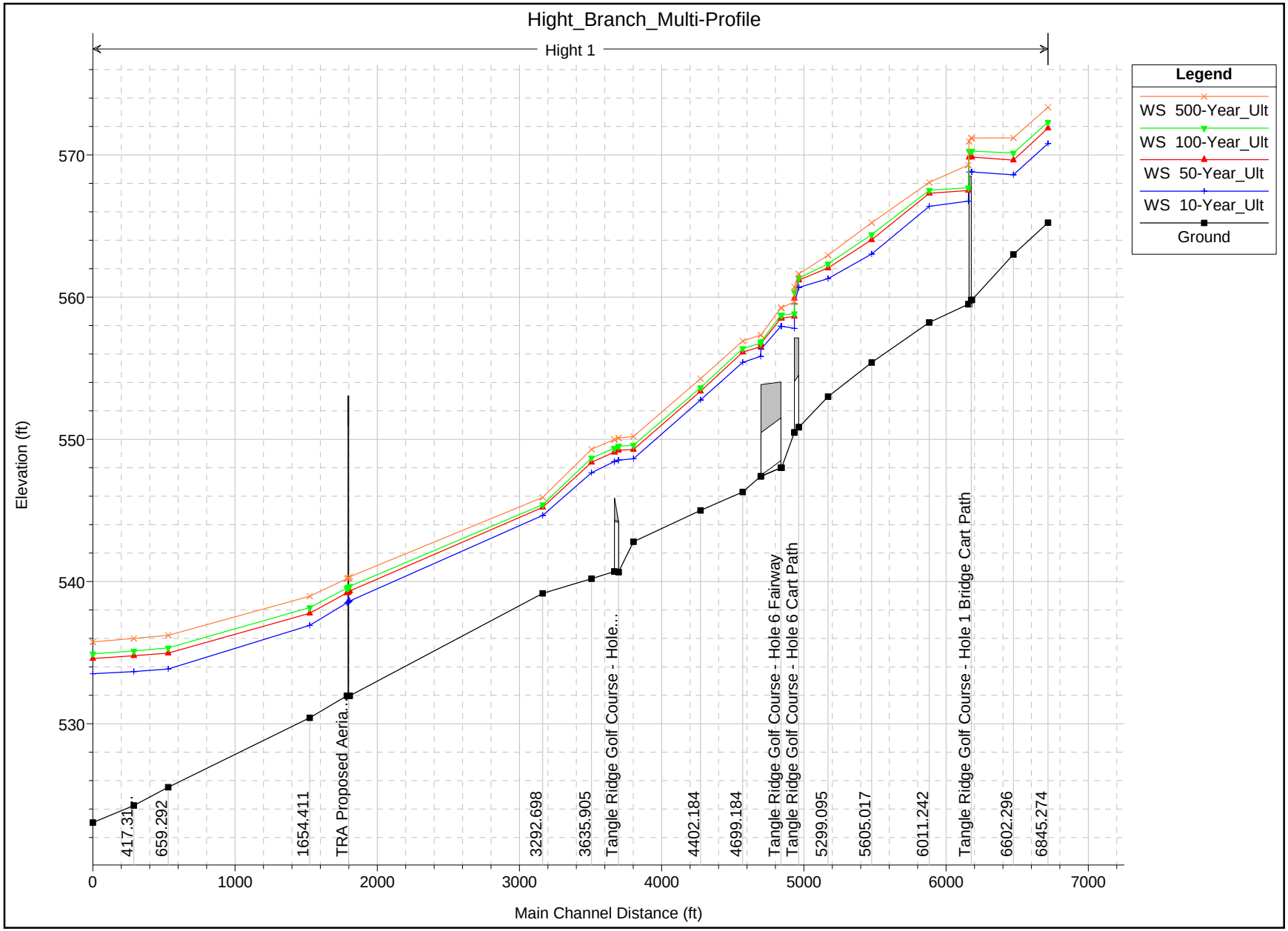
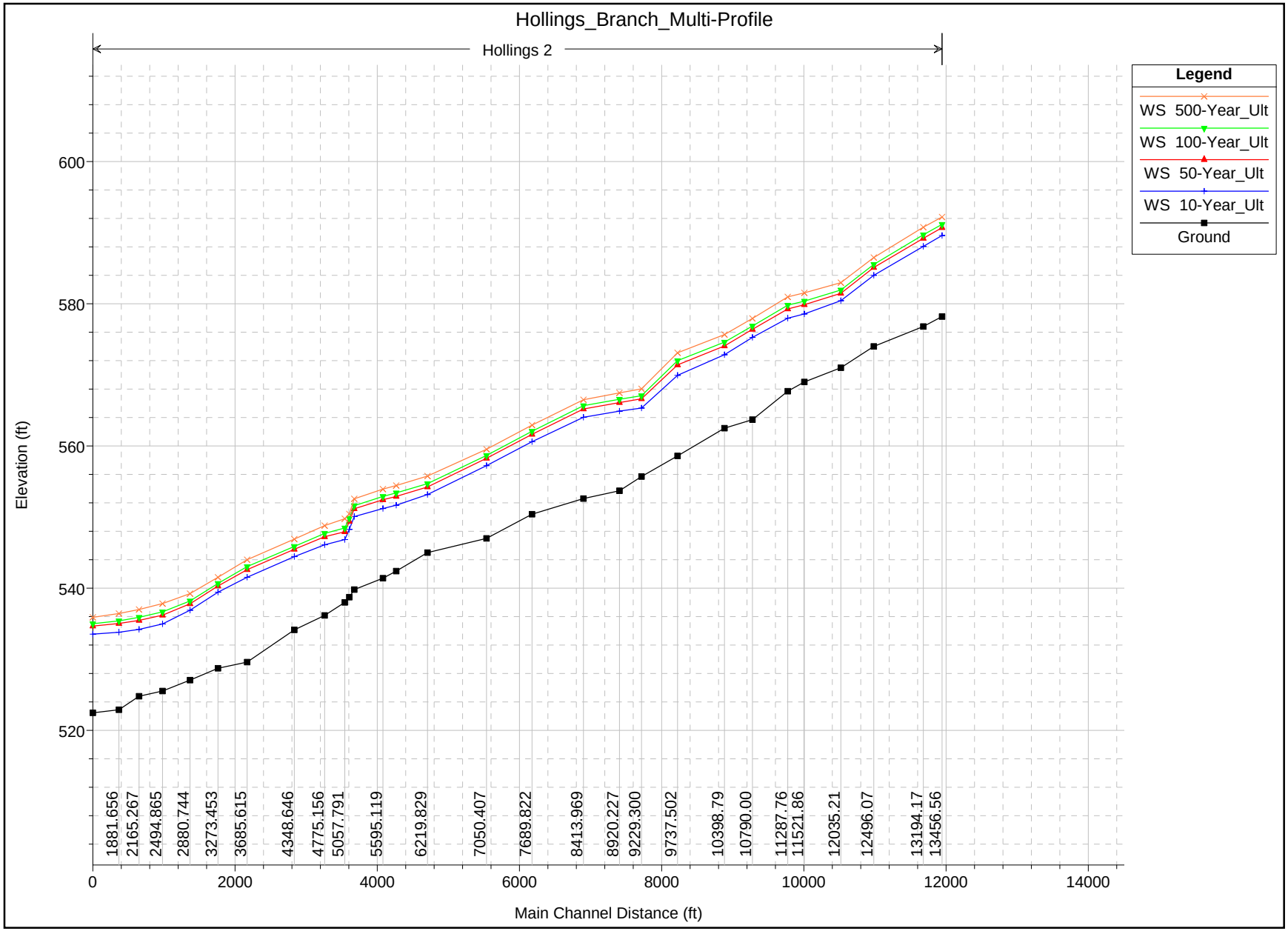


1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



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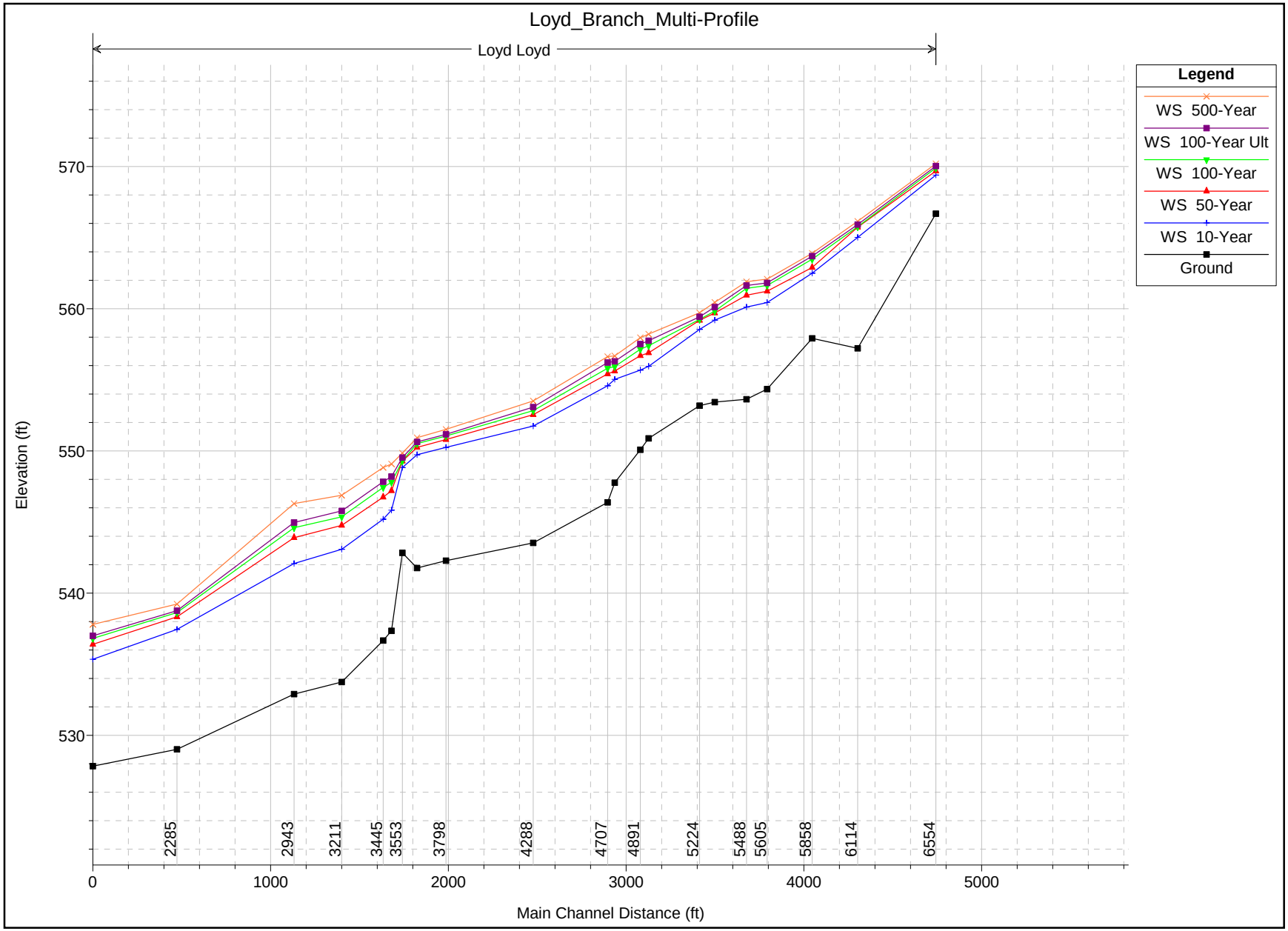

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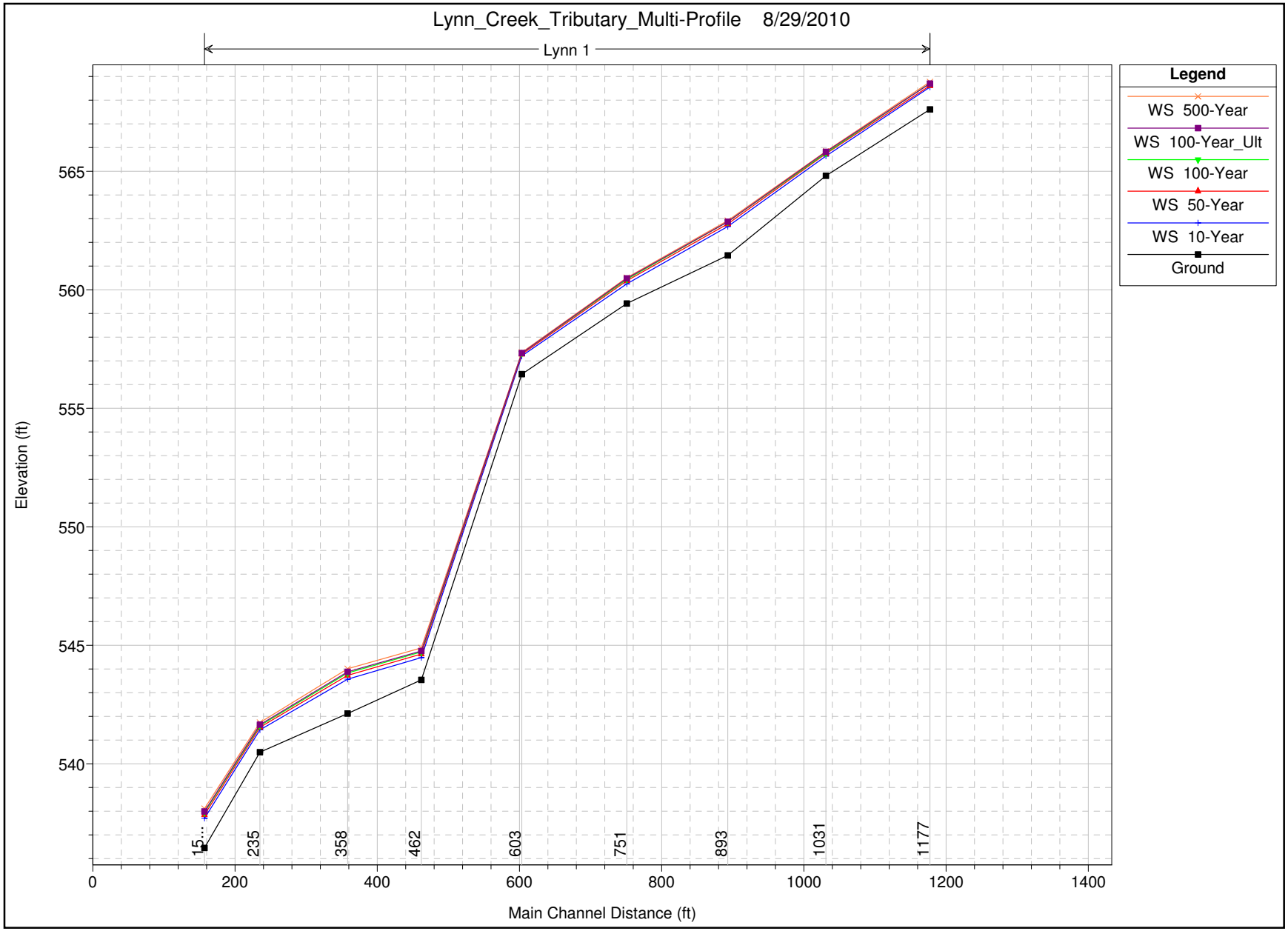

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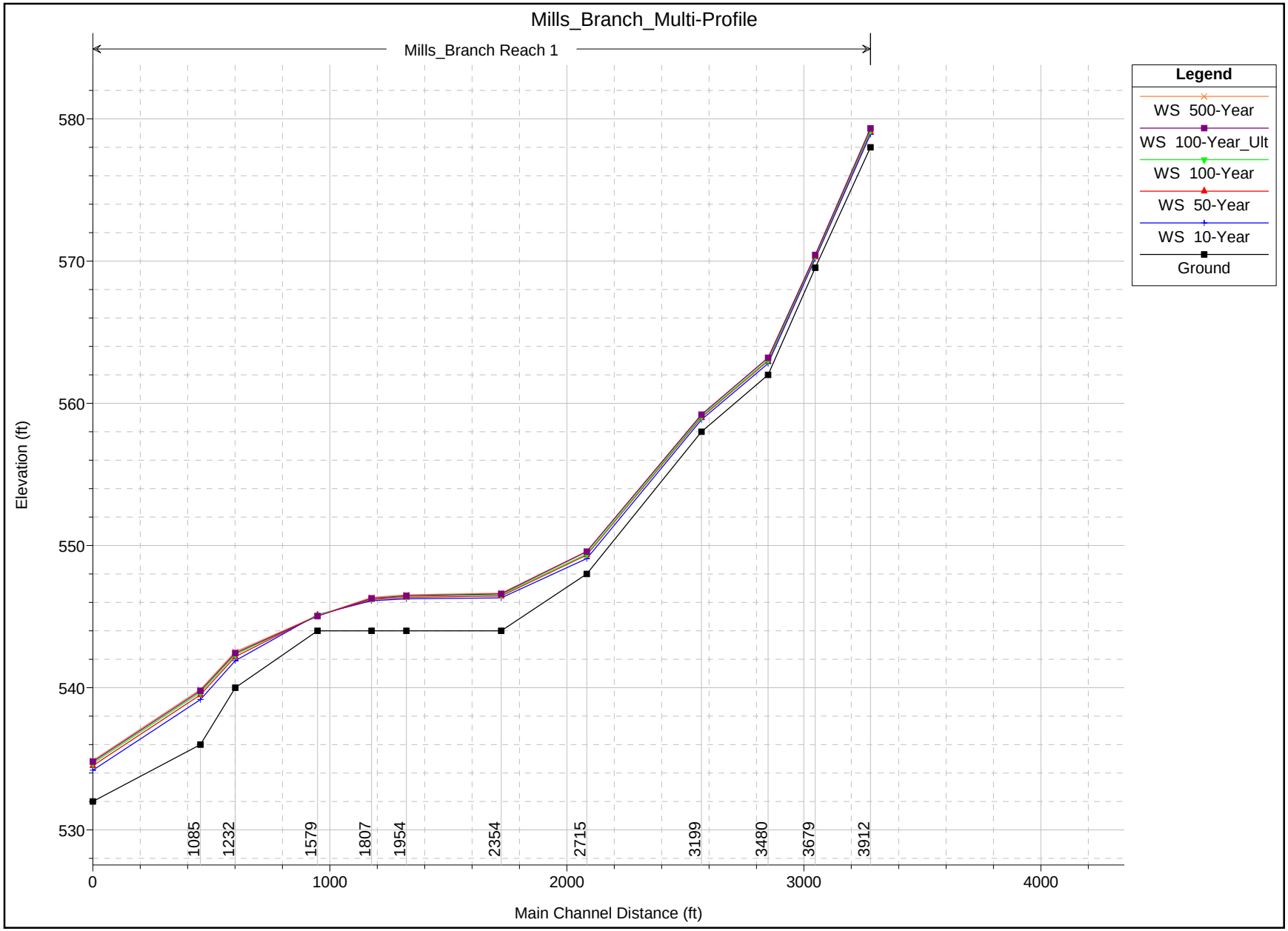

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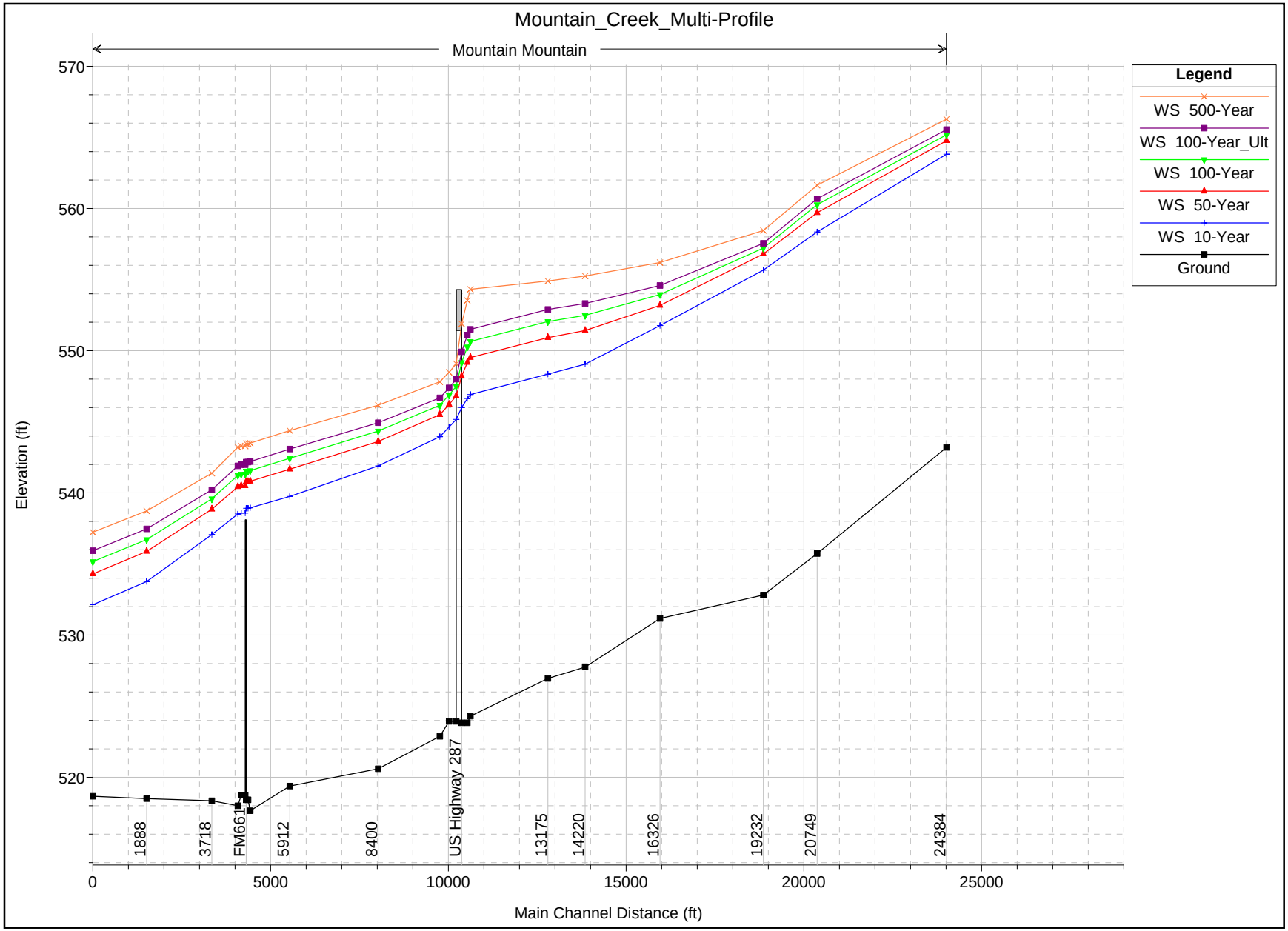

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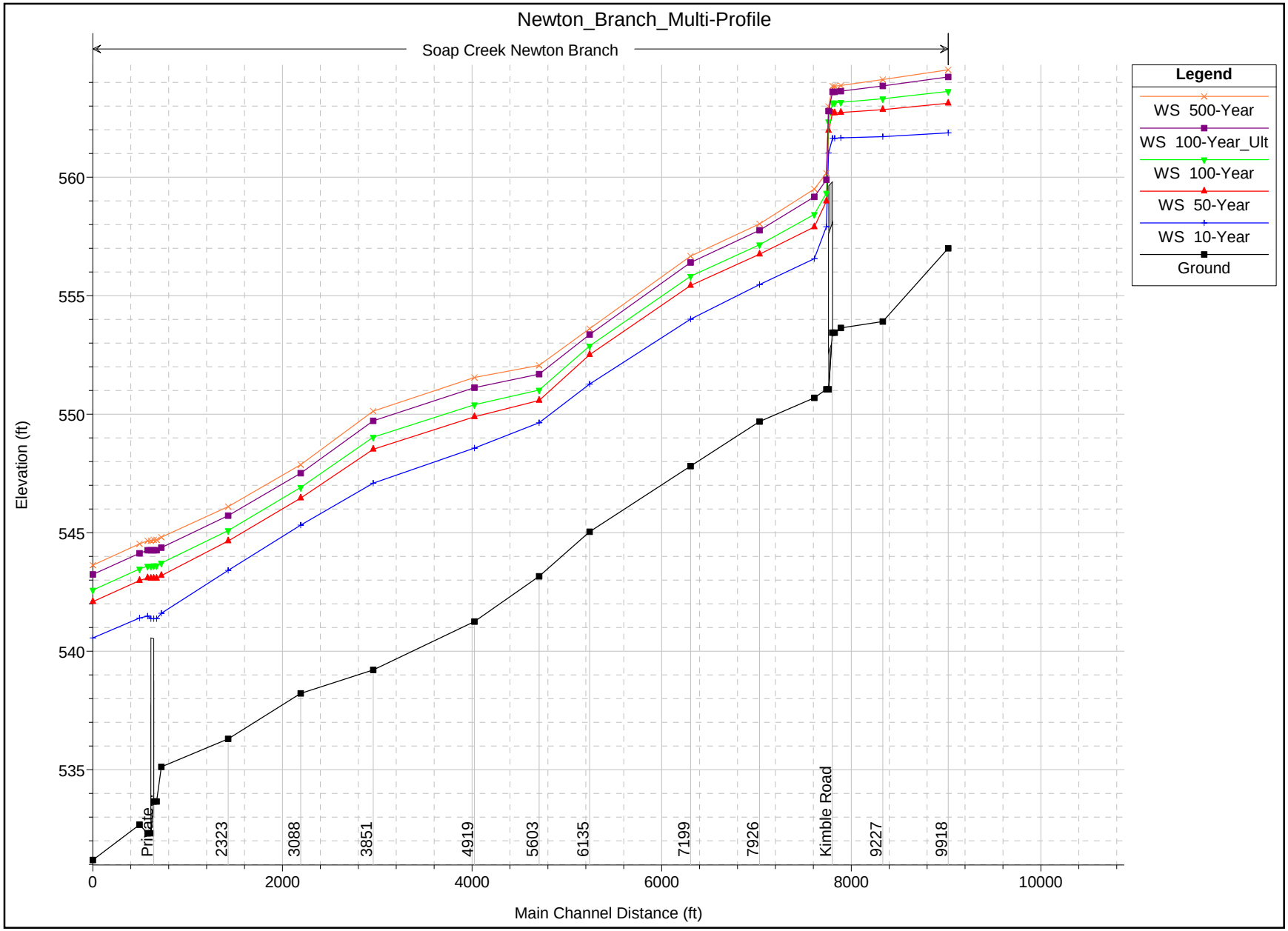

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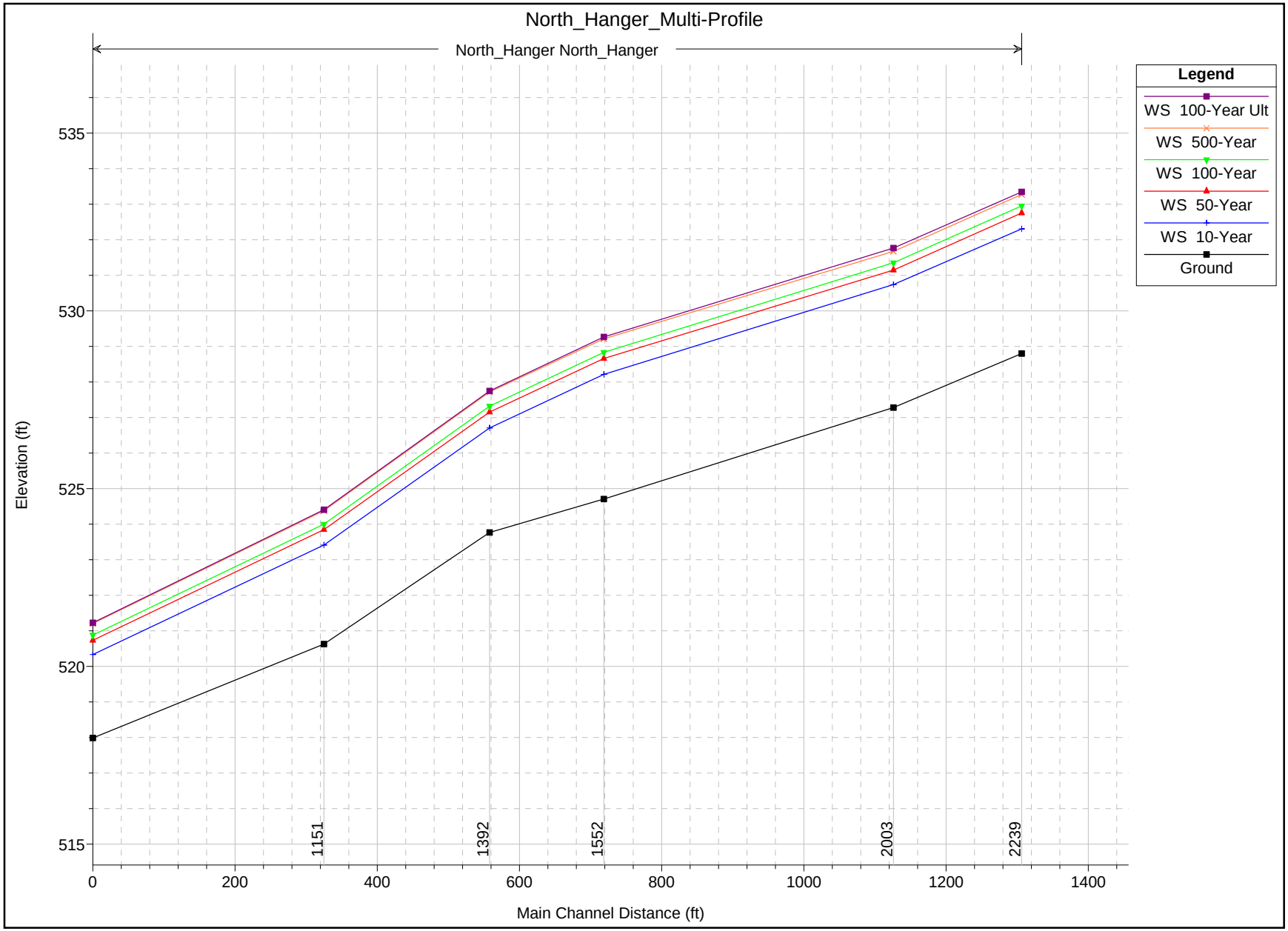

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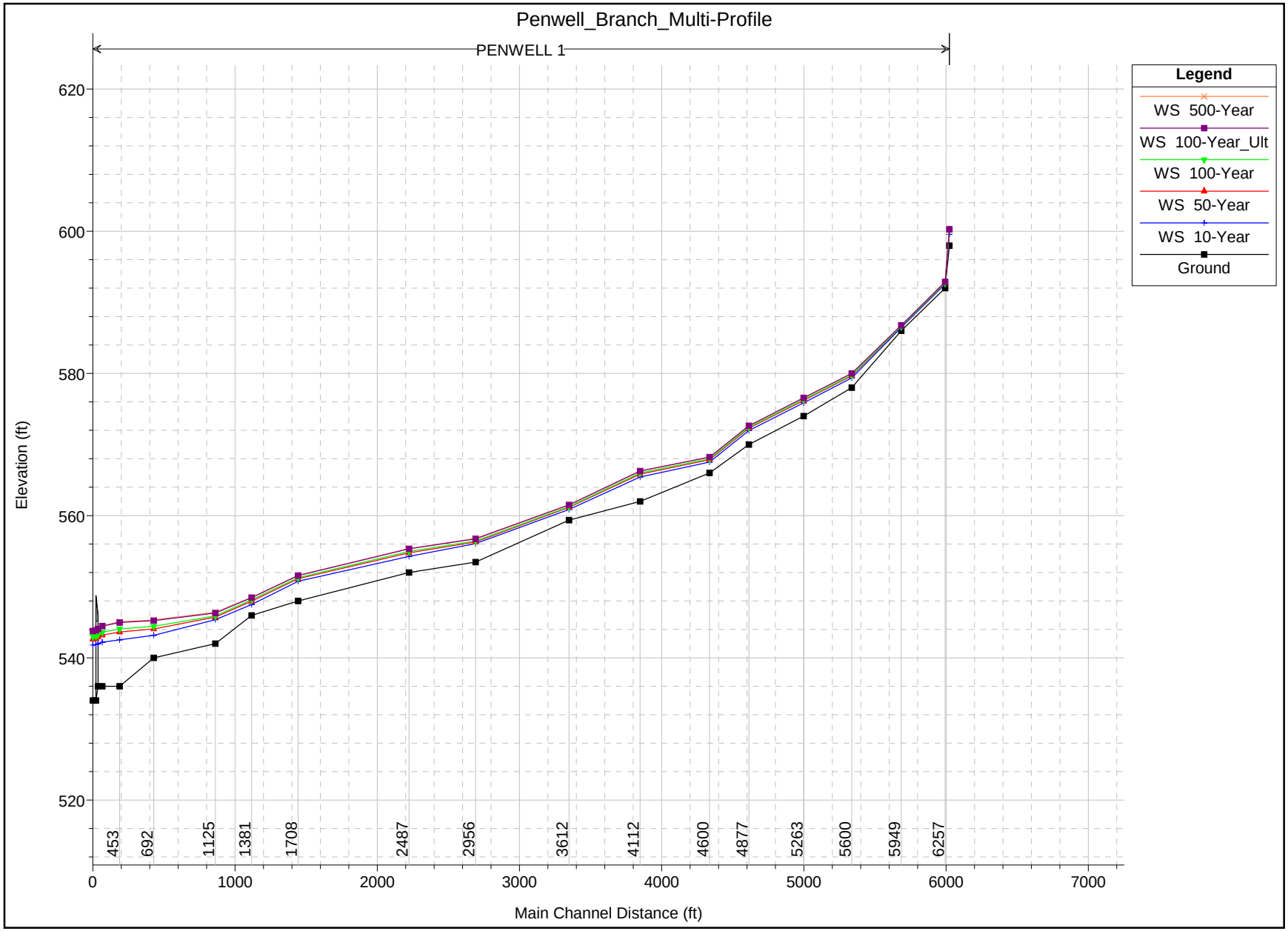

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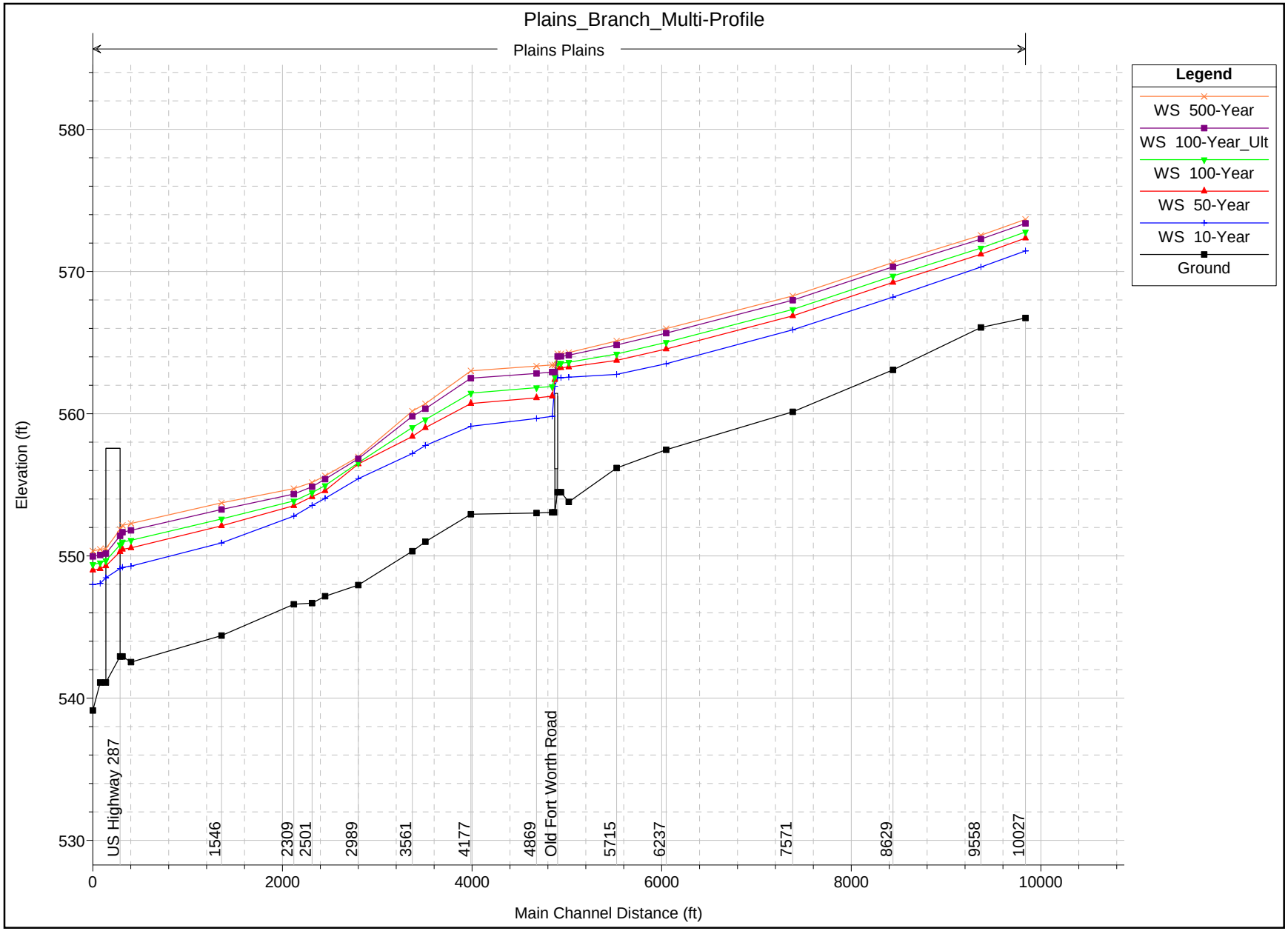

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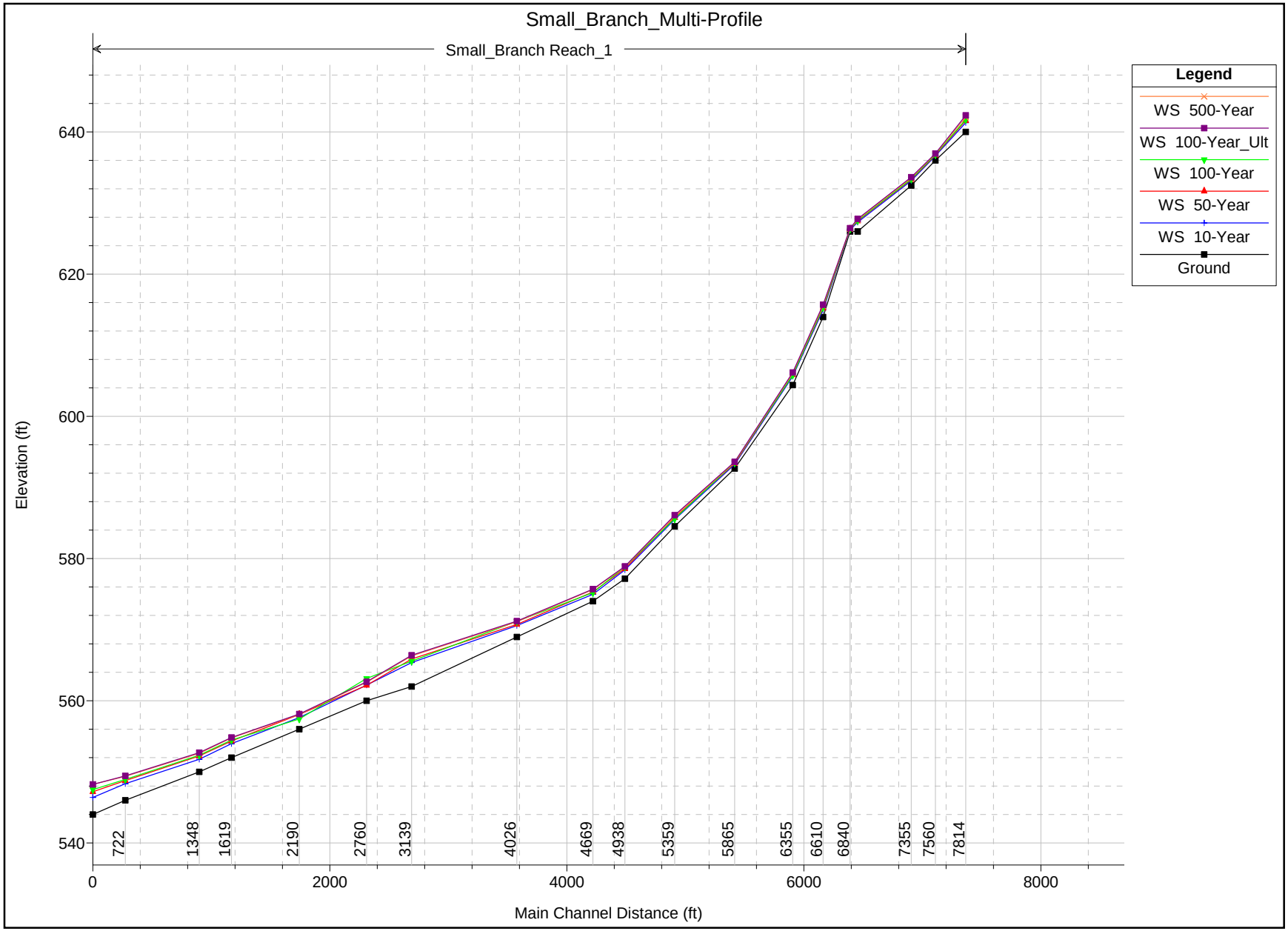

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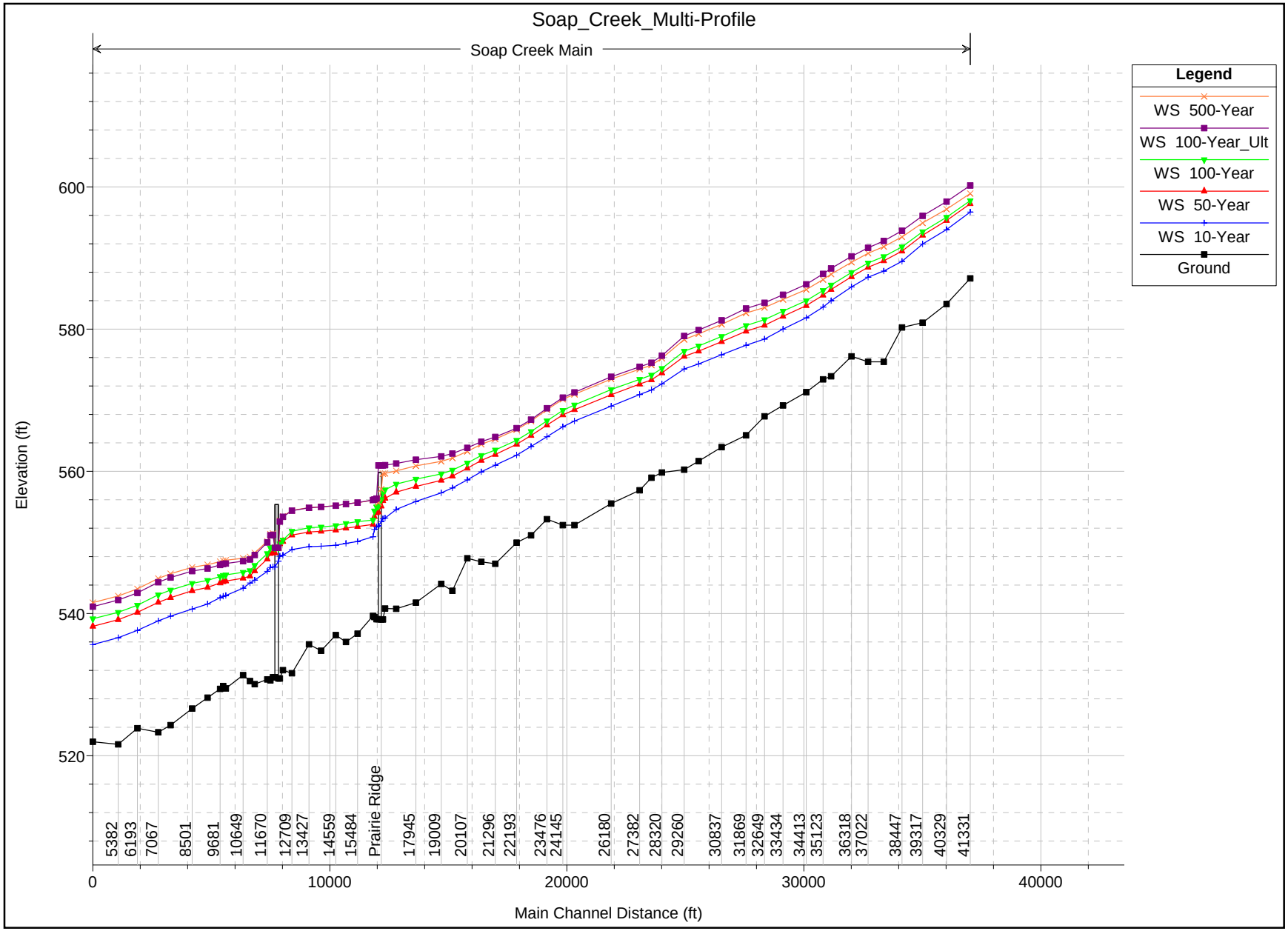

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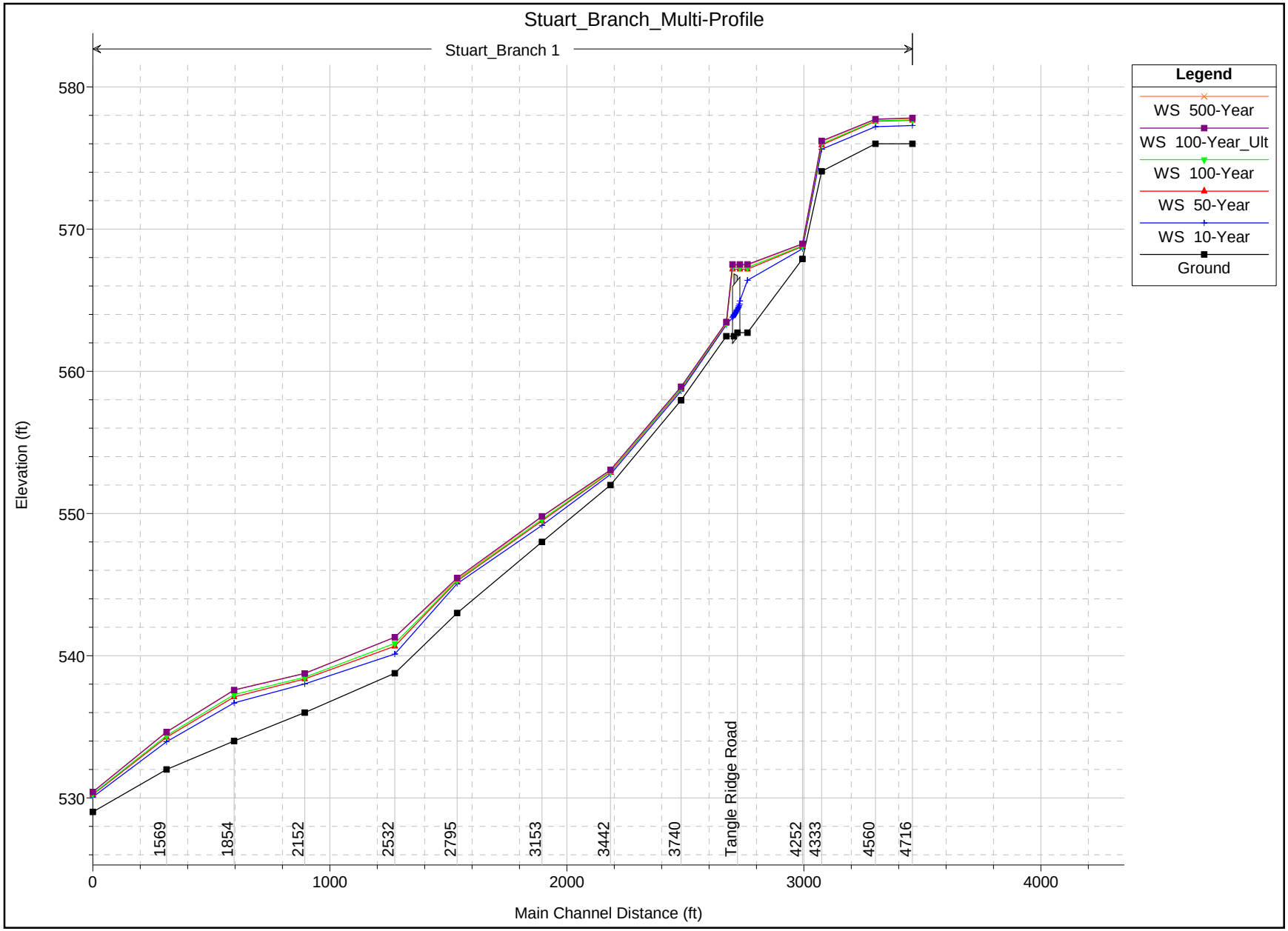

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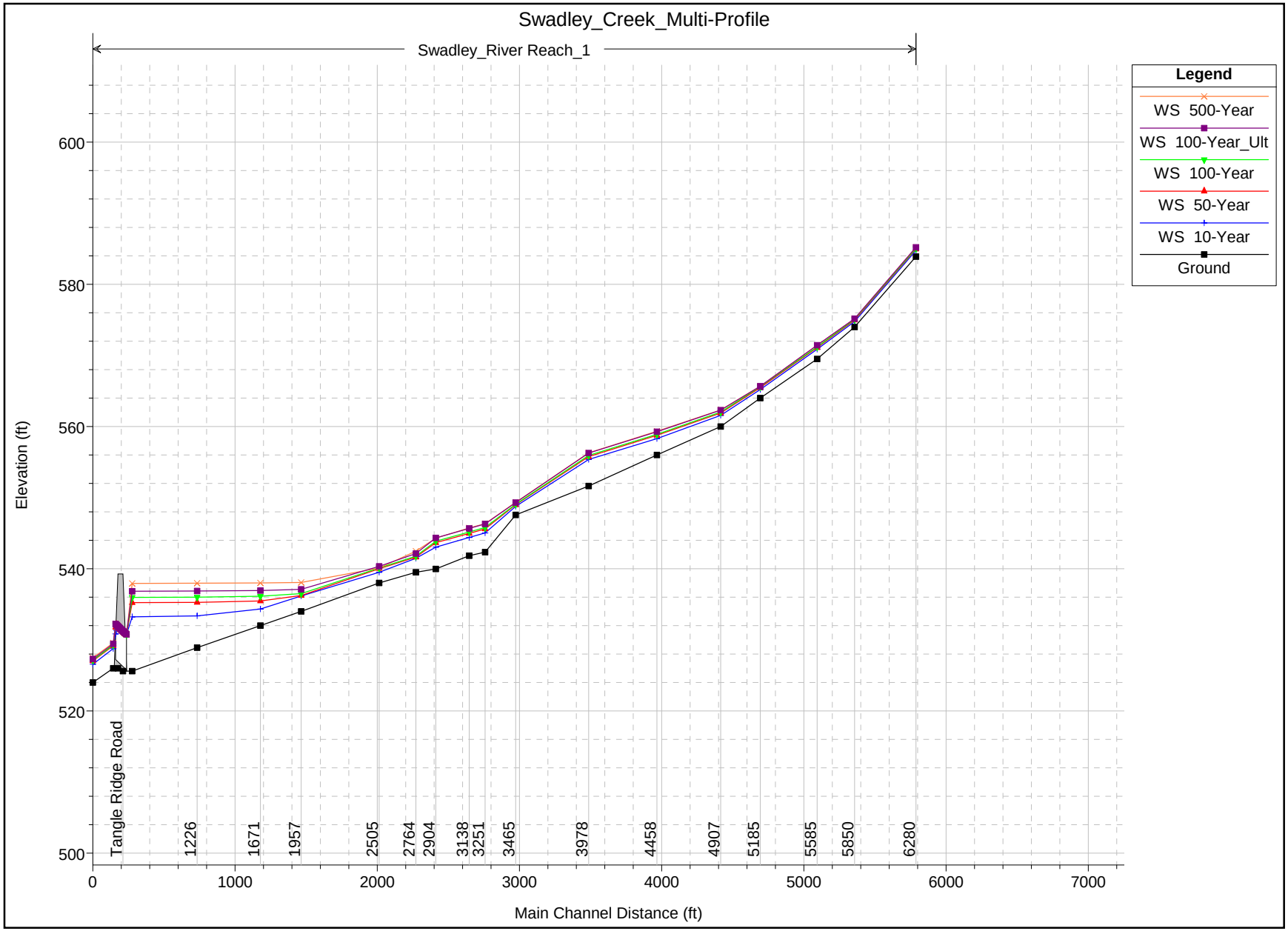

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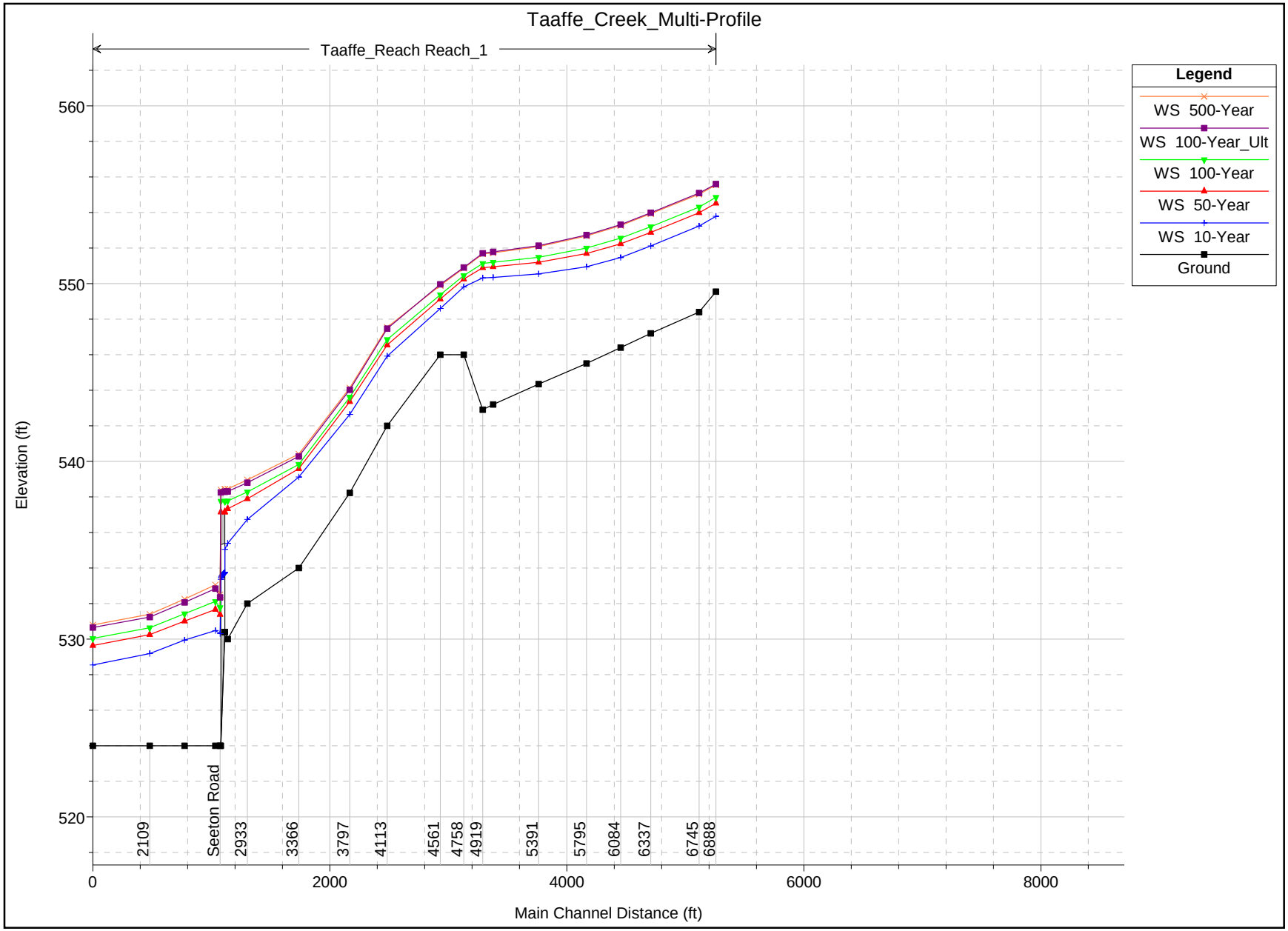

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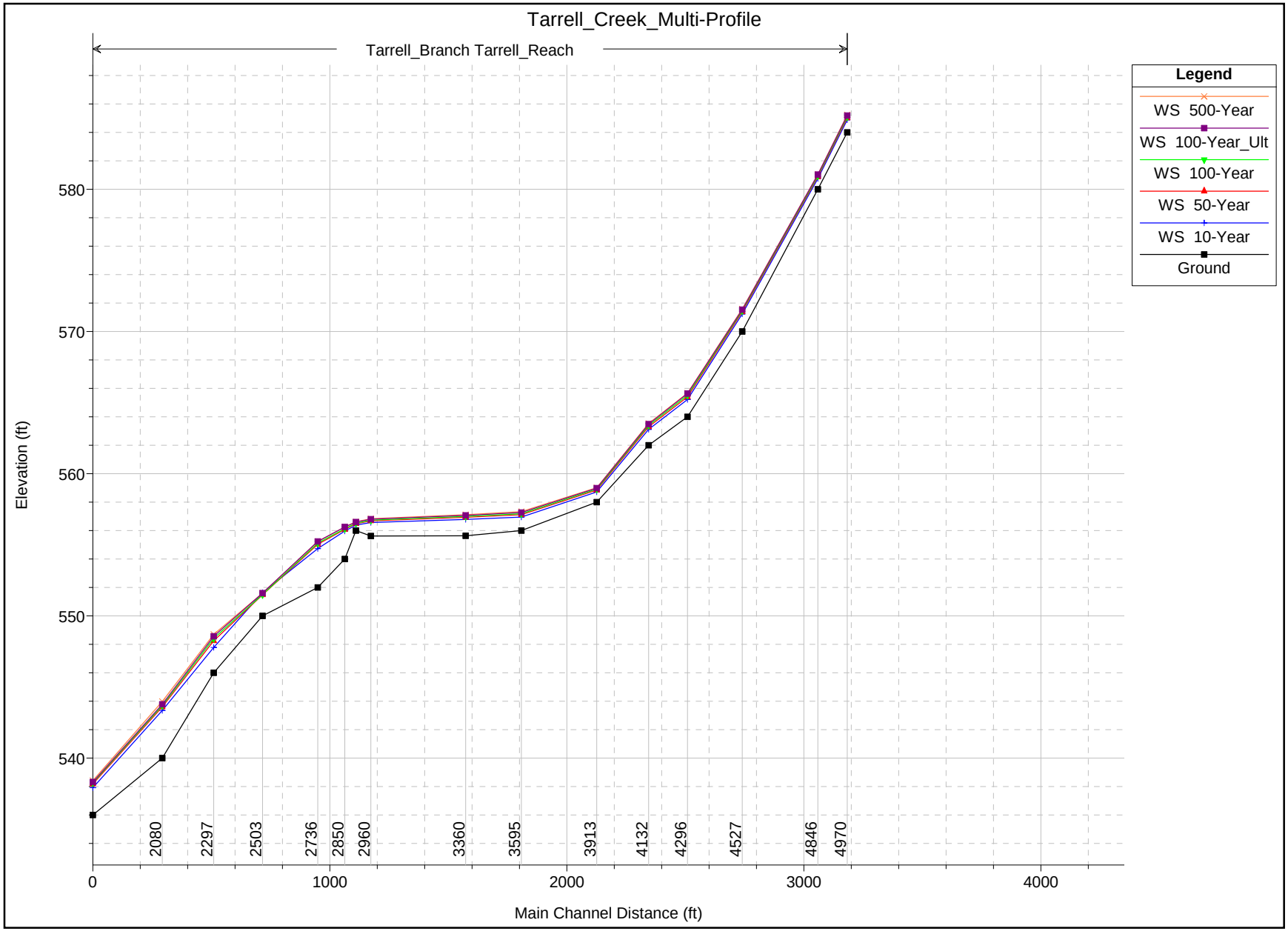

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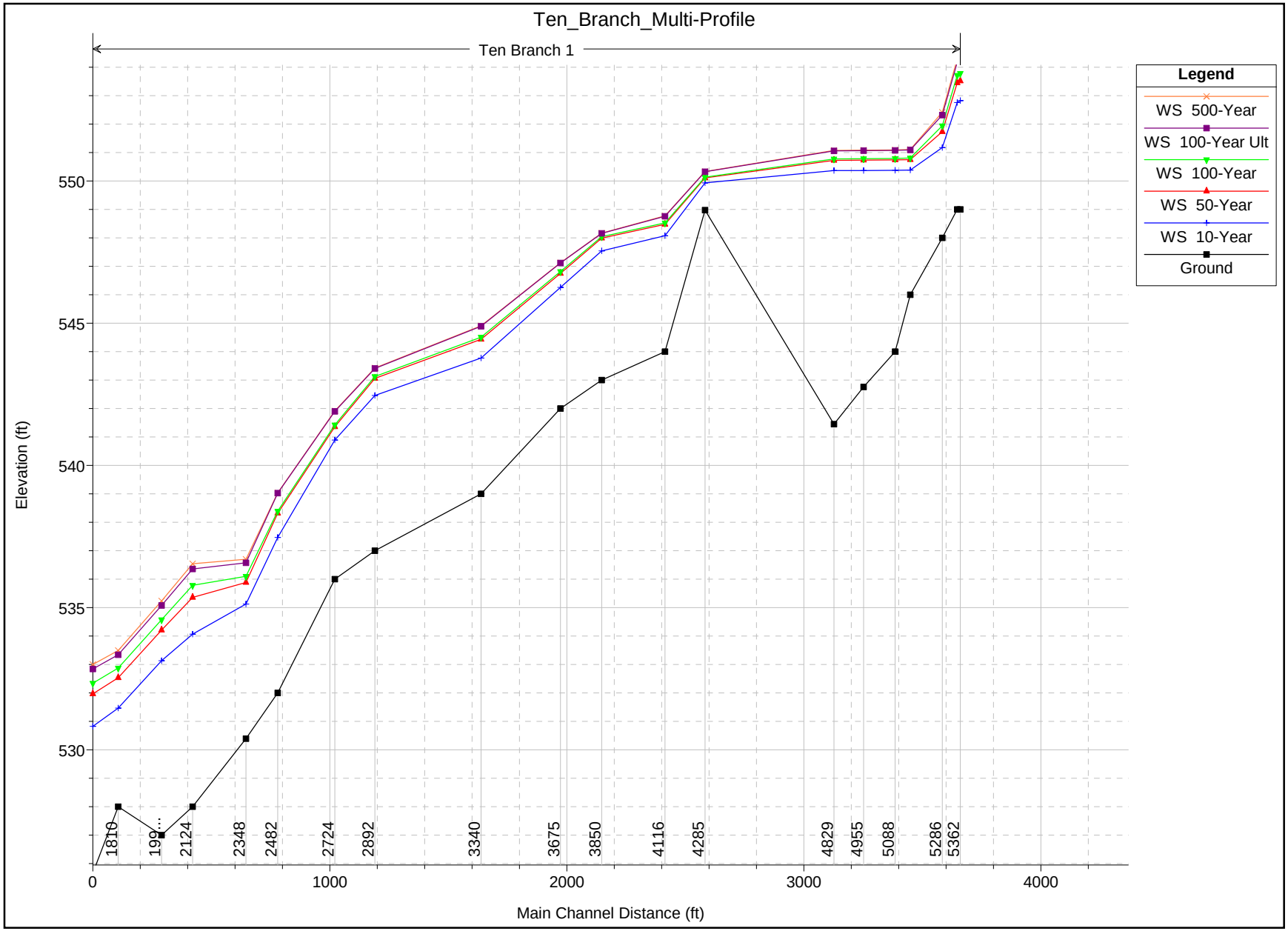

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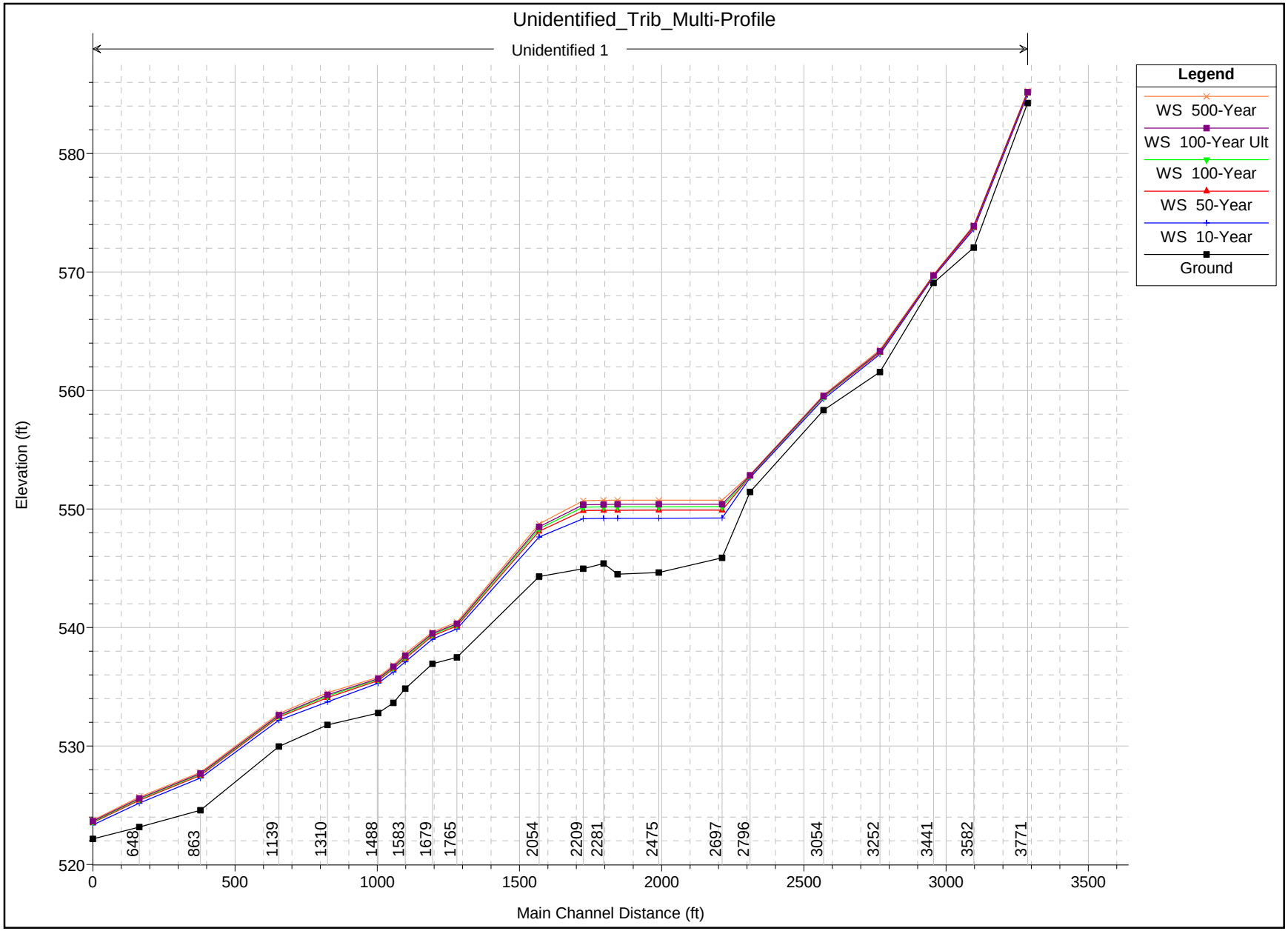

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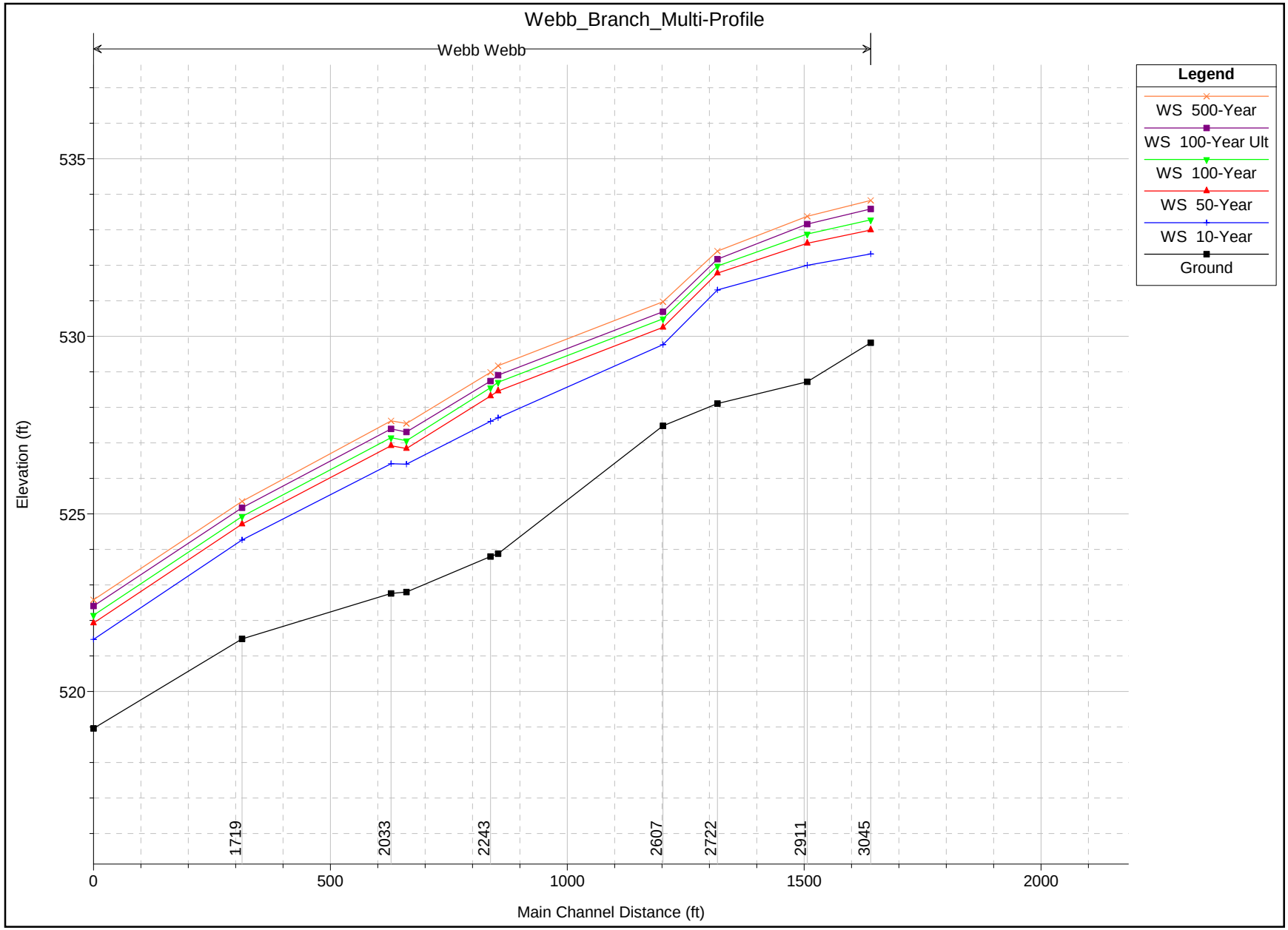

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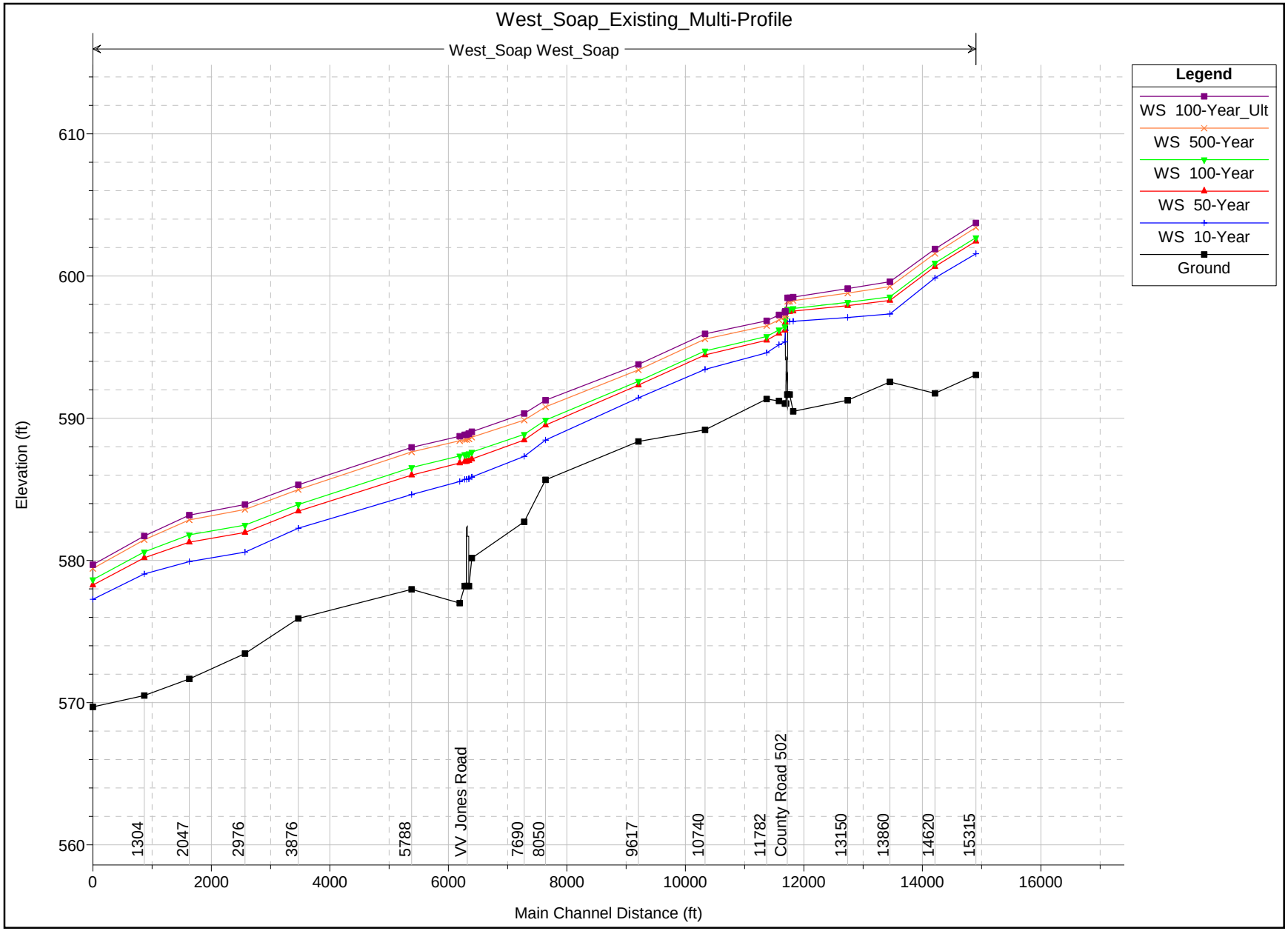


1 in Horiz. = 2400 ft 1 in Vert. = 10 ft

Response to QC Comments

HALFF

May 28, 2010
AVO 26418

Gabe G. Johnson, PE, PH, CFM
Floodplain Administrator
City of Grand Prairie
206 West Church Street
Grand Prairie, Texas 75053-4045

Re: **City-wide Drainage Master Plan for Joe Pool Lake, W.O. #581.40**
Response to QC Comments Received May 14, 2010

Dear Mr. Johnson:

Halff Associates, Inc. has reviewed the QC comments for the H&H models for the CWDMP for Joe Pool Lake (excluding Soap Creek) received on May 14, 2010. We appreciate the comments from Pacheco Koch and feel that a few revisions have been brought to our attention that will enhance the accuracy of the final models. Several of the comments were based on individual modeler preference or referred to working files that had not been updated. For the preference based comments, Halff made every effort to accommodate the suggestions of the reviewer. Mapping and Workmap comments will be considered for the final exhibits, but they were not addressed in our response since they were considered draft work maps provided to accommodate the model reviews. The H&H models have been revised and our responses to the review comments have been included on the following pages.

After reviewing our comments, please feel free to contact me, Cindy Mosier, or Stephen Crawford if you have any questions or concerns.

Sincerely,

HALFF ASSOCIATES, INC.

Benjamin B. Pylant, PE, CFM

enclosures

Cc:

HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TX 76137-2720
TEL (817) 847-1422
FAX (817) 232-9784
WWW.HALFF.COM

DAVIS BRANCH HYDROLOGY

(B.1)

- The high point of SH360 on the east side of sub-basin DB1 may not be delineated correctly. It appears the road drains to the north outside of the basin. The contours may indicate a ditch that captures additional drainage area located on the south side of DB1. Sub-basins DB1 and DB2 were re-delineated according to the high point of SH360 on the east side of sub-basin DB1. The south side of DB1 was re-delineated to capture the additional drainage area from a ditch indicated by the contours.

(B.2)

- Need to field verify the east and south drainage delineation of DB1 along SH360 and what appears to be a fence line. The east and south drainage area of DB1 along SH360 was re-delineated to follow the ridge indicated by the contours. This delineation was confirmed by field visits.

(E.1)

- Channel flow – Velocity does not agree with Manning's Equation based on channel area and wetted perimeter provided in spreadsheet. A note is provided indicating Area and WP was taken at bank full. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(E.5)

- Ultimate overland flow n values in spreadsheet for paved surfaces = 0.11. Table 5.4A of DDM and TR55 both indicate n for paved surfaces should be 0.011. (DB1 & DB2). The overland paved surface n-value was changed to 0.011 in the spreadsheet. Ultimate lag times in the HEC-HMS model were updated.

DAVIS BRANCH HEC-RAS

(A.3)

- The model defaults to critical depth for the 100-year and 100-year Ultimate at Sections 638, 1365, and 3453 (not consecutive). Critical Depth defaults for non-consecutive sections were not addressed unless it appeared to be affecting the model in an unnatural manner.
- 50-year and 100-year profiles cross at Section 2457. Adjustments to Manning's N values per comment A.9 have resolved the crossing profiles.

(A.9)

- From Section 265 to 1365 aerial image shows heavily wooded on both sides of the channel for the entire length of the cross-section. The roughness coefficient should be revised to 0.1 for the entire overbank area. Manning's N values for the reach have been revised based on the aerial image to be consistent with other N values in the area.

(A.11)

- Large secondary channel located in the ROB may need additional ineffective flow from Section 5708 to 6468. May want to exclude if it causes crossing profiles and critical depth. Ineffective flows were added but removed due to the resulting instabilities and critical flow sections. Although the two channels are mostly separated, it is believed that both convey effective flow.

(E.2)

- 50-year and 100-year profiles cross at Section 2457. Adjustments to Manning's N values per comment A.9 have resolved the crossing profiles.

(G.1)

- Does the downstream floodplain tie into the Harmon Branch effective FIRM? Need to verify. Harmon Branch 100-year water surface elevation is at approximately 550. This should allow for a

smooth tie in that will be provided in the floodplain mapping for the FEMA LOMR submittal.

DAVIS BRANCH MAPPING & EXHIBITS

Relevant workmap comments will be incorporated in the final report exhibits.

(A.1) – Floodplain Work Map

- Cross Sections 357, 3695, 6974 are not labeled.

(A.2)

- BFE located at Section 5531 and between Section 265 and 1365 are not labeled.

(A.3)

- Spot checked with GIS floodplain layers. The floodplain width from the model does not agree with the mapping because islands are not shown in the floodplain delineation. FEMA may require an explanation at the time of review.

(A.7)

- Under Notes there is a typo ("based o on").
- May want to re-label BFE as "Ultimate 100-Year BFE" in the legend.

(B.3) – Watershed Work Map

- Road labels are hard to read. May try a masking road labels. This is not a critical comment.

(C.3) – Existing and Future Land-Use Maps

- Road labels are hard to read. May try a masking road labels. This is not a critical comment.

(D.3) – Soils Map

- Road labels are hard to read. May try a masking road labels. This is not a critical comment.

(D.4)

- Soil type B and water are very similar in the Legend. Consider revising one to make it easier to differentiate between the two on the map. This is not a critical comment.

FOSTER BRANCH & FOSTER BRANCH TRIBUTARY HYDROLOGY

(A.1)

- Basin FST8 may need to be divided into two sub-basins. The drainage area to the northeast appears to have separate characteristics that should be isolated in the model. Basin FST8 was divided into two sub-basins.

(D.1)

- Existing lag time spreadsheet shows an overland roughness based on short grass for FS1 & FS10. Aerial indicates wooded conditions. The overland roughness coefficient was revised to reflect wooded conditions based on the City's DDM Table 5.3B for FS1 and FS10.

- Channel flow roughness is not documented for both existing and future conditions throughout. Spreadsheet notes indicate n values were taken from RAS routing model. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(D.2)

- Overland flow does not match GIS flow path attribute for FST6. It was verified with contours, slope should be changed from 0.007 to 0.0018 (both existing and future conditions). This comment may not critically affect the results of the Zone A mapping. Overland flow slope changed to 0.0018 for basin FST6.

(E.1)

- Calculations not provided for channel flow computations. (no Manning's roughness, Area or wetted perimeter). Some of the channel lag times were computed based on velocity and length others were

entered with no documentation. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

- Title at top of future lag calculation sheet is labeled as "Existing Lag Time Calculations for Joe Pool Lake Trib". Title changed to "Ultimate Lag Time Calculations for Joe Pool Lake Trib" for the ultimate lag calculation spreadsheet.

(F.1)

- Future Land use does not include open space dedicated to electric easements running northeast through Mira Lagos and does not include open bodies of water. This comment may not critically affect the results of the Zone A mapping. Future Land Use was taken directly from the City of Grand Prairie shapefile. No revisions were made.

FOSTER BRANCH & FOSTER BRANCH TRIBUTARY HEC-RAS

(A.3)

- Foster Branch - The model defaults to critical depth for the 100-year and 100-year ultimate at Sections 1039 and 1516 (not consecutive). Critical Depth defaults for non-consecutive sections were not addressed unless it appeared to be affecting the model in an unnatural manner.
- Foster Tributary – Critical depth occurs at Sections 563 and 1121 (not consecutive). Critical Depth defaults for non-consecutive sections were not addressed unless it appeared to be affecting the model in an unnatural manner.
- Comment will not critically affect floodplain delineation because it is controlled by backwater from Joe Pool Lake. No action needed.

HANGER CREEK HYDROLOGY

(B.1)

- Basin HC1 may be delineated incorrectly. As-built Plans (P-1198) show the undeveloped area located in the southeast corner of the drainage basin is collected in the culvert contained in the North Hanger Creek watershed. The Grand Peninsula, Phase 1 as-built plans (P-838B) do not include this area routed through their detention pond. Basin HC1 was re-delineated based on the 2009 contours and then divided into two sub-basins. The area to the east of the detention pond is no longer routed through the detention pond.

(B.2)

- The undeveloped area located at the northwest corner of Lake Ridge Parkway and Hanger Lowe Road should be field investigated to verify the drainage delineation. Field visits along with the as-built plans (P1198 & P-838B) were used to verify the drainage delineation for this area.

(D.1)

- Channel flow roughness is not documented for both existing and future conditions throughout. Spreadsheet notes indicate n values were taken from RAS routing model. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(E.1)

- Calculations not provided for channel flow computations. (no Manning's roughness, Area or wetted perimeter). Some of the channel lag times were computed based on velocity and length, others were entered with no documentation. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.
- Title at top of future lag calculation sheet is labeled as "Existing Lag Time Calculations for Joe Pool Lake Trib". Title changed to "Ultimate Lag Time Calculations for Joe Pool Lake Trib" for the ultimate lag calculation spreadsheet.

(F.1)

- Future Landuse does not include open bodies of water. This comment may not critically affect the results of the Zone A mapping. Future Land Use was taken directly from the City of Grand Prairie shapefile. No revisions were made.

HANGER CREEK HEC-RAS

(A.11)

- Missing ineffective flow at Section 2302 located in the ROB (station 196.77, elevation 539.52). Ineffective flow area added.

NORTH HANGER CREEK HYDROLOGY

(B.1)

- Basin NHC2 may be delineated incorrectly. As-built Plans (P-1198) show the undeveloped area located in the southwest corner of the drainage basin is collected in the culvert contained in the North Hanger Creek watershed. The Grand Peninsula, Phase 1 as-built plans (P-838B) do not include this area routed through their detention pond. Basin NHC2 was re-delineated according to the re-delineation of the Hanger Creek sub-basins in this area.

(B.2)

- The undeveloped area located at the northwest corner of Lake Ridge Parkway and Hanger Lowe Road should be field investigated to verify the drainage area delineation. Basin NHC2 was re-delineated according to the re-delineation of the Hanger Creek sub-basins in this area. Field visits verified the delineation.

(D.1)

- Channel flow roughness is not documented for both existing and future conditions (NHC1& NHC3 for existing and future). Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(E.1)

- Calculations for NHC1& NHC3 not provided for channel flow computations (no Manning's roughness, Area or wetted perimeter). Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.
- Existing channel velocity for NHC6 does not match Manning's Equation results. Value in spreadsheet is 2.7 fps, equation is 0.93 fps. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels.
- Title at top of future lag calculation sheet is labeled as "Existing Lag Time Calculations for Joe Pool Lake Trib". Title changed to "Ultimate Lag Time Calculations for Joe Pool Lake Trib" for the ultimate lag calculation spreadsheet.

NORTH HANGER CREEK HEC-RAS

(G.1)

- Additional cross-sections are provided in the mapping but not in the model (Sections 2740 and 2466). Sections have been updated to be consistent with the final model.

WEBB BRANCH HYDROLOGY

(A.1)

- Basin WB7 may need to be divided into two sub-basins. The drainage area to the north appears to have separate characteristics that should be isolated in the model. Basin WB7 was divided into two sub-basins.

(D.1)

- Channel flow roughness is not documented for either existing or future conditions throughout. Spreadsheet notes indicate n values were taken from RAS routing model. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(E.1)

- Calculations not provided for channel flow computations. (no Manning's roughness, Area or wetted perimeter). Some of the channel lag times were computed based on velocity and length, others were entered with no documentation. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.
- Title at top of future lag calculation sheet is labeled as "Existing Lag Time Calculations for Joe Pool Lake Trib". Title changed to "Ultimate Lag Time Calculations for Joe Pool Lake Trib" for the ultimate lag calculation spreadsheet.

(F.1)

- Future Landuse does not include open bodies of water. This comment may not critically affect the results of the Zone A mapping. Future Land Use was taken directly from the City of Grand Prairie shapefile. No revisions were made.

(H.2)

- Routing step for R_WB3 does not match routing step spreadsheet values. Value in model = 8, value in table = 2. The reach names were not updated in the model or the spreadsheet when dynamic modeling was introduced. The additional routing reaches were deleted from the spreadsheet. The reach names in the model and the spreadsheet now match. R_WB3 mentioned above is now R_WB2 with a routing step value = 8.
- Creek/River Name in table is listed as Dry Creek. Stream name changed to Webb Branch.
- Two additional routing steps are shown in the table without corresponding routes in the model. The additional routing reaches were deleted from the spreadsheet and were no longer necessary in the model after dynamic modeling was introduced for the series of detention ponds. The reach names and routing steps have been updated in the model and in the spreadsheet.

(H.3)

- The outflow hydrograph for (DET_HYD) is the same for all storm events (10-, 50-, 100-, 500- and 100-year Ult). The correct storm event outfall hydrograph has been linked to the correct corresponding basin model.

WEBB BRANCH HEC-RAS

(A.3)

- The model defaults to critical depth for the 100-year and 500-year at Sections 2065. It also causes a dip in the profile below the previous computed flood elevation (all profiles). Some N values were increased in the downstream reach of the model to better reflect overbank conditions. There is still a dip in the profile but it is not being affected by a critical section.

PENINSULA WATERSHED MAPPING & EXHIBITS
(FOSTER BRANCH, FOSTER BRANCH TRIBUTARY, WEBB BRANCH, HANGER CREEK, NORTH HANGER CREEK)

Relevant workmap comments will be incorporated in the final report exhibits.

(A.1) – Floodplain Work Map

- Missing some cross-section labels for Foster Branch, Webb Branch, Hanger Creek and North Hanger

Creek.
- Cross-section not provided for Foster Branch Tributary.

(A.2)
- No BFE's are provided. Joe Pool Lake backwater controls.
- Hanger Creek may require BFE's on the west side of Lake Ridge Drive where the 100-year floodplain is above elevation 538 (Joe Pool BFE).

(A.4)
- Foster Branch and Hanger Creek are not labeled. The label of Foster Branch Tributary covers up the floodplain limits and should be moved.

(A.5)
- The Mansfield Road label should be moved because it obscures the floodplain limits of Foster Branch. Lake Ridge is labeled twice near Webb Branch.

(A.7)
- Under Notes there is a typo ("based o on").
- Peninsula is spelled incorrectly.
- May want to re-label BFE as "Ultimate 100-Year BFE" in the legend.

(B.2) – Watershed Map
- Foster Branch, Foster Branch Tributary and Hanger Creek are not labeled.

(B.3)
- Road labels are hard to read. May try a masking road labels. Lake Ridge is labeled multiple times in the same area. This is not a critical comment.

(B.5)
- Peninsula is spelled incorrectly in the title.

(C.1) – Existing and Future Land-Use Maps
- Ultimate land use is not clipped to the watershed limits as in the existing land use map. Comment not required but inconsistent between the two maps.

(C.2)
- Stream centerlines are not labeled. They may not have been labeled for clarity. This is not a critical comment.

(C.3)
- Lake Ridge is labeled twice near Webb Branch.

(C.4)
- Peninsula is spelled incorrectly in the title for both maps.

(D.2) – Soils Map
- Webb Branch is labeled but no other streams are labeled.

(D.3)
- Lake Ridge is labeled twice near Webb Branch.

(D.4)
- Peninsula is spelled incorrectly in the title.
- Soil type B and water are very similar in the Legend. Consider revising one to make it easier to differentiate between the two on the map. This is not a critical comment.

UNIDENTIFIED TRIBUTARY HYDROLOGY

(A.1)
- Basin UNID8 may need to be broken into two sub-basins. It appears to have two separate drainage

paths, one on the east side and one on the west that should be isolated in the model. Basin UNID8 does not contribute to the Unidentified tributary being mapped and was not broken.

(D.1)

- Manning's roughness coefficients for channel flow not provided for UNID2 & UNID4. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(D.2)

- Shallow concentrated flow does not match GIS flow path attribute for UNID8. It was verified with contours, slope should be changed from 0.054 to 0.090 (both existing and future conditions). Shallow concentrated flow slope changed to 0.09 for basin UNID8.

(D.2)

- Shallow concentrated length for existing UNID1 is 975' and for future is 1025'. The length as shown in GIS is 1935'. Shallow concentrated lengths updated for existing and ultimate conditions for basin UNID1.
- Maximum overland flow length for Residential is 50'. The future overland flow lengths were revised from 100' to 50' for UNID 1, 3, 5, 6, 7 & 8. The land use does not change between existing and future conditions. Ultimate overland flow lengths were revised to match the existing overland flow lengths.

(E.1)

- Channel area and wetted perimeter not provided for UNID2 & UNID4. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.
- Title at top of future lag calculation sheet is labeled as "Existing Lag Time Calculations for Joe Pool Lake Trib". Title changed to "Ultimate Lag Time Calculations for Joe Pool Lake Trib" for the ultimate lag calculation spreadsheet.

(F.1)

- Existing land use does not match aerial. Multiple areas identified as Open Space have existing houses and roads/drives. Existing land use shapefile updated with 2009 aerial photography.

(H.2)

- Routing step for RUNID4 is 5 in the spreadsheet and 4 in the model. Routing step value changed to 4 for RUNID4.

(I.3)

- The Lag Time for UNID5, UNID6 & UNID7 (future) are under 1 minute. A minimum cap for Lag Time should be used based on the limitation of a 1 minute model computation interval. Lag time capped at 4 min. to allow for a 1 minute model computation interval.

(J.4)

- Model computational interval is 1 minute. Maximum time step is 0.4 minute. Lag time capped at 4 min. to allow for a 1 minute model computation interval.

UNIDENTIFIED TRIBUTARY HEC-RAS

(A.3)

- The model defaults to critical depth for the 100-year and 100-year ultimate at Sections 1488 and 1597 (consecutive) and Sections 2054, 2796, 3441 and 3771 (not consecutive). Some n values were increased based on the 2009 aerial photos to help with the model stability. Section 1597 was moved slightly downstream to prevent the road embankment from being included in the model geometry. A section was added at Station 1541. Some critical sections still exist but they are non consecutive.

(A.7)

- ROB and LOB stations fall outside of the 100-year ultimate floodplain at Sections 1597, 3054, 3252, 3441, 3582 and 3771. Overbank stations were revised based on the channel geometry. They are currently within the 100 year floodplain extents.

(A.8)

- Expansion and contraction coefficients for Sections 2209 and 2054 may need to be set at 0.5 and 0.3 respectively because of the sudden contraction in the floodplain. Contraction and expansion coefficients have been revised as suggested.

(A.11)

- Section 1765 potentially needs ineffective flow to account for expansion in pond area. Ineffective Flow area added to account for expansion from pond. Additional ineffective areas added downstream to help stabilize model.

(B.1)

- Bentwater Parkway crossing is not accounted for in the model. Roadway crossings not modeled for Zone A streams.

(C.2)

- Flow data for the 10-year event for JUNID2 is 150 cfs in RAS and 231 cfs in HMS. All other flows rounded up to nearest 10. Flow data has been corrected in the HMS model.

UNIDENTIFIED TRIBUTARY MAPPING & EXHIBITS

Relevant workmap comments will be incorporated in the final report exhibits.

(A.1) – Floodplain Work Map

- Missing labels for cross-sections 1488, 1679, 2054 and 3771.

(A.2)

- All BFEs are not labeled.

(A.7)

- Under Notes there is a typo ("based o on").
- May want to re-label BFE as "Ultimate 100-Year BFE" in the legend.

LYNN CREEK HYDROLOGY

(D.2)

- Shallow concentrated and channel flow does not match GIS flow path attribute for LT3. It was verified with contours, slope should be changed from 0.014 to 0.044 for shallow concentrated and from 0.064 to 0.028 for channel flow (both existing and future conditions). Shallow concentrated and channel flow slopes updated for existing and ultimate conditions.

(D.3)

- The shallow concentrated flow path length for LT1 future conditions should match the existing conditions of 1,021' (50' was inadvertently added to the future length). Future shallow concentrated flow changed to match existing (1,021').

(E.1)

- Calculations not provided for channel flow computations. (no Manning's roughness, Area or wetted perimeter). Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.
- Title at top of future lag calculation sheet is labeled as "Existing Lag Time Calculations for Joe Pool

Lake Trib". Title changed to "Ultimate Lag Time Calculations for Joe Pool Lake Trib" for the ultimate lag calculation spreadsheet.

LYNN CREEK HEC-RAS

(A.3)

- The model defaults to critical depth for the 100-year at Sections 235, 603, 893 and 1177 (not consecutive) and 100-year ultimate at Sections 66 and 235 (consecutive) and 603 and 1177 (not consecutive). The most downstream cross section was moved slightly upstream to provide a more reasonable starting water surface elevation. Some n values were increased based on the 2009 aerial photos to help with the model stability. Some critical sections still exist but they are non consecutive for the 100-year.

(A.7)

- ROB and LOB are located very close to the 100-year floodplain throughout the model. The stream is very small with very little channel definition. The overbanks have been lowered as much as seems reasonable.

(C.2)

- No consistency on how the flows data was rounded. Some flows do not match the model. Flows were rounded up to the nearest ten. No discrepancies were found between the flows in the submitted models but discharges were updated based on the revised hydrology anyway.

(E.2)

- Profiles cross in several places. Two ineffective flow areas that did not seem entirely necessary were removed. The profiles are no longer crossing.

(G.1)

- The mapping may not show up at the FIRM scale because the tributary watershed is only 25 acres. No action needed.

LYNN CREEK MAPPING & EXHIBITS

Relevant workmap comments will be incorporated in the final report exhibits.

(A.1) – Floodplain Work Map

- Missing labels for cross-sections 235.

(A.2)

- Not all BFEs are labeled.

(A.7)

- Under Notes there is a typo ("based o on").
- May want to re-label BFE as "Ultimate 100-Year BFE" in the legend.

GRASSY CREEK & GRASSY CREEK TRIBUTARY HYDROLOGY

(A.2)

- Smallest to largest basin ratio is 0.12. Consider subdividing both GRS1 and GRS2 into two sub-basins. This will bring the basin ratio closer to 1/5. The basin ratio appears reasonable considering the number of sub-basins. GRS1 and GRS2 are larger sub-basins because they are outside of the city limits. No change was made.

(B.1)

- GRS8 – The drainage divide located at the center line of Pikes Peak Drive may need to be shifted southeast between the road and building faces. The drainage ditch draining to the northwest may pick

connect to the southern ditch paralleling the roadway. GRS8 was re-delineated at Pikes Peak Drive by shifting the divide southeast between the road and the building faces as suggested.

(B.2)

- Field verify drainage divide at Pikes Peak Drive within Basin GRS8. GRS8 was re-delineated at Pikes Peak Drive by shifting the divide southeast between the road and the building faces as suggested. Field visits verified the delineation.

(C.2)

- A difference of 15.2 acres is gained in the model through rounding. Use 3 significant digits in the model drainage area to reduce rounding error. The sub-basin areas were rounded to 3 decimal places.

(D.1)

- Channel flow roughness is not documented for both existing and future conditions throughout. Spreadsheet notes indicate n values were taken from RAS routing model. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(D.2)

- Channel flow slopes do not match GIS flow path attributes for GRS7, GRS9, GRS10, GRS12, GRS16 and GRS18. It is unclear from the spreadsheet how the velocities used in the calculations were computed. If the velocities were determined through other methods, this comment regarding slopes is not relevant. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(D.3)

- The future overland flow length for GRS17 should be revised from 100' to 50'. The land use map shows this area to be "unknown" and "multi-family". Ultimate overland flow length changed to 50'. N Value for overland flow was changed to represent paved conditions.
- The shallow concentrated flow length for Basin GRS4 does not match the length in the GIS flow path attribute table. The spreadsheet has a value of 4,531 feet. The actual length is 4,868 feet. The shallow concentrated flow length for basin GRS4 was changed to 4,868 feet.

(E.1)

- Calculations not provided for channel flow computations. (no Manning's roughness, Area or wetted perimeter). Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.
- The channel flow calculation for GRS10 does not include the second channel component in the calculation (missing 924 feet). The channel flow calculation for GRS10 was updated to include the second channel component.

(F.1)

- The aerial image and existing landuse conflict within basin GRS2 along Macadamia Street. The landuse indicates open space while the aerial indicates low density residential. This comment will not significantly change the results of the hydrologic model. The existing landuse shapefile was updated to include the area identified as low density residential from the aerial image.

(H.2)

- The Creek/River Name is labeled as Dry Creek in routing steps spreadsheet. Stream name changed to Grassy Creek.

GRASSY CREEK HEC-RAS

(A.9)

- Section 7362 – An n-value based on medium to dense brush was used in open field areas (portions of the LOB and ROB). N value changed to reflect open field area.
- Section 17236 – The roughness coefficient should be revised to an n-value reflecting medium to dense brush from station 282.27 to 423.94. N value was revised to reflect medium to dense brush.

(B.8)

- The upstream flowline invert of Culvert Section 18546 (County Road 619) does not match the survey elevation for the right barrel of the culvert. The survey data indicates it should be 687.06. A discrepancy between the survey and model downstream culvert invert was corrected, but the 687.06 elevation appears to be erroneous.

(C.2)

- The flow change location for Sections 11910, 8633 and 7362 do not match the hydrologic model output. The 10-year flow data had not been updated with the current HMS model flow data. All flow data has now been updated to reflect the current revised HMS model.
- Some of the flows for the 10-year and 50-year decrease in a downstream direction. In these cases consider using the previous flow until the next flow change location. The decreases in flow are on the order of 2% or less. The decreases in flow appear legitimately from storage effects in the routing model and not calculation errors. No change was made.

(C.4)

- Known water-surface elevations are used in the model for reach boundary conditions. Typically backwater effects are not used as boundary conditions in a Zone AE. Please provide documentation of known water-surface elevations. Known water-surface elevations taken from coincident flow calculated for Mountain Creek.

(D.7)

- Section 25478 carries the majority of floodway overbank conveyance on the LOB and then shifts to the ROB at the next downstream section. Consider revising encroachment stations to allow additional conveyance in the ROB. Encroachment stations shifted for section 25478 to allow additional conveyance in the ROB.
- Sections 21576 to 19713 also contain an abrupt shift in overbank conveyance from one section to the next. However, the stream meanders with cut banks and the abrupt conveyance shift appears unavoidable. No action needed.

(G.1)

- The tie-in to the upstream Zone A floodplain should be verified. Tie-in to upstream Zone A floodplain correct.

(G.2)

- There is a dip in the profile at Bridge Section 23244 (CR 506). The water-surface elevation dips below the previous cross-section at this location (all profiles). The dip in the profile is considered insignificant for this situation as it is less than one tenth of a foot. No change was made.

(G.3)

- There is a small discrepancy between the model and mapping at Section 31019 for the existing 100-year floodplain (model width = 616', mapping width = 641'). However, the difference may be within mapping tolerances. This discrepancy is within the FEMA mapping tolerance; no action needed.

GRASSY CREEK TRIBUTARY HEC-RAS

(A.3)

- The model defaults to critical depth for the 100-year and 100-year ultimate at Sections 696 and 1217 (not consecutive). Critical Depth defaults for non-consecutive sections were not addressed unless it

appeared to be affecting the model in an unnatural manner.

(A.7)

- Right and left overbanks dramatically change in elevation for Sections 696 and 1217. Consider lowering the ROB and LOB to be consistent with other sections. Dramatic change in bank station elevations due to the series of detention ponds in the downstream reach of Grassy Tributary. No changes were made for the bank station elevations.

(A.8)

- Expansion and contraction coefficients for Sections 696 and 786 may need to be set at 0.5 and 0.3 respectively because of the sudden contraction in the floodplain. Expansion and contraction coefficients set to 0.5 and 0.3 respectively for sections 696 and 786.

(A.9)

- Consider revising n-value for channel at Section 1685 to reflect sluggish reach/deep pools. Section 1685 channel v-value adjusted to reflect sluggish reach/ deep pools.

(A.11)

- Section 786 potentially needs ineffective flow located near the sudden contraction within the breached lake area. Ineffective flow added on the left side of section 786 to account for the breached lake area.

(C.2)

- The flow data does not agree with the hydrologic model at Section 4121 for the 10-year storm. All flow data has now been updated to reflect the revised HMS model.
- The 100-year ultimate profile (all flow change locations) does not agree with the HMS model results. All flow data has now been updated to reflect the revised HMS model.

(G.1)

- The tie-in to the upstream Zone A floodplain should be verified. Tie-in to upstream Zone A floodplain correct.

MOUNTAIN CREEK HYDROLOGY

(A.1)

- Basin MTC5 contains 4,000 feet of roadway with a contributing drainage area that is approximately 300 feet wide. The flow path used to develop the lag time for this drainage basin travels through the narrow strip of drainage area. It may be more appropriate to isolate this area or choose a flow path more representative of the overall drainage basin. The flow path was adjusted to give a more accurate representation of basin MTC5.

(B.1)

- A small portion of the drainage area (approx. 12 acres) located at the north side of MTC5 may need to be reconsidered. See comments on Davis Branch hydrology review for further detail (joins with basin DB1). MTC5 was re-delineated to follow the ridge indicated by the contours.

(D.1)

- Channel flow roughness is not documented for both existing and future conditions throughout. Spreadsheet notes indicate n values were taken from RAS routing model. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(E.1)

- Calculations not provided for channel flow computations. (no Manning's roughness, Area or wetted perimeter). Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe

taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(E.3)

- The shallow concentrated flow lengths for all Mountain Creek sub-basins seem excessively high. Consider limiting the length to 3,000 feet. Example: MCT4 has a drainage area of 1.47 square miles and a shallow concentrated flow length of 2.28 miles. The longest flow paths were re-evaluated to determine areas where shallow concentrated flow could be considered channel flow.

(H.2)

- The routing step for R_MTC1 is entered incorrectly in the model (spreadsheet = 38, model = 15). The spreadsheet routing step calculation of 38 did not seem to accurately represent routing for this basin. The routing step was capped at 15.

MOUNTAIN CREEK HEC-RAS

(A.1)

- Section 1888 is slightly skewed across the floodway. Consider shifting the section alignment so it cuts across the island located in the LOB or add an additional section. After assessing the area it was determined the current alignment is sufficient to model the floodway.

(A.11)

- Ineffective flow should be included between Sections 3718 and 5912 inline with the two up and downstream islands located on the ROB. If ineffective flow is added, the floodway may also need to be revised so the encroachment stations on the ROB are located outside the ineffective flow area. Some flow between these islands could ultimately be considered effective given that it acts somewhat like a diversion, but to be conservative ineffective flow was added between sections 3718 and 5912 inline with the two up and downstream islands. Floodway encroachments updated in the ROB.

(B.4)

- The left sloping abutment is not included in the model for the FM661 Bridge. Left abutment added to model.
- Highway 287 was modeled as a single bridge. The northbound and southbound bridges were within the tolerance to be modeled as one bridge.
- Bridge elevation data not verified. The elevation and description are blank in the survey point file provided by Halff. No action needed.

(B.9)

- Ineffective flow was not used at FM661 on the ROB. The islands up and downstream of the roadway may also have some influence on ineffective flow near the bridge. Ineffective flow not used for FM661 since the roadway was overtopped by the 10-year event. Ineffective flow added between sections 3718 and 5912 inline with the two up and downstream islands.

(C.2)

- The flow data does not agree with the hydrologic model at all flow change locations and profiles. The flow data agrees with the flows which were calculated within HMS to include an aerial reduction for basins larger than 10 sq. mi. Regardless, all flow data has now been updated to reflect the revised HMS model.

(G.1)

- The tie-in to the upstream Zone A floodplain should be verified. Tie-in to upstream Zone A floodplain correct.

(G.2)

- Bridge modeling approach for Highway 287 should also consider the effects of momentum due to the piers. The highest energy answer should be used. Momentum was considered but the standard step method produced the higher energy answer.

(G.3)

- There is a discrepancy between the model and mapping at Section 5912 for the existing 100-year floodplain (model width = 1658', mapping width = 1816'). A small island was considered flooded in the right overbank resulting in a greater mapping width.

MOUNTAIN CREEK, GRASSY CREEK & GRASSY CREEK TRIBUTARY MAPPING & EXHIBITS

Relevant workmap comments will be incorporated in the final report exhibits.

(A.1) – Floodplain Work Maps

- Grassy Floodplain Workmap - Missing some cross-section labels for Grassy Creek and Grassy Creek Tributary.
- A match line is recommended between the Grassy Creek and Mountain Creek Floodplain Workmaps.
- Mountain Floodplain Workmap - Missing some cross-section labels for Soap Creek. Cross-section at confluence is cutoff and label is not shown. Should Soap Creek section labels include two significant digits?

(A.2)

- Grassy Floodplain Workmap – Grassy Creek Tributary BFE is labeled with an elevation of zero near the confluence.
- Mountain Floodplain Workmap – The Mountain Creek BFE contour at section 24384 is cutoff.

(A.3)

- Grassy Floodplain Workmap – The floodplain should be connected in the secondary overflow of the breached dam located near the Grassy Creek Tributary confluence.
- Mountain Floodplain Workmap – The 500-year floodplain delineation near the confluence of Mountain Creek and Soap Creek should tie to the 100-year floodplain or show the correct tie-in rather then cutting across the stream.

(A.4)

- Mountain Floodplain Workmap – Consider rotating Soap Creek label with the stream alignment near Section 14559.

(A.5)

- Grassy Floodplain Workmap – Consider removing driveway labels.

(A.7)

- Grassy and Mountain Floodplain Workmaps - May want to re-label BFE as "Ultimate 100-Year BFE" in the legend.

(B.3) – Watershed Work Map

- Road labels are hard to read. May try masking road labels.
- City Limits and ETJ not provided on Watershed Work Map.

(B.4)

- Contour labels are not provided.

(C.2) – Existing and Future Land-Use Maps

- Grassy Creek not labeled on both existing and ultimate landuse maps.

(C.3)

- City Limits and ETJ not show on both existing and ultimate landuse maps.

(C.4)

- Re-label "LU_DSCR" as "Existing Landuse" on the existing landuse map.

TEN BRANCH HYDROLOGY

(B.1)

- The area to the south of basin TEN1 does not drain into Ten Branch. There is a ridge line that roughly divides the drainage basin in half running east to west. The majority of drainage area does not appear to contribute to the hydraulic model. Basin TEN1 was re-delineated to exclude the area to the south.

(D.1)

- Channel flow roughness is not documented for both existing and future conditions throughout. Spreadsheet notes indicate n values were taken from RAS routing model. Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.

(D.3)

- The Lag Time channel flow length for TEN3 does not match flow path length in GIS attribute table. The spreadsheet has a value of 2,677 feet while the flow path length is actually 1,958 feet (existing and future lag times). Channel flow length updated for basin TEN3.
- The total flow path length for the future lag time calculation is reduced by 50 feet for basins TEN1 and TEN3. The shallow concentrated flow length should be increased by 50 feet to account for the difference in overland flow length when changing from open space to commercial landuse. The shallow concentrated flow lengths were increased by 50 feet.

(E.1)

- Calculations not provided for channel flow computations. (no Manning's roughness, Area or wetted perimeter). Channel flow computations were based on velocities taken from RAS models or Flowmaster based on bank full water surface profiles for open channels and the calculated time in pipe taken from City plan sets for storm sewers. N-values, area, and wetted perimeter were not needed in the spreadsheet to calculate channel flow.
- Title at top of future lag calculation sheet is labeled as "Existing Lag Time Calculations for Joe Pool Lake Trib". Title changed to "Ultimate Lag Time Calculations for Joe Pool Lake Trib" for the ultimate lag calculation spreadsheet.

(E.3)

- The shallow concentrated flow path for basin TEN3 appears to be routed through a commercial development and building located in the northwest corner of the basin. The shallow concentrated flow path for basin TEN3 has been re-routed around the commercial development.

(H.2)

- The final routing path flow length may change for R_TEN2 if basin TEN1 is re-delineated. R_TEN2 updated in model.

(I.1)

- The areas shown in Table II-Hydrologic Parameters are entered incorrectly in the spreadsheet (TEN2 and TEN3 are swapped). The areas are entered correctly in the hydrologic model. The areas for TEN2 and TEN3 have been corrected in Table II – Hydrologic Parameters.

TEN BRANCH HEC-RAS

(A.3)

- The model defaults to critical depth at Sections 2724 and 5286 (not consecutive). Critical Depth defaults for non-consecutive sections were not addressed unless it appeared to be affecting the model in an unnatural manner.

(E.1)

- The LOB of Section 1702 does not contain the 100-year Ultimate and 500-year floodplains. The revised HMS model produced flows which were contained in within the limits of the section 1702.

LOYD BRANCH HYDROLOGY

(D.3)

- Overland flow lengths for sub-basins LYD3 and LYD4 need to be reduced in the future model from 100' to 50' based on Future LU of commercial. Overland flow lengths for basins LYD3 and LYD4 were reduced from 100' to 50'.

LOYD BRANCH HEC-RAS

(A.3)

- The model defaults to critical depth for the 100-year and 100-year ultimate at Sections 3553 and 5858 (not consecutive). Critical Depth defaults for non-consecutive sections were not addressed unless it appeared to be affecting the model in an unnatural manner.

(B.1)

- Ragland Road and S. SH360 crossings are not accounted for in the model. Roadway crossings were not modeled for Zone A streams.

TEN BRANCH & LOYD BRANCH MAPPING & EXHIBITS

Relevant workmap comments will be incorporated in the final report exhibits.

(A.1) – Floodplain Work Map

- Missing some cross-section labels (Loyd Branch and Ten Branch).

(A.2)

- Not all BFE's are labeled (Loyd Branch and Ten Branch).

(A.3)

- The floodplain width on the map does not match the model for Ten Branch at Sections 5286 and 2892.

(A.7)

- Under Notes there is a typo ("based o on").
- May want to re-label BFE as "Ultimate 100-Year BFE" in the legend.

(B.3) – Watershed Work Map

- Road labels are not provided on both Ten Branch and Loyd branch watershed workmaps.

(B.5)

- A red dot shows up on the Loyd Branch Watershed map located north of LYD-3. It should be removed or identified in the legend.

(C.1) – Existing and Future Land-Use Maps

- The Ten Branch Ultimate Landuse exhibit is blank (not reviewed).

(C.3)

- No road labels are provided on the Ten Branch Existing Landuse exhibit.

(C.4)

- A red dot shows up on the Loyd Branch Existing Landuse exhibit. It should be removed or identified in the legend.

(D.3) – Soils Map

- Roads are not labeled on the Ten Branch Soils exhibit.

(D.4)

- Soil type B and water are very similar in the Legend. Consider revising one to make it easier to differentiate between the two on the map. This is not a critical comment.

HALFF

June 23, 2010
AVO 26418

Gabe G. Johnson, PE, PH, CFM
Floodplain Administrator
City of Grand Prairie
206 West Church Street
Grand Prairie, Texas 75053-4045

Re: **City-wide Drainage Master Plan for Joe Pool Lake, W.O. #581.40**
Response to Soap QC Comments Received June 15, 2010

Dear Mr. Johnson:

Halff Associates, Inc. has reviewed the QC comments for the Soap Creek Watershed Hydraulic models for the CWDMP for Joe Pool Lake received on June 15, 2010. We appreciate the comments from Pacheco Koch. The hydraulic models have been revised and our responses to the review comments are included on the following pages.

After reviewing our comments, please feel free to contact me, Cindy Mosier, or Stephen Crawford if you have any questions or concerns. Once the models are finalized, we will begin finalizing the floodplain mapping and floodway delineations.

Sincerely,

HALFF ASSOCIATES, INC.

Benjamin B. Pylant, PE, CFM

enclosures

Cc:

HALFF ASSOCIATES, INC.
4000 FOSSIL CREEK BOULEVARD
FORT WORTH, TX 76137-2720
TEL (817) 847-1422
FAX (817) 232-9784
WWW.HALFF.COM

EAST SOAP CREEK

(A.8)

- Section 2692 contains contraction/expansion coefficients of 0.6/0.8. They should be changed to reflect normal sections (0.1/0.3). Contraction/expansion coefficients were raised at section 2692 to account for the sudden contraction and expansion of flow downstream of Miller Road. Contraction/expansion coefficients of 0.6/0.8 respectively are being used for model stability. The coefficients were not changed.

(B.9)

- Expansion and contraction coefficients at section 2692 are 0.8 and 0.6, respectively. Consider revising to 0.3 and 0.1 for normal channel geometry. Contraction/expansion coefficients were originally raised at section 2692 to account for the sudden contraction and expansion of flow downstream of Miller Road. Contraction/expansion coefficients of 0.6/0.8 respectively are being used for model stability. The coefficients were not changed.

(B.11)

- Culvert 3816 – The scale and chart disagree with the entrance loss of 0.9. The chart and scale have been corrected. The entrance loss of 0.9 was selected to account for the losses due to the partially blocked culverts at Turner Road. The entrance loss was not changed.

(C.1)

- Flow decreases from cross section 6027 to 4363. Please verify with hydrologic model. Flow decreases from cross section 6027 to 4363 match the current effective steady flow data.

(D.7)

- Section 5749 carries the majority of floodway overbank conveyance on the LOB and then shifts to the ROB at the next downstream section. Consider revising encroachment stations to allow additional conveyance in the ROB. Encroachment station revised to allow additional conveyance in the ROB at section 5749.
- Sections 3588 to 3347 and 2360 to 2029 also contain abrupt shifts in overbank conveyance from one section to the next. However, the stream meanders with cut banks and the abrupt conveyance shift appears unavoidable. No change was made to the floodway in these areas.

NEWTON BRANCH

(A.9)

- Section 894 – An n-value of 0.045 was used for the ROB heavily treed area, other sections utilized 0.1 for similar conditions. N-value changed to 0.1 for heavily wooded area in the ROB.
- Section 2323 – An n-value of 0.05 was used for the ROB open space, other sections downstream utilized 0.06 for similar conditions. N-value of 0.06 was used for the sections downstream of 2323 in the ROB due to the fences located in that area. The n-value of 0.05 in the ROB of section 2323 is appropriate for the open space.
- Section 3851 and 4919 – An n-value of 0.09 was used for the ROB treed area, other sections utilized 0.1 for similar conditions. N-value was changed to 0.1 in the ROB for sections 3851 and 4919 to maintain consistency for heavily wooded areas.

(A.11)

- Culvert 1520 – Sections 1471 and 1567 do not show a right ineffective flow area. Ineffective flow at this structure does not impact the events being considered for this project. If higher frequency events are considered in future models, ineffective areas will need to be added which are appropriate for those specific events.
- Culvert 1520 – Sections 1388 and 1617 do not show left or right ineffective flow areas. Ineffective flow areas should be shown based on 1:1 contraction and 4:1 expansion. The ineffective flow areas

could affect the higher frequency storm events. Ineffective flow at this structure does not impact the events being considered for this project. If higher frequency events are considered in future models, ineffective areas will need to be added which are appropriate for those specific events.

- Culvert 8676 – Sections 8505 and 8783 do not show left or right ineffective flow areas. Ineffective flow areas should be shown based on 1:1 contraction and 4:1 expansion. The ineffective flow areas could affect the higher frequency storm events. Ineffective flow at this structure does not impact the events being considered for this project. If higher frequency events are considered in future models, ineffective areas will need to be added which are appropriate for those specific events.

(E.1)

- Section 894 – Backwater from Soap Creek is not contained within section. Section 894 contains all storm events for Newton Branch, independent of the Soap Creek backwater. No action was taken.

(G.1)

- Bridge modeling approach for section 520 & 8676 should include pressure and/or weir for the high flow methods. The bridge modeling approach was tested as pressure and/or weir for the high flow methods at sections 520 & 8676 and there was no change in water surface elevation. When the bridge becomes highly submerged, HECRAS switches to the energy equation automatically. The bridge modeling approach was left as energy for the high flow methods.

PLAINS BRANCH

(G.1)

- Bridge modeling approach for section 5078 should include pressure and/or weir for the high flow methods. The bridge modeling approach was tested as pressure and/or weir for the high flow methods at sections 5078 and there was no change in water surface elevation. When the bridge becomes highly submerged, HECRAS switches to the energy equation automatically. The bridge modeling approach was left as energy for the high flow method.

SOAP CREEK

(A.8)

- Sections 13427 & 12709 contain contraction/expansion coefficients of 0.3/0.5. They should be changed to reflect normal sections (0.1/0.3). The right overbank is quickly contracting and expanding due to the encroachment at section 12709. It appears that the 0.3/0.5 contraction/expansion is justified. No change was made.

(A.9)

- Sections 20698 & 21296 appear to be heavily wooded in the LOB. However the quality of the aerial image used for comparison is in question at this location please verify roughness in the LOB for these sections. The N-values used in the LOB appear to be appropriate. No heavily wooded conditions were found in this area.

(C.2)

- Note: The flow decreases at several of the flow change locations in a downstream direction. Please confirm with the hydrologic model. Flow decreases match the current effective steady flow data.

(C.4)

- Normal depth was used with a slope of 0.14%. No action needed.

(G.1)

- The mapping tie-ins to the upstream and downstream floodplains should be verified. The tie-ins were verified to be correct.

WEST SOAP CREEK

(A.11)

- Ineffective flow not used at roadway crossings. May affect higher frequency floods related to future modeling efforts. Ineffective flow near the structure crossings did not impact the events being considered for this project. If higher frequency events are considered in future models, ineffective areas will need to be added which are appropriate for those specific events.

(B.6)

- Culvert 6727 – Max submergence of 0.95 was used for VV Jones culvert. Culvert 12117 used the program default of 0.98. Please verify. Current Effective model used max submergence of 0.95, however, the max submergence has been changed back to the program default of 0.98.

(B.11)

- Culvert 6727 and 12117 – The scale and chart disagree with the entrance loss of 0.9. The chart and scale were updated for Corrugated Metal Pipe Culvert and Pipe projecting from fill, respectively. The entrance loss was kept at 0.9.

(B.12)

- Consider revising roughness coefficient of culvert at CR502 from 0.03 to .015 to reflect RCP roughness. The culverts at CR502 are corrugated metal pipe. The roughness coefficient of 0.03 is within the recommended range. No action taken.

Appendix C
Stream and Open Channel Alternatives

General Guidance for Non-Structural Alternatives

APPENDIX C - GENERAL GUIDANCE FOR NON-STRUCTURAL ALTERNATIVES

A number of alternative measures can be used, either separately or collectively, to reduce the threat of flooding. The alternatives can be grouped into three broad categories: (1) No Action; (2) Non-Structural Measures; (3) Relief Measures. This section discusses the alternatives to flood reduction and their applicability to the City-wide Drainage Master Plan for Joe Pool Lake.

A. NO ACTION

Taking no action is a non-structural measure that must always be considered. Taking no action towards the flooding problems identified would mean that the City of Grand Prairie would rely on its current floodplain zoning and subdivision ordinances to regulate all future development along the creeks, and on its Flood Insurance Program regulations to manage future and existing development in the 100-year floodplain and floodway fringe. The interest and significant effort undertaken in the production of this study indicates that the City of Grand Prairie is willing to initiate action where necessary to alleviate existing and future flooding problems in the Joe Pool watershed.

B. NON-STRUCTURAL MEASURES

Non-structural methods are the management techniques and/or legislative safeguards intended to decrease flooding and reduce flood damage to individual structures or to land in or around a community. Structures can be protected by elevating in place or by regulating or acquiring specific areas of land in fee or easement. Non-structural measures considered for this study are discussed below:

1. Land Use Zoning and Subdivision Regulations

One means of preventing flood damage is to keep industrial, commercial, and residential structures from being built within the floodplain. Floodplain zoning restricts floodplain utilization to uses that can sustain floods without endangering life or valuable property. Regulatory ordinances are intended to secure the maximum benefits and productivity of flood-prone land by allowing floodplains to convey the design flood; promoting the public's health, safety and general welfare; and minimizing potential flood losses.

Non-structural measures such as land use zoning and subdivision regulations allow a community to regulate development within the floodplain. As participants in the National Flood Insurance Program, the City of Grand Prairie has adopted regulations that equal or exceed the minimal FEMA requirements of controlling the existing 100-year floodplain.

2. Construction Regulations

Construction regulations constitute an important means of preventing flood damage in a developing watershed. Some cities have building codes that contain general flood-protection provisions whereby the building inspector tries to route all building-permit applications in flood-prone areas through the City Engineer. The City Engineer should then carefully review each application to determine if the proposed building may be flooded and ensure that all buildings adjacent to a flood-hazard area are built with a finished floor elevation that is at least 1-foot above the fully developed 100-year flood elevation and 2-feet above the existing conditions 100-year flood elevation. The City should require that all finished floor elevations be specified on the final plat of each new subdivision to help ensure all new structures are built above 100-year floodplain elevations.

To limit erosion and downstream sediment, construction projects should be phased to limit the land area that is bare at any one time, and vegetation should be left undisturbed wherever possible. Other practices, such as proper placement of hay bales and silt fences, should also be required. Graded areas should be replanted as soon as possible, and mulches should be used during periods that are not suitable for replanting.

3. Municipal Purchase or Private Donation of Land for Public Use

The municipal purchase or private donation of floodplain land is the most secure way for a city to control flood-prone areas. A floodplain could be used as dedicated open spaces, recreational areas, lakes, streets, or wildlife refuges. Greenbelt parks are an example of municipally owned land that serves as a drainage course and a popular recreational area. Municipal parks can often improve the quality of urban life and enhance property values.

The City may acquire land in the floodplain by three avenues: (1) dedication to municipal ownership on the final plat of a new subdivision; (2) purchase; or (3) gift.

The land should be permanently reserved for flood conveyance, open spaces, and/or recreation.

4. Informing the Public

Studies have indicated that most flood-related deaths in Texas occur at undersized bridges that are either overtopped or washed out by floodwaters. The frequency of flooding and the depth of water overtopping each roadway were calculated and can be seen in Section VI.

An alternative to improving dangerous bridges and culverts is to install flood warning signs, barricades, or other systems to inform and alert motorists of hazardous crossings. The City should consider the need for a flood warning sign at all crossings that are overtopped by water during the 100-year and more frequent floods.

Flood warning systems can be passive or active. A passive system would be a warning sign, such as "BEWARE OF HIGH WATER", which would notify people using the bridge that flooding may occur. A gage with easy-to-read depth markings, measured in feet, should show motorists the height of water over the roadway. Guardrails can be installed to prevent vehicles from being washed off a dangerous road crossing, and can be used to identify the edge of the road surface where it may be obscured by floodwater.

Passive warning systems are feasible on lightly traveled residential streets where the motorists are familiar with the area, and are used at crossings with minor flooding. Installation of a passive warning system would be relatively inexpensive. Features include warning signs, staff gages, and guardrails.

Active warning systems use a sensing device which monitor the water level in the channel and alerts motorists before the water is actually flowing over the roadway. The active system could be an automatic unfolding warning sign with flashing lights and sirens, or a relayed signal that would alert city workers to barricade the crossings. An active system could also be used to alert local residents of rising floodwaters and to evacuate prior to the flood. Active warning systems are necessary on heavily traveled thoroughfares or at crossings which are extremely hazardous.

The National Weather Service uses radar to locate severe and turbulent weather. The Weather Service declares a flash-flood watch when potentially severe storms are likely. A flash-flood warning is issued when a severe storm has developed and flooding is imminent. The warning is sent to weather wire services, counties and municipalities in the area, and to local Civil Defense authorities. Flood-prediction and early-warning systems usually give populated areas time to prepare flood defenses, evacuate flood-hazard areas, and close dangerous stream crossings.

The City of Grand Prairie has installed a flood-warning system that can be used to alert city officials to barricade flood-prone streets in the Joe Pool watershed that become treacherous when overtopped. This system would not reduce or prevent property inundation or flood damages; however, it would increase public safety.

Many developed areas are flood prone, even if floods have not occurred within the memory of local residents. Flood-hazard maps delineating flood-prone areas, such as those included with this report, have been prepared by the Federal Emergency Management Agency and by the U.S. Army Corps of Engineers. Dissemination of such flood-hazard information helps landowners to understand the need for compliance with floodplain zoning regulations. It also gives residents in dangerous flood-prone areas evidence of the need to consider relocating their families and businesses.

This report, by accurately updating and delineating the flood-prone areas, pinpoints dangerous flood-prone stream crossings, makes residents aware of local flood hazards, and helps the city and the public evaluate proposed plans to minimize existing and future flood problems.

5. Watershed Management

The reduction of runoff in a watershed lowers peak discharges and flood stages. Soil conservation and the maintenance of vegetative ground cover retain water on the soil's surface, allowing infiltration into the soil. Urban development increases the percentage of impervious surfaces in an area, which generally increases the runoff potential. The preservation of trees, the maintenance of lawns, and the discharge of roof drains into vegetated areas all increase the infiltration of storm water into soils in developed areas.

Bare soils are easily eroded, resulting in transportation of sediment through water courses. The flood-carrying capacity of creeks and the storage capacity of flood-control reservoirs are greatly reduced by deposits of this sediment. To limit erosion, vegetation should be left undisturbed wherever possible. Graded areas should be replanted as soon as possible, and mulches should be used during periods that are not suitable for replanting.

Refer to this report Section XI - Maintenance for a discussion of maintenance issues identified for the Joe Pool Lake watershed.

6. Debris Removal

The accumulation of trees, brush, sediment, and other debris at bridges, culverts, pipe crossings, or other obstructions has several dangerous consequences. Obstructions to flow could cause higher flood stage elevations upstream of the crossing. In addition, masses of debris can break loose as flood flows increase, producing a destructive wall of water and debris that surges downstream. The force of water on the upstream side of a bridge plugged by debris may exceed the structural capacity of the bridge, causing it to fail. Prevention of debris obstructions can reduce flood damage and potential hazards.

The City should designate a maintenance division responsible for creek-debris removal. This department could inspect bridges quarterly, or upon request, and remove debris from bridge openings. It is not always economically practical for the city to take responsibility for debris removal on private property. The removal of debris is an essential flood-reduction technique, the use of which should be continued and increased.

Creeks should be inspected periodically to identify, cut, and remove dead trees or trees whose root systems have been undermined by erosion. An inspection program of this type should be aimed at the prevention of stream obstructions before they occur. Erosion-prevention measures should be instituted in areas where significant trees would be in danger of being uprooted by floodwaters. The inspection program should also identify areas in which siltation and debris could significantly decrease the flood-carrying capacity of the stream channel or the waterway under a bridge. Refer to this Figures Section of this report for the Floodplain Workmaps which identify areas with the potential for erosion and sedimentation.

Refer to this report Section XI - Maintenance for a discussion of maintenance issues identified for the Joe Pool Lake watershed.

7. Raising of Finished Floor Elevations

Another non-structural measure is the physical raising of structures affected by flooding. Such a measure requires the placement of the structure on a raised pier foundation, adjusting utilities and site aesthetics, and flood proofing utility connections. The types of structures ideally suited for raising are residential and light commercial structures with pier and beam foundations. Slab-on-grade structures are not normally feasible to raise. Federal studies show that raising of structures is generally not cost-effective if the buildings are above the 10-year flood level.

8. Greenbelt Alternatives

Generally, greenbelt/park alternatives are based on the results of an Environmental Inventory. Greenbelt alternatives can be developed as individual projects, or combined with several other alternatives. Greenbelt plans can be integrated with other floodplain management options. Some alternatives that could be considered include:

- Establishment of Low Maintenance Greenbelts,
- Hike and Bike Trails,
- Equestrian Trails,
- Active Recreation in Broad Floodplain Areas.

C. RELIEF MEASURES

1. Flood Insurance

Flood insurance helps to alleviate the cost to individuals of flood damages after flooding has occurred. However, flood insurance does not prevent damaging floods, which remain burdensome to insurance institutions, property owners, and local and Federal Governments. Purchase of more flood insurance for property owners in the study area will offer some relief from expensive flood damages. This alternative may be advantageous for many of the areas too infrequently flooded to justify any other flood damage mitigation measure. The City of Grand Prairie is a participant in

the National Flood Insurance Program (NFIP). As a condition to property owners purchasing flood insurance offered by the NFIP, participating communities have agreed to adopt and administer local floodplain management measures aimed at protecting lives and new construction from future flooding. The Federal Emergency Management Agency (FEMA), as part of this program, published Flood Insurance Rate Maps (FIRM) as part of the City of Grand Prairie Flood Insurance Study. In communities where a flood map has been published, Section 102 of the Flood Disaster Protection Act of 1973, as amended, requires the purchase of flood insurance as a condition of Federal or Federally-related financial assistance for acquisition or construction of buildings in special flood hazard areas, as shown on the FIRMs. The act also requires local Governments to furnish the following:

- Copies of land use and control measures,
- Maps identifying jurisdictional limits and floodplain areas,
- Estimates of buildings and populations in floodplains,
- A local depository where flood-insurance and flood-hazard maps will be available for public inspection, and
- A summary of the community's history of flooding.

The City of Grand Prairie has chosen to enforce more restrictive measures than the minimum NFIP criteria which, along with other actions, have resulted in a favorable rating in the "Community Rating System" (CRS). The CRS rating has significantly reduced flood insurance rates for citizens within the City.

Appendix D
Elevation Certificates

ID	Address	Owner	Building Use
1	23 Spring Creek Circle	Alejandro Duran	Primary Residential
2	23 Spring Creek Circle	Alejandro Duran	Garage
3	20 Spring Creek Circle	Herbert Myers Jr.	Primary Residential
4	19 Spring Creek Circle	Donny Donald	Primary Residential
5	Greasy Road	Beall Concrete Enterprises Ltd	Non-Residential
6	4740 Old Fort Worth Road	Mitch Canepa	Workshop
7	4730 Old Fort Worth Road	L & Nancy McSpadden & N Canoe	Garage
8	4730 Old Fort Worth Road	L & Nancy McSpadden & N Canoe	Primary Residential
9	2410 Miller Road	Troy L Phillips	Primary Residential
10	2410 Miller Road	Troy L Phillips	Secondary Residential
11	2410 Miller Road	Troy L Phillips	Storage
12	17 Spring Creek Circle	Glenn Wilson	Primary Residential

Grand Prairie TEXAS

CWDMP for Joe Pool Lake

ELEVATION CERTIFICATE MAP

Legend

- Elevation Certificate Survey
- 100-Year Ultimate Floodplain

N.T.S.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

OMB No. 1660-0008
Expires March 31, 2012

Important: Read the instructions on pages 1-9.

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Duran, Alejandro

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
23 Spring Creek Circle
City Grand Prairie State TX ZIP Code 75054

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
Curry, James A Survey - A 338 Tr 3C

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Residential
A5. Latitude/Longitude: Lat. 32 34 45.9 Long. 97 02 59.2 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 5
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) N/A sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade 0
c) Total net area of flood openings in A8.b 0 sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Grand Prairie - 485472	Tarrant County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0485	K		09/25/2009	A	546.6

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☐ FIRM ☒ Community Determined ☐ Other (Describe) ____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

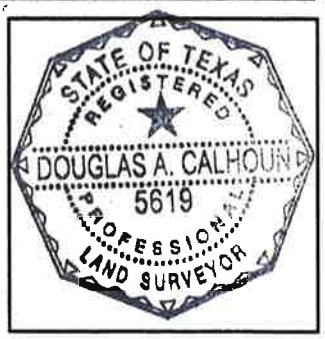
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 125 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	549.14	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	____.____	☐ feet	☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	544.88	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	547.65	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	547.95	☒ feet ☐ meters (Puerto Rico only)	

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd. City Fort Worth State TX ZIP Code 76137
Signature Douglas A. Calhoun Date 7/8/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 23 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments There are 2 separate structures on the property. This certificate is for the primary residential structure

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____.____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____.____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____.____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 23 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 07/08/2010

Rear View – 07/08/2010

FILE: 66071892.10o 000112124

NGS OPUS-RS SOLUTION REPORT

USER: barbuckle@halff.com
RINEX FILE: 6607189o.10o

DATE: July 16, 2010
TIME: 14:22:49 UTC

SOFTWARE: rsgps 1.35 RS10.prl 1.60
EPHEMERIS: igr15914.eph [rapid]
NAV FILE: brdc1890.10n
ANT NAME: TRM_R8_GNSS
ARP HEIGHT: 2.0

START: 2010/07/08 14:46:00
STOP: 2010/07/08 15:45:45
OBS USED: 5200 / 5552 : 94%
QUALITY IND. 5.07/ 28.97
NORMALIZED RMS: 0.414

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.51681)	
X:	-660284.228(m)	0.014(m)	-660284.951(m)	0.014(m)
Y:	-5339228.792(m)	0.019(m)	-5339227.365(m)	0.019(m)
Z:	3414747.506(m)	0.014(m)	3414747.326(m)	0.014(m)
LAT:	32 34 42.97977	0.007(m)	32 34 42.99805	0.007(m)
E LON:	262 57 0.78929	0.015(m)	262 57 0.75507	0.015(m)
W LON:	97 2 59.21071	0.015(m)	97 2 59.24493	0.015(m)
EL HGT:	140.514(m)	0.022(m)	139.299(m)	0.022(m)
ORTHO HGT:	167.616(m)	0.022(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES (UTM (Zone 14))	STATE PLANE COORDINATES (SPC (4202 TXNC))
Northing (Y) [meters]	3606250.603	2102065.075
Easting (X) [meters]	683057.414	736151.171
Convergence [degrees]	1.05039977	0.79094148
Point Scale	1.00001323	0.99990648
Combined Factor	0.99999117	0.99988442

US NATIONAL GRID DESIGNATOR: 14SPB8305706250(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DF8988	TXES ELLIS CORS ARP	N322210.894	W0965145.960	29083.0
DH7149	TXSG SAGINAW TX CORS ARP	N325120.556	W0972038.984	41305.3
DF8990	TXKA KAUFMAN CORS ARP	N323418.297	W0961851.372	69068.4
DH7153	TXWE WEATHERFORD CORS ARP	N324532.010	W0974924.489	75278.8
DH7139	TXDC DECATUR CORS ARP	N331410.382	W0973631.186	89737.6
DH7147	TXMW MINERAL WELLS CORS ARP	N324814.987	W0980834.369	105517.2
DG9808	TXWA WACO CORS ARP	N313439.759	W0970637.810	111136.1
DH7143	TXJA JACKSBORO CORS ARP	N331141.335	W0980844.215	123227.6

NEAREST NGS PUBLISHED CONTROL POINT

CS2915	POOL	N323807.482	W0970123.418	6798.2

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

Important: Read the instructions on pages 1-9.

OMB No. 1660-0008
Expires March 31, 2012

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Duran, Alejandro

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
23 Spring Creek Circle
City Grand Prairie State TX ZIP Code 75054

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
Curry, James A Survey - A 338 Tr 3C

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Accessory
A5. Latitude/Longitude: Lat. 32 34 45.3 Long. 97 02 59.2 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 1B
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) N/A sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade 0
c) Total net area of flood openings in A8.b 0 sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Grand Prairie - 485472	Tarrant County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0485	K		09/25/2009	A	546.6

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☐ FIRM ☒ Community Determined ☐ Other (Describe) ____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

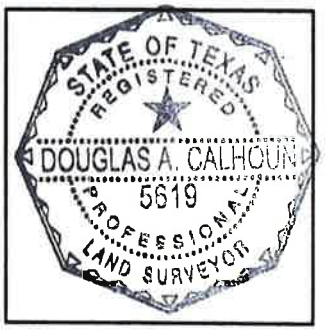
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 125 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	548.55	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	____.____	☐ feet	☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	547.62	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	548.73	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	____.____	☐ feet	☐ meters (Puerto Rico only)

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd. City Fort Worth State TX ZIP Code 76137
Signature Douglas A. Calhoun Date 7/8/13 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 23 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments There are 2 separate structures on the property. This certificate is for the structure that appears to serve as an accessory/garage.

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____.____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____.____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____.____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 23 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 07/08/2010

Rear View – 07/08/2010

FILE: 66071892.10o 000112124

NGS OPUS-RS SOLUTION REPORT
==========

USER: barbuckle@halff.com
RINEX FILE: 6607189o.10o

DATE: July 16, 2010
TIME: 14:22:49 UTC

SOFTWARE: rsgps 1.35 RS10.prl 1.60
EPHEMERIS: igr15914.eph [rapid]
NAV FILE: brdc1890.10n
ANT NAME: TRM_R8_GNSS
ARP HEIGHT: 2.0

START: 2010/07/08 14:46:00
STOP: 2010/07/08 15:45:45
OBS USED: 5200 / 5552 : 94%
QUALITY IND. 5.07/ 28.97
NORMALIZED RMS: 0.414

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.51681)	
X:	-660284.228(m)	0.014(m)	-660284.951(m)	0.014(m)
Y:	-5339228.792(m)	0.019(m)	-5339227.365(m)	0.019(m)
Z:	3414747.506(m)	0.014(m)	3414747.326(m)	0.014(m)
LAT:	32 34 42.97977	0.007(m)	32 34 42.99805	0.007(m)
E LON:	262 57 0.78929	0.015(m)	262 57 0.75507	0.015(m)
W LON:	97 2 59.21071	0.015(m)	97 2 59.24493	0.015(m)
EL HGT:	140.514(m)	0.022(m)	139.299(m)	0.022(m)
ORTHO HGT:	167.616(m)	0.022(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3606250.603	2102065.075
Easting (X) [meters]	683057.414	736151.171
Convergence [degrees]	1.05039977	0.79094148
Point Scale	1.00001323	0.99990648
Combined Factor	0.99999117	0.99988442

US NATIONAL GRID DESIGNATOR: 14SPB8305706250(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DF8988	TXES ELLIS CORS ARP	N322210.894	W0965145.960	29083.0
DH7149	TXSG SAGINAW TX CORS ARP	N325120.556	W0972038.984	41305.3
DF8990	TXKA KAUFMAN CORS ARP	N323418.297	W0961851.372	69068.4
DH7153	TXWE WEATHERFORD CORS ARP	N324532.010	W0974924.489	75278.8
DH7139	TXDC DECATUR CORS ARP	N331410.382	W0973631.186	89737.6
DH7147	TXMW MINERAL WELLS CORS ARP	N324814.987	W0980834.369	105517.2
DG9808	TXWA WACO CORS ARP	N313439.759	W0970637.810	111136.1
DH7143	TXJA JACKSBORO CORS ARP	N331141.335	W0980844.215	123227.6

NEAREST NGS PUBLISHED CONTROL POINT

CS2915	POOL	N323807.482	W0970123.418	6798.2

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

OMB No. 1660-0008
Expires March 31, 2012

Important: Read the instructions on pages 1-9.

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Myers, Herbert Jr.

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
20 Spring Creek Circle
City Grand Prairie State TX ZIP Code 75054

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
Adams, Caroline M Survey - A 38 Tr 1D A 338 Tr 3U & 3G

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Residential
A5. Latitude/Longitude: Lat. 32 34 43.3 Long. 97 02 60.0 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 5
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) N/A sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade 0
c) Total net area of flood openings in A8.b 0 sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Grand Prairie - 485472	Tarrant County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0485	K		09/25/2009	A	548.6

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☐ FIRM ☒ Community Determined ☐ Other (Describe) ____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

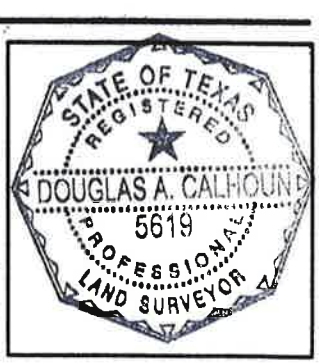
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 125 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	550.38	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	547.34	☒ feet ☐ meters (Puerto Rico only)	
f)	Lowest adjacent (finished) grade next to building (LAG)	547.40	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	548.81	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	548.97	☒ feet ☐ meters (Puerto Rico only)	

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd. City Fort Worth State TX ZIP Code 76137
Signature Douglas A Calhoun Date 7/8/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 20 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments There are 2 separate structures on the property. This certificate is for the primary residential structure.

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____.____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____.____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____.____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 20 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 07/08/2010

Rear View – 07/08/2010

Building Photographs

Continuation Page

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 20 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

If submitting more photographs than will fit on the preceding page, affix the additional photographs below. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View."

Left Side View – 07/08/2010

FILE: 66071892.10o 000112124

NGS OPUS-RS SOLUTION REPORT

USER: barbuckle@halff.com
RINEX FILE: 6607189o.10o

DATE: July 16, 2010
TIME: 14:22:49 UTC

SOFTWARE: rsgps 1.35 RS10.prl 1.60
EPHEMERIS: igr15914.eph [rapid]
NAV FILE: brdc1890.10n
ANT NAME: TRM_R8_GNSS
ARP HEIGHT: 2.0

START: 2010/07/08 14:46:00
STOP: 2010/07/08 15:45:45
OBS USED: 5200 / 5552 : 94%
QUALITY IND. 5.07/ 28.97
NORMALIZED RMS: 0.414

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.51681)	
X:	-660284.228(m)	0.014(m)	-660284.951(m)	0.014(m)
Y:	-5339228.792(m)	0.019(m)	-5339227.365(m)	0.019(m)
Z:	3414747.506(m)	0.014(m)	3414747.326(m)	0.014(m)
LAT:	32 34 42.97977	0.007(m)	32 34 42.99805	0.007(m)
E LON:	262 57 0.78929	0.015(m)	262 57 0.75507	0.015(m)
W LON:	97 2 59.21071	0.015(m)	97 2 59.24493	0.015(m)
EL HGT:	140.514(m)	0.022(m)	139.299(m)	0.022(m)
ORTHO HGT:	167.616(m)	0.022(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3606250.603	2102065.075
Easting (X) [meters]	683057.414	736151.171
Convergence [degrees]	1.05039977	0.79094148
Point Scale	1.00001323	0.99990648
Combined Factor	0.99999117	0.99988442

US NATIONAL GRID DESIGNATOR: 14SPB8305706250(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DF8988	TXES ELLIS CORS ARP	N322210.894	W0965145.960	29083.0
DH7149	TXSG SAGINAW TX CORS ARP	N325120.556	W0972038.984	41305.3
DF8990	TXKA KAUFMAN CORS ARP	N323418.297	W0961851.372	69068.4
DH7153	TXWE WEATHERFORD CORS ARP	N324532.010	W0974924.489	75278.8
DH7139	TXDC DECATUR CORS ARP	N331410.382	W0973631.186	89737.6
DH7147	TXMW MINERAL WELLS CORS ARP	N324814.987	W0980834.369	105517.2
DG9808	TXWA WACO CORS ARP	N313439.759	W0970637.810	111136.1
DH7143	TXJA JACKSBORO CORS ARP	N331141.335	W0980844.215	123227.6

NEAREST NGS PUBLISHED CONTROL POINT

CS2915	POOL	N323807.482	W0970123.418	6798.2

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

OMB No. 1660-0008
Expires March 31, 2012

Important: Read the instructions on pages 1-9.

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Donald, Donny

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
19 Spring Creek Circle
City Grand Prairie State TX ZIP Code 75054

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
Adams, Caroline M Survey - Abst 38 Tr 1C Abst 338 Tr 3F

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Residential
A5. Latitude/Longitude: Lat. 32 34 42.8 Long. 97 03 01.5 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 5
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) N/A sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade 0
c) Total net area of flood openings in A8.b 0 sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage _____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade _____
c) Total net area of flood openings in A9.b _____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Grand Prairie - 485472	Tarrant County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0485	K		09/25/2009	A	549.2

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☐ FIRM ☒ Community Determined ☐ Other (Describe) _____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) _____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date _____ ☐ CBRS ☐ OPA

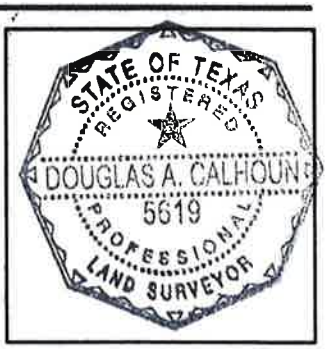
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 125 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	551.15	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	_____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	_____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	_____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	_____.____	☐ feet	☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	547.08	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	549.15	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	548.76	☒ feet ☐ meters (Puerto Rico only)	

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd City Fort Worth State TX ZIP Code 76137
Signature Douglas A Calhoun Date 7/8/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 19 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____.____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____.____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____.____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 19 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 07/08/2010

Rear View – 07/08/2010

Building Photographs

Continuation Page

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 19 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

If submitting more photographs than will fit on the preceding page, affix the additional photographs below. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View."

Right Side View – 07/08/2010

FILE: 66071892.10o 000112124

NGS OPUS-RS SOLUTION REPORT
==========

USER: barbuckle@halff.com
RINEX FILE: 6607189o.10o

DATE: July 16, 2010
TIME: 14:22:49 UTC

SOFTWARE: rsgps 1.35 RS10.prl 1.60
EPHEMERIS: igr15914.eph [rapid]
NAV FILE: brdc1890.10n
ANT NAME: TRM_R8_GNSS
ARP HEIGHT: 2.0

START: 2010/07/08 14:46:00
STOP: 2010/07/08 15:45:45
OBS USED: 5200 / 5552 : 94%
QUALITY IND. 5.07/ 28.97
NORMALIZED RMS: 0.414

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.51681)	
X:	-660284.228(m)	0.014(m)	-660284.951(m)	0.014(m)
Y:	-5339228.792(m)	0.019(m)	-5339227.365(m)	0.019(m)
Z:	3414747.506(m)	0.014(m)	3414747.326(m)	0.014(m)
LAT:	32 34 42.97977	0.007(m)	32 34 42.99805	0.007(m)
E LON:	262 57 0.78929	0.015(m)	262 57 0.75507	0.015(m)
W LON:	97 2 59.21071	0.015(m)	97 2 59.24493	0.015(m)
EL HGT:	140.514(m)	0.022(m)	139.299(m)	0.022(m)
ORTHO HGT:	167.616(m)	0.022(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3606250.603	2102065.075
Easting (X) [meters]	683057.414	736151.171
Convergence [degrees]	1.05039977	0.79094148
Point Scale	1.00001323	0.99990648
Combined Factor	0.99999117	0.99988442

US NATIONAL GRID DESIGNATOR: 14SPB8305706250(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DF8988	TXES ELLIS CORS ARP	N322210.894	W0965145.960	29083.0
DH7149	TXSG SAGINAW TX CORS ARP	N325120.556	W0972038.984	41305.3
DF8990	TXKA KAUFMAN CORS ARP	N323418.297	W0961851.372	69068.4
DH7153	TXWE WEATHERFORD CORS ARP	N324532.010	W0974924.489	75278.8
DH7139	TXDC DECATUR CORS ARP	N331410.382	W0973631.186	89737.6
DH7147	TXMW MINERAL WELLS CORS ARP	N324814.987	W0980834.369	105517.2
DG9808	TXWA WACO CORS ARP	N313439.759	W0970637.810	111136.1
DH7143	TXJA JACKSBORO CORS ARP	N331141.335	W0980844.215	123227.6

NEAREST NGS PUBLISHED CONTROL POINT

CS2915	POOL	N323807.482	W0970123.418	6798.2

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

Important: Read the instructions on pages 1-9.

OMB No. 1660-0008
Expires March 31, 2012

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Beall Concrete Enterprises, Ltd.

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
Greasy Rd
City Midlothian State TX ZIP Code 76065

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
Beall Concrete Plant

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Industrial
A5. Latitude/Longitude: Lat. 32 30 32.10 Long. 97 03 56.97 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 1B
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) N/A sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade 0
c) Total net area of flood openings in A8.b 0 sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage _____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade _____
c) Total net area of flood openings in A9.b _____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Midlothian - 480801	Ellis County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0075	E		01/05/2006	AE	552.4

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☒ FIRM ☐ Community Determined ☐ Other (Describe) _____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) _____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date _____ ☐ CBRS ☐ OPA

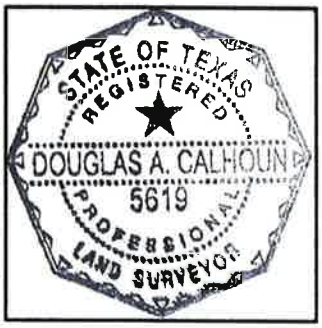
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 127 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	555.30	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	_____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	_____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	_____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	_____.____	☐ feet	☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	554.10	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	554.88	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	_____.____	☐ feet	☐ meters (Puerto Rico only)

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd City Fort Worth State TX ZIP Code 76137
Signature Douglas A Calhoun Date 8/27/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. Greasy Road	Policy Number
City MidlothianState TX ZIP Code 76065	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____.____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____.____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____.____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. Greasy Road	Policy Number
City Midlothian State TX ZIP Code 76065	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 08/27/2010

Rear View – 08/27/2010

Building Photographs

Continuation Page

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. Greasy Road	Policy Number
City De Soto State TX ZIP Code 75123	Company NAIC Number

If submitting more photographs than will fit on the preceding page, affix the additional photographs below. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View."

Side View – 08/27/2010

#127

FILE: 66071901.10o 000112129

NGS OPUS-RS SOLUTION REPORT
==========

USER: barbuckle@halff.com
RINEX FILE: 6607190q.10o

DATE: July 16, 2010
TIME: 14:20:14 UTC

SOFTWARE: rsgps 1.35 RS23.prl 1.60
EPHEMERIS: igr15915.eph [rapid]
NAV FILE: brdc1900.10n
ANT NAME: TRM_R8_GNSS
ARP HEIGHT: 2.0

START: 2010/07/09 16:33:15
STOP: 2010/07/09 17:33:00
OBS USED: 4248 / 4770 : 89%
QUALITY IND. 18.28/ 57.88
NORMALIZED RMS: 0.399

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.51976)	
X:	-662242.243(m)	0.009(m)	-662242.966(m)	0.009(m)
Y:	-5343189.760(m)	0.037(m)	-5343188.333(m)	0.037(m)
Z:	3408211.564(m)	0.021(m)	3408211.384(m)	0.021(m)
LAT:	32 30 31.27827	0.005(m)	32 30 31.29650	0.005(m)
E LON:	262 56 4.96845	0.011(m)	262 56 4.93424	0.011(m)
W LON:	97 3 55.03155	0.011(m)	97 3 55.06576	0.011(m)
EL HGT:	141.081(m)	0.042(m)	139.865(m)	0.042(m)
ORTHO HGT:	168.180(m)	0.042(m)	[NAVD88 (Computed using GEOID09)]	

551.77

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3598471.694	2094292.943
Easting (X) [meters]	681742.601	734801.406
Convergence [degrees]	1.04005338	0.78248470
Point Scale	1.00000732	0.99991721
Combined Factor	0.99998517	0.99989506

US NATIONAL GRID DESIGNATOR: 14SPA8174298471(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DF8988	TXES ELLIS CORS ARP	N322210.894	W0965145.960	24501.5
DH7149	TXSG SAGINAW TX CORS ARP	N325120.556	W0972038.984	46531.9
DF8990	TXKA KAUFMAN CORS ARP	N323418.297	W0961851.372	70893.3
DH7153	TXWE WEATHERFORD CORS ARP	N324532.010	W0974924.489	76367.6
DF8982	TXCO COLLIN CORS ARP	N330954.927	W0963740.571	83539.1
DH7139	TXDC DECATUR CORS ARP	N331410.382	W0973631.186	95374.9
DG9808	TXWA WACO CORS ARP	N313439.759	W0970637.810	103323.0
DH7151	TXST STEPHENVILLE CORS ARP	N321357.314	W0981055.862	109483.6
DH7143	TXJA JACKSBORO CORS ARP	N331141.335	W0980844.215	126560.1

NEAREST NGS PUBLISHED CONTROL POINT

CS2920	SOAP	N323022.729	W0970328.502	740.6

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

OMB No. 1660-0008
Expires March 31, 2012

Important: Read the instructions on pages 1-9.

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Mitch Canepa

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
4740 Old Fort Worth Road
City Midlothian State TX ZIP Code 76065

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Accessory
A5. Latitude/Longitude: Lat. 32 29 39.9 Long. 97 03 24.8 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 1A
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) ____ sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A8.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Ellis County (Unincorporated Areas) - 480798	Ellis County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0075	E		01/05/2006	AE	566.5

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☒ FIRM ☐ Community Determined ☐ Other (Describe) ____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

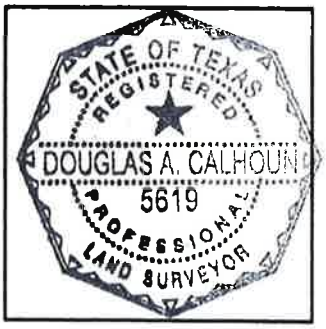
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 129 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	563.23	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	____.____	☐ feet	☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	562.22	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	563.58	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	____.____	☐ feet	☐ meters (Puerto Rico only)

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd City Fort Worth State TX ZIP Code 76137
Signature Douglas A Calhoun Date 8/27/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 4740 Old Fort Worth Road	Policy Number
City MidlothianState TX ZIP Code 76065	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments The structure surveyed appears to be a garage/workshop.

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____.____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____.____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____.____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 4740 Old Fort Worth Road	Policy Number
City Midlothian State TX ZIP Code 76065	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 8/27/2010

Rear View – 8/27/2010

#129

FILE: 66072391.10o 000131720

NGS OPUS-RS SOLUTION REPORT

USER: lholder@halff.com DATE: August 30, 2010
RINEX FILE: 6607239q.10o TIME: 11:44:15 UTC

SOFTWARE: rsgps 1.35.1 RS11.prl 1.61 START: 2010/08/27 16:22:30
EPHEMERIS: igr15985.eph [rapid] STOP: 2010/08/27 17:23:15
NAV FILE: brdc2390.10n OBS USED: 6336 / 6786 : 93%
ANT NAME: TRMR8_GNSS NONE QUALITY IND. 17.24/ 39.63
ARP HEIGHT: 2.0 NORMALIZED RMS: 0.354

REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000) ITRF00 (EPOCH:2010.65398)

X:	-661573.006(m)	0.007(m)	-661573.730(m)	0.007(m)
Y:	-5344123.426(m)	0.013(m)	-5344121.999(m)	0.013(m)
Z:	3406893.347(m)	0.016(m)	3406893.166(m)	0.016(m)
LAT:	32 29 40.46112	0.008(m)	32 29 40.47931	0.008(m)
E LON:	262 56 34.80726	0.008(m)	262 56 34.77302	0.008(m)
W LON:	97 3 25.19274	0.008(m)	97 3 25.22698	0.008(m)
EL HGT:	144.849(m)	0.019(m)	143.632(m)	0.019(m)
ORTHO HGT:	171.921(m)	0.019(m)	[NAVD88 (Computed using GEOID09)]	

564.04

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3596920.716	2092738.496
Easting (X) [meters]	682549.866	735601.625
Convergence [degrees]	1.04410782	0.78700524
Point Scale	1.00001095	0.99991956
Combined Factor	0.99998820	0.99989682

US NATIONAL GRID DESIGNATOR: 14SPA8254996920(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)

DF8988 TXES ELLIS CORS ARP N322210.894 W0965145.960
22923.4
DH7145 TXKE KEENE CORS ARP N322434.932 W0971923.622
26744.4
DH7149 TXSG SAGINAW TX CORS ARP N325120.556 W0972038.984
48265.3
DF8992 TXNA NAVARRO CORS ARP N320230.397 W0963219.446
70039.7
DH7153 TXWE WEATHERFORD CORS ARP N324532.010 W0974924.489
77675.1
DF8982 TXCO COLLIN CORS ARP N330954.927 W0963740.571
84537.0
DH7139 TXDC DECATUR CORS ARP N331410.382 W0973631.186
97115.2
DG9808 TXWA WACO CORS ARP N313439.759 W0970637.810
101794.9
DH7147 TXMW MINERAL WELLS CORS ARP N324814.987 W0980834.369
107509.7

NEAREST NGS PUBLISHED CONTROL POINT
CS2920 SOAP N323022.729 W0970328.502
1309.9

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

OMB No. 1660-0008
Expires March 31, 2012

Important: Read the instructions on pages 1-9.

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Larry & Nancy McSpadden & Nicole Canoe

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
4730 Old Fort Worth Road
City Midlothian State TX ZIP Code 76065

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Residential
A5. Latitude/Longitude: Lat. 32 29 37.14 Long. 97 03 18 60 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 5
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) N/A sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade 0
c) Total net area of flood openings in A8.b 0 sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Ellis County (Unincorporated Areas) - 480798	Ellis County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0075	E		01/05/2006	AE	566.5

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☒ FIRM ☐ Community Determined ☐ Other (Describe) ____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

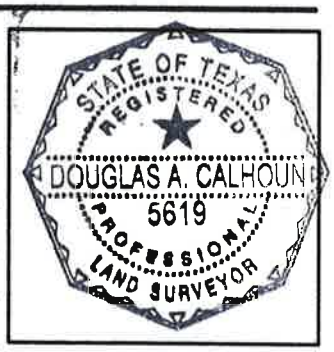
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 8122 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	569.50	☒ feet ☐ meters (Puerto Rico only)
b)	Top of the next higher floor	____.____	☒ feet ☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet ☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet ☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	566.10	☒ feet ☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	566.01	☒ feet ☐ meters (Puerto Rico only)
g)	Highest adjacent (finished) grade next to building (HAG)	566.90	☒ feet ☐ meters (Puerto Rico only)
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	565.14	☒ feet ☐ meters (Puerto Rico only)

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd City Fort Worth State TX ZIP Code 76137
Signature Douglas A. Calhoun Date 4/27/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 4730 Old Fort Worth Road	Policy Number
City MidlothianState TX ZIP Code 76065	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments There is one residential structure and one attached garage on the property. This certificate is for the primary residential structure.

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____.____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____.____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____.____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 4730 Old Fort Worth Road	Policy Number
City Midlothian State TX ZIP Code 76065	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 4/27/10

Rear View – 4/27/10

FILE: 8122.10o 000069909

NGS OPUS-RS SOLUTION REPORT
==========

USER: lholder@halff.com DATE: April 23, 2010
RINEX FILE: 8122112t.10o TIME: 18:59:01 UTC

SOFTWARE: rsgps 1.35 RS23.prl 1.57 START: 2010/04/22 19:43:30
EPHEMERIS: igr15804.eph [rapid] STOP: 2010/04/22 20:44:15
NAV FILE: brdc1120.10n OBS USED: 5985 / 6363 : 94%
ANT NAME: TRMR8_GNSS NONE QUALITY IND. 16.15/ 38.54
ARP HEIGHT: 2.0 NORMALIZED RMS: 0.383

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.30642)	
X:	-661379.687(m)	0.013(m)	-661380.407(m)	0.013(m)
Y:	-5344184.499(m)	0.014(m)	-5344183.071(m)	0.014(m)
Z:	3406837.986(m)	0.015(m)	3406837.806(m)	0.015(m)
LAT:	32 29 38.30246	0.008(m)	32 29 38.32071	0.008(m)
E LON:	262 56 42.44344	0.013(m)	262 56 42.40935	0.013(m)
W LON:	97 3 17.55656	0.013(m)	97 3 17.59065	0.013(m)
EL HGT:	146.200(m)	0.019(m)	144.983(m)	0.019(m)
ORTHO HGT:	173.267(m)	0.022(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3596857.865	2092674.752
Easting (X) [meters]	682750.400	735801.857
Convergence [degrees]	1.04523113	0.78816211
Point Scale	1.00001185	0.99991966
Combined Factor	0.99998890	0.99989671

US NATIONAL GRID DESIGNATOR: 14SPA8275096857(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)

DF8988 TXES ELLIS CORS ARP N322210.894 W0965145.960
22724.4
DH7145 TXKE KEENE CORS ARP N322434.932 W0971923.622
26908.1
DF5387 TXAR ARLINGTON RRP2 CORS ARP N324532.499 W0970336.990
29399.0
DH7149 TXSG SAGINAW TX CORS ARP N325120.556 W0972038.984
48431.8
DF8984 TXDA DALLAS CORS ARP N324759.927 W0964022.453
49356.8
DF8992 TXNA NAVARRO CORS ARP N320230.397 W0963219.446
69852.9
DF8990 TXKA KAUFMAN CORS ARP N323418.297 W0961851.372
70108.0
DH7141 TXGR GLEN ROSE CORS ARP N321425.372 W0974515.972
71594.4
DH7153 TXWE WEATHERFORD CORS ARP N324532.010 W0974924.489
77884.8

NEAREST NGS PUBLISHED CONTROL POINT
CS2920 SOAP N323022.729 W0970328.502
1403.1

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

OMB No. 1660-0008
Expires March 31, 2012

Important: Read the instructions on pages 1-9.

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Larry & Nancy McSpadden & Nicole Canoe

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
4730 Old Fort Worth Road
City Midlothian State TX ZIP Code 76065

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Addition
A5. Latitude/Longitude: Lat. 32 29 37.69 Long. 97 03 18.91 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 1A
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) ____ sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A8.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Ellis County (Unincorporated Areas) - 480798	Ellis County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0075	E		01/05/2006	AE	566.5

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☒ FIRM ☐ Community Determined ☐ Other (Describe) ____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

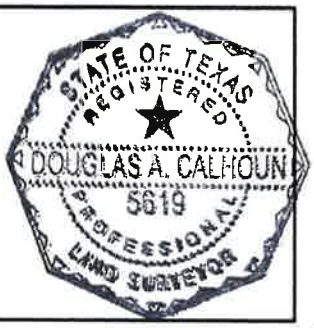
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 8122 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	566.21	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	____.____	☐ feet	☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	565.91	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	566.21	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	____.____	☐ feet	☐ meters (Puerto Rico only)

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd City Fort Worth State TX ZIP Code 76137
Signature Douglas A Calhoun Date 4/27/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 4730 Old Fort Worth Road	Policy Number
City MidlothianState TX ZIP Code 76065	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments There is one residential structure and one attached garage on the property. This certificate is for the attached garage.

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____._____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____._____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____._____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 4730 Old Fort Worth Road	Policy Number
City Midlothian State TX ZIP Code 76065	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 4/27/10

Rear View – 4/27/10

FILE: 8122.10o 000069909

NGS OPUS-RS SOLUTION REPORT
==========

USER: lholder@halff.com DATE: April 23, 2010
RINEX FILE: 8122112t.10o TIME: 18:59:01 UTC

SOFTWARE: rsgps 1.35 RS23.prl 1.57 START: 2010/04/22 19:43:30
EPHEMERIS: igr15804.eph [rapid] STOP: 2010/04/22 20:44:15
NAV FILE: brdc1120.10n OBS USED: 5985 / 6363 : 94%
ANT NAME: TRMR8_GNSS NONE QUALITY IND. 16.15/ 38.54
ARP HEIGHT: 2.0 NORMALIZED RMS: 0.383

	REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.30642)	
X:	-661379.687(m)	0.013(m)	-661380.407(m)	0.013(m)
Y:	-5344184.499(m)	0.014(m)	-5344183.071(m)	0.014(m)
Z:	3406837.986(m)	0.015(m)	3406837.806(m)	0.015(m)
LAT:	32 29 38.30246	0.008(m)	32 29 38.32071	0.008(m)
E LON:	262 56 42.44344	0.013(m)	262 56 42.40935	0.013(m)
W LON:	97 3 17.55656	0.013(m)	97 3 17.59065	0.013(m)
EL HGT:	146.200(m)	0.019(m)	144.983(m)	0.019(m)
ORTHO HGT:	173.267(m)	0.022(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3596857.865	2092674.752
Easting (X) [meters]	682750.400	735801.857
Convergence [degrees]	1.04523113	0.78816211
Point Scale	1.00001185	0.99991966
Combined Factor	0.99998890	0.99989671

US NATIONAL GRID DESIGNATOR: 14SPA8275096857(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)

DF8988 TXES ELLIS CORS ARP N322210.894 W0965145.960
22724.4
DH7145 TXKE KEENE CORS ARP N322434.932 W0971923.622
26908.1
DF5387 TXAR ARLINGTON RRP2 CORS ARP N324532.499 W0970336.990
29399.0
DH7149 TXSG SAGINAW TX CORS ARP N325120.556 W0972038.984
48431.8
DF8984 TXDA DALLAS CORS ARP N324759.927 W0964022.453
49356.8
DF8992 TXNA NAVARRO CORS ARP N320230.397 W0963219.446
69852.9
DF8990 TXKA KAUFMAN CORS ARP N323418.297 W0961851.372
70108.0
DH7141 TXGR GLEN ROSE CORS ARP N321425.372 W0974515.972
71594.4
DH7153 TXWE WEATHERFORD CORS ARP N324532.010 W0974924.489
77884.8

NEAREST NGS PUBLISHED CONTROL POINT
CS2920 SOAP N323022.729 W0970328.502
1403.1

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

Important: Read the instructions on pages 1-9.

OMB No. 1660-0008
Expires March 31, 2012

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Troy L. Phillips

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
2410 Miller Road
City Midlothian State TX ZIP Code 76065

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
14B Cottonwood Acres - REV 6.271 Acres

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Residential
A5. Latitude/Longitude: Lat. 32 27 29.0 Long. 97 03 35.5 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 5
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) N/A sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade 0
c) Total net area of flood openings in A8.b 0 sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Ellis County (Unincorporated Areas) - 480798	Ellis County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0075	E		01/05/2006	AE	613.3

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☒ FIRM ☐ Community Determined ☐ Other (Describe) ____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

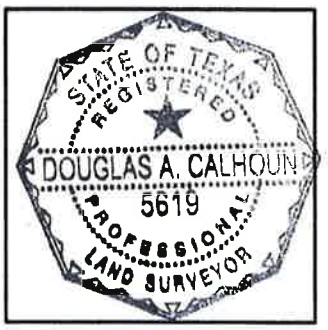
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 8121 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	615.15	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	612.80	☒ feet ☐ meters (Puerto Rico only)	
f)	Lowest adjacent (finished) grade next to building (LAG)	612.14	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	613.11	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	612.75	☒ feet ☐ meters (Puerto Rico only)	

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd City Fort Worth State TX ZIP Code 76137
Signature Douglas A Calhoun Date 4/27/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 2410 Miller Road	Policy Number
City MidlothianState TX ZIP Code 76065	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments There are 3 separate structures on the property. This certificate is for the manufactured home that appears to serve as the main residential structure.

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____.____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____.____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____.____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 2410 Miller Road	For Insurance Company Use: Policy Number
City Midlothian State TX ZIP Code 76065	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 4/27/10

Rear View – 4/27/10

FILE: 8121.10o 000069898

NGS OPUS-RS SOLUTION REPORT
==========

USER: lholder@halff.com DATE: April 23, 2010
RINEX FILE: 8121112s.10o TIME: 18:49:16 UTC

SOFTWARE: rsgps 1.35 RS29.prl 1.57 START: 2010/04/22 18:08:15
EPHEMERIS: igr15804.eph [rapid] STOP: 2010/04/22 19:11:15
NAV FILE: brdc1120.10n OBS USED: 4428 / 5040 : 88%
ANT NAME: TRMR8_GNSS NONE QUALITY IND. 18.58/ 49.47
ARP HEIGHT: 2.0 NORMALIZED RMS: 0.374

	REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.30624)	
X:	-662171.343(m)	0.010(m)	-662172.063(m)	0.010(m)
Y:	-5346250.109(m)	0.028(m)	-5346248.681(m)	0.028(m)
Z:	3403488.797(m)	0.014(m)	3403488.617(m)	0.014(m)
LAT:	32 27 29.15514	0.009(m)	32 27 29.17336	0.009(m)
E LON:	262 56 22.07525	0.009(m)	262 56 22.04117	0.009(m)
W LON:	97 3 37.92475	0.009(m)	97 3 37.95883	0.009(m)
EL HGT:	159.300(m)	0.030(m)	158.083(m)	0.030(m)
ORTHO HGT:	186.361(m)	0.032(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3592870.517	2088689.851
Easting (X) [meters]	682291.067	735324.715
Convergence [degrees]	1.04116467	0.78507636
Point Scale	1.00000979	0.99992590
Combined Factor	0.99998477	0.99990089

US NATIONAL GRID DESIGNATOR: 14SPA8229192870(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)

DF8988 TXES ELLIS CORS ARP N322210.894 W0965145.960
21028.9
DH7145 TXKE KEENE CORS ARP N322434.932 W0971923.622
25282.2
DF5387 TXAR ARLINGTON RRP2 CORS ARP N324532.499 W0970336.990
33373.1
DH7149 TXSG SAGINAW TX CORS ARP N325120.556 W0972038.984
51501.8
DF8984 TXDA DALLAS CORS ARP N324759.927 W0964022.453
52543.3
DF8992 TXNA NAVARRO CORS ARP N320230.397 W0963219.446
67449.0
DH7141 TXGR GLEN ROSE CORS ARP N321425.372 W0974515.972
69639.7
DF8990 TXKA KAUFMAN CORS ARP N323418.297 W0961851.372
71244.6
DH7153 TXWE WEATHERFORD CORS ARP N324532.010 W0974924.489
79002.3

NEAREST NGS PUBLISHED CONTROL POINT
CS3043 WYATT N322707.365 W0970330.720
699.5

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

Important: Read the instructions on pages 1-9.

OMB No. 1660-0008
Expires March 31, 2012

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Troy L. Phillips

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
2410 Miller Road
City Midlothian State TX ZIP Code 76065

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
14B Cottonwood Acres - REV 6.271 Acres

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Residential Addition
A5. Latitude/Longitude: Lat. 32 27 28.50 Long. 97 03 35.98 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 5
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) ____ sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A8.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Ellis County (Unincorporated Areas) - 480798	Ellis County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0075	E		01/05/2006	AE	613.3

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☒ FIRM ☐ Community Determined ☐ Other (Describe) ____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 8121 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	612.76	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	____.____	☒ feet	☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	611.70	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	611.98	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	____.____	☐ feet	☐ meters (Puerto Rico only)

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No

Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd City Fort Worth State TX ZIP Code 76137
Signature Douglas A. Calhoun Date 4/27/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 2410 Miller Road	Policy Number
City MidlothianState TX ZIP Code 76065	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments There are 3 separate structures on the property. This certificate is for the mobile structure that appears to function as a secondary residential structure.

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____._____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____._____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____._____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 2410 Miller Road	Policy Number
City Midlothian State TX ZIP Code 76065	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 4/27/10

Rear View – 4/27/10

Building Photographs

Continuation Page

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.	Policy Number
City State ZIP Code	Company NAIC Number

If submitting more photographs than will fit on the preceding page, affix the additional photographs below. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View."

FILE: 8121.10o 000069898

NGS OPUS-RS SOLUTION REPORT
==========

USER: lholder@halff.com DATE: April 23, 2010
RINEX FILE: 8121112s.10o TIME: 18:49:16 UTC

SOFTWARE: rsgps 1.35 RS29.prl 1.57 START: 2010/04/22 18:08:15
EPHEMERIS: igr15804.eph [rapid] STOP: 2010/04/22 19:11:15
NAV FILE: brdc1120.10n OBS USED: 4428 / 5040 : 88%
ANT NAME: TRMR8_GNSS NONE QUALITY IND. 18.58/ 49.47
ARP HEIGHT: 2.0 NORMALIZED RMS: 0.374

	REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.30624)	
X:	-662171.343(m)	0.010(m)	-662172.063(m)	0.010(m)
Y:	-5346250.109(m)	0.028(m)	-5346248.681(m)	0.028(m)
Z:	3403488.797(m)	0.014(m)	3403488.617(m)	0.014(m)
LAT:	32 27 29.15514	0.009(m)	32 27 29.17336	0.009(m)
E LON:	262 56 22.07525	0.009(m)	262 56 22.04117	0.009(m)
W LON:	97 3 37.92475	0.009(m)	97 3 37.95883	0.009(m)
EL HGT:	159.300(m)	0.030(m)	158.083(m)	0.030(m)
ORTHO HGT:	186.361(m)	0.032(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3592870.517	2088689.851
Easting (X) [meters]	682291.067	735324.715
Convergence [degrees]	1.04116467	0.78507636
Point Scale	1.00000979	0.99992590
Combined Factor	0.99998477	0.99990089

US NATIONAL GRID DESIGNATOR: 14SPA8229192870(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)

DF8988 TXES ELLIS CORS ARP N322210.894 W0965145.960
21028.9
DH7145 TXKE KEENE CORS ARP N322434.932 W0971923.622
25282.2
DF5387 TXAR ARLINGTON RRP2 CORS ARP N324532.499 W0970336.990
33373.1
DH7149 TXSG SAGINAW TX CORS ARP N325120.556 W0972038.984
51501.8
DF8984 TXDA DALLAS CORS ARP N324759.927 W0964022.453
52543.3
DF8992 TXNA NAVARRO CORS ARP N320230.397 W0963219.446
67449.0
DH7141 TXGR GLEN ROSE CORS ARP N321425.372 W0974515.972
69639.7
DF8990 TXKA KAUFMAN CORS ARP N323418.297 W0961851.372
71244.6
DH7153 TXWE WEATHERFORD CORS ARP N324532.010 W0974924.489
79002.3

NEAREST NGS PUBLISHED CONTROL POINT
CS3043 WYATT N322707.365 W0970330.720
699.5

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

Important: Read the instructions on pages 1-9.

OMB No. 1660-0008
Expires March 31, 2012

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Troy L. Phillips

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
2410 Miller Road
City Midlothian State TX ZIP Code 76065

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
14B Cottonwood Acres - REV 6.271 Acres

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Accessory
A5. Latitude/Longitude: Lat. 32 27 28.42 Long. 97 03 35.76 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983
A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.
A7. Building Diagram Number 5
A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) ____ sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A8.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Ellis County (Unincorporated Areas) - 480798	Ellis County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0075	E		01/05/2006	AE	613.3

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☒ FIRM ☐ Community Determined ☐ Other (Describe) ____
B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____
B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

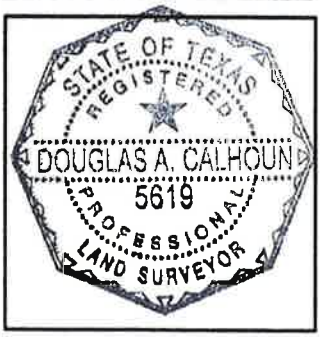
SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.
C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 8121 Vertical Datum NAVD 88
Conversion/Comments OPUS Solution (see attached)

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	612.58	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	____.____	☐ feet	☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	611.91	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	612.03	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	____.____	☐ feet	☐ meters (Puerto Rico only)

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619
Title Survey Manager Company Name Halff Associates, Inc.
Address 4000 Fossil Creek Blvd City Fort Worth State TX ZIP Code 76137
Signature Douglas A. Calhoun Date 4/27/10 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 2410 Miller Road	Policy Number
City MidlothianState TX ZIP Code 76065	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments There are 3 separate structures on the property. This certificate is for the structures that appears to serve as an accessory/storage building.

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____.____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____.____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____.____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____.____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 2410 Miller Road	Policy Number
City Midlothian State TX ZIP Code 76065	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 4/27/10

Rear View – 4/27/10

FILE: 8121.10o 000069898

NGS OPUS-RS SOLUTION REPORT
==========

USER: lholder@halff.com DATE: April 23, 2010
RINEX FILE: 8121112s.10o TIME: 18:49:16 UTC

SOFTWARE: rsgps 1.35 RS29.prl 1.57 START: 2010/04/22 18:08:15
EPHEMERIS: igr15804.eph [rapid] STOP: 2010/04/22 19:11:15
NAV FILE: brdc1120.10n OBS USED: 4428 / 5040 : 88%
ANT NAME: TRMR8_GNSS NONE QUALITY IND. 18.58/ 49.47
ARP HEIGHT: 2.0 NORMALIZED RMS: 0.374

	REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.30624)	
X:	-662171.343(m)	0.010(m)	-662172.063(m)	0.010(m)
Y:	-5346250.109(m)	0.028(m)	-5346248.681(m)	0.028(m)
Z:	3403488.797(m)	0.014(m)	3403488.617(m)	0.014(m)
LAT:	32 27 29.15514	0.009(m)	32 27 29.17336	0.009(m)
E LON:	262 56 22.07525	0.009(m)	262 56 22.04117	0.009(m)
W LON:	97 3 37.92475	0.009(m)	97 3 37.95883	0.009(m)
EL HGT:	159.300(m)	0.030(m)	158.083(m)	0.030(m)
ORTHO HGT:	186.361(m)	0.032(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3592870.517	2088689.851
Easting (X) [meters]	682291.067	735324.715
Convergence [degrees]	1.04116467	0.78507636
Point Scale	1.00000979	0.99992590
Combined Factor	0.99998477	0.99990089

US NATIONAL GRID DESIGNATOR: 14SPA8229192870(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)

DF8988 TXES ELLIS CORS ARP N322210.894 W0965145.960
21028.9
DH7145 TXKE KEENE CORS ARP N322434.932 W0971923.622
25282.2
DF5387 TXAR ARLINGTON RRP2 CORS ARP N324532.499 W0970336.990
33373.1
DH7149 TXSG SAGINAW TX CORS ARP N325120.556 W0972038.984
51501.8
DF8984 TXDA DALLAS CORS ARP N324759.927 W0964022.453
52543.3
DF8992 TXNA NAVARRO CORS ARP N320230.397 W0963219.446
67449.0
DH7141 TXGR GLEN ROSE CORS ARP N321425.372 W0974515.972
69639.7
DF8990 TXKA KAUFMAN CORS ARP N323418.297 W0961851.372
71244.6
DH7153 TXWE WEATHERFORD CORS ARP N324532.010 W0974924.489
79002.3

NEAREST NGS PUBLISHED CONTROL POINT
CS3043 WYATT N322707.365 W0970330.720
699.5

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
National Flood Insurance Program

ELEVATION CERTIFICATE

Important: Read the instructions on pages 1-9.

OMB No. 1660-0008
Expires March 31, 2012

SECTION A - PROPERTY INFORMATION

For Insurance Company Use:
Policy Number
Company NAIC Number

A1. Building Owner's Name Wilson, Glenn

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
17 Spring Creek Circle
City Grand Prairie State TX ZIP Code 75054

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
Adams, Caroline M Survey - Abst 38 Tr 1Bb & 1Cc

A4. Building Use (e.g., Residential, Non-Residential, Addition, Accessory, etc.) Residential

A5. Latitude/Longitude: Lat. 32 34 41.52 Long. 97 03 02.75 Horizontal Datum: ☐ NAD 1927 ☒ NAD 1983

A6. Attach at least 2 photographs of the building if the Certificate is being used to obtain flood insurance.

A7. Building Diagram Number 5

A8. For a building with a crawlspace or enclosure(s):
a) Square footage of crawlspace or enclosure(s) N/A sq ft
b) No. of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A8.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

A9. For a building with an attached garage:
a) Square footage of attached garage ____ sq ft
b) No. of permanent flood openings in the attached garage within 1.0 foot above adjacent grade ____
c) Total net area of flood openings in A9.b ____ sq in
d) Engineered flood openings? ☐ Yes ☐ No

SECTION B - FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

B1. NFIP Community Name & Community Number	B2. County Name	B3. State
Grand Prairie - 485472	Tarrant County	TX

B4. Map/Panel Number	B5. Suffix	B6. FIRM Index Date	B7. FIRM Panel Effective/Revised Date	B8. Flood Zone(s)	B9. Base Flood Elevation(s) (Zone AO, use base flood depth)
0485	K		09/25/2009	A	550.45

B10. Indicate the source of the Base Flood Elevation (BFE) data or base flood depth entered in Item B9.
☐ FIS Profile ☐ FIRM ☒ Community Determined ☐ Other (Describe) ____

B11. Indicate elevation datum used for BFE in Item B9: ☐ NGVD 1929 ☒ NAVD 1988 ☐ Other (Describe) ____

B12. Is the building located in a Coastal Barrier Resources System (CBRS) area or Otherwise Protected Area (OPA)? ☐ Yes ☒ No
Designation Date ____ ☐ CBRS ☐ OPA

SECTION C - BUILDING ELEVATION INFORMATION (SURVEY REQUIRED)

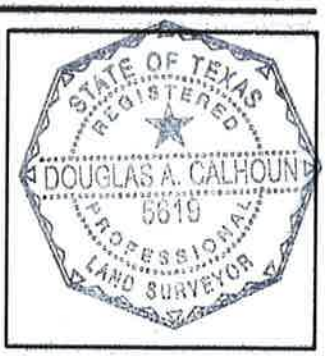
C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finished Construction
*A new Elevation Certificate will be required when construction of the building is complete.

C2. Elevations – Zones A1-A30, AE, AH, A (with BFE), VE, V1-V30, V (with BFE), AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO. Complete Items C2.a-h below according to the building diagram specified in Item A7. Use the same datum as the BFE.
Benchmark Utilized 125 Vertical Datum NAVD 88
Conversion/Comments ____

			Check the measurement used.	
a)	Top of bottom floor (including basement, crawlspace, or enclosure floor)	552.15	☒ feet ☐ meters (Puerto Rico only)	
b)	Top of the next higher floor	____.____	☐ feet	☐ meters (Puerto Rico only)
c)	Bottom of the lowest horizontal structural member (V Zones only)	____.____	☐ feet	☐ meters (Puerto Rico only)
d)	Attached garage (top of slab)	____.____	☐ feet	☐ meters (Puerto Rico only)
e)	Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	____.____	☐ feet	☐ meters (Puerto Rico only)
f)	Lowest adjacent (finished) grade next to building (LAG)	550.01	☒ feet ☐ meters (Puerto Rico only)	
g)	Highest adjacent (finished) grade next to building (HAG)	550.91	☒ feet ☐ meters (Puerto Rico only)	
h)	Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	550.64	☒ feet ☐ meters (Puerto Rico only)	

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION

This certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. *I certify that the information on this Certificate represents my best efforts to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.* ☐
Check here if comments are provided on back of form. Were latitude and longitude in Section A provided by a licensed land surveyor? ☐ Yes ☒ No



Certifier's Name Douglas A. Calhoun License Number 5619

Title Survey Manager Company Name Halff Associates, Inc.

Address 4000 Fossil Creek Blvd City Fort Worth State TX ZIP Code 76137

Signature Douglas A Calhoun Date 1/26/2011 Telephone (817) 847-1422

IMPORTANT: In these spaces, copy the corresponding information from Section A.	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 17 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

SECTION D - SURVEYOR, ENGINEER, OR ARCHITECT CERTIFICATION (CONTINUED)

Copy both sides of this Elevation Certificate for (1) community official, (2) insurance agent/company, and (3) building owner.

Comments

Signature Date

☐ Check here if attachments

SECTION E - BUILDING ELEVATION INFORMATION (SURVEY NOT REQUIRED) FOR ZONE AO AND ZONE A (WITHOUT BFE)

For Zones AO and A (without BFE), complete Items E1-E5. If the Certificate is intended to support a LOMA or LOMR-F request, complete Sections A, B, and C. For Items E1-E4, use natural grade, if available. Check the measurement used. In Puerto Rico only, enter meters.

E1. Provide elevation information for the following and check the appropriate boxes to show whether the elevation is above or below the highest adjacent grade (HAG) and the lowest adjacent grade (LAG).
a) Top of bottom floor (including basement, crawlspace, or enclosure) is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.
b) Top of bottom floor (including basement, crawlspace, or enclosure) is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the LAG.

E2. For Building Diagrams 6-9 with permanent flood openings provided in Section A Items 8 and/or 9 (see pages 8-9 of Instructions), the next higher floor (elevation C2.b in the diagrams) of the building is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E3. Attached garage (top of slab) is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E4. Top of platform of machinery and/or equipment servicing the building is _____._____ ☐ feet ☐ meters ☐ above or ☐ below the HAG.

E5. Zone AO only: If no flood depth number is available, is the top of the bottom floor elevated in accordance with the community's floodplain management ordinance? ☐ Yes ☐ No ☐ Unknown. The local official must certify this information in Section G.

SECTION F - PROPERTY OWNER (OR OWNER'S REPRESENTATIVE) CERTIFICATION

The property owner or owner's authorized representative who completes Sections A, B, and E for Zone A (without a FEMA-issued or community-issued BFE) or Zone AO must sign here. *The statements in Sections A, B, and E are correct to the best of my knowledge.*

Property Owner's or Owner's Authorized Representative's Name

Address City State ZIP Code

Signature Date Telephone

Comments

☐ Check here if attachments

SECTION G - COMMUNITY INFORMATION (OPTIONAL)

The local official who is authorized by law or ordinance to administer the community's floodplain management ordinance can complete Sections A, B, C (or E), and G of this Elevation Certificate. Complete the applicable item(s) and sign below. Check the measurement used in Items G8 and G9.

G1. ☐ The information in Section C was taken from other documentation that has been signed and sealed by a licensed surveyor, engineer, or architect who is authorized by law to certify elevation information. (Indicate the source and date of the elevation data in the Comments area below.)

G2. ☐ A community official completed Section E for a building located in Zone A (without a FEMA-issued or community-issued BFE) or Zone AO.

G3. ☐ The following information (Items G4-G9) is provided for community floodplain management purposes.

G4. Permit Number	G5. Date Permit Issued	G6. Date Certificate Of Compliance/Occupancy Issued

G7. This permit has been issued for: ☐ New Construction ☐ Substantial Improvement

G8. Elevation of as-built lowest floor (including basement) of the building: _____._____ ☐ feet ☐ meters (PR) Datum _____

G9. BFE or (in Zone AO) depth of flooding at the building site: _____._____ ☐ feet ☐ meters (PR) Datum _____

G10. Community's design flood elevation _____._____ ☐ feet ☐ meters (PR) Datum _____

Local Official's Name Title

Community Name Telephone

Signature Date

Comments

☐ Check here if attachments

Building Photographs

See Instructions for Item A6.

	For Insurance Company Use:
Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No. 17 Spring Creek Circle	Policy Number
City Grand Prairie State TX ZIP Code 75054	Company NAIC Number

If using the Elevation Certificate to obtain NFIP flood insurance, affix at least two building photographs below according to the instructions for Item A6. Identify all photographs with: date taken; "Front View" and "Rear View"; and, if required, "Right Side View" and "Left Side View." If submitting more photographs than will fit on this page, use the Continuation Page, following.

Front View – 01/26/2011

Rear View – 01/26/2011

FILE: 66071892.10o 000112124

NGS OPUS-RS SOLUTION REPORT
==========

USER: barbuckle@halff.com
RINEX FILE: 6607189o.10o

DATE: July 16, 2010
TIME: 14:22:49 UTC

SOFTWARE: rsgps 1.35 RS10.prl 1.60
EPHEMERIS: igr15914.eph [rapid]
NAV FILE: brdc1890.10n
ANT NAME: TRM_R8_GNSS
ARP HEIGHT: 2.0

START: 2010/07/08 14:46:00
STOP: 2010/07/08 15:45:45
OBS USED: 5200 / 5552 : 94%
QUALITY IND. 5.07/ 28.97
NORMALIZED RMS: 0.414

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2010.51681)	
X:	-660284.228(m)	0.014(m)	-660284.951(m)	0.014(m)
Y:	-5339228.792(m)	0.019(m)	-5339227.365(m)	0.019(m)
Z:	3414747.506(m)	0.014(m)	3414747.326(m)	0.014(m)
LAT:	32 34 42.97977	0.007(m)	32 34 42.99805	0.007(m)
E LON:	262 57 0.78929	0.015(m)	262 57 0.75507	0.015(m)
W LON:	97 2 59.21071	0.015(m)	97 2 59.24493	0.015(m)
EL HGT:	140.514(m)	0.022(m)	139.299(m)	0.022(m)
ORTHO HGT:	167.616(m)	0.022(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 14)	STATE PLANE COORDINATES SPC (4202 TXNC)
Northing (Y) [meters]	3606250.603	2102065.075
Easting (X) [meters]	683057.414	736151.171
Convergence [degrees]	1.05039977	0.79094148
Point Scale	1.00001323	0.99990648
Combined Factor	0.99999117	0.99988442

US NATIONAL GRID DESIGNATOR: 14SPB8305706250(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DF8988	TXES ELLIS CORS ARP	N322210.894	W0965145.960	29083.0
DH7149	TXSG SAGINAW TX CORS ARP	N325120.556	W0972038.984	41305.3
DF8990	TXKA KAUFMAN CORS ARP	N323418.297	W0961851.372	69068.4
DH7153	TXWE WEATHERFORD CORS ARP	N324532.010	W0974924.489	75278.8
DH7139	TXDC DECATUR CORS ARP	N331410.382	W0973631.186	89737.6
DH7147	TXMW MINERAL WELLS CORS ARP	N324814.987	W0980834.369	105517.2
DG9808	TXWA WACO CORS ARP	N313439.759	W0970637.810	111136.1
DH7143	TXJA JACKSBORO CORS ARP	N331141.335	W0980844.215	123227.6

NEAREST NGS PUBLISHED CONTROL POINT

CS2915	POOL	N323807.482	W0970123.418	6798.2

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

Appendix E
Storm Drain Outfalls

I. INTRODUCTION

Following is a description of the U.S. Army Corps of Engineers (USACE) permitting and easement requirements as it relates to development in the Joe Pool Lake Watershed. Section 404 permitting requirements potentially apply to any development that results in discharges to waters of the U.S., such as Joel Pool Lake, or it contributing creeks. The easement requirements apply specifically to USACE-owned properties or USACE-restricted areas, such as USACE property or flowage easements adjacent to Joe Pool Lake (Appendix A).

II. 404 PERMITS

Section 404 of the Clean Water Act created a program to regulate the discharge of dredged and fill material into "waters of the U.S.," described below, including wetlands. The USACE is responsible for administering the day-to-day 404 program, including individual permit decisions and jurisdictional determinations; developing policy and guidance; and enforcing Section 404 provisions.

A. Waters of the US

Any activity that results in the placement of fill material into creeks, wetlands, lakes or other aquatic features designated as "waters of the United States" by the U.S. Army Corps of Engineers (USACE) must be approved by the USACE. The Clean Water Act, Section 404 addresses the provisions for this type of authorization. The USACE has developed a system that includes general permits (Nationwide Permits (NWP) and Regional General Permits (RGP)) and individual permits. General conditions, such as the protection of endangered and threatened species, cultural resources and water quality must be adhered to for all 404 permit authorizations.

B. 404 Permit Options

Potential permitting options for projects that intersect waters of the U.S. include coverage by one of the following types of permits:

- Nationwide Permits (NWP)
- Regional General Permits (RGP)
- Individual Permits (IP)

Nationwide Permits

Nationwide permits (NWPs) are pre-approved permits that authorize a variety of specific activities that the USACE has determined to have no significant adverse impact on waters of the U.S. Most NWPs contain specific limitations on volume, area, and/or linear feet of fill in waters of the U.S. Some NWPs require the permittee to notify the USACE, while others require pre- or post-construction notification under certain circumstances. All NWPs must follow the NWP General Conditions and Section 401 Water Quality Certification Conditions. The actual text of the NWP should be reviewed to verify the applicability, and individual requirements, of a permit. Full texts for each individual NWP can be obtained at www.swf.usace.army.mil. Some likely activities that might be covered under a NWP are listed in Table 1, along with the corresponding NWP.

Table 1. Common Project Activities Covered by Nationwide Permits

Activity*	Potential Permit Coverage	PCN Required?	Potential Alternative Permits
Repair/ replace an existing structure	NWP 3	No	IP
Remove Sediments/debris near an existing structure and place rip rap to protect structure	NWP 3	Yes	IP, NWPs 7, 13, or 19
Restore uplands (e.g. stream bank) damaged by storms, etc.	NWP 3	Yes	NWP 18, IP
(i) Outfall/intake structure; (ii) Maintenance excavation and debris removal from outfall/intake structures	NWP 7	Yes	NWP 12 or 19, IP
(i) Utility lines; (ii) Utility line substations; (iii) Foundations for utility towers/ poles / anchors; (iv) Utility access roads	NWP 12	Certain Instances	IP
Bank Stabilization	NWP 13	Certain Instances	IP
Road/bridge/railway construction	NWP 14	Certain Instances	IP
Minor discharges	NWP 18	Certain Instances	IP
Minor dredging	NWP 19	No, if project meets all criteria	IP
Structural discharge into sealed forms	NWP 25	No	N/A
Discharge of dredged / fill material for maintenance of existing flood control facilities	NWP 31	Yes	NWP 3, IP
Temporary cofferdams/dewatering structures	NWP 33	Yes	IP
Dredging / filling to modify an existing drainage ditch	NWP 41	Certain Instances	NWP 3, IP
Hiking trails / bike paths / horse paths / nature centers / campgrounds	NWP 42	Certain Instances	IP
Construction/maintenance of storm water management facilities	NWP 43	Certain Instances	IP

**The user should consult the terms and conditions of the Nationwide Permits for clarification and complete description of authorized activities.*

Regional General Permits

The USACE Fort Worth District has issued Regional General Permits (RGPs) for frequently recurring types of projects within the District. These are granted for proposed activities that are considered minor, that will not have significant individual or cumulative impact on the environment, and are expected to have no appreciable public opposition. Some of the topics covered by the RGPs are aerial utility line and cable crossings, or boat ramps and minor recreational facilities. RGPs require the applicant to notify the USACE, but the USACE is not required to solicit comments from other agencies.

Individual Permits

The last option is an Individual Permit (IP). These are typically required for large projects with potentially significant impacts. Applications for IPs undergo intensive review, and the USACE is required to publish a public notice to give citizens an opportunity to comment on the impacts of the proposed project.

Individual permits apply to any project that results in the placement of fill into waters of the U.S. but that is not eligible for a nationwide or regional general permit. Significant environmental investigation, coordination with the USACE, coordination with other agencies, including but not limited to U.S. Fish and Wildlife Service, Texas Historical Commission, and Texas Parks and Wildlife Department, and mitigation of impacts are required for individual permits.

C. 404 Permit Approval Process

Following is a brief description of the general requirements and approach for obtaining Section 404 permit approval. The information in this section is separate from the requirements for obtaining an easement on USACE real estate. If wetlands or other waters of the U.S. impacts are expected for structures across USACE property, then the requirements in the following section for USACE Easements will be necessary to be followed as well.

If the 404 permit is being requested along with a USACE easement, follow the 404 permitting instructions along with the easement guidelines in the following section.

Field Survey

A field survey of the project area is necessary to address environmental issues, including the following:

- The presence of "waters of the U. S." as defined by USACE regulations
- The identification of wetlands; ephemeral, intermittent, or perennial streams; or other open waters
- The presence of potential habitat for any federally listed threatened or endangered species
- Indications of the presence of significant cultural resources, such as historic properties or archaeologically significant sites
- Evidence of any obvious environmental contamination such as stained soils, sheens on water, etc.

Section 404 Documentation, Permit Application or Preconstruction Notification

Depending on the project impacts, notification of the USACE may be required, either in the form of a preconstruction notification for nationwide permits, a permit application for individual permits, or a letter of permission. If no notification is required, internal file documentation is recommended in case questions arise in the future.

Preparation of Mitigation Plan

The Fort Worth USACE District's guidance for permit submittals, dated June 11, 2001, indicates that a mitigation plan will be necessary to compensate for unavoidable impacts if notification of the USACE is required (Appendix B). The plan should address measures to compensate for the loss of aquatic functions caused by the project activity.

Coordination and Consultation with the USACE

Following submittal of appropriate information to the USACE, coordination and consultation with the USACE is usually necessary to respond to requests for additional information, address changes in the mitigation plan, and other data required by to USACE in order to complete the permit application.

Water Quality Certification Conditions

Construction must comply with the Water Quality Certification Conditions issued by the Texas Commission on Environmental Quality (TCEQ). For small projects (Tier I) that affect less than three acres of waters in the state

and less than 1,500 linear feet of streams, TCEQ requires that best management practices and other requirements be incorporated into the project to protect water quality, but agency notification or coordination is not required. All other projects are considered Tier II projects, which are subject to a certification review by TCEQ (Appendix C).

Protection of Historic Properties

If historic properties, archeological resources, or cultural resources may be impacted by the project activity, notification and coordination with the Texas Historical Commission may be necessary. The THC may require an investigation be conducted by a qualified professional to evaluate the presence of significant resources in the project area. In the event significant resources are identified, coordination with the THC is necessary to demonstrate that the project will not adversely impact the resources.

Endangered Species

Notification of the USACE is required if endangered species or habitat suitable for endangered species is identified in a project area. This notification applies to any permit type. The U.S. Fish and Wildlife Service is the proper source for identifying potentially present endangered species or habitat (http://www.fws.gov). The information is provided by county, which for the Joe Pool Lake area includes Tarrant, Dallas, Johnson, and Ellis counties. A pedestrian survey by qualified professionals is recommended to address this requirement.

Adherence to 404 Permit Conditions

Throughout the project, all applicable permit conditions must be adhered to. Type, location, and quantities of fill must comply with the relevant permit requirements throughout the project duration. This may include long-term mitigation monitoring activities after the construction activity is completed.

III. CORPS OF ENGINEERS DRAINAGE REQUIREMENTS

Drainage at the Corps of Engineers boundary must be managed according to Corps requirements. Option A described below describes what is required to avoid required coordination and authorization from the Corps of Engineers for drainage management to Joe Pool Lake. Option B describes the Corps of Engineers procedure to obtain an easement for a

drainage structure, such as a storm water outfall directly into Joe Pool Lake.

A. Sheet Flow - No Corps Coordination Required

The Corps of Engineers requires storm water discharges across USACE property to be sheet flow at the Corps property boundary or flowage easement, whichever is encountered first, unless the drainage is already in a defined channel. The Corps considers sheet flow to be defined as one (1) cubic foot per second per linear foot (1cfs/ft) at the Corps boundary.

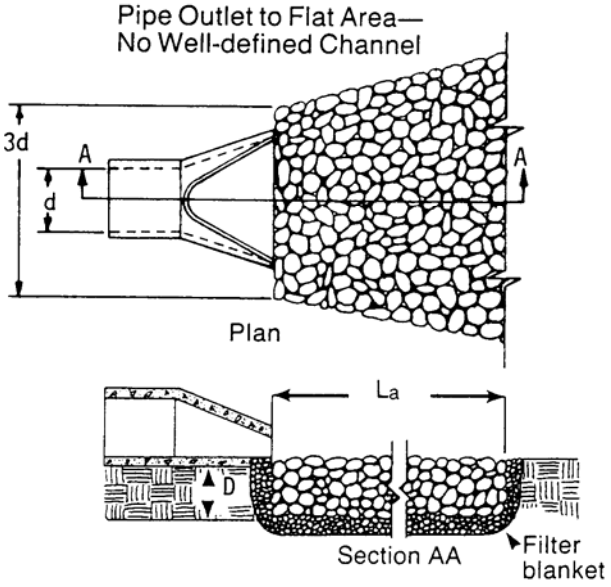
The developer can avoid required coordination with the Corps with regards to drainage management by restricting flow at the Corps property boundary to 1cfs/ft or by placing storm water runoff in an existing channel prior to entry either on Corps property or within the flowage easement. Discharges must be in accordance with City drainage design guidelines.

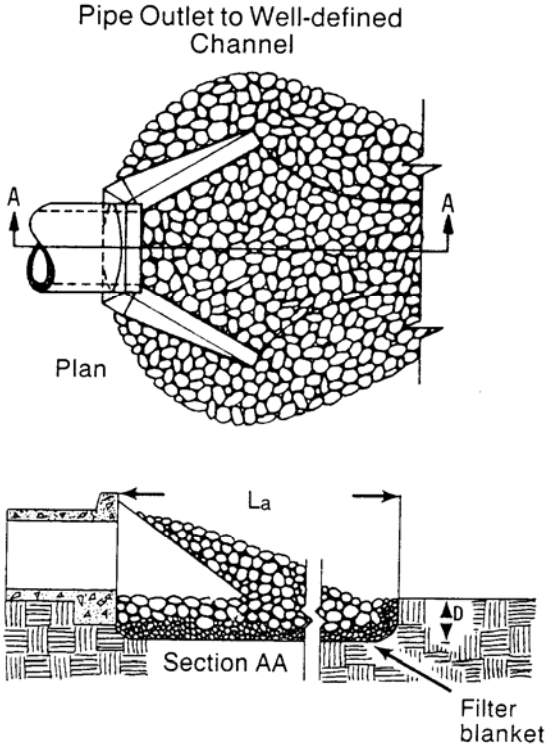
Example details are provided for several storm water outfall designs that can be utilized independently or in combination to return collected storm water runoff to sheet flow conditions at the Corps boundary. Other approaches are available provided they comply with Corps and City requirements. The example outfall designs provided are the following:

1. Riprap Apron
2. Riprap Outlet Basin (Stilling Basin)
3. Baffled Outlet
4. Weirs
5. Energy Dissipation Blocks

Additionally, the North Central Texas Council of Governments (NCTCOG) *integrated Storm Water Management (iSWM) Design Manual for Site Development* (January 2006) contains design options for storm water outfalls with energy dissipation features. This information can be found in Sections 4.6 and 4.7 of the *iSWM Design Manual for Site Development* or in Appendix I of the City of Grand Prairie Drainage Design Manual (October 2006 Update).

Figure 1. Riprap Apron
(Source: Manual for Erosion and Sediment Control in Georgia, 1996)

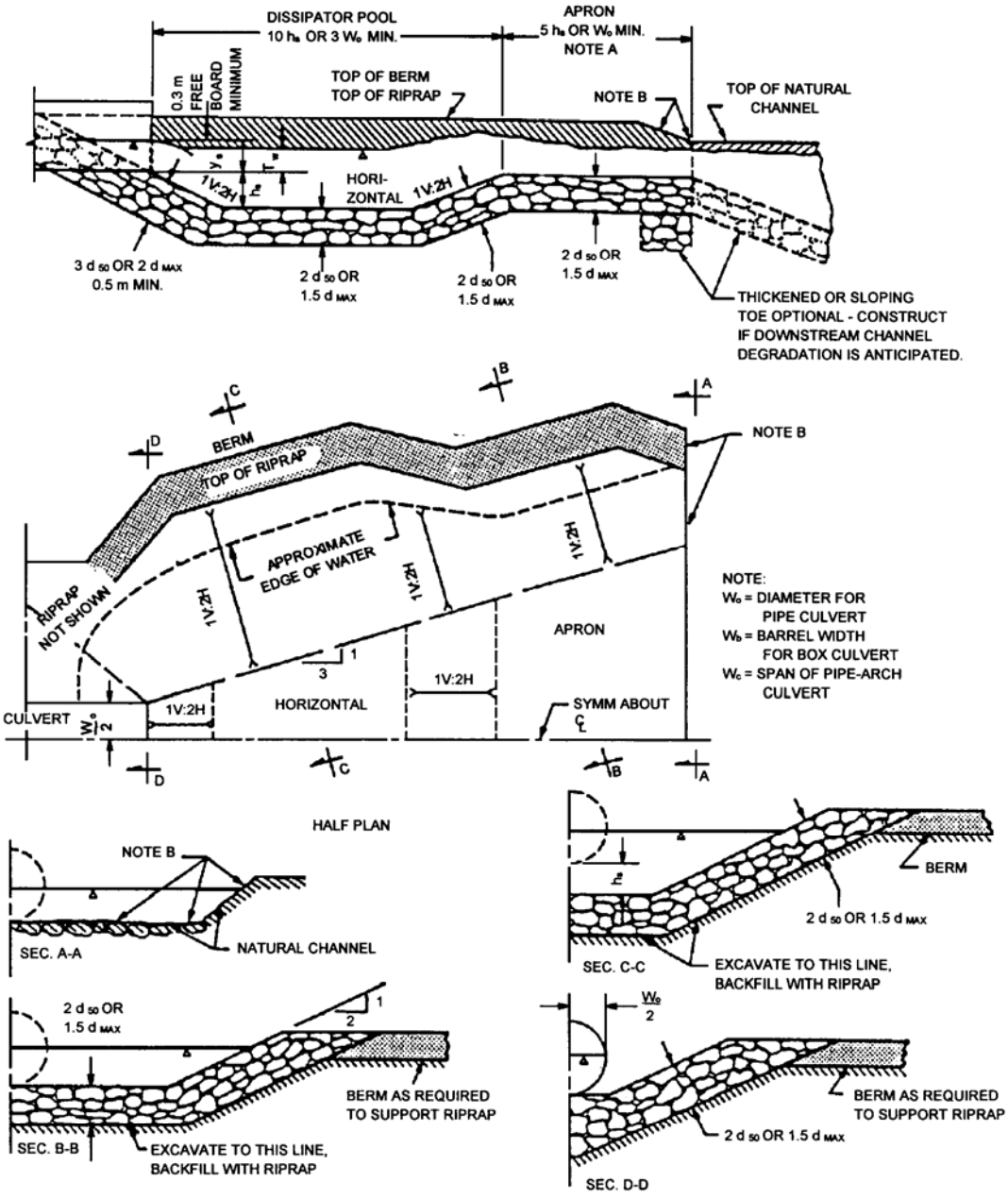




Notes

1. L_a is the length of the riprap apron.
2. D = 1.5 times the maximum stone diameter but not less than 6".
3. In a well-defined channel extend the apron up the channel banks to an elevation of 6" above the maximum tailwater depth or to the top of the bank, whichever is less.
4. A filter blanket or filter fabric should be installed between the riprap and soil foundation.

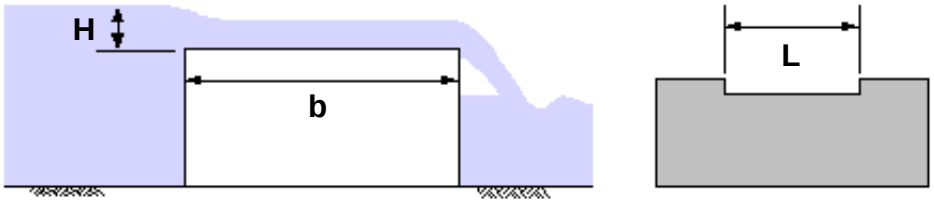
Figure 2. Details of Riprap Outlet Basin
(Source: HEC-14, 1983)



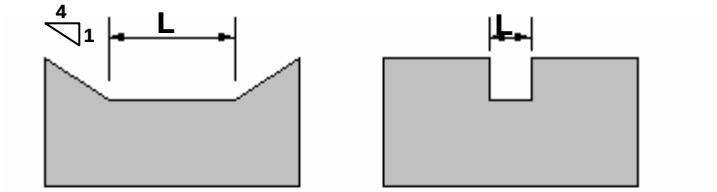
NOTE A - IF EXIT VELOCITY OF BASIN IS SPECIFIED, EXTEND BASIN AS REQUIRED TO OBTAIN SUFFICIENT CROSS-SECTIONAL AREA AT SECTION A-A SUCH THAT Q/(CROSS SECTION AREA AT SEC. A-A) = SPECIFIED EXIT VELOCITY.

NOTE B - WARP BASIN TO CONFORM TO NATURAL STREAM CHANNEL. TOP OF RIPRAP IN FLOOR OF BASIN SHOULD BE AT THE SAME ELEVATION OR LOWER THAN NATURAL CHANNEL BOTTOM AT SEC. A-A.

Figure 4. Weirs
(Source: North Central Texas Council of Governments, January 2006)

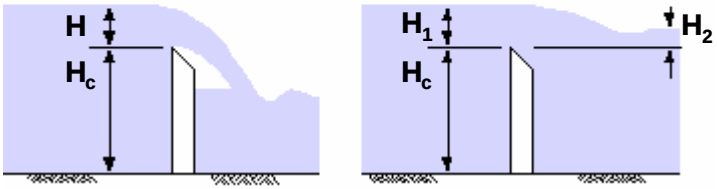


Broad-Crested Weir

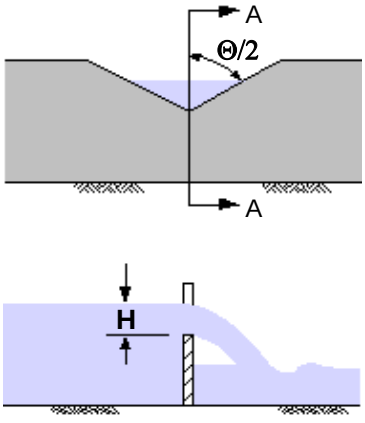


Cipolletti Weir end contraction compensation

With end contractions

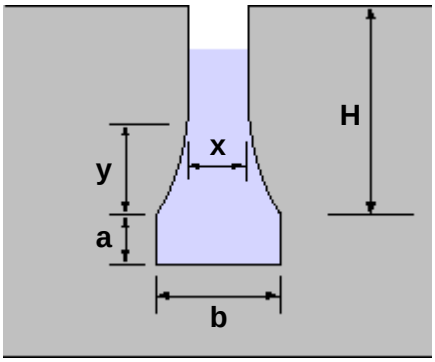


Sharp-Crested Weir



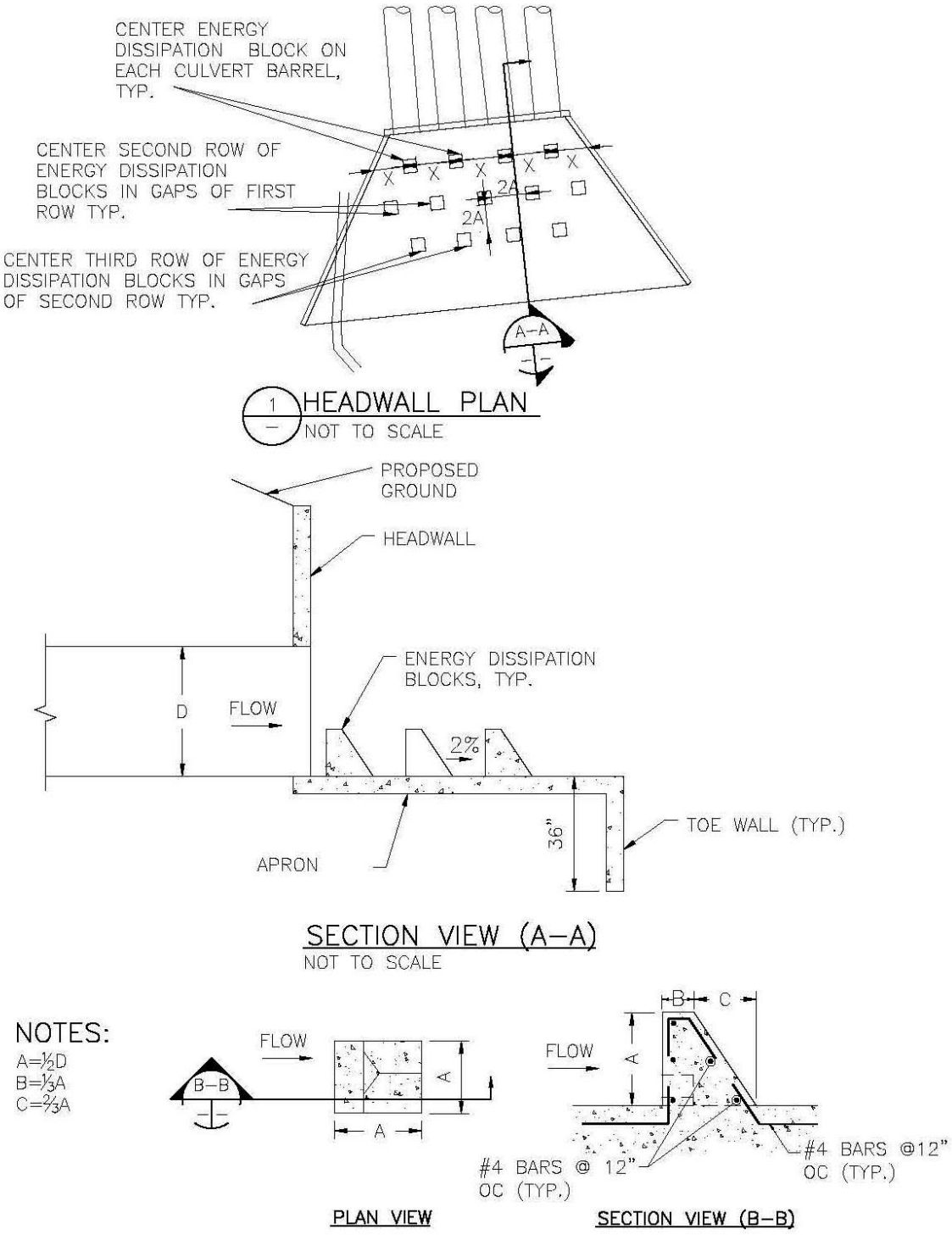
Section A-A

V-Notch Weir



Proportional Weir

Figure 5. Energy Dissipation Blocks



B. Corps of Engineer Drainage Easement

The Corps of Engineers has developed a standard procedure to apply for and obtain an easement on USACE property. An easement from the USACE is required for the placement of any structure on USACE property or within the flowage easement of Joe Pool Lake. The flowage easement for Joe Pool Lake is tied to the 541-foot elevation contour as it surrounds the lake.

Approval of an easement request is at the discretion of the USACE and requires a technical and public need to be shown, as well as a demonstration of no significant adverse impacts to the environment. The basic sequence for easement application and approval is shown in Figure 6 and is described in detail in this section.

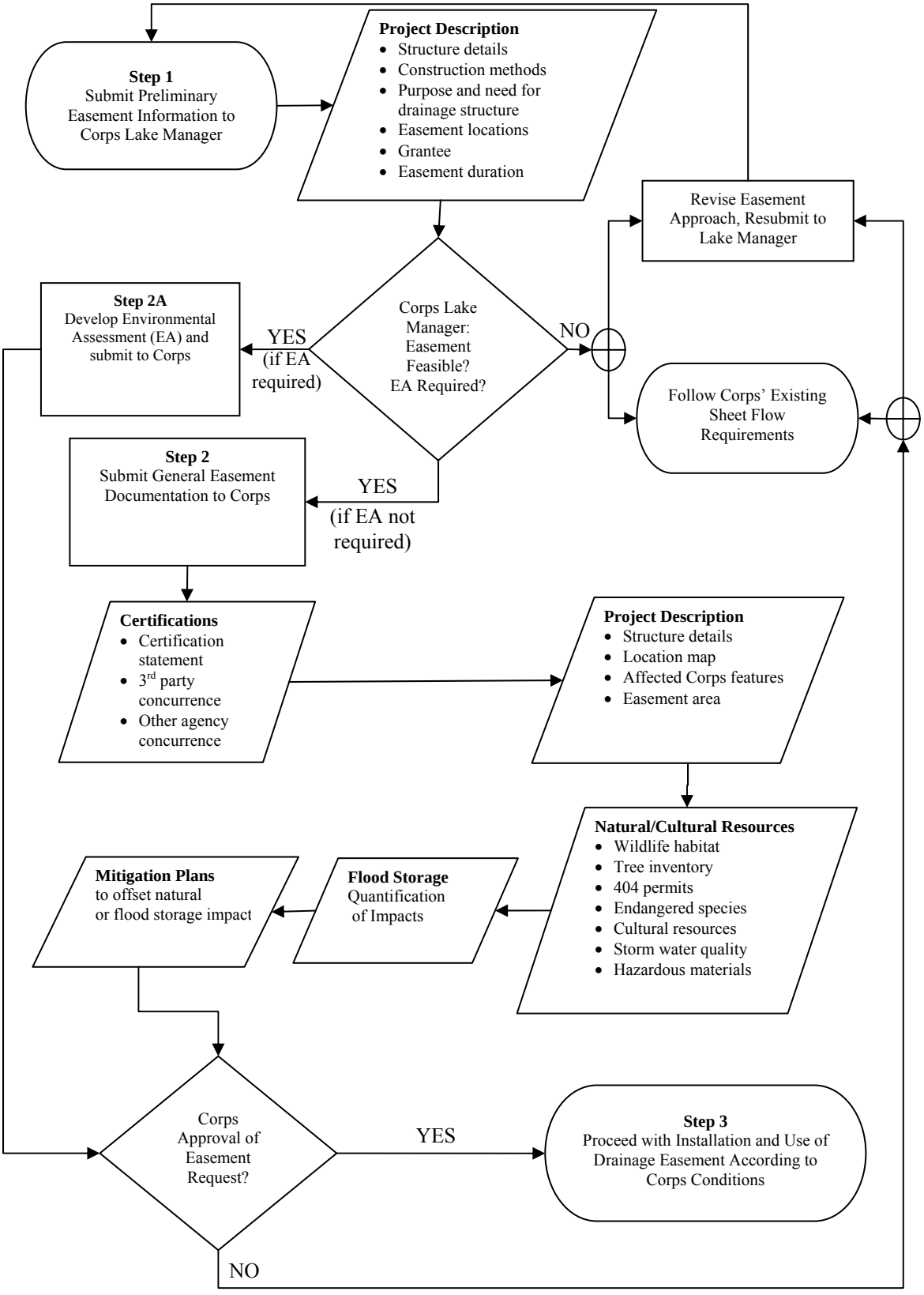
Preliminary easement information meeting the requirements of Step 1 of the USACE easement guidance has been submitted to the USACE Lake Manager by the City. This preliminary information was evaluated by the USACE to determine the general feasibility of the proposed easement. The initial information required for the preliminary easement submittal is contained within **Step 1: Preliminary Easement Information** of this manual. Coordinate with the City to determine the status of the USACE's review of the preliminary easement information submitted for the proposed drainage structure of interest to you.

The specific easement information necessary to be submitted for the USACE's evaluation to determine whether the easement will be approved is listed in **Step 2: General Easement Information**. This information is necessary and must be developed at the time that the site specific development is being planned in order to properly locate and integrate the storm water outfall structure into the site design.

Step 1: Preliminary Easement Information

The USACE requires the following information to be evaluated to determine if an easement proposal is appropriate and will not interfere with lake operations. The preliminary information is also to be used to determine if the proposed drainage features will require an Environmental Assessment (EA). The following preliminary information has been prepared for submission to the Lake Manager:

Figure 6. Corps of Engineers Easement Approval Process



Description of structure/facility

Storm water outfalls consisting of buried piping are proposed to the lake from areas that currently sheet flow in the undeveloped condition across the USACE boundary (property line or 541' contour).

Provide basic construction methods (e.g. open trench, close trench, other).

Construction of the storm water outfalls is proposed to be conducted by open trench cutting. Contours would be replaced to their pre-existing condition and the surface revegetated upon outfall installation.

Purpose and need for drainage structures

The proposed approach is needed to simplify development requirements around Joe Pool Lake and protect USACE property from overland flow erosion and the lake from excess sedimentation.

Development adjacent to Joe Pool Lake is currently required to discharge storm water in sheet flow conditions across the USACE boundary. The USACE has defined sheet flow conditions at Joe Pool Lake as 1 cfs/ft.

Sheet flow conditions are typically applicable for a distance up to 200 feet, after which concentrated flow characteristics are expected. Having sheet flow conditions at the USACE property boundary may not protect USACE property from erosion within the property, even though development would be complying with USACE requirements.

Local development circumstances often make the sheet flow requirements infeasible or impracticable, possibly resulting in additional cost with minimal benefit to the protection of the USACE's property or the lake.

Justification of placement of drainage structures, with routes identified

Drainage structures are proposed only for areas that naturally drain across USACE property prior to entering a natural drainage feature, such as a creek. Development will be required to direct storm water runoff to a natural drainage feature prior to crossing the USACE boundary if it already does so in the undeveloped condition. Figure 7 shows the areas proposed for placement of storm water outfall structures across USACE property.

Freese and Nichols
4055 International Plaza, Suite 200
Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

N E S W

City of Grand Prairie
Joe Pool Lake Storm Water Mater Plan

Drainage Areas For Storm Water Outfalls

FN JOB NO	HAF05330
FILE	fromFW JOEPOOL_AREAA.MXD
DATE	July 21, 2006
SCALE	1:48,000
DESIGNED	NB
DRAFTED	TS

7
FIGURE

Drainage structure size will vary from location to location, but no drainage structure is proposed to be greater than 48 inches in diameter. Each drainage structure would be buried piping with an outfall located below the normal pool elevation of the lake.

Grantee

Name:	City of Grand Prairie
Address:	206 W. Church Street
	Grand Prairie, TX 75053-4045
Phone:	(972) 237-8137
Contact:	Chris Agnew, P.E. – Drainage Engineer

Easement duration

The City requests permanent drainage easements from the USACE for each proposed drainage structure location identified herein.

General description (location and dimensions) of requested easement areas

Figure 7 above shows the general location of each proposed drainage easement area. Figures 8 – 13 show each individual area. The specific location of each easement will depend on the nature of the development that occurs, but each requested permanent easement is proposed to be no more than 10 feet in width.

A temporary construction easement for each drainage structure of no more than 40 feet is proposed to allow for the necessary maneuvering of construction equipment. The length of each easement varies from location to location, is generally limited to the proposed path from the USACE property boundary to the outfall location for each drainage structure, and will be specifically identified at the time general easement information is submitted to the USACE.

Step 2: General Easement Information

If the USACE Lake Manager has determined that an easement may be feasible and an EA is no required, then the following steps must be followed to continue the easement approval process. Providing the requested information below to the USACE does not guarantee easement approval but is necessary for the USACE to properly evaluate the request.

Freese and Nichols
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Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

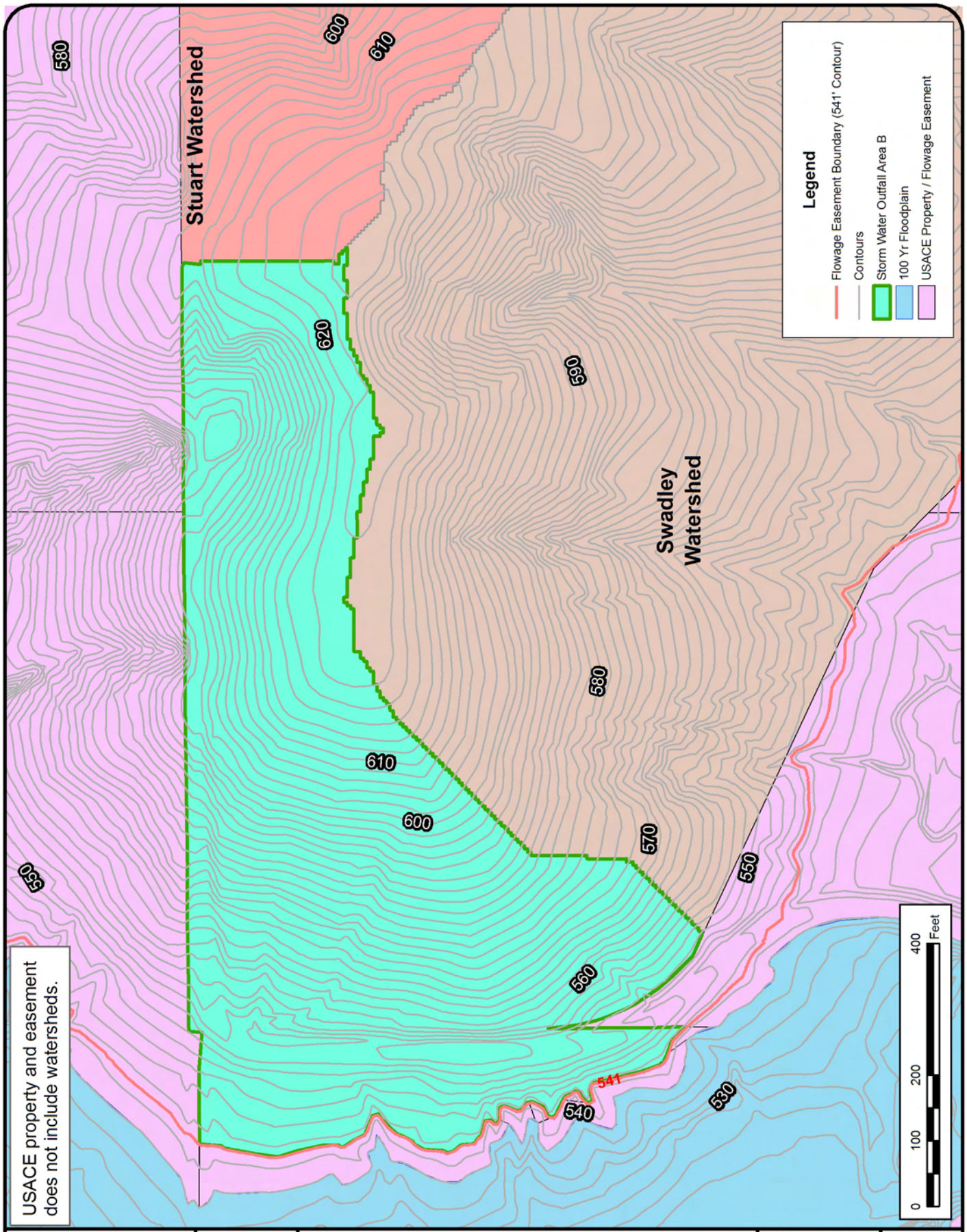
N E S W

City of Grand Prairie
Joe Pool Lake Storm Water Master Plan

Drainage Area for Storm Water Outfalls Area A

FN JOB NO	H:\[illegible]\HAF05330
FILE	AreaA.mxd
DATE	July. 21 2006
SCALE	1:5,800
DESIGNED	NB
DRAFTED	TS

8
FIGURE



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4055 International Plaza, Suite 200
Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

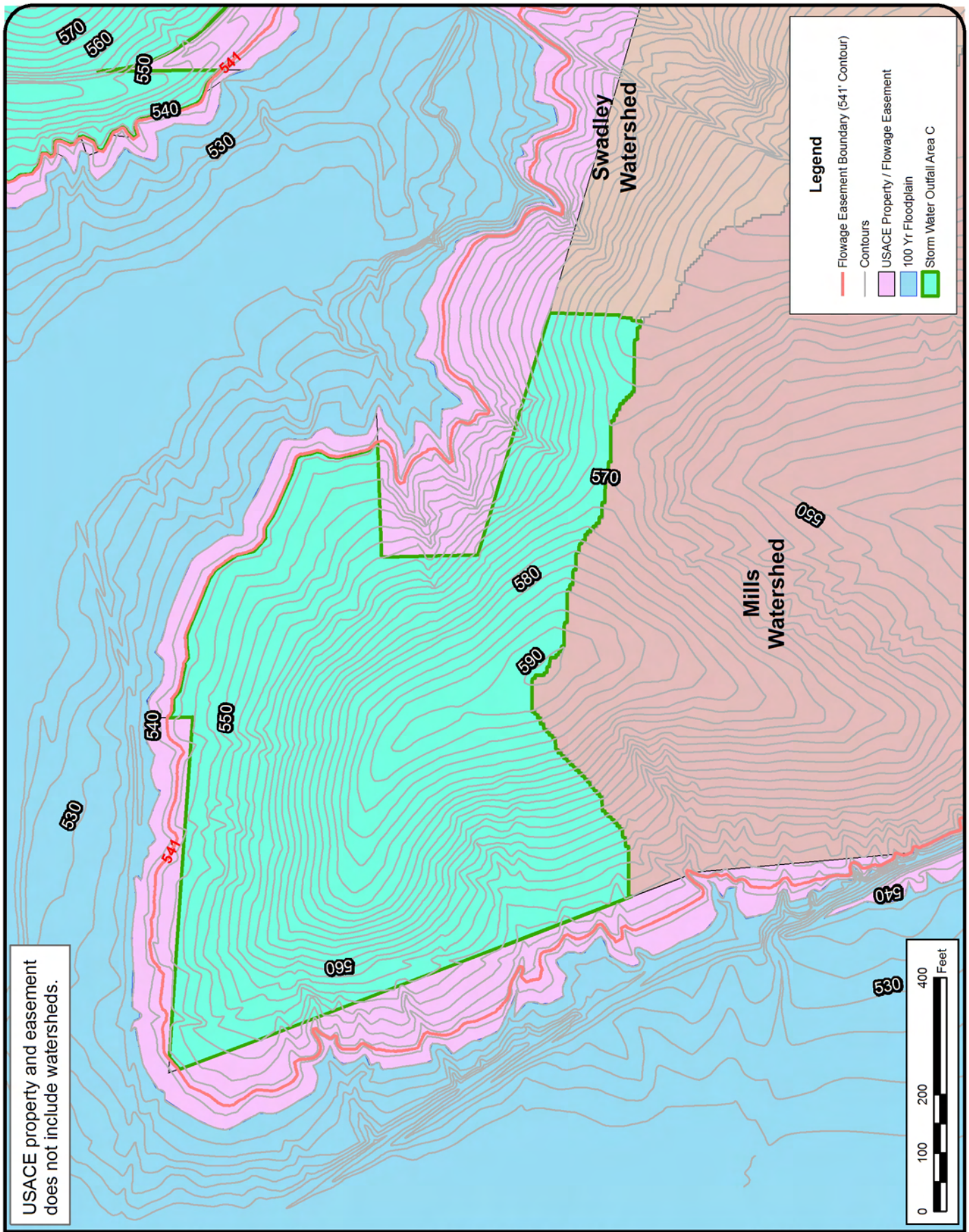
N E S W

City of Grand Prairie
Joe Pool Lake Storm Water Master Plan

Drainage Area for Storm Water Outfalls Area B

FN JOB NO	H:\HAF05330\Proj\Fi
FILE	AreaB.mxd
DATE	July 21, 2006
SCALE	1:2,400
DESIGNED	NB
DRAFTED	TS

9
FIGURE



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Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

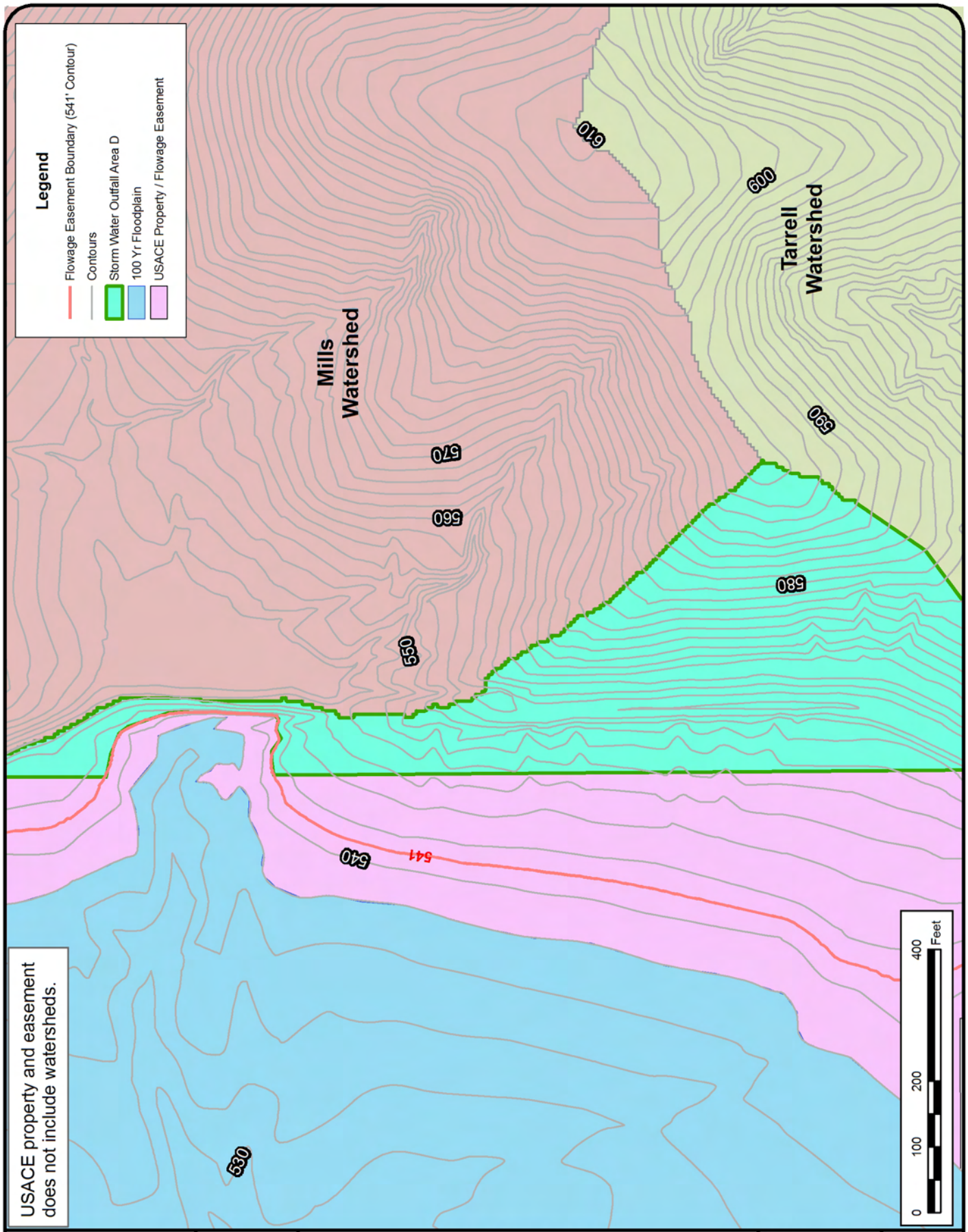
N E S W

City of Grand Prairie
Joe Pool Lake Storm Water Master Plan

Drainage Area for Storm Water Outfalls Area C

FN JOB NO	H:\HAF05330\Prom\Work\AreaC.mxd
DATE	July 21, 2006
SCALE	1:2,400
DESIGNED	NB
DRAFTED	TS

10
FIGURE



Freese and Nichols
4055 International Plaza, Suite 200
Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

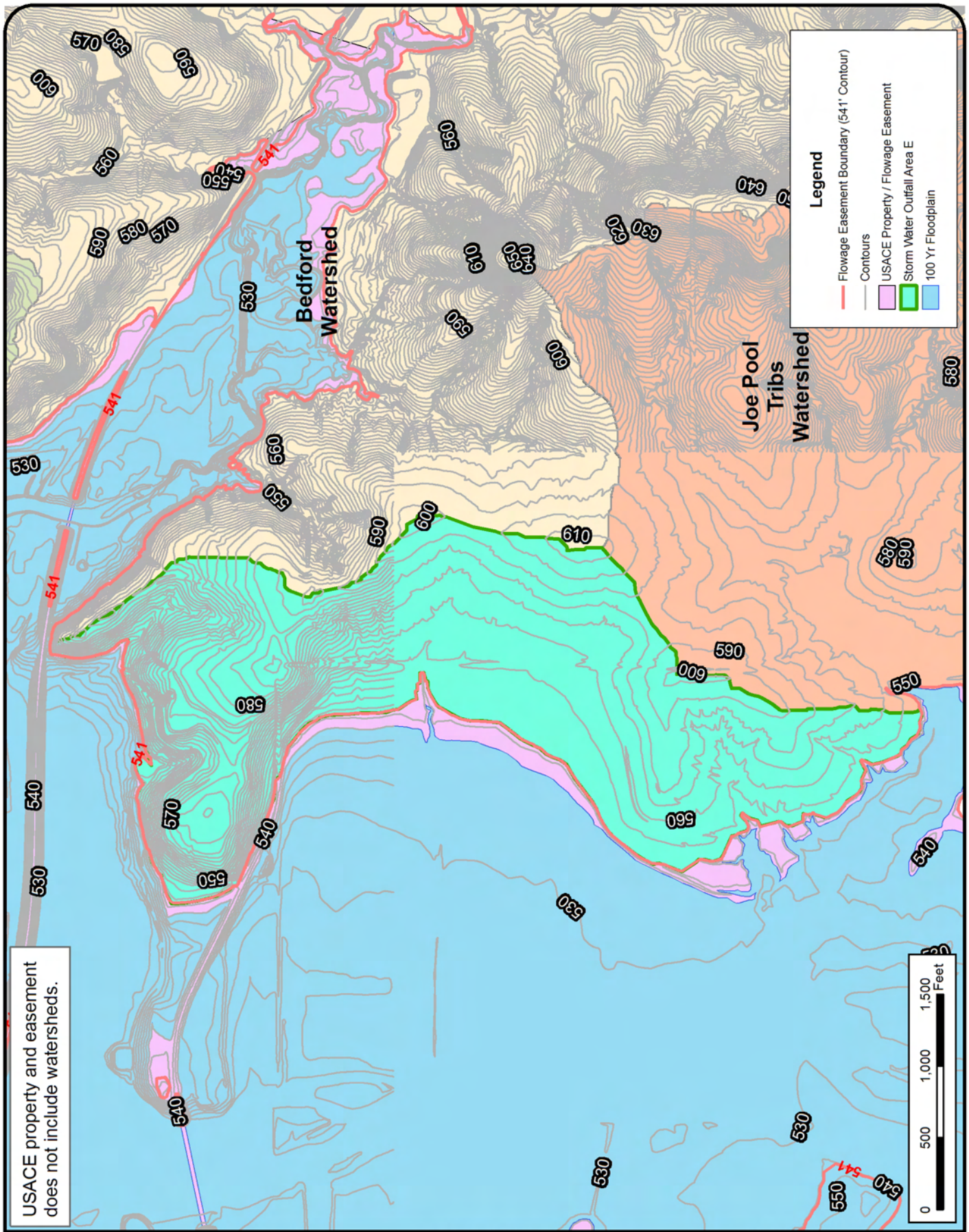
N E S W

City of Grand Prairie
Joe Pool Lake Storm Water Master Plan

Drainage Area for Storm Water Outfalls Area D

FN JOB NO	H:\HAF05330\Prom\Fi
FILE	AreaD.mxd
DATE	July 21, 2006
SCALE	1:2,400
DESIGNED	NB
DRAFTED	TS

11
FIGURE



Freese and Nichols
4055 International Plaza, Suite 200
Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

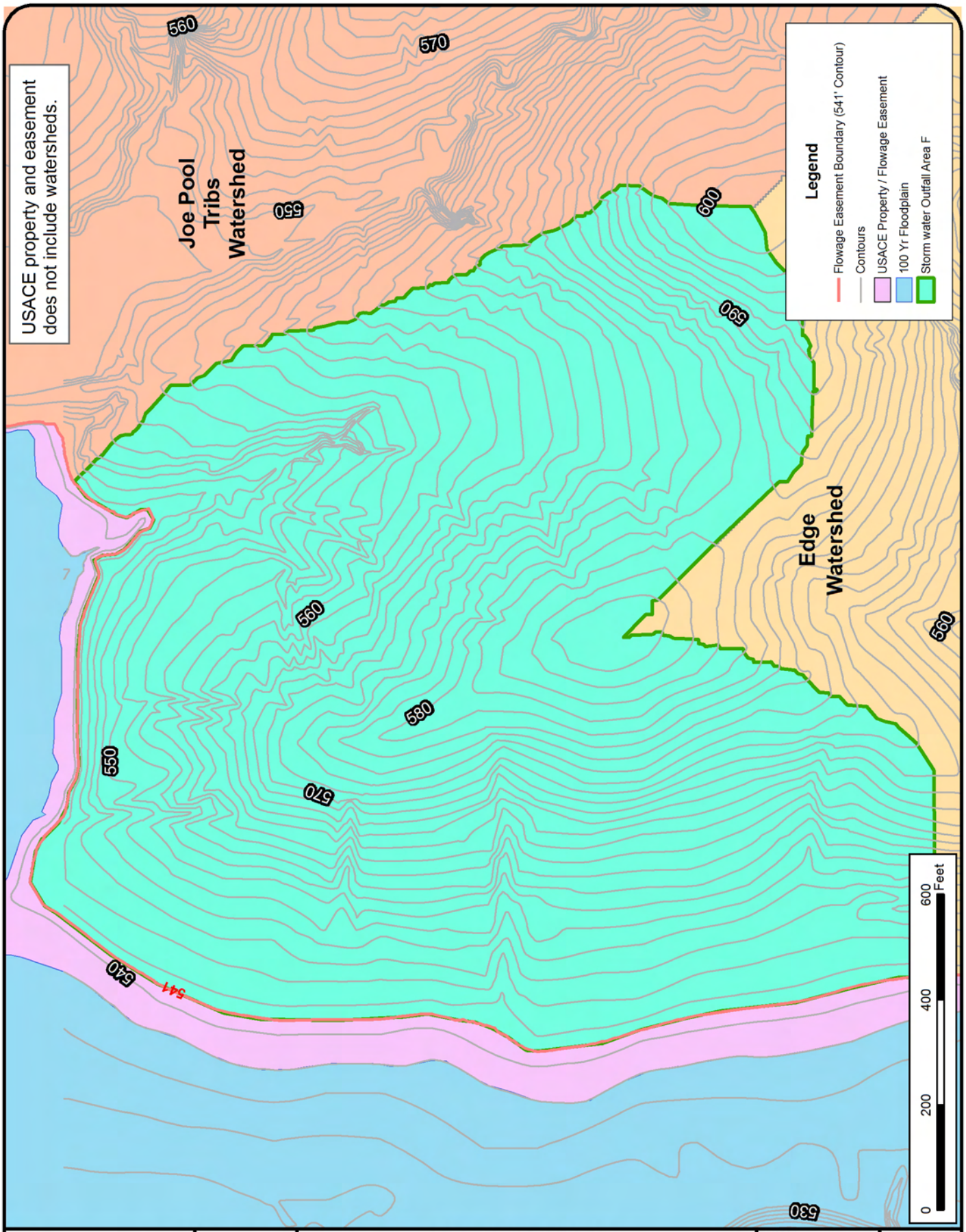
N E S W

City of Grand Prairie
Joe Pool Lake Storm Water Master Plan

Drainage Area for Storm Water Outfalls Area E

FN JOB NO	H:\HAF05330\Proj\Fr\AreaA.mxd
DATE	July 21, 2006
SCALE	1:11,000
DESIGNED	NB
DRAFTED	TS

12
FIGURE



Freese and Nichols
4055 International Plaza, Suite 200
Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

N E S W

City of Grand Prairie
Joe Pool Lake Storm Water Master Plan

Drainage Area for Storm Water Outfalls Area F

FN JOB NO	H:\...\HAF05330
FILE	AreaA.mxd
DATE	July 21, 2006
SCALE	1:3,000
DESIGNED	NB
DRAFTED	TS

13
FIGURE

If the easement is determined not to be feasible, then the proposed drainage structures will not be an option. The development will then either be required to restrict overland storm water runoff to sheet flow conditions across the USACE boundary or will need to identify an alternative drainage easement approach to propose to the USACE for consideration.

Certifications of Concurrence

Certification Statement

The City requires that each drainage structure on USACE property be constructed, operated, and maintained in compliance with all Federal, State, local laws and regulations. The developer must coordinate with the City, and potentially the USACE, to determine proper construction and operation requirements and to determine responsibility for maintenance of the structure.

Each developer requesting a drainage easement to install a storm water outfall structure on USACE property is required to certify that each drainage structure on USACE property will be constructed, operated, and maintained in compliance with all Federal, State, local laws and regulations.

Third party concurrence

During the preliminary siting of each storm water outfall structure, an evaluation must be made to identify potential impacts to other structures, facilities, utilities, easements, or outgrants. The placement of the storm water outfalls must seek to minimize potential conflicts with existing structures or facilities. In the event an unavoidable impact with an existing structure or facility will occur, it is the responsibility of the Developer to coordinate with each third party responsible for affected structures or facilities to obtain concurrence for the placement of the proposed storm water outfall structure.

The concurrence must be obtained in writing from each affected third party with the following information:

- Name of third party
- Responsible official for third party (if third part is other than an individual)
- Identification of structure or facility affected
- Written statement of concurrence for placement of proposed storm water outfall structure

- Dated signature of third party (or responsible official for third party)

Other Agency Concurrence

The Developer must identify any other legal or regulatory requirements applicable to the placement of the proposed storm water outfall structure, and provide documentation of concurrence from the Agency responsible for administering the regulation. The Texas Commission on Environmental Quality, Texas Railroad Commission, and water utility districts are examples of agencies or entities with potential oversight responsibility requiring concurrence.

The City of Grand Prairie is a regulated operator of a small municipal separate storm sewer system (Phase II MS4), and as such, is required to have a program to protect storm water quality. The City requires that each storm water outfall structure be designed, constructed, and maintained in a manner consistent with the City's goals to protect storm water quality.

Description of Project

The following detailed information is necessary to be provided to the USACE as part of the storm water outfall structure easement approval process. Field investigation and survey services will be necessary to identify the preferred route for each storm water outfall structure, impacted USACE structures, or affected environmental or natural resources.

If requested by the USACE Lake Manager, the centerline of the permanent easement on USACE property must be staked. A temporary real estate instrument is required prior to conducting any on-the-ground survey activities, including:

1. General description of the structure or facility, including basic construction methods
2. Physical description (length and width) of each proposed easement, including construction areas, if applicable
3. Narrative metes and bounds description of the easement. The description may include the centerline or the actual easement area. The metes and bounds must tie into a known Corps of Engineers property monument, as this description is used by the USACE Real Estate Division to write the legal description of the easement.

4. Map which includes the following:
    a. Easement location
    b. Metes and bounds depiction of the easement.
    c. Corps of Engineers property line
    d. Upper guide contours and elevation intervals appropriate to the terrain
    e. Any USACE structures that will be affected
        i. fences,
        ii. roads,
        iii. monuments,
        iv. gates,
        v. intake structures,
        vi. natural and environmental resources
        vii. restricted areas around USACE primary facilities (e.g.: drilling or blasting near the dam and spillway)
        viii. other relevant USACE structures
    f. Profile for all affected government property
    g. Acreage of the proposed easement and/or license
    h. Tracts must be identified within the proposed easement and noted if they are fee simple, flowage easement, or both.

Natural and Cultural Resources

A description of the direct and indirect adverse environmental effects, as well as any beneficial impacts that the project might cause must be provided to the USACE for evaluation.

Wildlife Habitat Analysis

The amount of acreage and quality of each biological community to be affected by the proposed project must be described. The use of the Texas Parks and Wildlife Department's Wildlife Habitat Appraisal Procedure is accepted as a method of describing habitat. Biological communities include:

- forests and woodlands,
- range and grasslands, riparian areas,
- others
- The quality of habitat must be described in the following terms:
- successional stage,
- uniqueness and relative abundance,
- vegetative species diversity, and
- structural diversity components (such as fallen logs, thickets, rocky crevices, and thick grass cover).

Tree Inventory

In developed park areas, along property boundaries bordering developed private property, and other areas where trees provide shade, screening, or other utilitarian functions, and for areas less than an acre, any trees that will be removed must be identified and mapped. Necessary tree information includes diameter, species and numbers of trees greater than three inches Diameter at Breast Height (DBH). The developer must also comply with any relevant City of Grand Prairie tree ordinance provisions.

Wetlands and Section 404 Permits

The Corps of Engineers has been assigned responsibility for administering the Section 404 permitting process under the Clean Water Act. All wetland information concerning a request shall first be submitted through the Lake Manager. The following wetland information must be submitted, if wetlands or waters of the U.S. will be impacted:

1. A vicinity map (e.g., county map, USGS quad sheet, etc.) showing the location of the project, including any borrow or disposal site(s) or other outlying features.
2. A delineation and description of wetlands and other waters of the United States in the area that would be affected by the proposed work.
3. The purpose of, and need for, the project. This information should be available from the Preliminary Easement request.
4. Plan, profile, and cross-section views of all work, both permanent and temporary, in or adjacent to waters of the United States, including wetlands.
5. The type, source, and volume of material proposed to be discharged into and/or excavated from waters of the United

States. In cases where the activity may result in a change to pre-construction contours or drainage patterns, a description must be provided of the reasons why the changes are necessary with a description of the anticipated outcome of the changes.

6. The width and depth of the water body and the distance of any structures from the existing shoreline if located on a navigable water or a USACE lake project.

7. A description of the project's likely temporary and permanent impact on the aquatic environment.

8. A description of actions in project design to avoid and minimize adverse impacts to the aquatic environment and to compensate for unavoidable adverse impacts to the aquatic environment.

9. Project schedule.

10. A statement disclosing whether or not the proposed project will jeopardize the continued existence of any federally (or state) listed threatened or endangered species; or will destroy or adversely modify their critical habitat. Direct coordination with the Fish and Wildlife Service concerning the potential impact of the entire project on threatened and endangered species is strongly encouraged.

11. Any other relevant information, including available information on cultural resources and hydrology.

Endangered Species

A statement must be provided addressing potential impacts to federal- or state-listed threatened or endangered species or their critical habitat. Coordination with the U.S. Fish and Wildlife Service and Texas Parks & Wildlife Department concerning the potential impact of the project on endangered and threatened species may be necessary.

Cultural Resources

Coordination with the Fort Worth District Operations Archaeologist is necessary to determine the requirements for an archaeological survey and/or proper mitigation. The archaeologist may require a written archaeological survey report of all areas to be disturbed. If a historic property would be adversely affected, activities should be relocated to

avoid the property. If the historic property cannot be avoided, a mitigation plan must be developed and submitted.

Storm Water Requirements

Applicants are required to develop and submit a storm water pollution prevention plan (SWP3) if any earth-disturbing activities are performed. This plan shall include means by which erosion and sedimentation will be controlled to protect the drainage courses. For activities that will disturb areas equal to or greater than five acres, a Notice of Intent must be submitted to the TCEQ.

Hazardous Materials

If applicable, a description must be provided of the proposed use of hazardous materials and/or the generation of hazardous wastes in the easement area. The description should identify the hazardous substance, the amount, its intended use, the method of storage, and plans for response and cleanup in the event of a spill.

Flood Storage

The impact to flood storage must be quantified, including any projected loss or gain of flood storage capacity. All calculations of cut and fill which will occur below the upper guide contour must be shown.

Mitigation Plans

Mitigation plans must be provided for damaged natural resources (including wetlands) and/or loss of flood storage. The mitigation plan must demonstrate that damaged or lost natural resources are fully mitigated and that no flood storage capacity is lost. Mitigation generally requires wildlife habitat improvement and vegetative plantings on the area of actual disturbance and on additional areas.

Easement Type Requirements (Storm Sewers and Outfalls)

The USACE has requirements for specific structures proposed to be placed on USACE property. The USACE's storm sewer and outfalls requirements are applicable to the proposed placement of drainage structures on USACE property.

The USACE requires a demonstration of the need for the placement of storm sewers and outfall structures on USACE property. The demonstration must show a technical need and an overriding public need for the structures.

Measures to protect water quality must be taken for any storm water outfall approved for placement on USACE property. The outfall specifically must be designed to prevent "litter, trash, and petroleum products" from being deposited on USACE property.

Development requirements to address this measure may include pretreatment best management practices (BMPs) such as trash screens or storm interceptors. Selected BMPs would be identified based on a variety of factors, including land use, expected pollutants, topography, maintenance requirements, treatment effectiveness, and initial and long-term cost.

Appendix F
Channel Stability Alternatives

Design Considerations for Siting Grade Control Structures

Halff Associates, Inc.

CWDMP for Joe Pool Lake (W.O.#581.40) **AVO 26418**

ERDC/CHL CHETN-VII-3
December 2001

US Army Corps of Engineers®

Design Considerations for Siting Grade Control Structures

by David S. Biedenharn and Lisa C. Hubbard

PURPOSE: The purpose of this Coastal and Hydraulics Engineering Technical Note (CHETN) is to provide guidance and highlight possible areas of concern that may require consideration before siting grade control structures.

INTRODUCTION: In the widest sense, the term grade control can be applied to any alteration in the watershed which provides stability to the streambed. By far the most common method of establishing grade control is the construction of in-channel grade control structures. There are two basic types of grade control structures. One type can be referred to as a bed control structure as it is designed to provide a hard point in the streambed that is capable of resisting the erosive forces of the degradational zone. The second type can be referred to as a hydraulic control structure as it is designed to function by reducing the energy slope along the degradational zone to the point that the stream is no longer capable of scouring the bed. The distinction between the operating processes of these two types is important whenever grade control structures are considered.

Design considerations for siting grade control structures include determination of the type, location, and spacing of structures along the stream, along with the elevation and dimensions of structures. Siting grade control structures is often considered a simple optimization of hydraulics and economics. However, these factors alone are usually not sufficient to define the optimum siting conditions for grade control structures. In practice, hydraulic considerations must be integrated with a host of other factors, which vary from site to site, to determine the final structure plan. Some of the more important factors to be considered when siting grade control structures are discussed in the following paragraphs.

HYDRAULIC CONSIDERATIONS: One of the most important steps in the siting of a grade control structure or a series of structures is the determination of the anticipated drop at the structure. This requires some knowledge of the ultimate channel morphology, both upstream and downstream of the structure, which involves assessment of sediment transport and channel morphologic processes.

The hydraulic siting of grade control structures is a critical element of the design process, particularly when a series of structures is planned. The design of each structure is based on the anticipated tailwater or downstream bed elevation which, in turn, is a function of the next structure downstream. Heede and Mulich (1973) suggested that the optimum spacing of structures is such that the upstream structure does not interfere with the deposition zone of the next downstream structure. Mussetter (1982) showed that the optimum spacing should be the length of the deposition above the structure, which is a function of the deposition slope (Figure 1). Figure 1 also illustrates the recommendations of Johnson and Minaker (1944) that the most desirable spacing can be determined by extending a line from the top of the first

structure at a slope equal to the maximum equilibrium slope of sediment upstream until it intersects the original streambed.

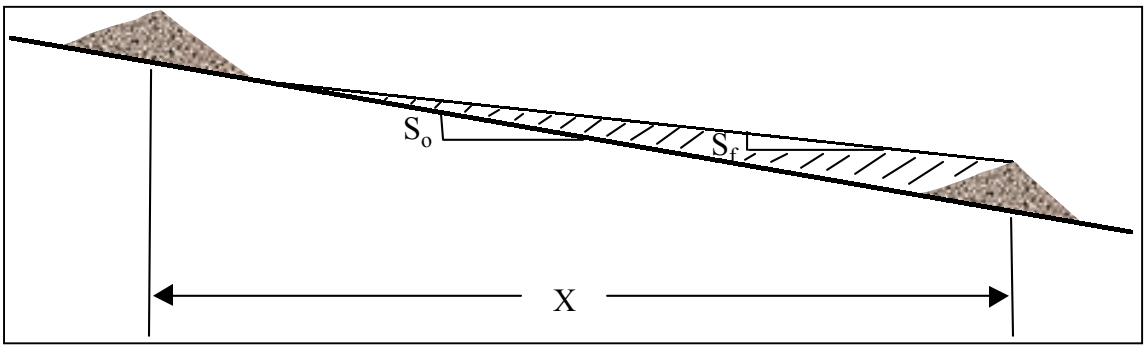


Figure 1. Spacing of grade control structure (adapted from Mussetter 1982)

Theoretically, the hydraulic siting of grade control structures is straightforward and can be determined by:

$$H = (S_o - S_f)X \tag{1}$$

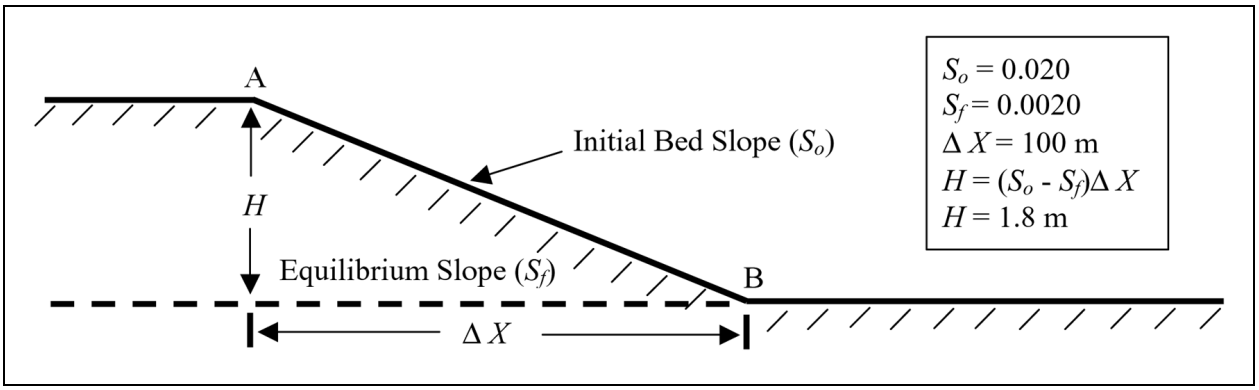
where H is the amount of drop to be removed from the reach, S_o is the original bed slope, S_f is the final, or equilibrium slope, and X is the length of the reach (Goitom and Zeller 1989). The number of structures (N) required for a given reach can then be determined by:

$$N = H/h \tag{2}$$

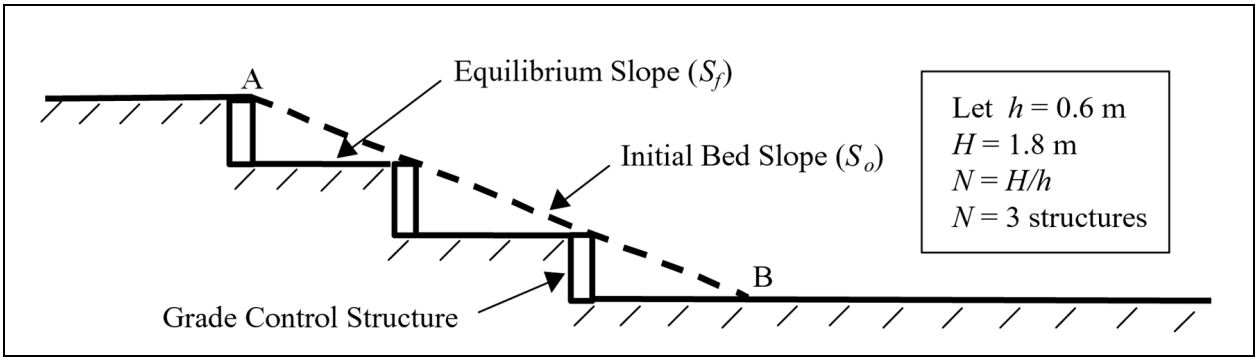
where h is the selected drop height of the structure.

The hydraulic siting of a series of bed control structures using the preceding procedure is illustrated in Figure 2. In contrast to bed control structures which are built at grade and the bed allowed to degrade between them (Figure 2b), hydraulic control structures are constructed with a raised and possibly constricted weir crest that drowns out the degradational zone (Figure 3b). It follows from Equation 1 that one of the most important factors to consider when siting grade control structures is the determination of the equilibrium slope (S_f). Unfortunately, this is also one of the most difficult parameters to define with any reliability. Failure to properly define the equilibrium slope can lead to costly, overly conservative designs, or inadequate design resulting in continued maintenance problems and possible complete failure of the structures.

The primary factors affecting the final equilibrium slope upstream of a structure include the incoming sediment concentration and load, the channel characteristics (slope, width, depth, roughness, etc.), and the hydraulic effect of the structure. Another complicating factor is the amount of time it takes for the equilibrium slope to develop. In some instances, the equilibrium slope may develop over a period of a few hydrographs while in others, it may take many years.



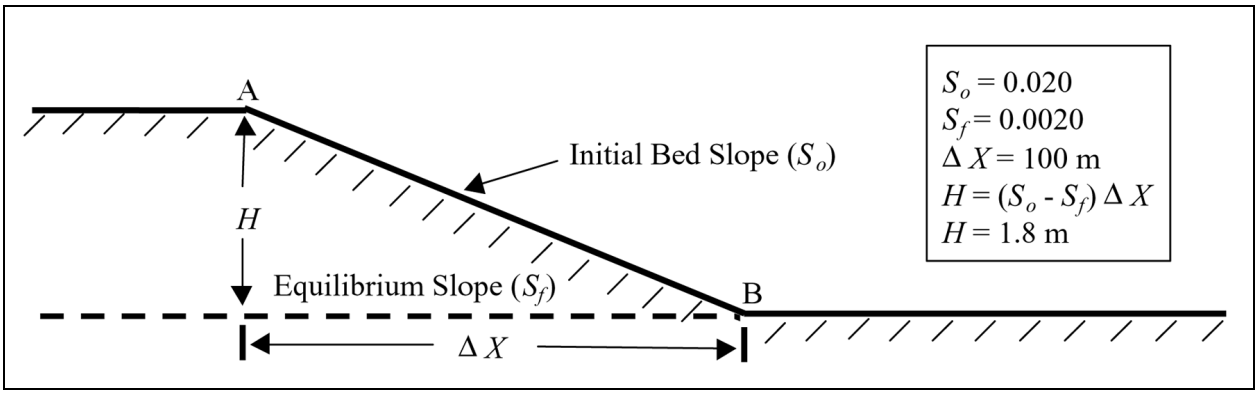
a. Initial condition of streambed showing degradational zone between points A and B. Total anticipated drop in reach is calculated to be 1.8 m



b. Stabilization of degradational zone using three bed control structures. Each structure has a design drop of 0.6 m

Figure 2. Hydraulic siting of bed control structures

There are many different methods for determining the equilibrium slope in a channel (Mussetter 1982; Federal Interagency Stream Restoration Working Group 1988; Watson, Biedenharn, and Scott 1999). These can range from detailed sediment transport modeling (Thomas et al. 1994; HQUSACE 1993) to less elaborate procedures involving empirical or process-based relationships such as regime analysis (Lacey 1931; Simons and Albertson 1963), tractive stress (Lane 1953a,b; Simons 1957; Simons and Sentürk 1992; HQUSACE 1994), or minimum permissible velocity (USDA 1977). In some cases, the equilibrium slope may be based solely on field experience with similar channels in the area. Regardless of the procedure used, the engineer must recognize the uses and limitations of that procedure before applying it to a specific situation. The decision to use one method or another depends upon several factors such as the level of study (reconnaissance or detail design), availability and reliability of data, project objectives, and time and cost constraints.



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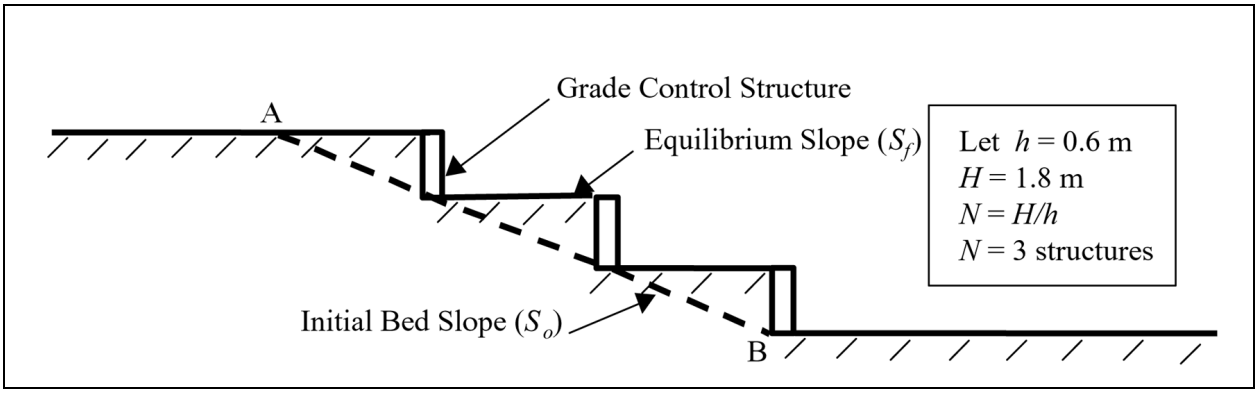

b. Stabilization of degradational zone using three hydraulic control structures. Each structure has a design drop of 0.6 m

Figure 3. Hydraulic siting of hydraulic control structures

GEOTECHNICAL CONSIDERATIONS: The preceding discussion focused only on the hydraulic aspects of siting grade control structures. However, in some cases, the geotechnical stability of the reach may be an important or even the primary factor to consider when siting grade control structures. This is often the case where channel degradation has caused, or is anticipated to cause, severe bank instability due to exceedance of the critical bank height (Thorne and Osman 1988). When this occurs, bank instability may be widespread throughout the system rather than restricted to the concave banks in bendways. Traditional bank stabilization measures may not be feasible in situations where system-wide bank instabilities exist. In these instances, grade control may be the more appropriate solution.

Grade control structures can enhance the bank stability of a channel in several ways. Bed control structures indirectly affect the bank stability by stabilizing the bed, thereby reducing the length of bank line that achieves an unstable height. With hydraulic control structures, two additional advantages with respect to bank stability are: (a) bank heights are reduced due to sediment deposition, which increases the stability of the banks with regard to mass failure; and (b) by

creating a backwater situation, velocities and scouring potential are reduced, which reduces or eliminates the severity and extent of basal cleanout of the failed bank material, thereby promoting self-healing of the banks.

FLOOD CONTROL IMPACTS: Channel improvements for flood control and channel stability often appear to be mutually exclusive objectives. For this reason, it is important to ensure that any increased postproject flood potential is identified. This is particularly important when hydraulic control structures are considered. In these instances, the potential for causing overbank flooding may be the limiting factor with respect to the height and amount of constriction at the structure. Grade control structures are often designed to be hydraulically submerged at flows less than bank-full so that the frequency of overbank flooding is not affected. However, if the structure exerts control through a wider range of flows including overbank, then the frequency and duration of overbank flows may be impacted. When this occurs, the impacts must be quantified and appropriate provisions such as acquiring flowage easements or modifying structure plans should be implemented.

Another factor that must be considered is the safe return of overbank flows back into the channel. This is particularly a problem when the flows are out of bank upstream of the structure but still within bank downstream. The resulting head differential can cause damage to the structure as well as severe erosion of the channel banks depending upon where the flow re-enters the channel. Some means of controlling the overbank return flows must be incorporated into the structure design. One method is simply to design the structure to be submerged below the top bank elevation, thereby reducing the potential for a head differential to develop across the structure during overbank flows. If the structure exerts hydraulic control throughout a wider range of flows including overbank, then a more direct means of controlling the overbank return flows must be provided. One method is to ensure that all flows pass only through the structure. This may be accomplished by building an earthen dike or berm extending from the structure to the valley walls which prevents any overbank flows from passing around the structure (Forsythe 1985). Another means of controlling overbank flows is to provide an auxiliary high-flow structure which will pass the overbank flows to a specified downstream location where the flows can re-enter the channel without causing significant damage (Hite and Pickering 1982).

ENVIRONMENTAL CONSIDERATIONS: In today's environment, projects must work in harmony with the natural system to meet the needs of the present without compromising the ability of future generations to meet their needs. Engineers and geomorphologists are responding to this challenge by trying to develop new and innovative methods for incorporating environmental features into channel projects. The final siting and design of a grade control structure is often modified to minimize adverse environmental impacts to the system.

Grade control structures can produce positive environmental impacts on a channel system in a number of ways. Grade control structures are typically placed in severely unstable stream reaches. By preventing the headward migration of zones of degradation, grade control structures provide vertical stability to the stream and reduce the amount of sediment eroded from the streambed and banks. This not only protects the upstream reaches from the destabilizing effects of bed lowering, but can also minimize sedimentation problems in the downstream reaches.

Therefore, the impacts of grade control structures are not restricted to a local area around the structure, but can have far-reaching impacts on the whole channel system.

Grade control structures can provide direct environmental benefits to a stream. Cooper and Knight (1987) conducted a study of fisheries resources below natural scour holes and man-made pools below grade control structures in north Mississippi. They concluded that, although there was greater species diversity in the natural pools, there was increased growth of game fish and a larger percentage of harvestable-size fish in the man-made pools. They also observed that the man-made pools provided greater stability of reproductive habitat. Shields et al. (1990) reported that the physical aquatic habitat diversity was higher in stabilized reaches of Twentymile Creek, MS, than in reaches without grade control structures. They attributed the higher diversity values to the scour holes and low-flow channels created by the grade control structures. The use of grade control structures as environmental features is not limited to the low-gradient sand bed streams of the southeastern United States. Jackson (1974) documented the use of gabion grade control structures to stabilize a high-gradient trout stream in New York. She observed that, following construction of a series of bed sills, there was a significant increase in the density of trout. The increase in trout density was attributed to the accumulation of gravel between the sills which improved the spawning habitat for various species of trout.

Adverse environmental impacts can also be associated with grade control structures. During the construction of any structure there is always the potential for the destruction of riparian habitat. However, with grade control structures, these impacts are usually limited to a localized area at the structure as opposed to other types of channel improvement features (levees, bank stabilization, or channelization) where habitat destruction may occur continuously over long reaches of stream.

Perhaps the most serious negative environmental impact of grade control structures is the obstruction to fish passage. In many instances, fish passage is one of the primary considerations and may lead the engineer to select several small fish passable structures in lieu of one or more high drops that would restrict fish passage. In some cases, particularly when drop heights are small, fish are able to migrate upstream past a structure during high flows (Cooper and Knight 1987). However, in situations where structures are impassable, and where the migration of fish is an important concern, openings, fish ladders, or other passageways must be incorporated into the design of the structure to address the fish movement problems (Nunnally and Shields 1985). The various methods of accomplishing fish movement through structures are not discussed here. Interested readers are referred to Nunnally and Shields (1985); Clay (1961); and Smith (1985) for a more detailed discussion.

Other potentially adverse impacts associated with grade control structures include changed substrate character due to sediment deposition, increased water temperature, altered energy and transport characteristics, general habitat modification, and reduction in stream dynamics including riparian succession. There may also be social considerations that should be considered, especially safety.

The environmental aspects of the project must be an integral component of the design process when siting grade control structures. A detailed study of all environmental features in the project

area should be conducted early in the design process. This will allow these factors to be incorporated into the initial plan rather than having to make costly and often less environmentally effective last minute modifications to the final design. Unfortunately, there is very little published guidance concerning the incorporation of environmental features into the design of grade control structures. One source of useful information can be found in the following technical reports published by the U.S. Army Engineer Research and Development Center (ERDC) Environmental Laboratory: Shields and Palermo (1982); Henderson and Shields (1984); and Nunnally and Shields (1985).

EXISTING STRUCTURES: Bed degradation can cause significant damage to bridges, culverts, pipelines, utility lines, and other structures along the channel perimeter. Grade control structures can prevent this degradation and thereby provide protection to these structures. For this reason, it is important to locate all potentially impacted structures when siting grade control structures. The final siting should be modified, as needed, within project restraints, to ensure protection of existing structures.

It must also be recognized that grade control structures can have adverse as well as beneficial effects on existing structures. This is a concern upstream of hydraulic control structures due to the potential for increased stages and sediment deposition. In these instances, the possibility of submerging upstream structures such as water intakes or drainage structures may become a deciding factor in the siting of grade control structures.

Whenever possible, the designer should take advantage of any existing structures which may already be providing some measure of grade control. This usually involves culverts or other structures that provide a nonerodible surface across the streambed. Unfortunately, these structures are usually not initially designed to accommodate any significant bed lowering and, therefore, cannot be relied on to provide long-term grade control. However, it may be possible to modify these structures to protect against the anticipated degradation. These modifications may be accomplished by simply adding some additional riprap with launching capability at the downstream end of the structure. In other situations, more elaborate modifications such as providing a sheet pile cutoff wall or energy dissipation devices may be required. Damage to and failure of bridges is the natural consequence of channel degradation. Consequently, it is not uncommon in a channel stabilization project to have several bridges that are in need of repair or replacement. In these situations it is often advantageous to integrate the grade control structure into the planned improvements at the bridge. If the bridge is not in immediate danger of failing and only needs some additional erosion protection, the grade control structure can be built at or immediately downstream of the bridge with the riprap from the structure tied into the bridge for protection. If the bridge is to be replaced, then it may be possible to construct the grade control structure concurrently with the road crossing.

LOCAL SITE CONDITIONS: When planning grade control structures, the final siting is often adjusted to accommodate local site conditions, such as the planform of the stream or local drainage. A stable upstream alignment that provides a straight approach into the structure is critical. Since failure to stabilize the upstream approach may lead to excessive scour and possible flanking of the structure, it is desirable to locate the structure in a straight reach. If this is not possible (as in the case in a very sinuous channel), it may be necessary to realign the

channel to provide an adequate approach. Stabilization of the realigned channel may be required to ensure that the approach is maintained. Even if the structure is built in a straight reach, the possibility of upstream meanders migrating into the structure must be considered. In this case, the upstream meanders should be stabilized prior to, or concurrent with, the construction of the grade control structure.

Local inflows from tributaries, field drains, roadside ditches, or other sources often play an important part in the siting of grade control structures. Failure to provide protection from local drainage can result in severe damage to a structure (U.S. Army Corps of Engineers 1981). During the initial siting of the structure, all local drainage should be identified. Ideally, the structure should be located to avoid local drainage problems. However, there may be some situations where this is not possible. In these instances, the local drainage should either be redirected away from the structure or incorporated into the structure design in such a manner that there will be no damage to the structure.

DOWNSTREAM CHANNEL RESPONSE: Since grade control structures affect the sediment delivery to downstream reaches, it is necessary to consider the potential impacts to the downstream channel when grade control structures are planned. Bed control structures reduce the downstream sediment loading by preventing the erosion of the bed and banks, while hydraulic control structures have the added effect of trapping sediments. The ultimate response of the channel to the reduction in sediment supply will vary from site to site. In some instances, the effects of grade control structures on sediment loading may be so small that downstream degradational problems may not be encountered. However, in some situations such as when a series of hydraulic control structures is planned, the cumulative effects of sediment trapping may become significant. In these instances, it may be necessary to modify the plan to reduce the amount of sediment being trapped or to consider placing additional grade control structures in the downstream reach to protect against the induced degradation.

GEOLOGIC CONTROLS: Geologic controls often provide grade control in a similar manner to a bed control structure. In some cases, a grade control structure can actually be eliminated from the plan if an existing geologic control can be utilized to provide a similar level of bed stability. However, caution must always be used when relying on geologic outcrops to provide long- term grade control. In situations where geologic controls are to be used as permanent grade control structures, a detailed geotechnical investigation of the outcrop is needed to determine its vertical and lateral extent. This is necessary to ensure that the outcrop will neither be eroded, undermined, or flanked during the project life.

EFFECTS ON TRIBUTARIES: The effect of main stem structures on tributaries should be considered when siting grade control structures. As degradation on a main stem channel migrates upstream it may branch up into the tributaries. Therefore, the siting of grade control structures should consider effects on the tributaries. If possible, main stem structures should be placed downstream of tributary confluences. This will allow one structure to provide grade control to both the main stem and the tributary. This is generally a more cost-effective procedure than having separate structures on each channel.

SUMMARY: The preceding discussion illustrates that the siting of grade control structures is not simply a hydraulic exercise, and there are many other factors that must be included in the design process. For any specific situation, some or all of the factors discussed in this section may be critical elements in the final siting of grade control structures. It is recognized that this does not represent an all inclusive list since there may be other factors not discussed here that may be locally important. For example, in some cases, maintenance requirements, debris passage, ice conditions, esthetics or safety considerations may be controlling factors. Consequently, there is no definitive cookbook procedure for siting grade control structures that can be applied universally. Rather, each situation must be assessed on an individual basis.

ADDITIONAL INFORMATION: Questions about this CHETN can be addressed to David S. Biedenharn (601-634-4653), e-mail: *David.S.Biedenharn@erdc.usace.army.mil* or Lisa C. Hubbard (601-634-4150), e-mail: *Lisa.C.Hubbard@erdc.usace.army.mil*. This CHETN should be referenced as follows:

> Biedenharn, D. S., and Hubbard, L. C. (2001). "Design considerations for siting grade control structures," Coastal and Hydraulics Engineering Technical Note CHETN-VII-3 U.S. Army Engineer Research and Development Center, Vicksburg, MS. *http://chl.wes.army.mil/library/publications/chetn/*

REFERENCES

Clay, C. H. (1961). "Design of fishways and other fish facilities," Department of Fisheries and Oceans, Canada, Queen's Printer, Ottawa.

Cooper, C. M., and Knight, S. S. (1987). "Fisheries in man-made pools below grade control structures and in naturally occurring scour holes of unstable streams," *Journal of Soil and Water Conservation*, 42, 370-373.

Federal Interagency Stream Restoration Working Group. (1998). "Stream corridor restoration: Principles, processes, and practices."

Forsythe, P. (1985). "Performance of a grade control structure system during extreme floods," American Society of Agricultural Engineers Winter Meeting, Chicago IL.

Goitom, T. G., and Zeller, M. E. (1989). "Design procedures for soil-cement grade control structures," Proceedings of the National Conference on Hydraulic Engineering, American Society of Civil Engineers, New Orleans, LA.

Headquarters, U.S. Army Corps of Engineers. (1981). "Final Report to Congress, Streambank Erosion Control and Demonstration Project (Section 32), Appendix F, Yazoo River Basin Demonstration Projects," Washington, DC.

_____. (1993). "Scour and deposition in rivers and reservoirs (HEC-6)," Washington, DC.

_____. (1994). "Channel stability assessment for flood control projects," EM 1110-2-1418, Washington, DC.

Heed, B. H., and Mulich, J. G. (1973). "Functional relationships and a computer program for structural gully control," *Journal of Environmental Management*, Vol.1.

Henderson, J. E., and Shields, F. D. (1984). "Environmental features for streambank protection projects," Technical Report E-84-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hite, J. W., and Pickering, G. A. (1982). "South Fork Tillatoba Creek drop structures, Mississippi; Hydraulic model investigation," Technical Report HL-82-22, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Jackson, B. J. (1974). "Stream bed stabilization in Enfield Creek, New York," *New York Fish and Game Journal*, 21(10, 32-46.

Johnson, J. W., and Minaker, W. L. (1944). "Movement and deposition of sediment in the vicinity of debris-barriers," Transactions, American Geophysical Union, Part VI, 901-905.

Lacey, G. (1931). "Regime diagrams for the design of canals and distributaries," Technical Paper No. 1, United Provinces: P.W.D. Irrigation Branch.

Lane, E. W. (1953a). "Progress report on studies on the design of stable channels by the bureau of reclamation," Proceedings, American Society of Civil Engineers, 79, Separate No. 280, 1-31.

_____ . (1953b). "Design of stable channels," Transactions, American Society of Civil Engineers, 120, 1234-1260.

Mussetter, R. A. (1982). "Equilibrium slopes above channel control structures," Colorado State University, Civil Engineering Department, M.S. thesis, Fort Collins, CO.

Nunnally, N. R., and Shields, F. D. (1985). "Incorporation of environmental features in flood control channel projects," Technical Report E-85-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Shields, F. D., and Palermo, M. R. (1982). "Assessment of environmental considerations in the design and construction of waterways projects," Technical Report E-82-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Shields, F. D., Jr., Hoover, J. J., Nunnally, N. R., Kilgore, K. J., Schaefer, T. E., and Waller, T. N. (1990). "Hydraulic and environmental effects of channel stabilization Twentymile Creek, Mississippi," Technical Report EL-90-14, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Simons, D. B. (1957). "Theory and design of stable channels in alluvial materials," Ph.D. diss., Colorado State University, Fort Collins, CO.

Simons, D. B., and Albertson, M. L. (1963). "Uniform water conveyance channels in alluvial material," Transactions, American Society of Civil Engineers, 128, 65-167.

Simons, D. B., and Sentürk, F. (1992). "Sediment transfer technology," Water Resources Publication, Littleton, CO.

Smith, C. D. (1985). "Hydraulic structures," University of Saskatchewan Printing Services, Saskatoon, Canada.

Thomas, W. A., Copeland, R. R., Raphelt, N. K., and McComas, D. N. (1994). "User's manual for the hydraulic design package for channels (SAM)," U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Thorne, C. R., and Osman, A. M. (1988). "Riverbank stability analysis II: Applications," *Journal of Hydraulic Engineering*, ASCE, 114(2), 151-172.

U.S. Department of Agriculture. (1977). "Design of open channels," Technical Release No. 25.

Watson, C. C., Biedenharn, D. S., and Scott, S. H. (1999). "Draft – channel rehabilitation: Processes, design and implementation," U.S. Army Engineer Research and Development Center, Vicksburg, MS.

APPROVED PRODUCT LIST
ITEM 169 "SOIL RETENTION BLANKET"

Effective September 2006

The Contractor has the option of utilizing the following approved products in accordance with the Class and Type as specified on the plans. The current Approved Product List may be found on TxDOT's Web Page at http://www.dot.state.tx.us/services/maintenance/erosion_control.htm. Direct all questions to John Mason of the Maintenance Division, Vegetation Management Section, 125 E. 11th Street, Austin, TX 78701-2483, (512) 416-3081.

CLASS 1 "SLOPE PROTECTION"

Type A - Slopes 1:3 or Flatter - Clay Soils:

AEC Premier Straw
Airtrol
Anti-wash/Geojute
BioD-Mesh 60
Carthage Mills Veg Net
C-Jute
Contech Standard
Contech Standard Plus
Contech Straw/Coconut Fiber Mat w/Kraft Net
Contech C-35
Curlex 1
Curlex™-LT
Earth Bound
EcoAegis™
Econo-Jute
ECS Excelsior Blanket Standard
ECS High Velocity Straw Mat
ECS Standard Straw
EnviroGuard Plus
Enviro-Matrix
Enviro-Shield
Formula 480 Liquid Clay
Flexterra FGM
Futerra®
Grass Mat
Greenfix CFS072R
Greenfix WS05
Greenfix WSO72
Green Solutions DNS2
GreenSolutions SNS1
GeoTech TechMat™ SCKN
Green Triangle Regular
Green Triangle Superior
Greenstreak Pec-Mat
Hydro Blanket
Landlok S1
Landlok S2
Landlok CS2
Landlok 407
Landlok TRM 435
Miramat TM8
Multimat 100
North American Green S150
North American Green S75
North American Green® S75 BN
North American Green SC150
North American Green® S150 BN
Maccaferri MX287
Pennzsuppress®
Poplar Erosion Blanket
Rhino Erosion King Single Net
Rhino Erosion King Double Net
SEC-S2
Soil Guard
Soil Saver
SprayMat
Landlok SuperGro
S 31 Single Net Straw ECB
S 32 Double Net Straw ECB
Terra-Control®
TerraJute
Terra-Mulch
Verdyol Ero-Mat
Verdyol Excelsior High Velocity
Verdyol Excelsior Standard
Webtec Terraguard 44P
Excel R-1
Excel S-2
Excel CC-4
Excel CS-3 All Natural
Excel SS-2
Excel SR-1
Excel PP5-10

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CLASS 1 "SLOPE PROTECTION" (continued)

Type B - 1:3 or Flatter - Sandy Soils:

AEC Premier
C-Jute
Carthage Mills Veg Net
Contech Standard
Contech Standard Plus
Contech Straw/Coconut Fiber Mat w/Kraft Net
Contech C-35
Curlex 1
Curlex LT
Earth Bound
EarthGuard Fiber Matrix
ECS Standard Straw
ECS Excelsior Blanket Standard
ECS High Velocity Straw Mat
EnviroGuard Plus
Flexterra FGM
Futerra®
Greenfix CFS072R
Greenfix WS05
Greenfix WSO72
GreenSolutions SNS1
Geojute Plus 1
GeoTech TechMat™ SCKN
Green Triangle Regular
Green Triangle Superior
Landlok® S1
Landlok® S2
Landlok® CS2
Landlok 407
Landlok TRM 435
Maccaferri MX287
Miramat 1000
Miramat TM8
Multimat 100
North American Green S75
North American Green® S75 BN
North American Green S150
North American Green SC150
North American Green® S150 BN
Poplar Erosion Blanket
Rhino Erosion King Single Net
SEC-S2
Soil Guard
S 31 Single Net Straw ECB
S 32 Double Net Straw ECB
Terra-Control®
TerraJute
Verdyol Ero-Mat
Verdyol Excelsior Standard
Webtec Terraguard 44P
Excel R-1
Excel S-2
Excel CC-4
Excel CS-3 All Natural
Excel CS-3
Excel SS-2
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CLASS 1 "SLOPE PROTECTION" (continued)

Type C - Slopes Steeper than 1:3 - Clay Soils:

Airtrol
Anti-Wash/Geojute
Carthage Mills Veg Net
C-Jute
Contech Standard Plus
Contech Straw/Coconut Fiber Mat w/Kraft Net
Contech C-35
Curlex 1
Earth Bound
Eco-Aegis
Econo Jute
ECS High Velocity Straw Mat
ECS Standard Straw
EnviroGuard Plus
Formula 480 Liquid Clay
Flexterra FGM
Futerra®
Greenfix CFS072R
Greenfix WS05
Greenfix WSO72
GreenSolutions DNS2
Green Triangle Superior
GeoTech TechMat™ SCKN
Greenstreak Pec-Mat
Hydro Blanket
Landlok® S2
Landlok CS2
Landlok 407
Landlok TRM 435
Maccaferri MX287
Miramat TM8
Multimat 100
North American Green S150
North American Green S75
North American Green SC150
North American Green® S150 BN
Pennzsuppress®
Poplar Erosion Blanket
Rhino Erosion King Single Net
Rhino Erosion King Double Net
SEC-S2
SprayMat
Soil Guard
Soil Saver
Landlok SuperGro
S 32 Double Net Straw ECB
TerraJute
Verdyol Excelsior High Velocity
Webtec Terraguard 44P
Excel S-2
Excel CC-4
Excel CS-3 All Natural
Excel SS-2
Excel SR-1
Excel PP5-10

APPROVED PRODUCT LIST
ITEM 169 "SOIL RETENTION BLANKET"

Effective Date: September 2006

The Contractor has the option of utilizing the following approved products in accordance with the Class and Type as specified on the plans. The current Approved Product List may be found on TxDOT's Web Page at http://www.dot.state.tx.us/services/maintenance/erosion_control.htm. Direct all questions to John Mason of the Maintenance Division, Vegetation Management Section, 125 E. 11th Street, Austin, TX 78701-2483, (512) 416-3081.

CLASS 1 "SLOPE PROTECTION" (continued)

Type D - Slopes Steeper than 1:3 - Sandy Soils:

C-Jute
Carghage Mills Veg Net
Contech Standard Plus
Contech Straw/Coconut Fiber Mat w/Kraft Net
Contech C-35
Curlex 1
EarthGuard Fiber Matrix
ECS High Velocity Straw Mat
ECS Standard Straw
EnviroGuard Plus
Futerra®
Greenfix CFS072R
Greenfix WS05
Greenfix WSO72
Geojute Plus 1
GeoTech TechMat™ SCKN
Green Triangle Superior
Landlok® S2
Landlok® CS2
Landlok 407
Landlok TRM 435
Maccaferri MX287
Miramat 1000
Miramat TM8
North American Green S150
North American Green SC150
North American Green® S150 BN
Rhino Erosion King Single Net
SEC-S2
Soil Guard
S 32 Double Net Straw ECB
TerraJute
Webtec Terraguard 44P
Excel S-2
Excel CC-4
Excel CS-3 All Natural
Excel CS-3
Excel SS-2
Excel PP5-10
Excel PP5-12

APPROVED PRODUCT LIST
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CLASS 2 - "FLEXIBLE CHANNEL LINER"

Type E - Shear Stress Range 0 - 96 Pascal (0 - 2 Pounds Per Square Foot):

Contech TRM C-45
Contech C-35
Contech C50
Contech Coconut/Poly Fiber Mat
Contech Coconut Mat w/Kraft Net
Curlex® II Stitched
Curlex® III Stitched
Curlex® Channel Enforcer 1
Curlex® Channel Enforcer II
Earth-Lock
Earth-Lock II
ECS High Impact Excelsior
ECS Standard Excelsior
ECS High Velocity Straw Mat
Enkamat 7018
Enkamat 7020
Enkamat Composite 30
Enkamat Composite NPK**
Enviromat
Geotech TechMat™ CP 3-D
Geotech TechMat™ CKN
Greenfix CFG 2000
Greenstreak Pec-Mat
Koirmat™ 700
Landlok® C2
Landlok® CS2
Landlok S-2
Landlok TRM 435
Landlok TRM 450
Landlok TRM 1051
Maccaferri MX287
Miramat TM8
Multimat 100
North American Green C125 BN
North American Green C350 Three Phase
North American Green SC150 BN
North American Green S350
North American Green® P350
North American Green S150
Pyramat®
Recyclex TRM
Rhino Erosion King Single Net
Rhino Erosion King Double-Net
StayTurf
SureTurf® ST 1000
Webtec Terraguard 44P
Webtec Terraguard 45P
Excel CC-4
Excel CS-3
Excel CS-3 All Natural
Excel PP5-8
Excel PP5-10
Excel PP5-12
Excel R-1
Excel SD-3
Excel SS-2

APPROVED PRODUCT LIST
ITEM 169 "SOIL RETENTION BLANKET"

Effective Date: September 2006

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CLASS 2 - "FLEXIBLE CHANNEL LINER" (continued)

Type F - Shear Stress Range 0 - 192 Pascal (0 - 4 Pounds Per Square Foot):

Curlex® II Stitched
Curlex® III Stitched
Curlex® Channel Enforcer 1
Curlex® Channel Enforcer II
Contech C50
Contech TRM C-45
Contech C-35
Contech Coconut/Poly Fiber Mat
Contech Coconut Mat w/Kraft Net
Earth-Lock
Earth-Lock II
ECS High Impact Excelsior
ECS High Velocity Straw Mat
ECS Standard Excelsior
Enkamat 7018
Enkamat Composite 30
Enviromat
Geotech TechMat™ CP 3-D
Geotech TechMat™ CKN
Greenfix CFG 2000
Greenfix CFO 72RR
Greenstreak Pec-Mat
Koirmat™ 700
Landlok® C2
Landlok® CS2
Landlok® TRM 435
Landlok® TRM 450
Landlok® TRM 1051
Landlok® S2
Maccaferri MX287
Miramat TM8
Multimat 100
North American Green C125 BN
North American Green C350 Three Phase
North American Green SC150 BN
North American Green S350
North American Green P350
North American Green S150
Pyramat®
Recyclex TRM
Rhino Erosion King Double Net
SS Superior Straw
StayTurf
SureTurf® ST 1000
Webtec Terraguard 44P
Webtec Terraguard 45P
Excel CC-4
Excel PP5-8
Excel PP5-10
Excel PP5-12
Excel SD-3
Excel R-1

APPROVED PRODUCT LIST
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CLASS 2 - "FLEXIBLE CHANNEL LINER" (continued)

Type G - Shear Stress Range 0 - 287 Pascal (0 - 6 Pounds Per Square Foot):

Contech TRM C-45
Contech C-35
Contech C50
Contech Coconut/Poly Fiber Mat
Curlex® Channel Enforcer II
Earth-Lock
Earth-Lock II
Enkamat 7018
Enkamat Composite 30
Geotech TechMat™ CP 3-D
Greenfix CFG 2000
Greenstreak Pec-Mat
Koirmat™ 700
Landlok® BonTerra® CP2
Landlok® TRM 1051
Landlok® TRM 1060
Landlok® TRM 435
Landlok® TRM 450
Multimat 100
North American Green C350 Three Phase
North American Green S350
North American Green® P350
Pyramat®
Recyclex TRM
StayTurf
SureTurf® ST 1000
Webtec Terraguard 44P
Webtec Terraguard 45P
Excel PP5-8
Excel PP5-10
Excel PP5-12

APPROVED PRODUCT LIST
ITEM 169 "SOIL RETENTION BLANKET"

Effective Date: September 2006

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CLASS 2 - "FLEXIBLE CHANNEL LINER" (continued)

Type H - Shear Stress Range 0 - 383 Pascal (0 - 8 Pounds Per Square Foot):

Contech TRM C-45
Contech C-35
Contech C50
Contech Coconut/Poly Fiber Mat
Geotech TechMat™ CP 3-D
Landlok® TRM 435
Landlok® TRM 450
Landlok® TRM 1051
Multimat 100
North American Green C350 Three Phase
North American Green S350
North American Green® P350
Pyramat®
Recyclex TRM
StayTurf
SureTurf® ST 1000
Webtec Terraguard 44P
Webtec Terraguard 45P
Excel PP5-8
Excel PP5-10
Excel PP5-12

APPROVED PRODUCT LIST
ITEM 169 "SOIL RETENTION BLANKET"

Effective Date: September 2006

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CLASS 2 - "FLEXIBLE CHANNEL LINER" (continued)

Type I - Shear Stress Range 0 - 479 Pascal (0 - 10 Pounds Per Square Foot):

Landlok® TRM 450
StayTurf
SureTurf® ST 1000
Recyclex TRM
Excel PP5-8
Excel PP5-10
Excel PP5-12

APPROVED PRODUCT LIST
ITEM 169 "SOIL RETENTION BLANKET"

Effective Date: September 2006

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CLASS 2 - "FLEXIBLE CHANNEL LINER" (continued)

Type J - Shear Stress Range 0 - 575 Pascal (0 -12 Pounds Per Square Foot):
Landlok® TRM 450
Recyclex TRM
StayTurf
SureTurf® ST 1000
Excel PP5-12

APPROVED PRODUCT LIST
ITEM 164 "SEEDING FOR EROSION CONTROL"

Effective Date: September 2006

The Contractor has the option of utilizing the following approved cellulose fiber mulches. The current Approved Product List may be found on TxDOT's Web Page by pointing your browser to http://www.dot.state.tx.us/services/maintenance/erosion_control.htm. Direct all questions to John Mason of the Vegetation Management Section, Maintenance Division, 125 E. 11th Street, Austin, TX 78701-2483, (512) 416-3081.

MULCHES 4:1 OR FLATTER SLOPES

Clay or Tight Soils:

Agri-Fiber
American Fiber Mulch
American Fiber Mulch(Hydro-Stick)
Conweb Hydro Mulch
Enviro-Gro Fiber Mulch
Evercycle Hydro-Mulch
Excel Fibermulch II
GeoSkin Cotton Hydro Mulch
Hydro-Lok
Hydro Straw
Lay-Low Mulch
Lonestar Hydro-Grass
Oasis Fiber Mulch
Pennzsuppress®
Pro Mat
Pro Mat (with RMBplus)
Pro Mat X
Second Nature Regenerated Wood Fiber Mulch
Second Nature Wood Fiber Blend
Second Nature Recycled Paper Fiber
Second Nature Recycled Straw Tack
Silva Fiber Plus

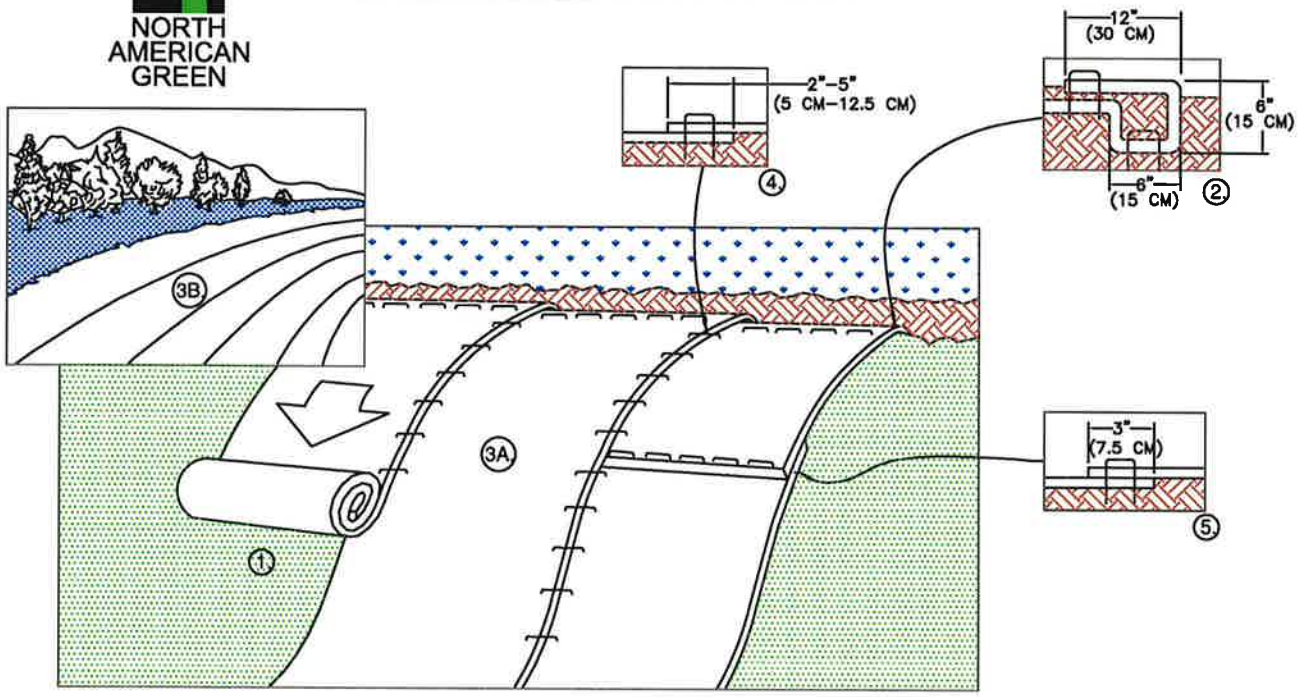
Sandy or Loose Soils:

American Fiber Mulch
American Fiber Mulch (with Hydro-Stick)
American Fiber Mulch with Stick Plus
Conwed Hydro Mulch
Enviro-Gro
Evercycle™ Hydro-Mulch
Excel Fibermulch II
GeoSkin Cotton Hydro Mulch
Hydro-Lok
Hydro Straw
Lay-Low Mulch
Lonestar Hydro-Grass
Oasis Fiber Mulch
Pennzsuppress®
Pro Mat
Pro Mat (with RMB Plus)
Pro Mat X
Pro Mat XL
Second Nature Regenerated Wood Fiber Mulch
Second Nature Wood Fiber Blend
Second Nature Recycled Paper Fiber
Second Nature Recycled Straw Tack

Slope Installation

NORTH AMERICAN GREEN

SLOPE INSTALLATION
APLICACIONES PARA TALUDES



1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED. NOTE: WHEN USING CELL–O–SEED DO NOT SEED PREPARED AREA. CELL–O–SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
2. BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE BLANKET IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF BLANKET EXTENDED BEYOND THE UP–SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART ACROSS THE WIDTH OF THE BLANKET.
3. ROLL THE BLANKETS (A.) DOWN OR (B.) HORIZONTALLY ACROSS THE SLOPE. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM™ , STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
4. THE EDGES OF PARALLEL BLANKETS MUST BE STAPLED WITH APPROXIMATELY 2" – 5" (5 CM – 12.5 CM) OVERLAP DEPENDING ON BLANKET TYPE.
5. CONSECUTIVE BLANKETS SPLICED DOWN THE SLOPE MUST BE PLACED END OVER END (SHINGLE STYLE) WITH AN APPROXIMATE 3" (7.5 CM) OVERLAP. STAPLE THROUGH OVERLAPPED AREA, APPROXIMATELY 12" (30 CM) APART ACROSS ENTIRE BLANKET WIDTH.

NOTE:
*IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY SECURE THE BLANKETS.

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1. PREPARE EL TERRENO ANTES DE INSTALAR LAS MANTAS, INCLUYENDO LA APLICACION DE CAL, FERTILIZANTE Y SEMILLA. NOTA: CUANDO ESTE USANDO CELL–O–SEED NO SIEMBRE EL AREA PREPARADA. CELL–O–SEED TIENE QUE INSTALARSE CON EL LADO DE PAPEL HACIA ABAJO.
2. COMIENCE EN LA CABECERA DEL TALUD SUJETANDO LA MANTA EN UNA ZANJA DE 6' (15 CM) DE PROFUNDIDAD FOR 6' (15 CM) DE ANCHO CON APROXIMADAMENTE 12" (30 CM) DE LA MANTA EXTENDIDA MAS ALLA DE LA PENDIENTE ALTA DE LA ZANJA. SUJETE LA MANTA AL FONDO DE LA ZANJA CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA OTRA. RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPE. RIEGE LA SEMILLA EN EL SUELO COMPACTADO Y DOBLE LAS 12" (30 CM) REMANENTES DE MANTA SOBRE LA SEMILLA EL SUELO COMPACTADO. ASEGURE LA MANTA SOBRE EL SUELO CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA OTRA A TRAVES DEL ANCHO DE LA MANTA.
3. DESENROLLE LAS MANTAS (3A) HACIA ABAJO U (3B) HORIZONTALMENTE A TRAVES DEL TALUD CON EL LADO APROPIADO HACIA LA SUPERFICIE DEL SUELO. TODAS LAS MANTAS DEBERAN ASEGURARSE A LA SUPERFICIE DEL SUELO POR MEDIO DE GRAPAS O ESTACAS EN LUGARES APROPIADOS TAL Y COMO SE INDICA EN EL PATRON GUIA DE ENGRAPADO. CUANDO ESTE USANDO EL DOT SYSTEM™ . LAS GRAPAS O ESTACAS DEBEN COLOCARSE A TRAVES DE CADU UNDO DE LOS PUNTOS CON COLOR CORRESPONDIENTES AL PATRON DE ENGRAPADO APROPIADO.
4. LOS BORDES DE LAS MANTAS PARALELAS TIENEN QUE ENGRAPARSE CON UN TRASLAPE DE APROXIMADAMENTE 2" – 5" (5 CM – 12.5 CM) DEPENDIENDO DEL TIPO DE MANTA.
5. MANTAS CONSECUTIVAS UNIDAS EN LA BAJADA DE LOS TALUDES, DEBEN COLOCARSE ORILLA SOBRE ORILLA (TIPO EXCALONADO) CON UN TRASLAPE DE APROXIMADAMENTE 3" (7.5 CM). ENGRAPE EL AREA TRASLAPADA CON UNA SEPARACION DE APROXIMADAMENTE 12" (30 CM) A TRAVES DE TODO EL ANCHO DE LA MANTA.

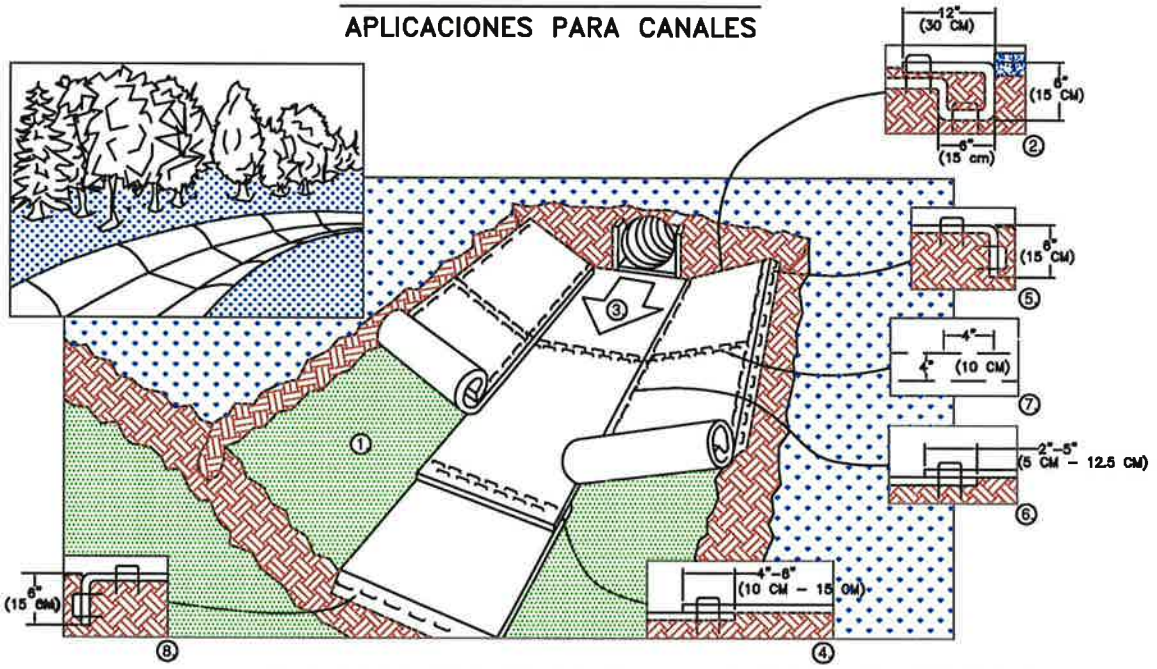
NOTA:
* EN CONDICIONES DE SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGURAR LAS MANTAS CORRECTAMENTE.

REV. 1/2004

NORTH AMERICAN GREEN

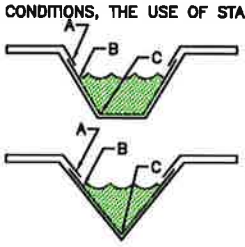
CHANNEL INSTALLATION

APLICACIONES PARA CANALES



1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED. NOTE: WHEN USING CELL-O-SEED DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
2. BEGIN AT THE TOP OF THE CHANNEL BY ANCHORING THE BLANKET IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30 CM) OF BLANKET EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMAPCT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) ACROSS THE WIDTH OF THE BLANKET.
3. ROLL CENTER BLANKET IN DIRECTION OF WATER FLOW IN BOTTOM OF CHANNEL. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM™, STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
4. PLACE CONSECUTIVE BLANKETS END OVER END (SHINGLE STYLE) WITH A 4" – 6" (10 CM –15 CM) OVERLAP. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10 CM) APART AND 4" (10 CM) ON CENTER TO SECURE BLANKETS.
5. FULL LENGTH EDGE OF BLANKETS AT TOP OF SIDE SLOPES MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.
6. ADJACENT BLANKETS MUST BE OVERLAPPED APPROXIMATELY 2" – 5" (5 CM –12.5 CM) (DEPENDING ON BLANKET TYPE) AND STAPLED.
7. IN HIGH FLOW CHANNEL APPLICATIONS, A STAPLE CHECK SLOT IS RECOMMENDED AT 30 TO 40 FOOT (9 M – 12 M) INTERVALS. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10 CM) APART AND 4" (10 CM) ON CENTER OVER ENTIRE WIDTH OF THE CHANNEL.
8. THE TERMINAL END OF THE BLANKETS MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.

NOTE:
* IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.



CRITICAL POINTS

A. OVERLAPS AND SEAMS
B. PROJECTED WATER LINE
C. CHANNEL BOTTOM/SIDE SLOPE VERTICES

NOTE:
* HORIZONTAL STAPLE SPACING SHOULD BE ALTERED IF NECESSARY TO ALLOW STAPLES TO SECURE THE CRITICAL POINTS ALONG THE CHANNEL SURFACE.

** IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 cm) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.

PUNTOS CRITICOS

A. TRASLAPES Y JUNTAS
B. LINEAS DE AGUA PROYECTADA
C. FONDO DEL CANAL/VERTICES DE LAS PENDIENTES LATERALES

NOTA:
* LA SEPARACION HORIZONTAL DE LAS GRAPAS SE DEBE ALTERAR SI SE NECESITA, PARA PERMITIR QUE LAS GRAPAS ASEGUREN LOS PUNTOS CRITICOS A LO LARGO DE LA SUPERFICIE DEL CANAL.

** EN CONDICIONES DE SUELO SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGURAR LAS MANTAS CORRECTAMENTE.

1. PREPARE EL SUELO DE COLOCAR LAS MANTAS, INCLUYENDO LA APLICASION DE CAL, FERTILIZANTE SEMILLA. NOTA: CUANDO ESTE USANDO CELL-O-SEED NO SIEMBRE EL AREA PREPARADA. CELL-O-SEED TIENE QUE INSTALARSE CON EL LADO DE PAPEL HACIA ABAJO.
2. COMIENCE EN LA CABECERA DEL CANAL SUJETANDO LA MANTA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM). DE ANCHO CON APROXIMADAMENTE 12" (30 CM) DE LA MANTA EXTENDIDA MAS ALLA DE LA PENDIENTE ALTA DE LA ZANJA. SUJETE RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPE. RIEGUE LA SEMILLA EN EL SUELO COMPACTADO Y DOBLE LAS 12" (30 CM) REMANENTES DE MANTA SOBRE LA SEMILLA Y EL SUELO COMPACTADO. ASEGURE LA MANTA SOBRE EL SUELO CON UNA LINEADE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA OTRA A TRAVES DEL ANCHO DE LA MANTA.
3. DESENROLLE LA MANTA DEL MEDIO EN EL FONDO DEL CANAL Y EN LA DIRECCION DEL FLUJO DE AGUA CON EL LADO APROPIADO HACIA LA SUPERFICIE DEL SUELO. TODAS LAS MANTAS DEBERAN ASEGURARSE A LA SUPERFICIE DEL SUELO POR MEDIO DE GRAPAS O ESTACAS EN LUGARESAPROPIADOS TAL Y COMO SE INDICA EN EL PATRON GUIA DE ENGRAPADO. CUANDO ESTE USANDO EL DOT SYSTEM™. LAS GRAPAS O ESTACAS DEBEN COLOCARSE A TRAVES DE CADA UNO DE LOS PUNTOS CON COLOR CORRESPONDIENTES AL PATRON DE ENGRAPADO APROPIADO.
4. COLOQUE LAS MANTAS CONSECUTIVAS BORDE SOBRE BORDE (TIPO ESCALONADO) CON UN TRASLAPE DE 4" – 6" (10 CM – 15 CM). USE UNA LINEA DOBLE DE GRAPAS ESCALONADAS, SEPARADAS POR 4" (10 CM) Y CADA 4" (10 CM) SOBRE EL CENTRO PARA ASEGURAR LAS MANTAS.
5. EN EL TOPE DE LAS DOS PENDIENTES LATERALES DEL CANAL, SE DEBE SUJETAR TODO EL LARGO DE LA ORILLA DE LAS MANTAS CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE CADA 12" (30 CM) UNA DE LA OTRA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO. RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPE.
6. LAS MANTAS ADYACENTES DEBEN TRASLAPARSE APROXIMADAMENTE DE 2" – 5" (5 CM– 12.5 CM) (DEPENDIENDO DEL TIPO DE. MANTA) Y ENGRAPPARSE.
7. EN APLICACIONES PARA CANALES DE FLUJO ALTO, SE RECOMIENDA DEJAR UNA RANURA PARA EL CHEQUEO DE LAS GRAPAS A INTERVALOS DE 30 A 40 PIES (9 M – 12 M). USE UNA LINEA DOBLE DE PRAPAS ESCALONADAS, SEPARADAS POR 4" (10 CM) Y CADA 4" (10 CM) SOBRE EL CENTRO A TRAVES DE TODO EL ANCHO DEL CANAL.
8. LOS BORDES FINALES DE LAS MANTAS DEBEN SUJETARSE CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE CADA 12" 30 CM) UNA DE LA OTRA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO. RELLENE Y COMPACTE DESPUES DEL ENGRAPADO.

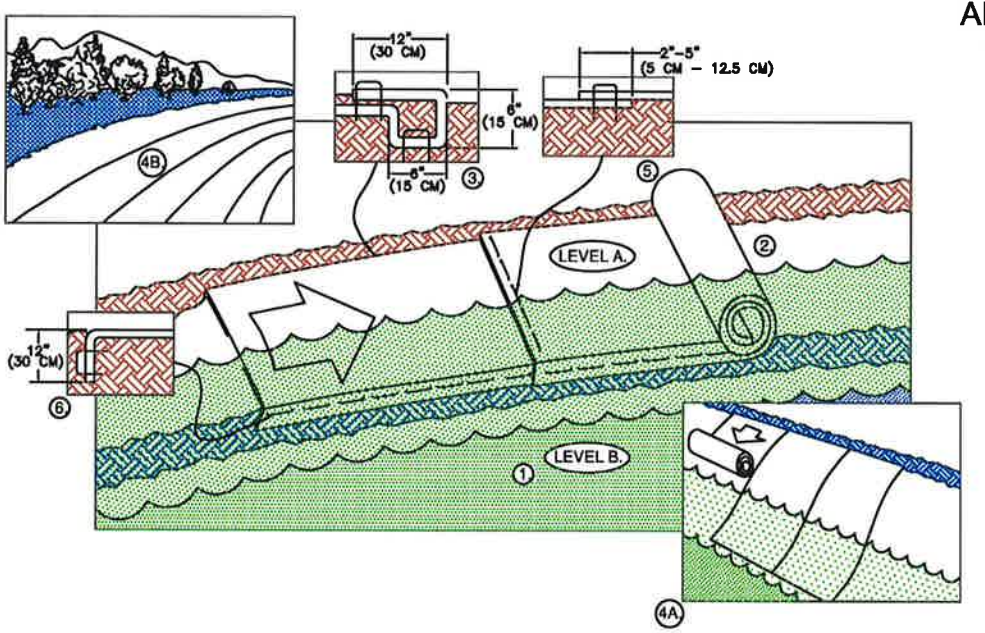
NOTA:
* EN CONDICIONES DE SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGURAR LAS MANTAS CORRECTAMENTE.

REV. 1/2004

NORTH AMERICAN GREEN

SHORELINE INSTALLATION

APLICACIONES PARA LAS LINEAS COSTERAS



1. FOR EASIER INSTALLATION, LOWER WATER FROM LEVEL A TO LEVEL B BEFORE INSTALLATION.
2. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED NOTE: WHEN USING CELL-O-SEED, DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
3. BEGIN AT THE TOP OF THE SHORELINE BY ANCHORING THE BLANKET IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30 CM) OF BLANKET EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART ACROSS THE WIDTH OF THE BLANKET.
4. ROLL BLANKETS EITHER (A.) DOWN THE SHORELINE FOR LONG BANKS, (TOP TO BOTTOM) OR (B.) HORIZONTALLY ACROSS THE SHORELINE SLOPE. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM™, STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
5. THE EDGES OF ALL HORIZONTAL AND VERTICAL BLANKET SEAMS MUST BE STAPLED WITH APPROXIMATELY 2" – 5" (5 CM – 12.5 CM) OVERLAP.

   NOTE:
   * SEAM OVERLAP SHOULD BE SHINGLED ACCORDING TO PREDOMINANT EROSIVE ACTION.
6. THE EDGE OF THE BLANKET AT OR BELOW NORMAL WATER LEVEL MUST BE ANCHORED BY PLACING THE BLANKET IN A 12" (30 CM) DEEP X 6" (15 CM) WIDE ANCHOR TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART IN THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING (STONE OR SOIL MAY BE USED AS BACKFILL.)

   NOTE:
   * IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.

---

1. PARA UNA INSTALACION MAS FACIL, BAJE EL NIVEL DEL AGUA DEL PUNTO A AL PUNTO B, ANTES DE LA INSTALACION.
2. PREPARE EL TERRENO ANTES DE LA INSTALACION DE LAS MANTAS, INCLUYENDO APLICACION DE CAL, FERTILIZANTE Y SEMILLA. NOTA: CUANDO ESTE USANDO CELL-O-SEED NO SIEMBRE EL ARIA PREPARADA. CELL-O-SEED TIENE QUE INSTALARSE CON EL LADO DE PAPEL HACIA ABAJO.
3. COMIENCE EN LA CABECERA DE LA LINEA COSTERA SUJETANDO LA MANTA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO CON APROXIMADAMENTE 12" (30 CM) DE LA MANTA EXTENDIDA MAS ALLA DE LA PENDIENTE ALTA DE LA ZANJA. SUJETE LA MANTA AL FONDO DE LA ZANJA CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30cm) UNA BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30cm) DE LA ORTA. RELLENE Y COMPACTE LA ZNAJA DESPUES DEL ENGRAPE. RIEGUE LA SEMILLA EN EL SUELO COMPACTADO Y DOBLE LAS 12" (30 CM) REMANENTES DE MANTA SOBRE LA SEMILLA Y EL SUELO COMPACTADO. ASEGURE LA MANTA SOBRE EL SUELO CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA ORTA A TRAVES DEL ANCHO DE LA MANTA.
4. DESENROLLE LAS MANTAS (4A) HACIA ABAJO EN LA LINEA COSTERA PARA RIBERAS LARGAS U (4B) HORIZONTALMENTE A TRAVES DE LA PENDIENTE DE ESTA CON EL LADO APROPIADO HACIA LA SUPERFICIE DEL SUELO. TODAS LAS MANTAS DEBERAN ASEGURARSE A LA SUPERFICIE DEL SUELO POR NEDIO DE GRAPAS O ESTACAS EN LUGARES APROPIADOS TAL Y COMO SE INDICA EN EL PATRON GUIA DE ENGRAPADO. CUANDO ESTE USANDO EL DOT SYSTEM™, LAS GRAPAS O ESTACAS DEBEN COLOCARSE A TRAVES DE CADA UNO DE LOS PUNTOS CON COLOR CORRESPONDIENTES AL PATRON DE ENGRAPADO APROPIADO.
5. LOS BORDES DE LAS COSTURAS DE LAS MANTAS HORIZONTALES Y VERTICALES DEBEN ENGRAPARSE CON UN TRASLAPE DE APROXIMADAMENTE 2" – 5" (5 CM – 12.5 CM).

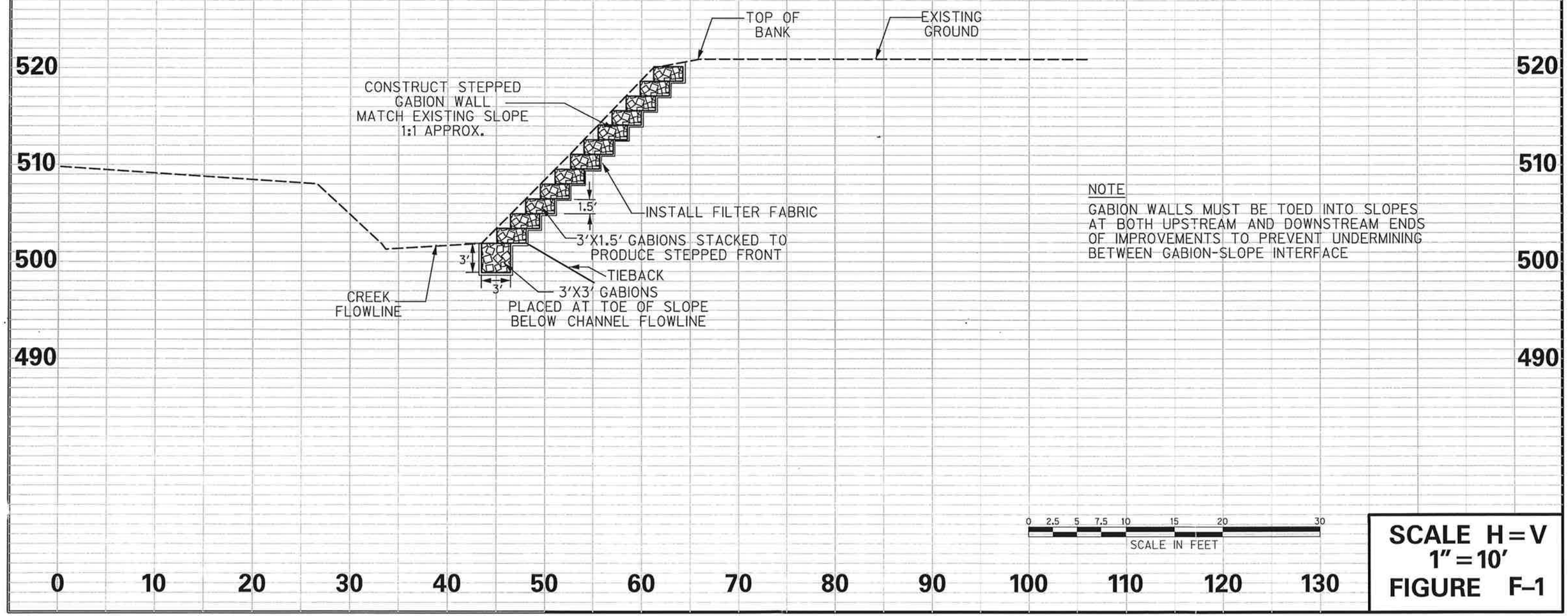
   NOTA:
   * LA COSTURA DEL TRASLAPE DEBE CUBRIRSE DE ACUERDO A LA ACCION PREDOMINANTE DE EROSION.
6. EL BORDE DE LA MANTA QUE ESTA AL O POR DEBAJO DEL NIVEL DE AGUA NORMAL DEBE ASEGURARSE COLOCANDOLO EN UNA ZANJA DE ANCLAJE DE 12" (30 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO. ASEGURE LA MANTA EN LA ZANJA CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE A 12" (30 CM) UNA DE LA OTRA. RELLENE Y COMPACTE LA ZANJA DESPUES DE ENGRAPAR (PIEDRAS O SUELO PUEDE USARSE COMO RELLENO).

   NOTA:
   * EN CONDICIONES DE SUELO SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGURAR LAS MANTAS CORRECTAMENTE.

Hard Armor Solutions

JOE POOL LAKE
STREAM BANK STABILITY
ASSESSMENT

TYPICAL SECTION
STEPPED GABION WALL



NOTE

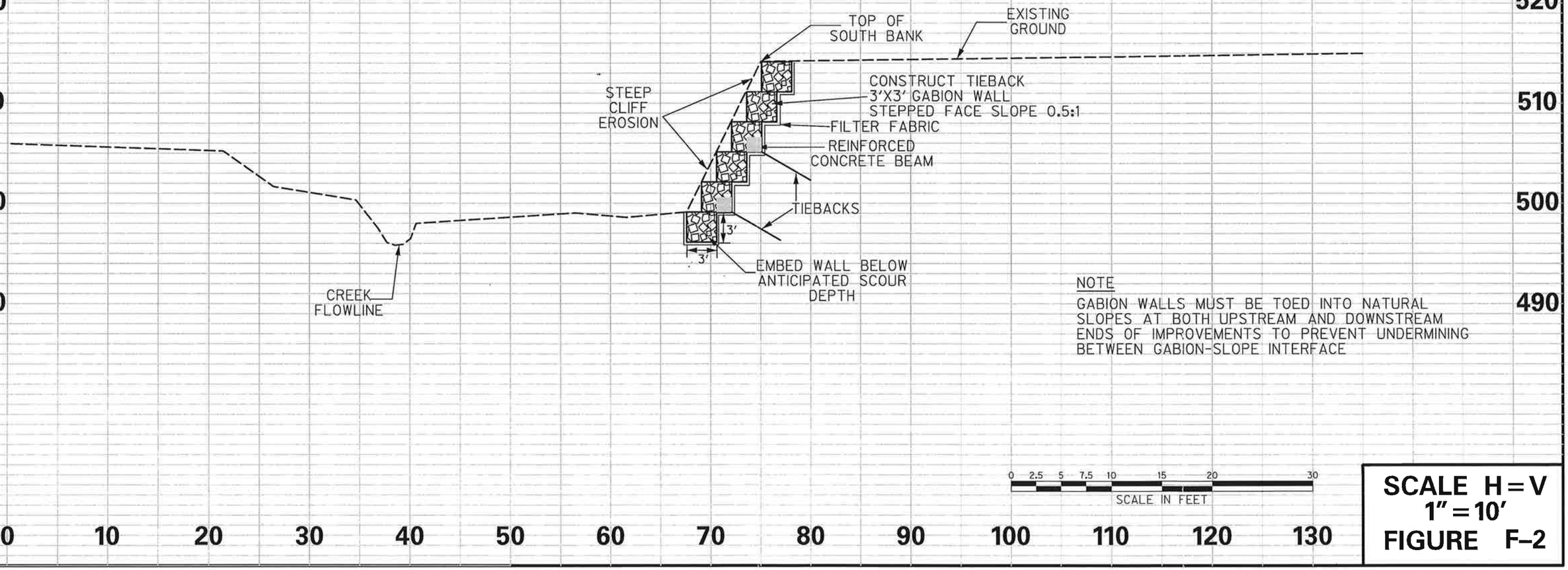
GABION WALLS MUST BE TOED INTO SLOPES AT BOTH UPSTREAM AND DOWNSTREAM ENDS OF IMPROVEMENTS TO PREVENT UNDERMINING BETWEEN GABION-SLOPE INTERFACE

0 2.5 5 7.5 10 15 20 30
SCALE IN FEET

SCALE H = V
1" = 10'
FIGURE F–1

JOE POOL LAKE
STREAM BANK STABILITY
ASSESSMENT

TYPICAL SECTION
TIEBACK GABION WALL



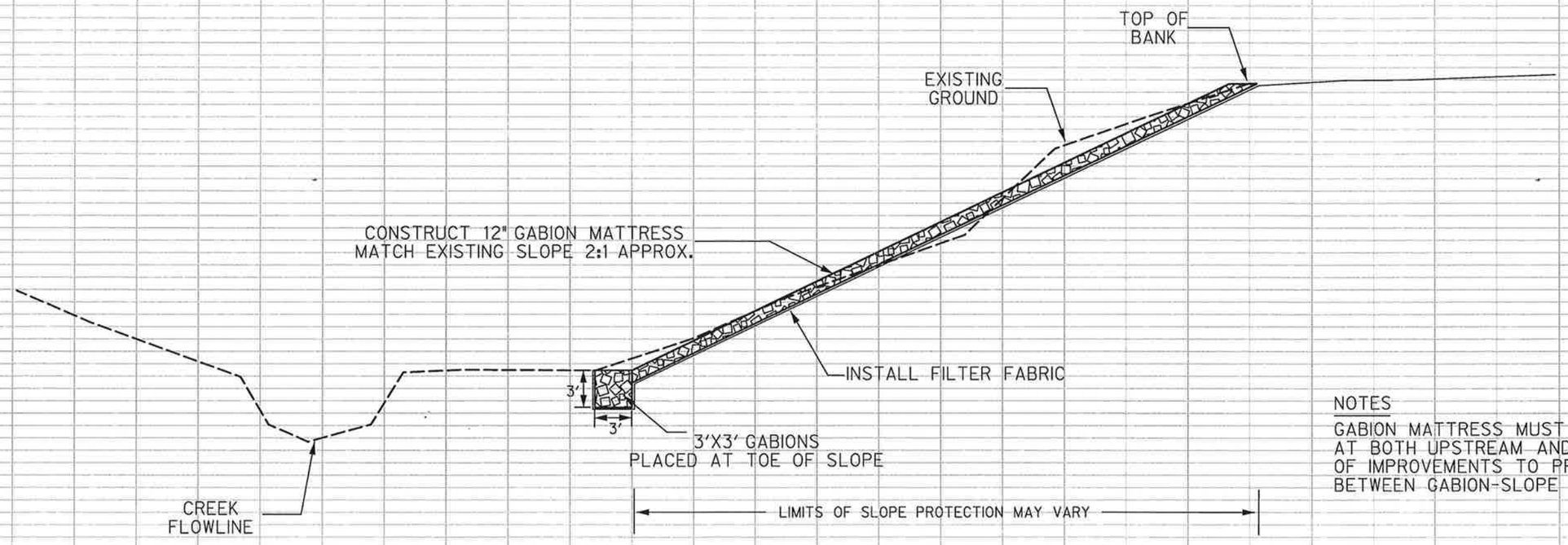
NOTE

GABION WALLS MUST BE TOED INTO NATURAL SLOPES AT BOTH UPSTREAM AND DOWNSTREAM ENDS OF IMPROVEMENTS TO PREVENT UNDERMINING BETWEEN GABION-SLOPE INTERFACE

SCALE H = V
1" = 10'
FIGURE F-2

JOE POOL LAKE
STREAM BANK
STABILITY ASSESSMENT

TYPICAL SECTION
GABION MATTRESS



NOTES

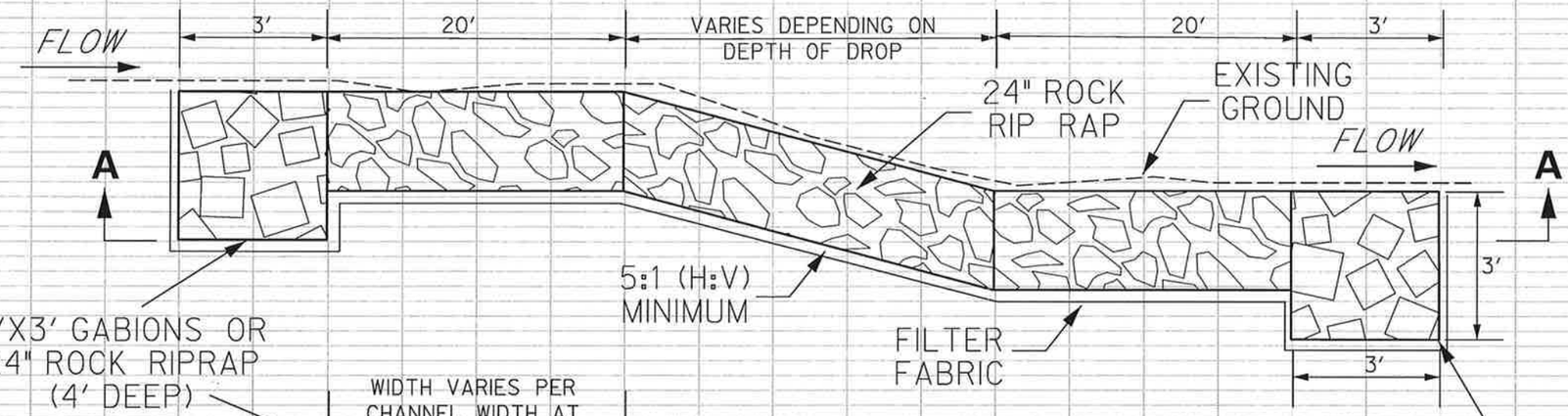
GABION MATTRESS MUST BE TOED INTO SLOPES AT BOTH UPSTREAM AND DOWNSTREAM ENDS OF IMPROVEMENTS TO PREVENT UNDERMINING BETWEEN GABION-SLOPE INTERFACE

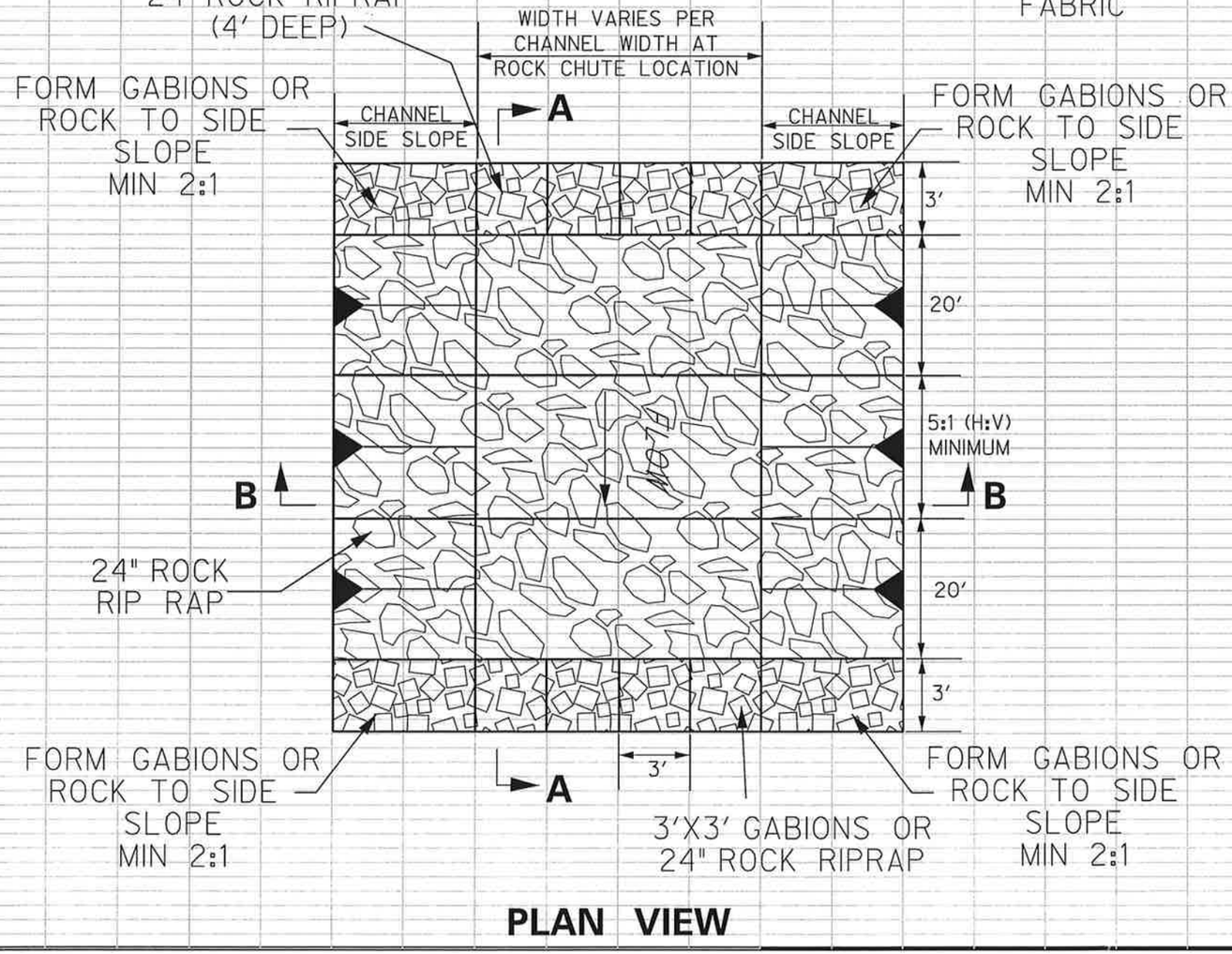
0 2.5 5 7.5 10 15 20 30
SCALE IN FEET

SCALE H = V
1" = 10'
FIGURE F-3

JOE POOL STUDY
ROCK CHUTE
TYPICAL SECTION

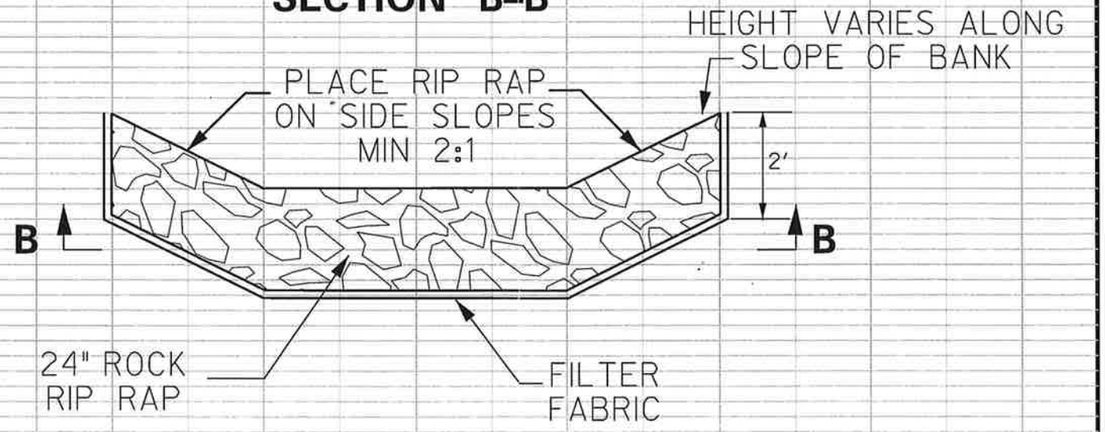
PROFILE VIEW
SECTION A–A





PLAN VIEW

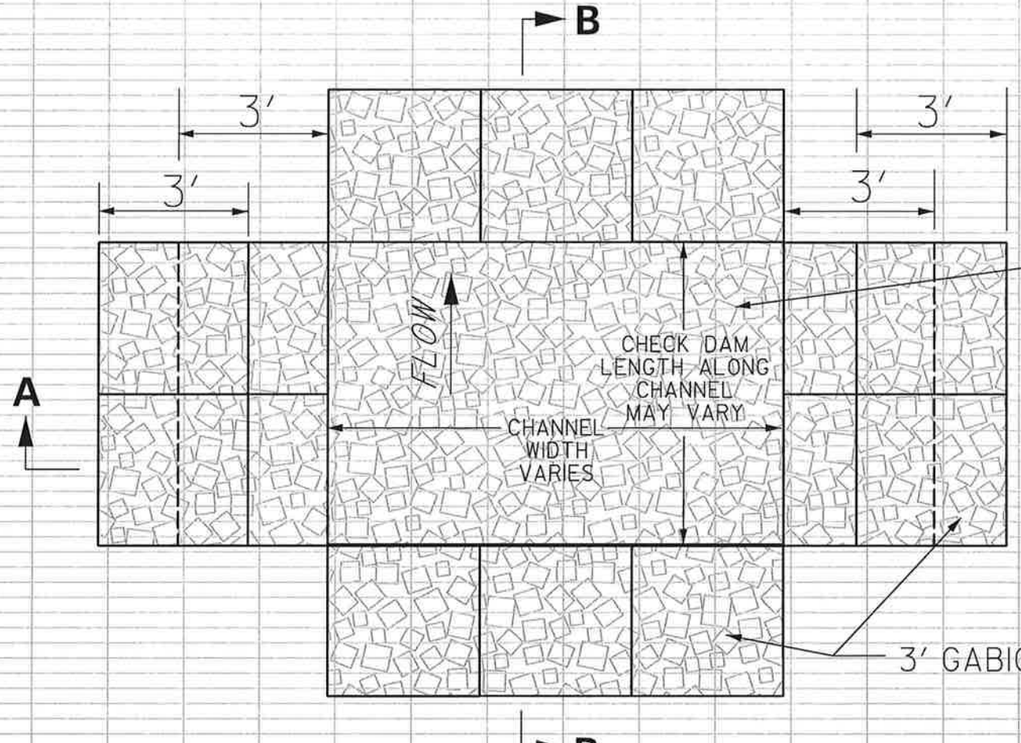
FRONT VIEW
SECTION B–B



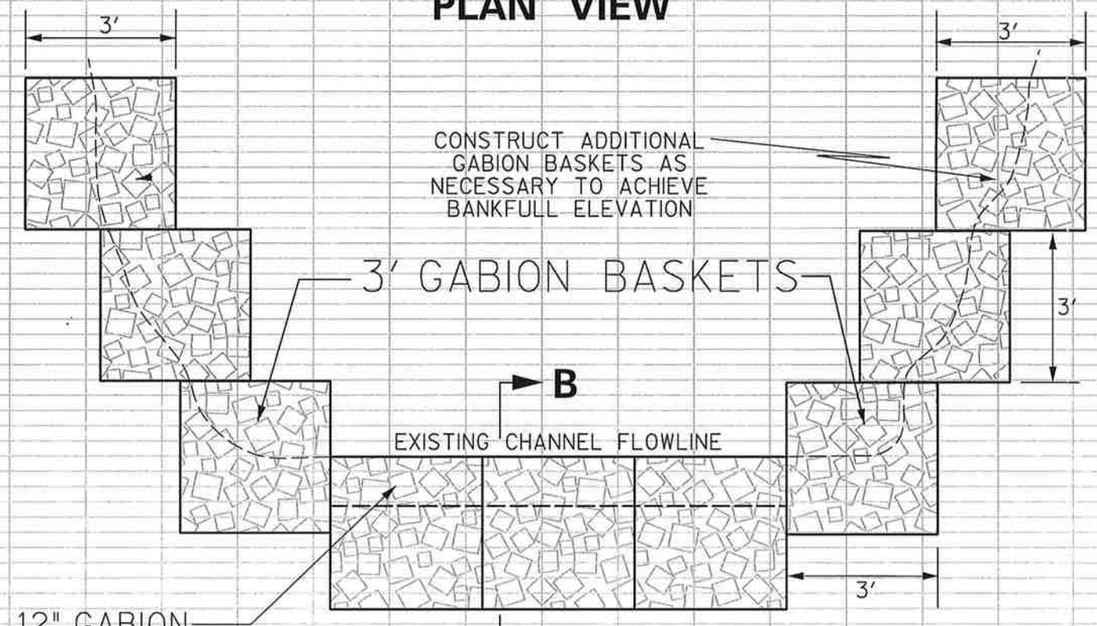
NOTE:
1. HEIGHT OF ROCK CHUTES WILL VARY ACCORDING TO BANKFULL ELEVATION AT SPECIFIC LOCATIONS.
2. IF NO GRADE CHANGE EXISTS, "DROP" PORTION OF CHUTE CAN BE REMOVED.

SCALE H=V
1"=3'
FIGURE F–4

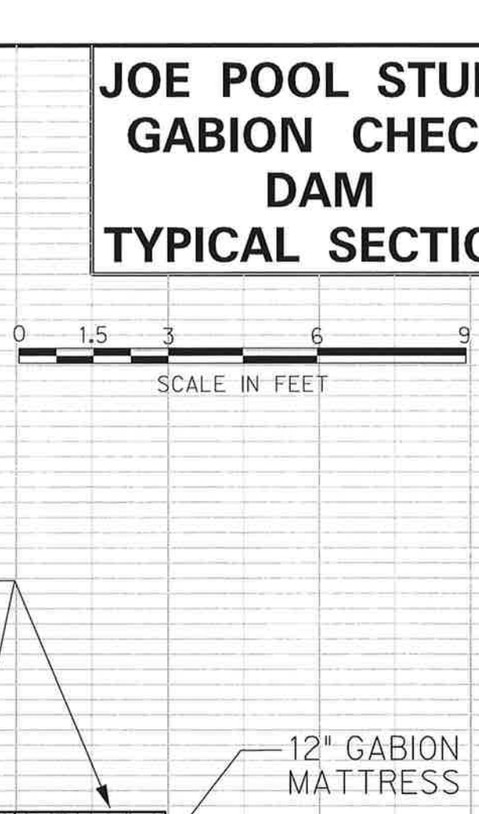
JOE POOL STUDY
GABION CHECK DAM
TYPICAL SECTION



PLAN VIEW



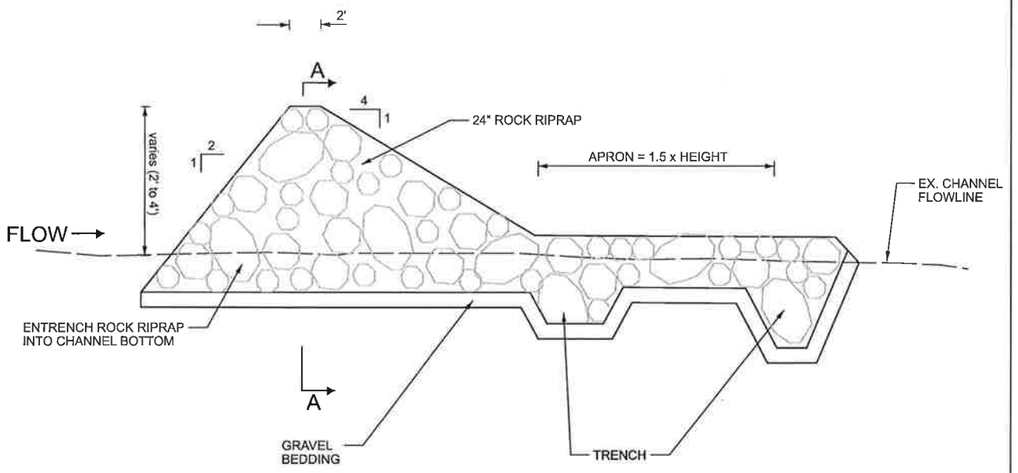
CHANNEL VIEW
SECTION A-A



SIDE VIEW
SECTION B-B

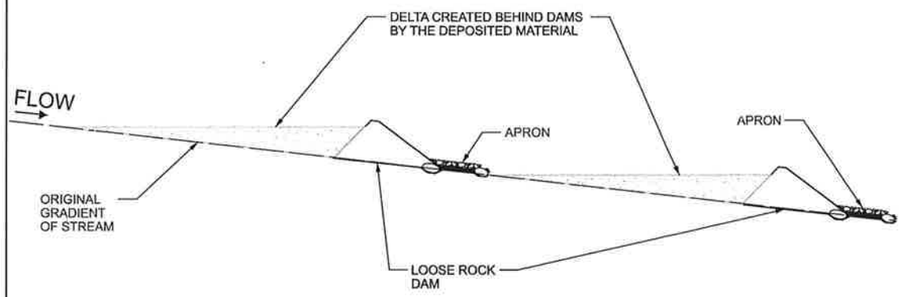
SCALE H = V
1" = 3′
FIGURE F-5

LOOSE ROCK DAM PROFILE



PROFILE VIEW SECTION A-A

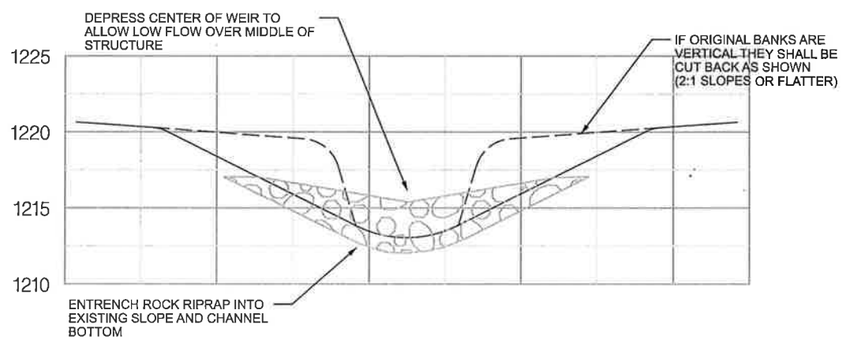
SCALE:
1" = 10' HORIZ.
1" = 4' VERT.



LOOSE ROCK DAMS

NO SCALE

LOOSE ROCK DAM PROFILE



SECTION A-A

SCALE:
1" = 10' HORIZ.
1" = 10' VERT.

GENERAL NOTES:

18" ROCK RIPRAP SHALL BE USED FOR LOOSE ROCK DAM CONSTRUCTION.

CUT A 4- TO 6-INCH TRENCH ACROSS THE GULLY AND UP THE SIDES TO ANCHOR LARGER HEAVY ROCKS ON THE DOWNSTREAM TOE OF THE DAM. PLACE A ROW OF LARGE ROCKS ALONG THIS TRENCH TO FORM THE DOWNSTREAM TOE. PROVIDE APRON WITH ADDITIONAL TOE DOWNSTREAM.

Symbol	Description	Tracking Action	Date

Date: APR 2007 | Rev.
Proj. No. 23159
Work Order No. W.O. #540.26
Designed by
Dwn. by: BBP
Reviewed by: SBC
Submitted by: SBC

Halff Associates
ENGINEERS • ARCHITECTS • PLANNERS • SURVEYORS

JOE POOL STUDY
LOOSE ROCK DAM

FIGURE
F-6

Appendix G
U.S. Army Corps of Engineers
Nationwide Permits
Individual Permit Application

US Army Corps of Engineers

Regulatory Program Information

- National Regulatory Program Home Page: http://www.usace.army.mil/inet/functions/cw/cecwo/reg/
- Fort Worth District Regulatory Home Page: http://www.swf.usace.army.mil/pubdata/environ/regulatory/index.asp
- Galveston District Regulatory Home Page: www.swg.usace.army.mil/reg/
- Tulsa District Regulatory Home Page: www.swt.usace.army.mil/permits/permits.cfm
- Albuquerque District Regulatory Home Page: www.spa.usace.army.mil/reg/

One Corps Serving The Army and the Nation

US Army Corps of Engineers

Corps Contacts in Texas and Southwestern Division

Fort Worth District	(817) 886-1731
Little Rock District	(501) 324-5296
Galveston District	(409) 766-3930
Tulsa District	(918) 669-7400
Albuquerque District	(915) 568-1359

One Corps Serving The Army and the Nation

Appendix H
Miscellaneous

City Resolution No. 3919

RESOLUTION NO. 3919

A RESOLUTION ESTABLISHING A POLICY CONCERNING EROSION AND OTHER DRAINAGE PROBLEMS RELATING TO WATERWAYS.

WHEREAS, the City Council has determined that Erosion problems along the Trinity River and Creeks in the city are of concern to the City.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF GRAND PRAIRIE, TEXAS:

SECTION 1. That it is hereby determined to be in the best interests of the City of Grand Prairie, Texas and its inhabitants to adopt the following drainage policy:

Erosion and/or flooding problems on private property will be investigated on a case-by-case basis. The City will focus on improvements to the waterways that will result in a general public benefit, such as lowering erosive velocities and increasing flow capacities in proximate streams for the general prevention of erosion and flooding.

Remedy of private property issues, such as flooding due to lot-to-lot drainage (no involvement of City property) and construction projects to protect specific private property due to proximate stream erosion, will not be undertaken by the City unless a general public benefit or public safety concern can be demonstrated, and the undertaking of such are approved by the City Council. Individual projects will be evaluated and prioritized based on available funding.

SECTION 2. That this resolution shall become effective immediately upon its passage and approval.

PASSED AND APPROVED BY THE CITY COUNCIL OF THE CITY OF GRAND PRAIRIE, TEXAS, this 17th **day of** June**, 2003.**

Mayor, Grand Prairie, Texas

ATTEST:

Catherine E. DiMaggio, City Secretary

APPROVED AS TO FORM:

Donald R. Postell, City Attorney

2006 Stream Assessment Report
Peter Allen

Halff Associates, Inc.

CWDMP for Joe Pool Lake (W.O.#581.40) **AVO 26418**

Joe Pool Stream Assessment

For the City of Grand Prairie

Halff Associates
Peter M. Allen and Jeff G. Arnold
December 2005

General Physiography

The study area is located in the Eagle Ford Prairie subdivision of the Blackland Prairie section of the Coastal Plain physiographic province. The major topographic feature of the area is the White Rock Escarpment which is located about a half mile east of the basins located on the east side of Joe Pool reservoir. The escarpment has a vertical relief of 200-250 feet and is the result of differential weathering and erosion of the Austin Chalk caprock and the underlying Eagle Ford shale by the ancestral Mountain Creek and its tributaries (Allen, 1977). The bedrock underlying the sub-basins consists of upper Cretaceous sediments of the Eagle Ford Formation. The Eagle Ford consists predominantly of soft to moderately hard clay shale with a thickness of about 225 feet in the vicinity of the project. This material dips to the southeast at approximately 50 feet per mile. There are three dominant outcropping units within the area, Figure 1 .

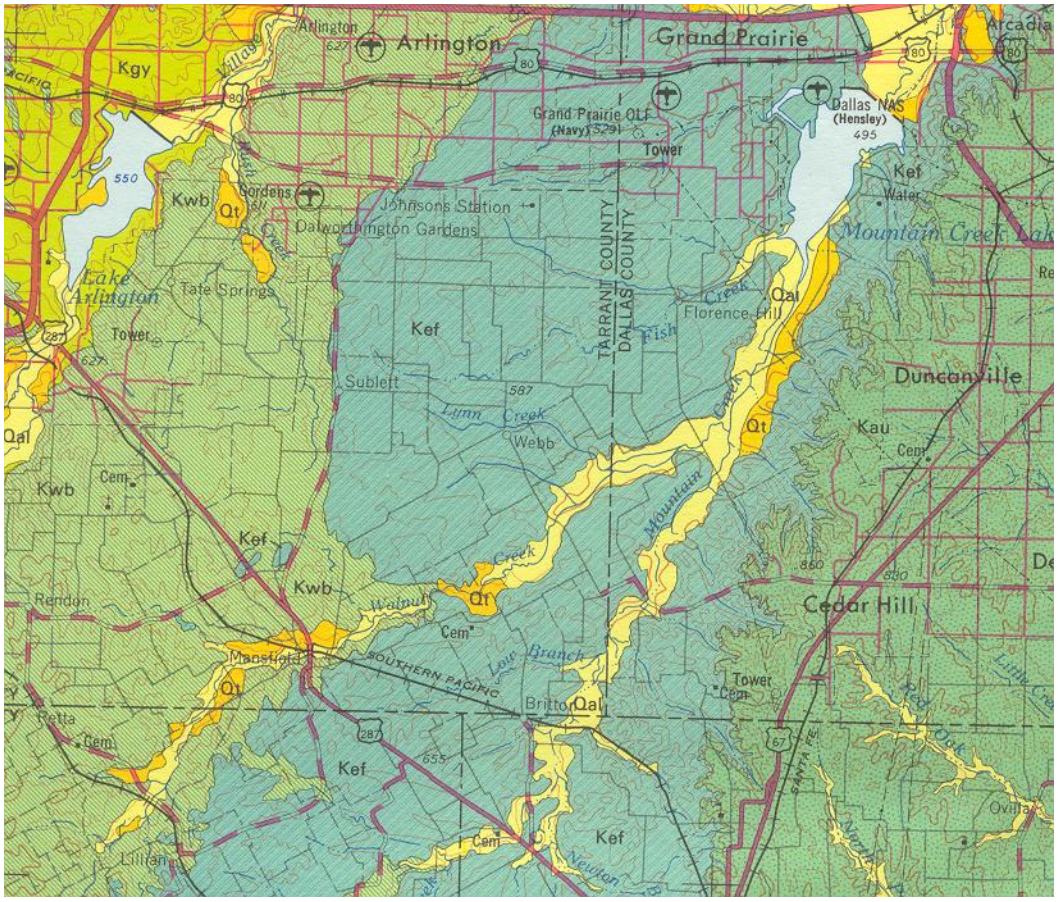
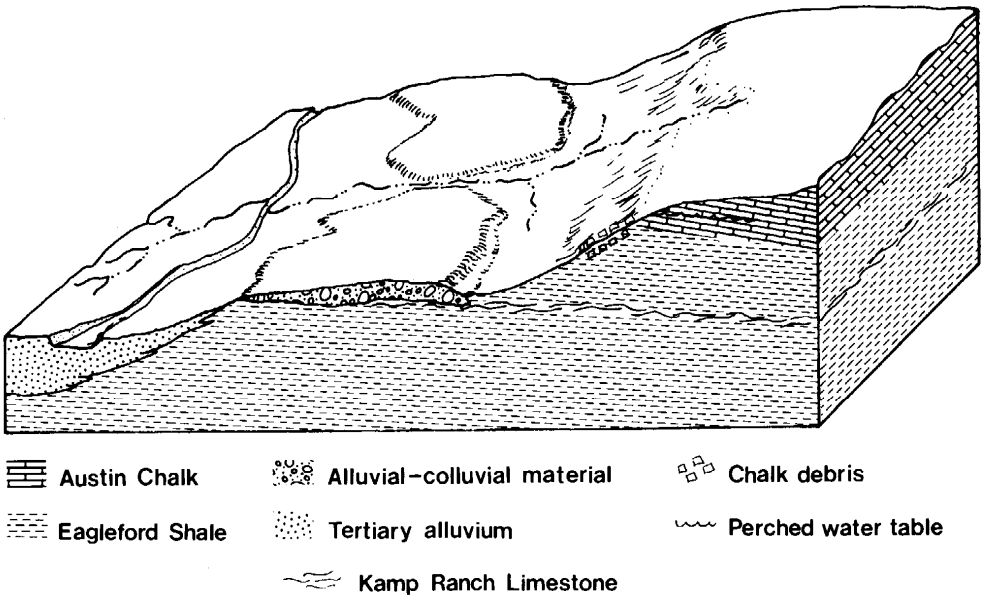


Figure 1 Geology Map of Study Area. Site falls in the outcropping area of Kef; Cretaceous age Eagle Ford Shale (Bureau of Economic Geology).



Surficial Units

Floodplain Unit

Definition
The portion of the river valley adjacent to the river; built of alluvial sediment by the present stream regime; covered with water when the river overflows its banks at flood stages.

Description
Dark gray to tan brown slight to moderately calcareous clay locally interbedded with sandy clay and minor quantities of gravel over areas of outcropping Eagle Ford Shale.

Thickness
Approximately 4 feet on small intermittent streams to a maximum of 20 feet near Mountain Creek.

Slope
Slope is from 0-3%.

Associated Soils
Frio, Trinity, Heiden

Terrace/Alluvial Colluvial Deposits

Definition

Flat to gently sloping topographic alluvial benches above the present floodplain which are remnants of an older floodplain

Description

Impervious brown to tan clay and semipervious clayey sand and gravel; gravel locally cemented to form conglomerate lentils 1-2 feet thick; abrupt changes in lithology both vertically and horizontally from clay to sand and limestone gravel. Materials occur as lenticular bodies which can seldom be traced from one gravel pit to another.

Thickness

Varies from a few feet to 20-55 feet; grades into recent alluvial deposits toward the west.

Slope

Natural slopes range from 1-3 %.

Associated Soils

Houston Black, Heiden

Alluvio-Colluvial Unit

Definition

Stream deposits and slope wash (colluvium) derived from the escarpment area to the west.

Description

Ranges from 2-10 feet of black to dark brown clay underlain in places by 4-10 feet of subangular gravel and weathered chalk debris covering Eagle Ford Shale; chalk debris is locally cemented into conglomerate lentils 1-2 feet thick. These old surfaces appear as dissected flat surfaces found to the west of the escarpment cuesta. They slope gently to the west toward Mountain Creek. They are interpreted to be old stream or alluvial

surfaces which were shed from the eroding escarpment during a dryer interval during the Quaternary period (Allen, 1977).

Thickness

Presumed maximum thickness over the shale bedrock is 15 feet.

Slope

Slope ranges from 2-8%.

Associated Soils

Houston Black, Brackett, Lewisville, Heiden

Bedrock Units

Acadia Park (Eagle Ford Shale)

Description

The Acadia Park member of the Eagle Ford is found in a few of the subbasins. It is a dark to grayis black, light olive gray weathering very finely laminated, very slightly calcareous to noncalcareous clay shale. The unit weathers into small flakes of shale. Large discoidal masses of limestone, concretions, occur in this unit about 4-60 feet below the Austin Eagle Ford Contact. These concretions range in size from a few inches to several feet in diameter.

Thickness

Approximately 80-100 feet

Slope

Ranges from 40% near the escarpment to 5% down slope.

Associated Soils

Ellis, Heiden Ferris

Kamp Ranch Limestone (Eagle Ford)

Description

This unit consists of 1-3 feet of yellow gray brown weathering, moderately hard limestone flags that are found approximately 100 feet below the Austin Chalk Eagle Ford Shale contact. This unit outcrops along stream channels where it typically forms a semi resistant knickpoint.

Thickness

1-3.5 feet

Upper Britton (Eagle Ford)

Description

This is the primary unit underlying the streams in the area. This rock consists of a dark blue gray fine to coarsely laminated concretion bearing, compaction type clay shale. It is much less calcareous and softer than the underlying Lower Britton. Limestone and clay-stone concretions and discontinuous seams up to one foot thick are common in this unit and are found about 20-30 feet below the Kamp Ranch Limestone member.

Thickness
Approximately 160-200 feet total

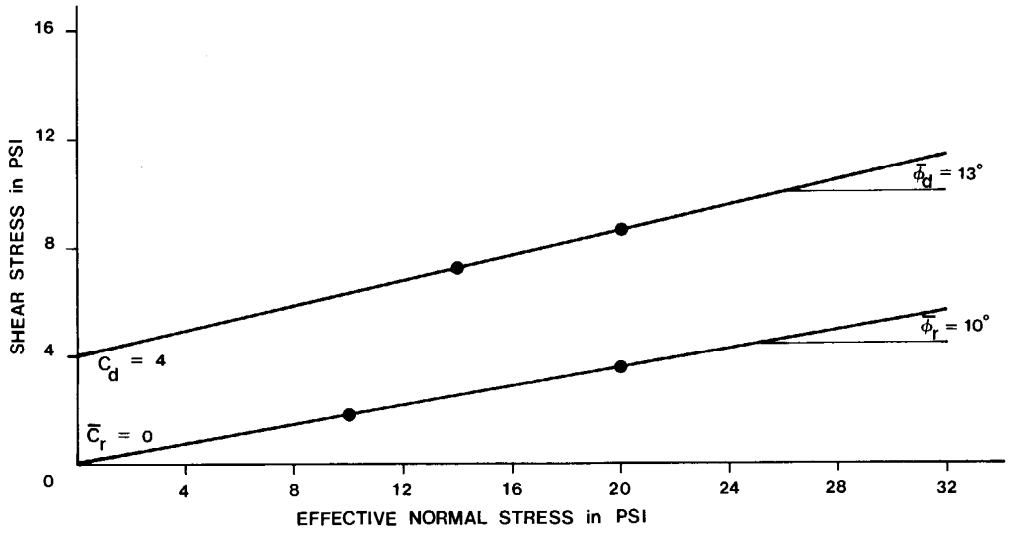
Slope
From 3-20%.

Associated Soils

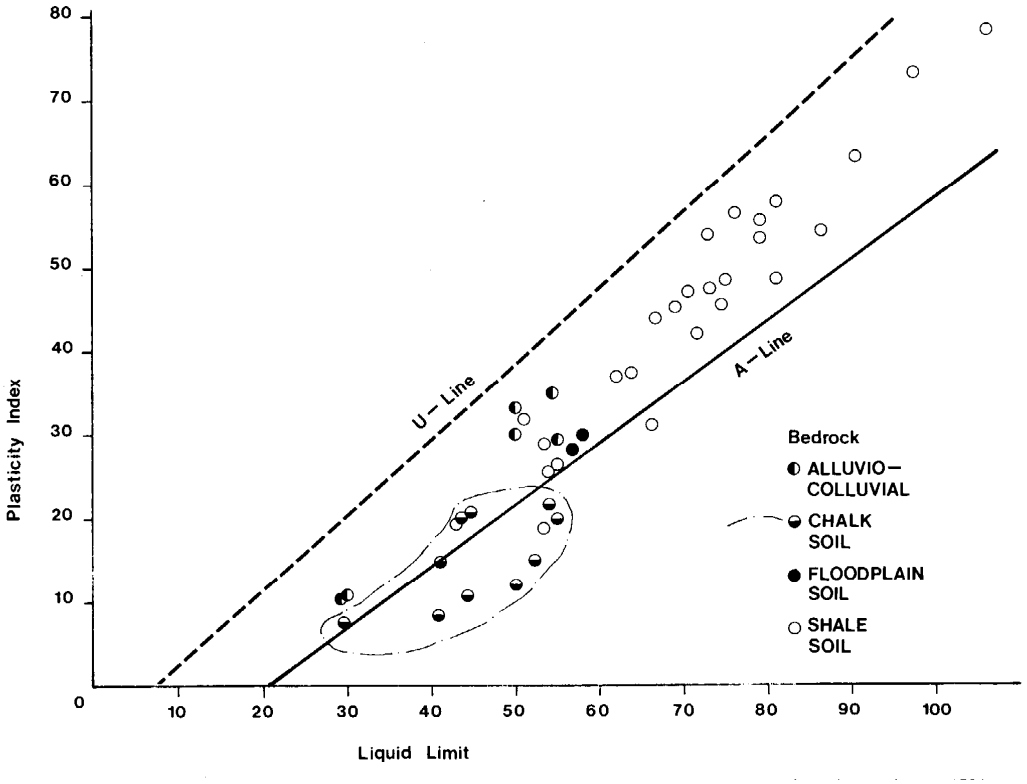
Heiden, Ferris

Engineering Properties

Laboratory tests indicate that the bedrock units are highly ductile with high liquid limits, plasticity indices, and clay content. Strength tests substantiate the fact that the shale is heavily over consolidated which tend to expand when subject to a shear stress, and typically exhibit negative pore water pressures at failure. According to the US Army Corps of Engineers, groundwater levels vary between 40-20 feet or less below the ground surface.



Typical shear tests for this area are shown after Font (1976) which indicate the consolidated drained and residual strength tests in this material. Of note is the large loss in strength with weathering which occurs over time in this shale; low residual strength values. For 25 slope failures in the shale in central Texas, post mortem analysis has shown the internal angle of friction to be in the range of 17 (std.dev. 3) and cohesion of 41 (std. dev. 21). These examples illustrate the loss of strength with weathering in the shale and the overall trend to residual values.



This diagram indicates the relationship of soil Atterberg limits to the geomorphic units in the sub-basins. In general, side slopes and floodplain soils possess the highest shrink swell characteristics; high PI's and high LL.

	Strength Parameters			
	Cohesive Intercepts (PSI)		Angles of Internal Friction (Degrees)	
Bedrock Unit	Consolidated Undrained C_{cu}	Residual Strength C_r	Consolidated Undrained ϕ_{cu}	Resudual Strength ϕ_r
Eagle Ford Shale	1.1–4.2	0	13.5	8–10

	Unconfined Compression Test (PSI) Qu
Austin Chalk	3744

	Index Properties					
	Water Contents			Potential Volume Swell Pressure	Clay Content	Dry Unit Weight
Bedrock	LL	PL	PI	(PSF)	(Percent)	(PCF)
Eagle Ford Shale	60–80	26–32	34–48	5,000–25,000	70	82–96

General Engineering Properties of Rocks in Study Area (not for design). After Font (1976).

Soils

Soils of the study watersheds are predominantly CH-CL clays and silty clays with high plasticity and high runoff potential (D hydrologic group). These soils exhibit a pronounced shrink swell behavior; soils crack in the summer months and swell in the wet season. The soils plasticity indices generally range from 35-55. The soils are moderately erodible with erodibility K factors averaging 0.32 for use in the Universal Soil Loss Equation or RUSLE2. (Appendix).

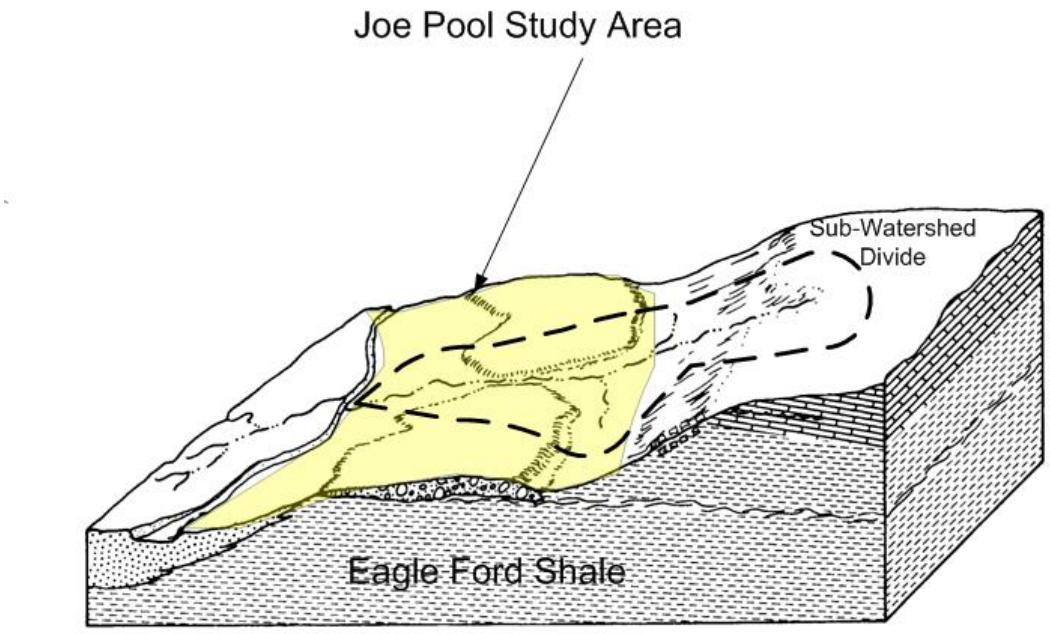
Stream Assessment

The purpose of this section is: (1) to describe the mechanisms of bank and bed erosion which have been observed within the alluvial to rock controlled channels along the watersheds bordering Joe Pool reservoir within the City of Grand Prairie, and (2) to assess rates of erosion and potential equilibrium conditions for the channel. This should aid in design, prioritization, and allocation of erosion control measures within this watershed, and allow for more realistic appraisal of stream stability.

Location

The study area occupies the extreme northern part of the humid subtropical belt which extends inland from the Gulf of Mexico. Average seasonal temperatures range form 46-85 degrees Fahrenheit. Annual precipitation averages 34 inches. Rainfall in the fall and winter is triggered by southward moving continental polar fronts. These fronts produce low intensity long duration storms. The most common storms in April to September are thunderstorms which are responsible for most of the serious flooding (100 year R.I.) in the smaller urban watersheds (1-10 square miles).

The Blackland Prairie study area is underlain by Cretaceous age shales which dip gently to the southeast at 0.54 degrees, (Allen and Flannigan, 1985). The alluvial soils, which form the channel banks, consist of silty clay loams (mollisols) to clays (vertisols). The banks contain over 75 percent silt-clay in the banks. Channel beds vary from hard clay (Quaternary Alluvium) to shale (lower Britton member of the Eagle Ford Shale). Channel slopes vary from approximately **1.5** to down to **0.13** percent. Slopes fall within the coarse bed alluvial region of Sklar and Dietrich (1998). This is consistent with the highly variable amount of bed load found in the channel bottom. Bed load material consists of sand to cobble size limestone, and shale.



A natural basin is defined as a basin with less than 10 percent impervious cover, less than 10 percent of its drainage controlled by reservoirs, and no other human-related factors that would affect peak streamflow (Asquith and Slade, 1999). The two year discharge for natural basins range in this region of Texas ranges from 293 cfs (1 sq. mile) to 1155 cfs (10 sq. miles). Analysis indicates that in a fully developed residential area, flood peaks will be 1.2 to 1.4 times larger than those of a comparable natural area; the annual direct runoff will be about double that of a natural area (Dempster, 1974).
The watersheds in this study are classified as a straight to sinuous (sinuosity of 1.09-1.5), mixed load, slightly entrenched stream with a low width depth ratio and moderately steep slope. Joe Pool streams would be classified as an E-4-5 stream using the Rosgen Classification. Major bed material for the stream is furnished from erosion of limestone found in the stream bed and banks.

Stream	Range Sinuosity
Penwell	1.39-1.62
Bedford	1.97
Small	1.34-1.72
Edge	1.39-1.91
Edge T1	1.4
Mills	1.2
Tarrell	1.05
Stuart	1.19
Swadley	1.37-1.81
Taaffe	1.09

Table 1. Sinuosity of Streams Channel Length/Valley Length

The geomorphic engineering approach used in this study consists of four phases; the general techniques shown in Figure 2.

Flow Chart: Phase I Stream Assessment

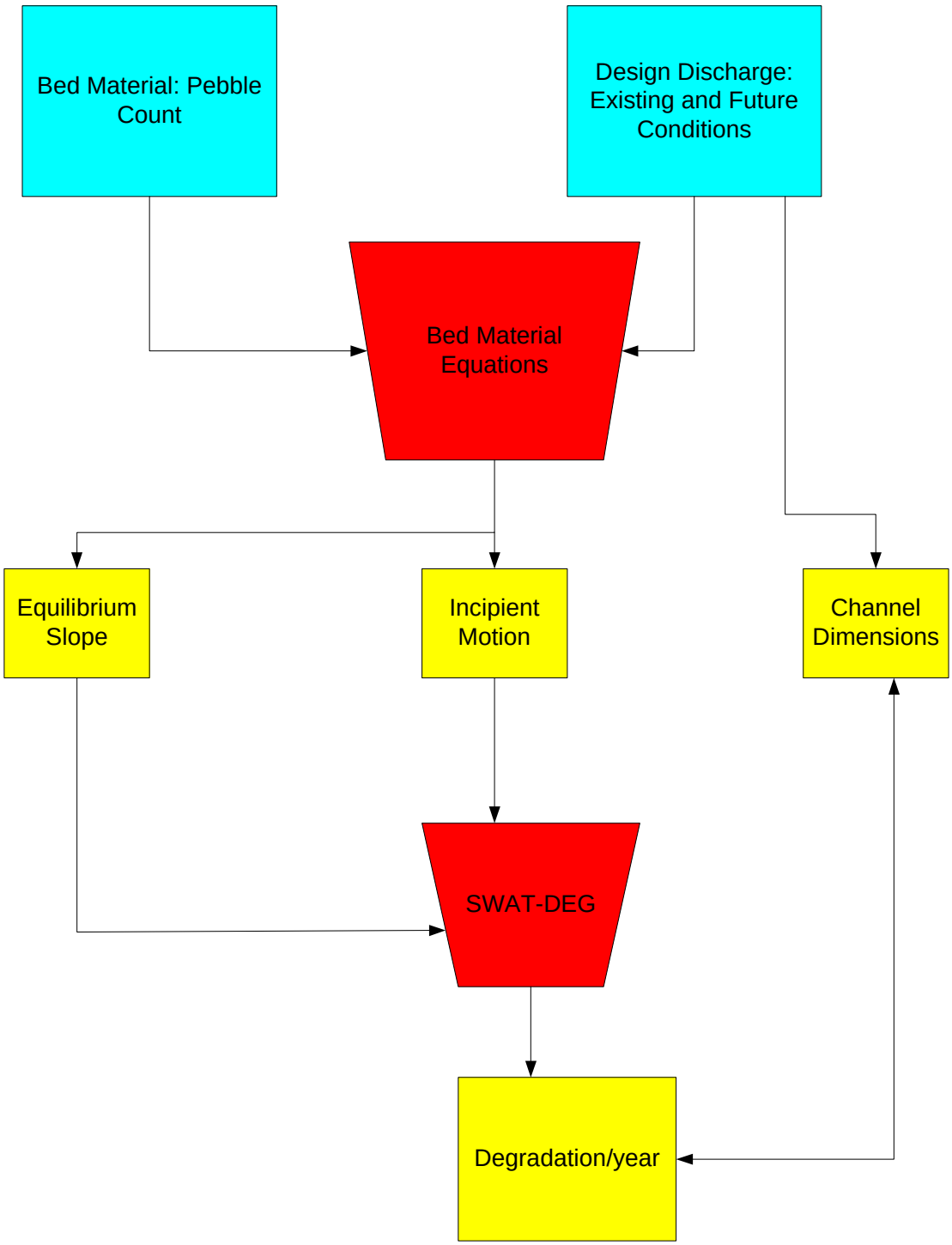


Figure 2. Flow Chart: Phase I Stream Assessment

Phase 1. Involves investigation of the restoration reach using detailed stream reconnaissance techniques. This involves characterizing the channel geometry (bars, pools, riffles, cross sectional characteristics), channel stability status (erosion, slumps, earthflows), bed and bank materials and riparian vegetation, the configuration of the floodplain, and man-made obstructions. Channel surveys record data in 200 foot sections using field data sheets and digital photography. In addition to field surveys, photographs, and maps are used to detail meander geometry. Samples of bed and bank material are taken in the field surveys to assess the size of bed material and the potential geotechnical characteristics of the bed and bank material. In this preliminary study, limited bed samples were taken and historical photographs were not analyzed.

Phase 2. Involves establishing the design or effective discharge for the restoration reach. This is based on the conditions in the approach reach upstream that furnishes the water and sediment and previous studies in the area on the magnitude and frequency of sediment and bed material transport. This discharge is the flow that is responsible for most of the sediment movement over the long term under the proposed land use in the basin.

Phase 3. Uses the bed material and design discharge to determine the equilibrium slope for the reach. This is done by substituting the design discharge into bed material formulas and back solving for the slope at which the bed material just begins to move. This slope is assumed to represent the slope of the stream that will be stable under the new flow conditions. This former approach assumes that the design discharge is adequate to predict changes in the channel system over time. Actually, a series of flows are necessary to maintain the channel; the design discharge is a simplified surrogate for this range of channel forming flows. To test the viability of this assumption, we also run a continuous simulation model to test this assumption. The model also gives us an indication of the timing of potential channel change.

Phase 4. Involves looking at the results of the stable slope analysis and the field derived geomorphic assessment. The stable slope details how far the stream will down cut from its existing condition. In general, channels have been shown to go through a series of steps as they adjust to newly imposed conditions (such as increased impervious surfaces). This series of changes has been documented as the Channel Evolution Model (CEM) by Schumm and Simons.

Threshold Channels

Shields et al. (2003) details the protocol for assessment of channels in which the bed material inflow is negligible and the channel boundary is immobile even at high flows. Much of the theory in channel restoration has evolved in channels in which the channel bed material is mobile and the channel will down cut or aggrade depending on the flow regime and upstream sediment delivery. In the case of the channels in the study area, the channels fall somewhere between alluvial or mobile bed channels and threshold channels. Basically, one must use both types of assessment to adequately design these channels.

The channels in the study area have the following characteristics:

- the bed material is supply limited; it is not present throughout the channel system
- bed material has a wide range in sizes owing to widely varying sources of bed material (local limestone ledges, old terrace deposits)
- the bottom of the channels range from clay to shale; the shale upon weathering/slaking is removed in cases as fast as the soil material

Therefore, the results of this analysis should be used as a general overview of the area. Each channel system will need a more thorough assessment prior to any channel alteration or future performance standards.

Technique	Significant sediment load and movable channel boundaries	Boundary material smaller than sand size	Boundary material larger than sand size	Boundary material does not act as discrete particles	No base flow in channel. Climate cannot support permanent vegetation
Allowable Velocity		**X**			
Allowable Shear Stress			**X**		
Tractive Power				**X**	
Grass Lined Channel					**X**
Alluvial Channel Design	**X**				

From NRCS 2005. Stream Restoration Design Handbook.

Channels in the study are fall into the areas of allowable shear stress and tractive power approaches.

Channel Surveys

During the summer, the sub watersheds were surveyed. Methods utilized in surveying the channels consisted of assessment of channel hydrology and hydraulics, walking each channel, recording channel dimensions, determining channel processes, and identifying potential structural problems.

Channel hydrology and hydraulics were analyzed (Halff associates) using detailed topographic control (2 ft. CI) maps, and HEC-1 and HEC-RAS or HEC-HMS, (U.S. Army Corps Engineers, HEC, 1990a,1990b) hydrology and hydraulics models for assessment of flood heights and channel velocities. General engineering properties of bed and bank materials to such as grain size, Atterberg limits, shear strength were obtained from the literature; and bed load gradation from limited pebble counts.

Channel surveys were conducted on 200 foot reaches; this distance was a compromise between survey speed and the accuracy needed for assessment of rapidly changing channel conditions. Distances were measured using a string-line, which was accurate to one foot. For each reach, data for the channel bottom, side slopes, and structural channel dimensions, were compiled on survey sheets. Information of use on the field sheets depends to some extent on the purpose of the survey. Thorne (1998) gives an excellent checklist of information to consider. For purposes of this survey, the following variables were routinely recorded for each 200 foot reach:

- top width, bottom width, active channel width and depth were measured
- bed material, bedload size (field estimate and photograph), bar location
- Knickpoints, gullies
- pool and riffle areas
- height of rock in channel bank, rock types, alluvium description
- degree and extent of bank erosion (low, moderate, high) The ratings used in this study were slight, moderate and high. High erosion was noted when greater than 75 percent of the active channel was scoured, the bank was near vertical and greater than 4 feet in height, and the roots of any plants were completely exposed. Moderate erosion was cited when the scour was from 50 to 75 percent of the bank and the bank was over 4 feet in height. Minimum scour was noted when the scour was less than 50 percent of the bank height or the bank was less than 4 feet high.
- mass movement, type, dimensions

Photographs were taken of the channel with a digital camera format. The survey information was compiled by stream and results tabulated for comparison of stream reaches within the study area. Based on the results of the channel survey, as well as previous work in the area (Allen and Narramore, 1985), specific erosion mechanisms were identified based on the type of channel boundary material and its position in the channel cross section.

Results and Discussion

Phase I :Channel Survey

The detailed study area includes the Bedford, Penwell, Small, Edge, Mill, Stuart, Swadley, Taaffe, and Tarrell watersheds within the City of Grand Prairie.
The detailed results of the channel survey are noted in the appendix and related photographs. A general summary of the survey results and predicted channel response is shown in Table 2. Shown in the Table and appendices are bed and bank processes and materials, degree of erosion, and associated land use features. In general, most channels began at about 300 feet from the drainage divide in tall grass. See Photographs, Figure 3. The channels ranged from wide swales in the grassland to pool riffle channels downstream (Figure 3). Often, as the valley side slopes widened, the channel became almost indeterminate as it was lost in tall grasses and brush.

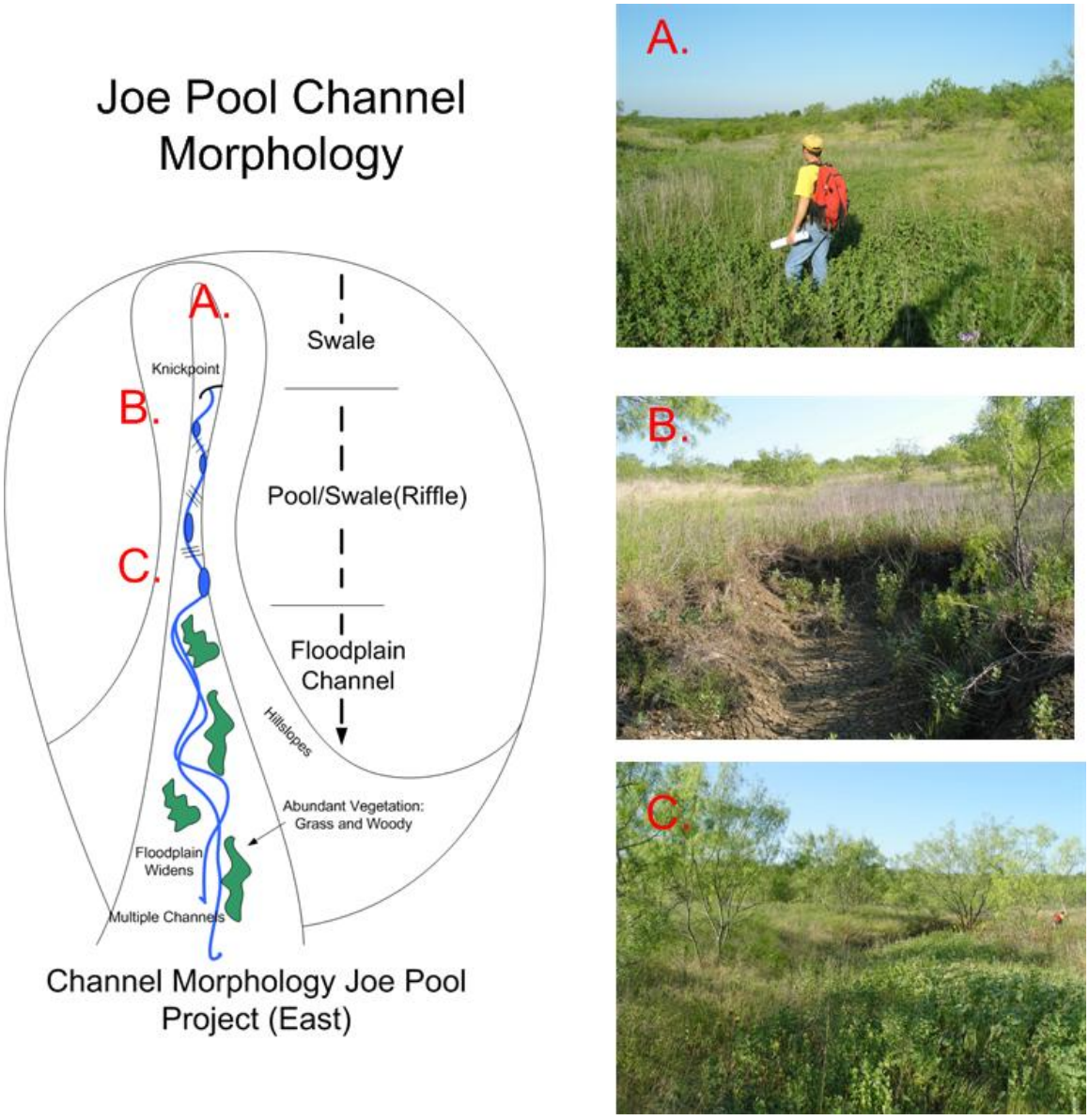
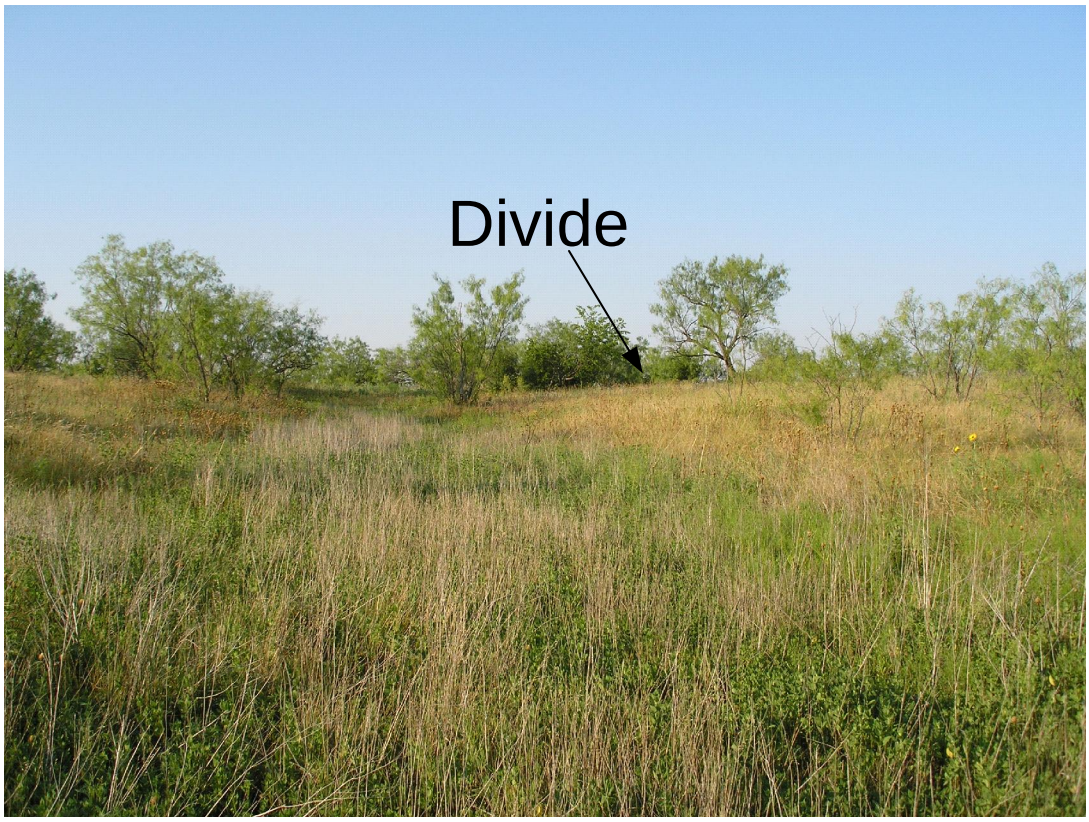
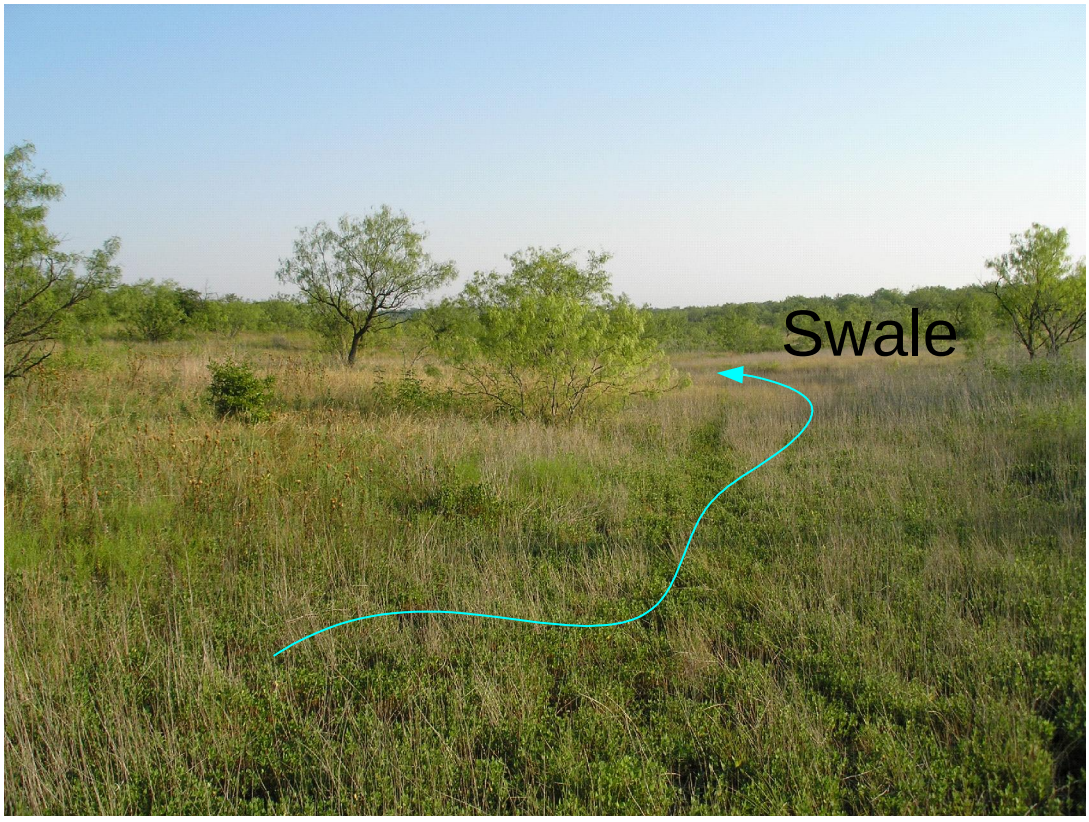
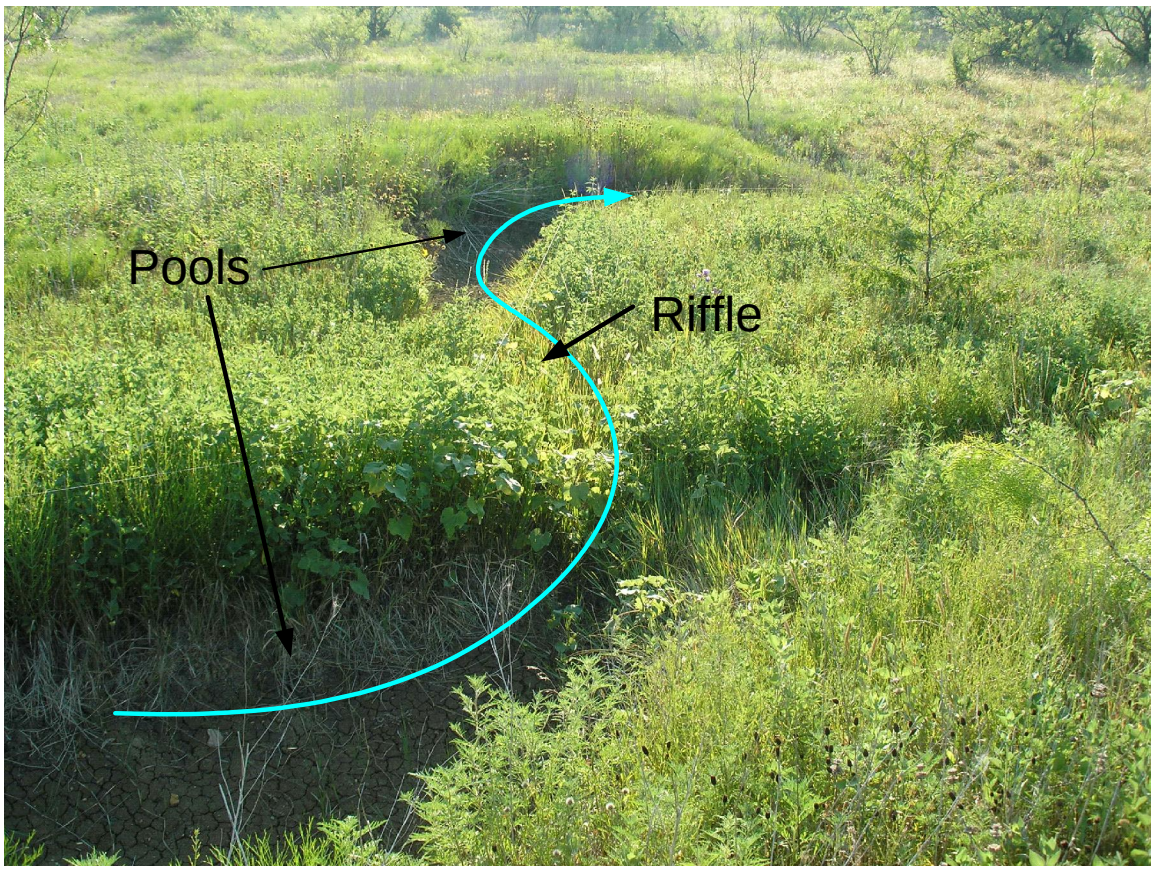


Figure 3. Joe Pool Channel Morphology


Divide


Swale



According to Schumm and others (1984), channels follow a predictable pattern of adjustment with time. The pattern of adjustment varies along the longitudinal profile of the channel, depending on the channel slope and sediment supply. This sequence has been elaborated by Simon and others (2000) who have shown that the sequence can be described as a series of steps toward equilibrium channel conditions. This sequence is often referred to as the Channel Evolution Model (CEM). A simplified figure illustrating the channel Types I-IV which illustrates each step is shown. In general, Type I represents the original channel prior to downcutting. In Type II channels, the major process is degradation, typically through the advance of knickpoints. As the channel downcuts, the sideslopes are oversteepened and the channel banks begin to fail. In Type III channels, the channel is still downcutting, but widening is the major process. As the channel downcuts and widens, it slowly begins to reach a new channel slope which is able to transport the available bed material downstream without long term degradation or aggradation. The channel has now established a new channel and floodplain and begins to establish a new channel and floodplain within this area.

In the study area, all streams are presently classed in Stage I-II; Table 2, Figure 4. The presence of knickpoints is thought to relate back to previous years where the watersheds were overgrazed and discharge was greater and the channels were in Stage II.

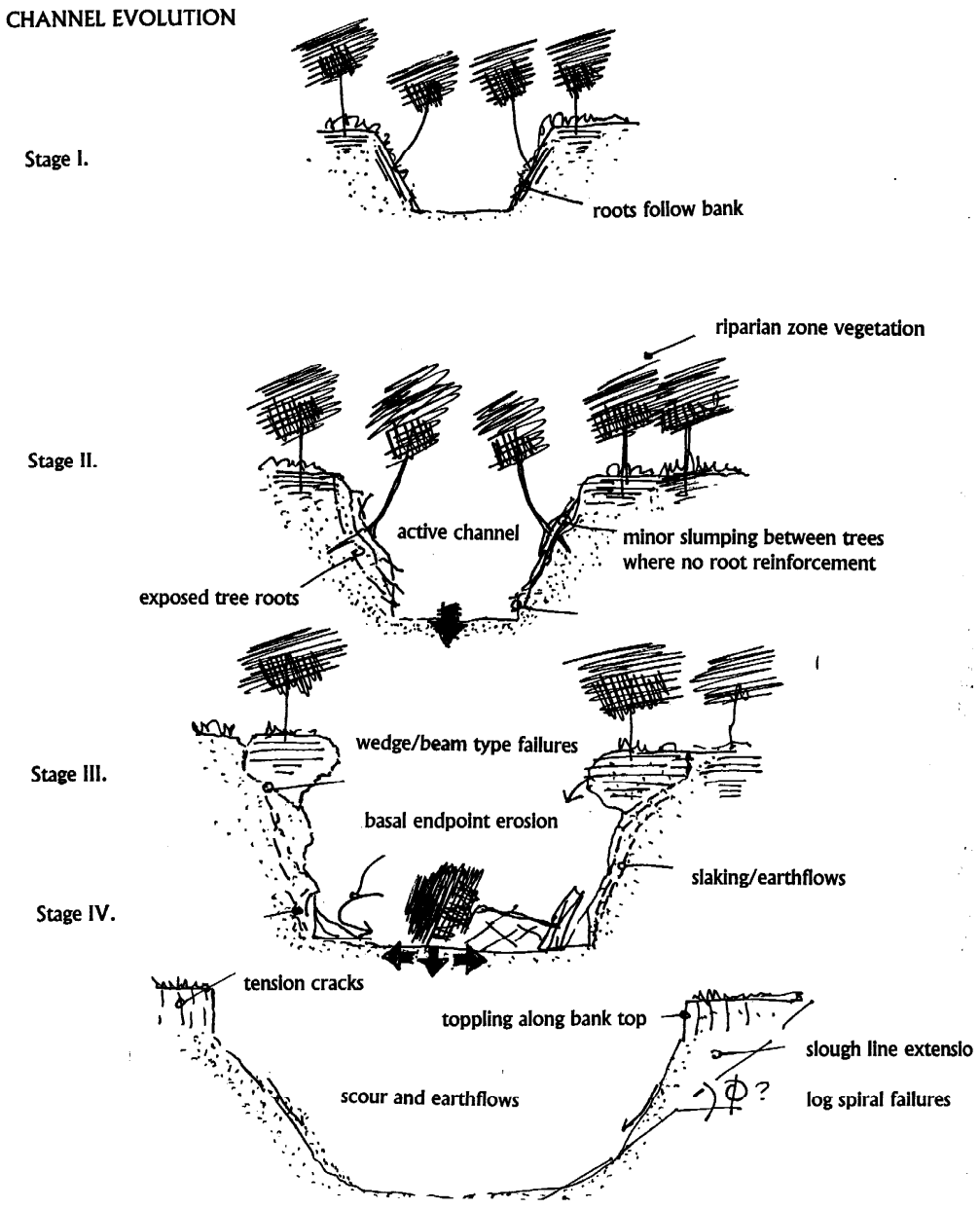


Figure 4. Channel Evolution Model (CEM)

Stream	Stream Type	Bed/Bank	Processes
Bedford	Meandering mixed load variable width channel; developed pool riffle system; Stage I-II.	Clay bed with limestone gravels channel whole length	Moderate bank erosion on near vertical cutbanks; gravel size fines downstream; channel ponded downstream; low woody debri dams
Penwell	Swale for 300 feet; grass, clay meandering channel to 2400 feet; mixed load meandering channel to confluence. Stage I-II. Downstream more incised.	Clay with limestone gravels begins at 2400 feet	Knickpoints (3) from 2400 to 3400 feet; gullys and tighter meanders with some tree loss 4000 feet to confluence.
Edge	Swale, 100 feet; knickzone shale with overlying limestone flags, 7 feet drop; grass/clay meandering channel to 2400 feet; Stage I. Abandoned golf course with walkways and culverts downstream.	Most channel is clay and grass until 2400 feet; culverts and dams with limestone gravels in channel. From last concrete walkway, swale with grass and brush to lake.	Slumps/infinite slope failures near pond at 3200; deposition in lake (SCS) structure; abundant backwater tree growth.
Mills	Swale to pool riffle channel with grass and clay bed and banks; Stage I-II. Slightly incised near end survey in altered channel.	Grass and clay bed and banks; shale in bottom from 2400 feet.	Abundant Knickpoints first 800 feet channel; Slumps in channel bank 2400 feet as channel cuts into hillside. Dangerous area for future slumps. Channel appears altered and rerouted here.
Small	Begins shale Knickpoint (Kamp Ranch member); 7-8 foot drop; meandering mixed load, pool riffle; channel flags fine to limestone gravel downstream; Stage I-II.	Limestone flags to 1600 feet, then wide floodplain and clay with limestone bed material.	Knickpoint in limestone at 200; small, 2-3 foot knickpoints 1600-3000 , large slumps 4500 to end along channel as it cuts into a hillslope.
Stuart	Lake to swale channel in grass and brush to about 800 feet, then mixed load meandering channel to end; Stage I-II.	Grass and clay to 800 then clay and limestone gravel.	Gullys begin at 800 and seen again at 1600 feet.
Swadley	Meandering clay and grass channel to 1600 feet then transitions to mixed load meandering channel to end.	Grass and clay bottom and banks to 1600, then clay banks, clay and limestone bottom to end.	Knickpoints (2) and gully first 800 feet; bank erosion at 1600; and again at 4800 as channel cuts into shale sideslopes.
Taaffe	Artificial trapezoidal channel to about 2300 feet; with gabions in bottom for grade control and some rip rap; abundant Johnson grass in bottom; pool riffle meandering channel to end.	Clay bottom to 3300 then bottom and banks in shale.	Tree falls and small knickpoints in unaltered channel section from 2300 to backwater near highway bridge;minor erosion of cutbanks in this area;drop structure at bridge
Tarrell	Swale to about 600 feet; then meandering clay/gravel pool riffle channel to lake. Below lake; incised Stage II for 800 feet then into heavy brush and mesquites as floodplain widens.	Clay to clay and limestone bed and clay to shale banks; shale occurs in banks just downstream of lake.	Erosion and slumping downstream of lake before floodplain widens.

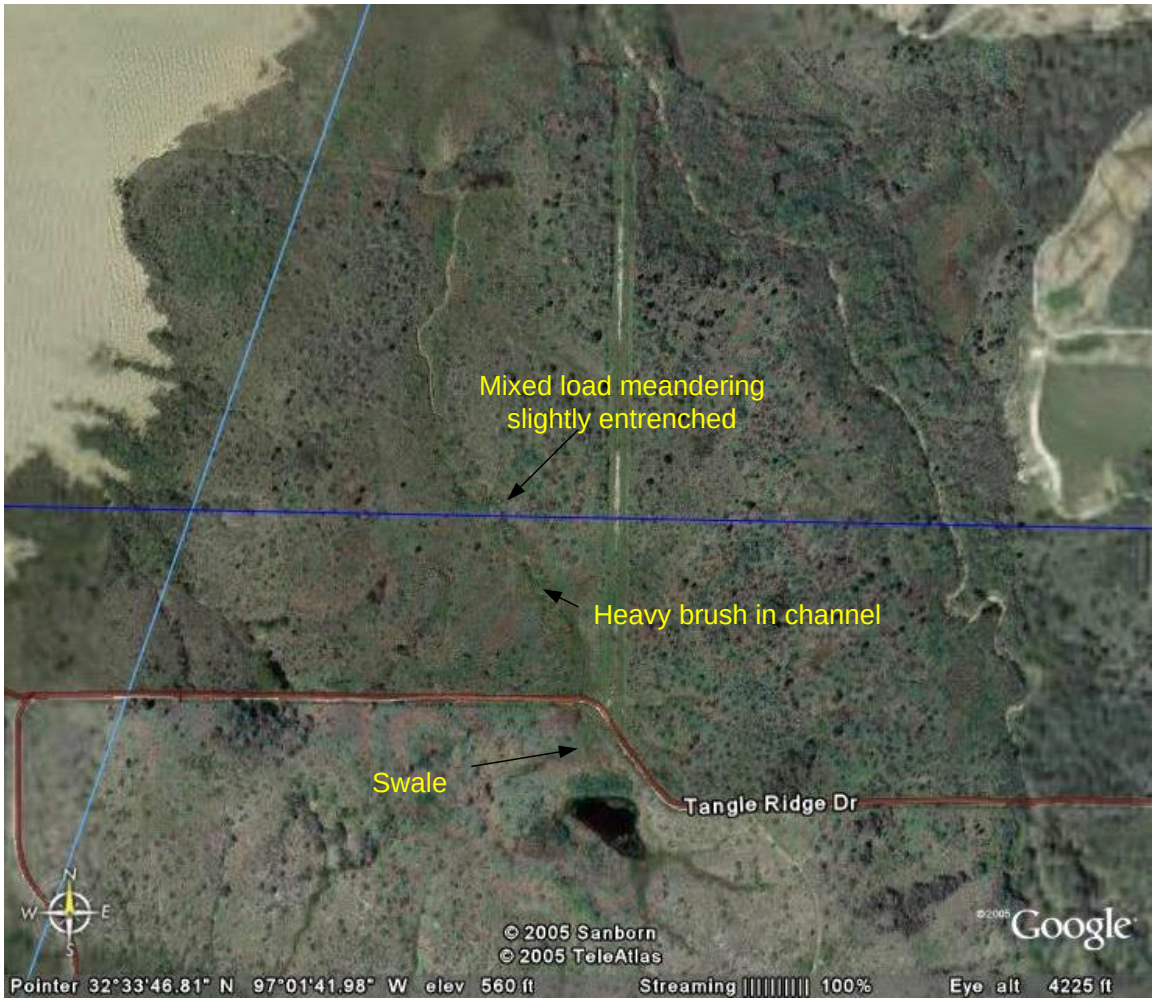
Table 2. Description of Streams Joe Pool Lake Project.

Swale with grass banks and clay bottom
A.
© 2005 TeleAtlas
© 2005 Sanborn
Google
Pointer 32°32'39.75" N 97°01'42.24" W elev 576 ft
Streaming 100%
Eye alt 6964 ft

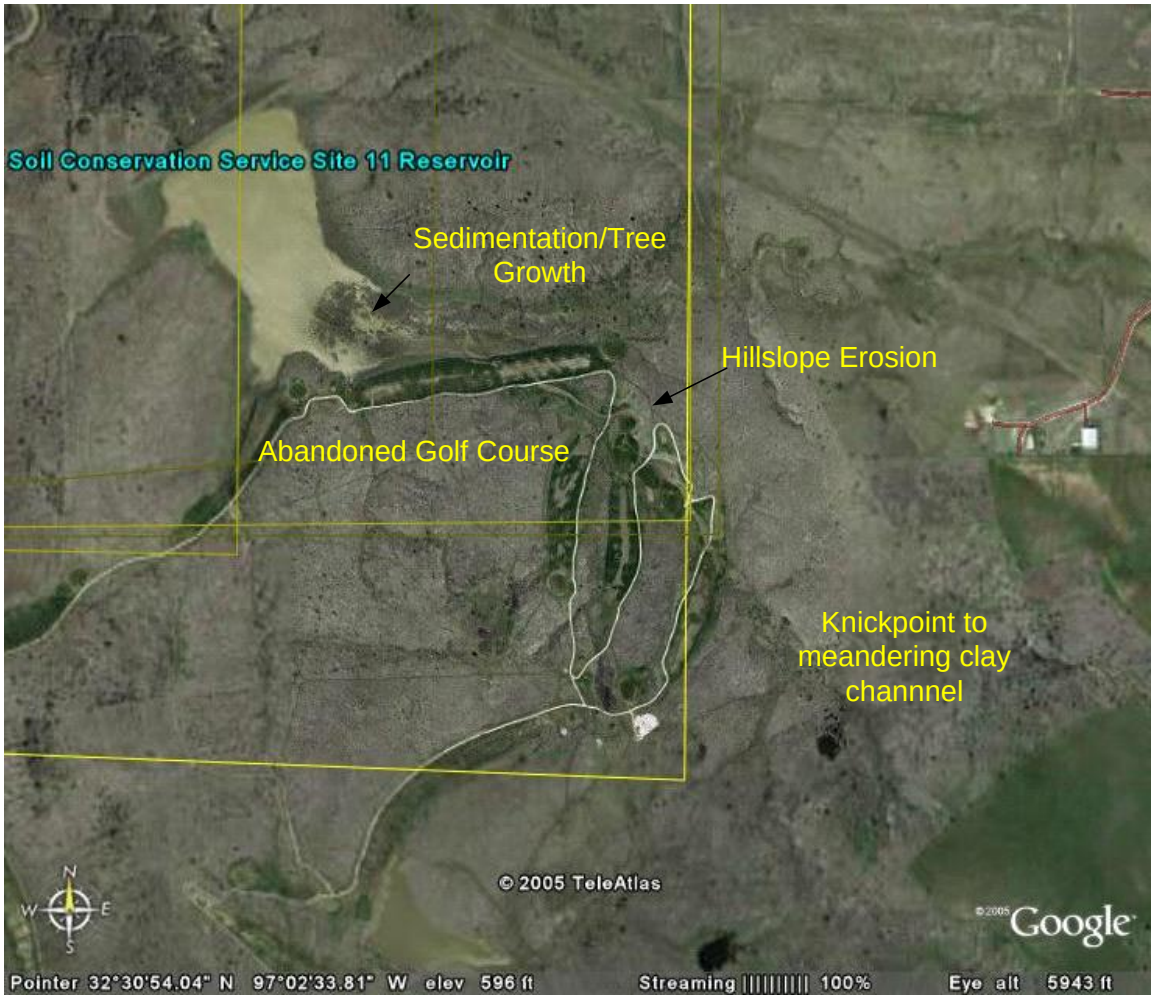
Penwell Cr.

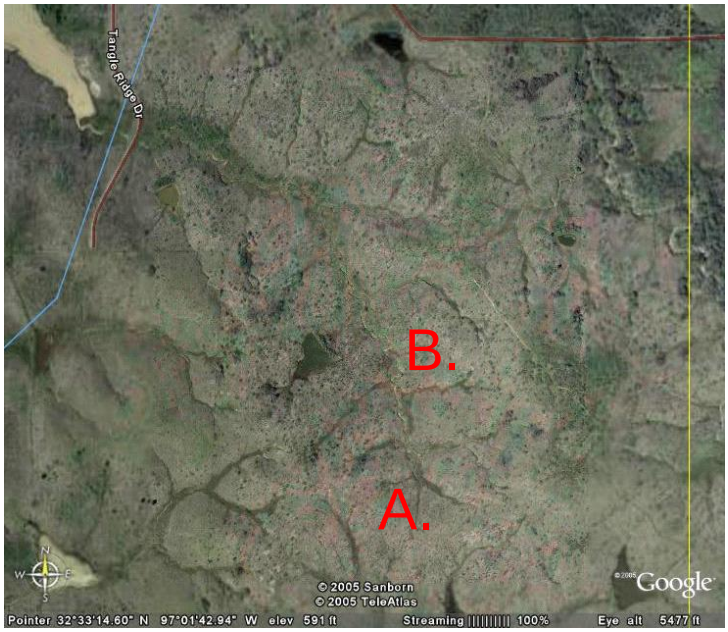
A.
Incised lower channel
© 2005 TeleAtlas
© 2005 Sanborn
Google
Pointer 32°32'28.85" N 97°01'50.90" W elev 548 ft
Streaming 86%
Eye alt 2053 ft

Stuart Cr.

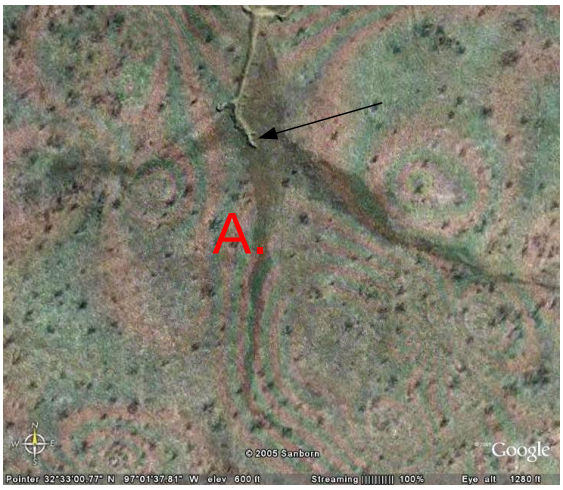

Mixed load meandering
slightly entrenched
Heavy brush in channel
Swale
Tangle Ridge Dr
© 2005 Sanborn
© 2005 TeleAtlas
Google
Pointer 32°33'46.81" N 97°01'41.98" W elev 560 ft
Streaming 100%
Eye alt 4225 ft

Edge Creek

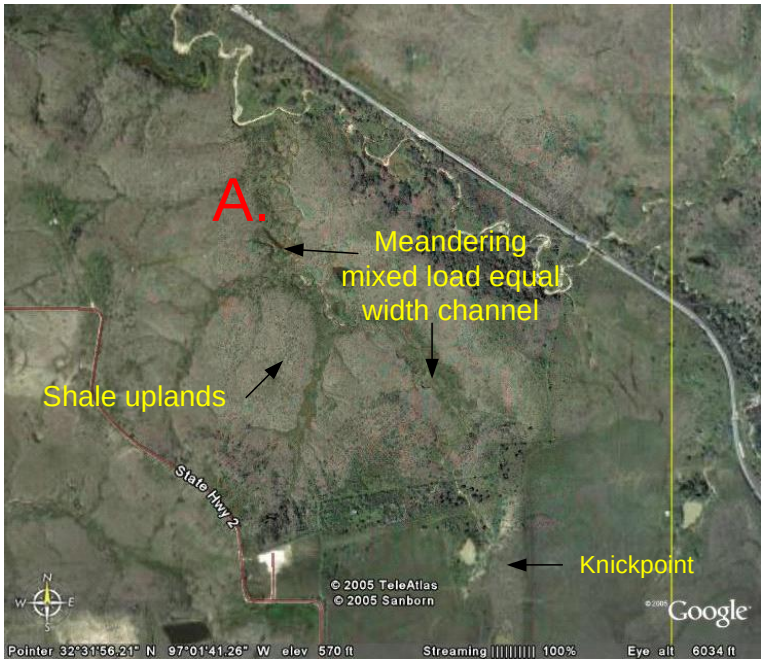

Soil Conservation Service Site 11 Reservoir
Sedimentation/Tree Growth
Hillslope Erosion
Abandoned Golf Course
Knickpoint to meandering clay channnel
© 2005 TeleAtlas
Google
Pointer 32°30'54.04" N 97°02'33.81" W elev 596 ft
Streaming 100%
Eye alt 5943 ft



Swadley Cr.

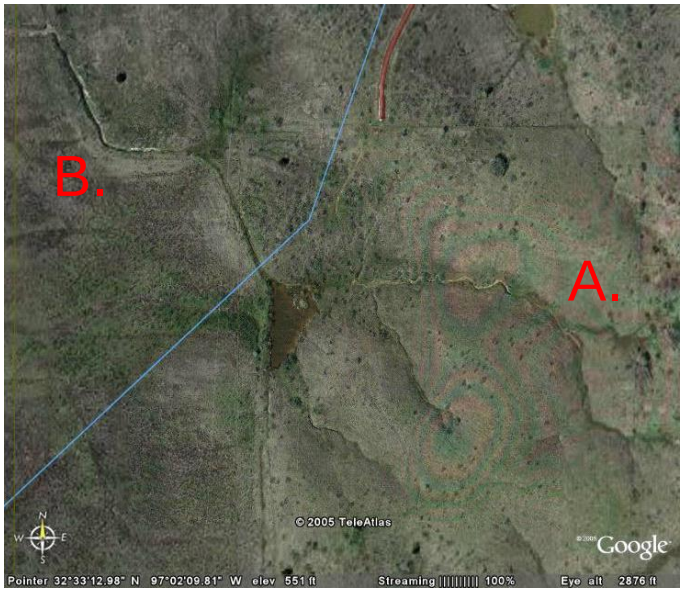


Headward Knickpoint
Migration

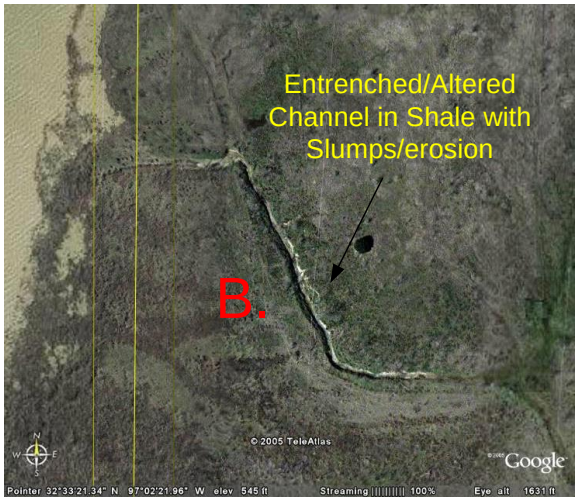

A.
Meandering
mixed load equal
width channel
Shale uplands
State Hwy 2
Knickpoint
© 2005 TeleAtlas
© 2005 Sanborn
Google
Pointer 32°31'56.21" N 97°01'41.26" W elev 570 ft
Streaming 100%
Eye alt 6034 ft

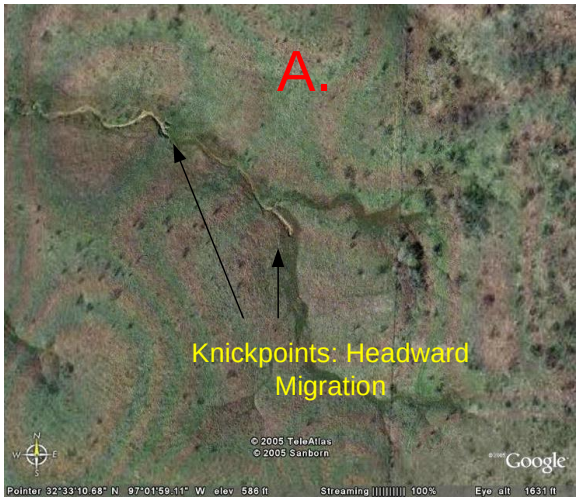
Small Br.

Old meander cutoffs
Slumps as river
cuts into shale
hillside
A.
© 2005 TeleAtlas
© 2005 Sanborn
Google
Pointer 32°32'10.53" N 97°01'53.25" W elev 548 ft
Streaming 100%
Eye alt 1888 ft

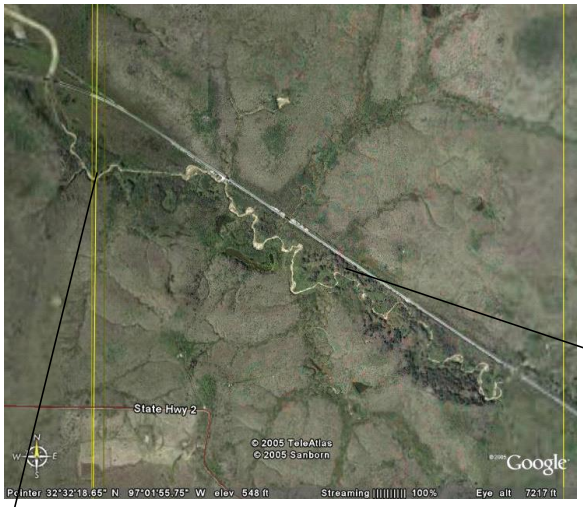

B.
A.
© 2005 TeleAtlas
Google

Mill Cr.


Entrenched/Altered Channel in Shale with Slumps/erosion
B.
© 2005 TeleAtlas
Google


A.
Knickpoints: Headward Migration
© 2005 TeleAtlas
© 2005 Sanborn
Google

Bedford


State Hwy 2
© 2005 TeleAtlas
© 2005 Sanborn
Google
Pointer 32°32'18.65" N 97°01'55.75" W elev 548 ft
Streaming 100%
Eye alt 7217 ft

Cutoff Old Meander
Mixed Load; Variable Width Meandering Stream
Hillslope Erosion
© 2005 TeleAtlas
© 2005 Sanborn
Google
Pointer 32°32'26.17" N 97°02'06.61" W elev 547 ft
Streaming 100%
Eye alt 3800 ft

Land Use Cycle 1.

Historically, this area was used as rangeland and limited agricultural uses on the flatter foot slopes. Overgrazing in the past lead to higher rates of runoff, increased sheet erosion and enhanced gully erosion. Gullies extended head ward, up the small streams.

Invading trees species such as the mesquite spread over the shale slopes and other species such as prickly pear cactus and broomweed.. As southwest Dallas County urbanized, land uses changed from pasture to rangeland. Without the cattle, the grass began to recover and the gully scars began to heal. However, knickpoints established during this phase are persistent and without grading will continue through such land use transitions.

Land Use Cycle 2.

The next cycle of land use anticipated for this region will be urban land uses including, sewer, water and roadways. With increased impervious surfaces, land clearing, and compaction, runoff will increase along with soil erosion. This area under grass land has an annual soil loss of 1.6 tons per acre. The same area under construction or fallow conditions would produce up to 16 tons per acre as indicated by models of hillslope erosion using the WEPP model (Appendix). In addition, the frequency and magnitude of channel forming events would increase. This will cause channel degradation and widening. The extent of the channel response to such changes is hard to predict as it is based on predicting climate, predicting the engineering characteristics of the banks and channel substrate, and predicting erosion and bed material transport within the channels.

Channel equilibrium involves four basic factors:

- Sediment discharge
- Sediment particle size
- Streamflow
- Stream slope

Lane (1955) showed this relationship qualitatively as :

$$Qs\ D_{50} = Q\ S$$

Where:

Qs = bed material transport rate

D_{50} = median size bed material

Q= dominant discharge

S = slope

Channel equilibrium occurs when all four variables are in balance. Changes in water and sediment may occur due to changes in land use. Streams that are free to adjust, will generally do so and reestablish new equilibrium conditions over a period ranging from decades to centuries. River restoration seeks to quantify Lane's equation so that river adjustments, which can cause significant damage to existing urban infrastructure, can be avoided or at least reduced in scope and severity. In the case of the streams draining to Joe Pool, an increase in discharge without any changes in bed material size or amount, will tend to cause the channel slope to decrease or for the channel to degrade.

General Processes

The following figures illustrate processes noted in the field. These include bed and bank erosion, headward gully migration, soil slips and slumping. The location of these processes is noted on the photograph records in the appendices. In general, it is believed that many of these processes are remnants of the former flow regime when this area was in pasture and discharge was greater. Urbanization will have a much greater impact on the flow regime and the magnitude of these processes shown in the following photographs.

Gully Head

Downstream

Slump

Bank Erosion

Phase II: Effective Discharge

In the Dallas area, the geomorphically effective discharge of urbanized watersheds seems to correspond to a recurrence interval slightly less than the 1.25 year frequency flood (Allen, Arnold, and Skipwith, 2002). The width, depth and hydrologic descriptions of the survey sites are given in Table 1. Dempster's (1974) equations, which include the percent of impervious surfaces in the drainage basin, allow prediction of future discharge under fully developed watersheds and are therefore useful in predicting current as well as ultimate active channel dimensions. While the Dempster equation has been shown to be helpful in predicting the effective discharge in local urban basins (Allen, Arnold, and Skipwith, 2003), it is a simple regression model and cannot be used in assessing reach hydrology and hydraulics. Therefore, analysis of the results indicate that multiplication of the HEC-HMS 1 year flood discharges by 0.8 results in an adequate preliminary design discharge for study watersheds.

Phase III: Bed Material and Erosion Potential of Bed Material

In the channel bottom, the potential for movement of the loose bed material was determined from incipient motion assessment. The competent bottom velocity equation (Pemberton and Lara ,1984) was used as a preliminary assessment to indicate if the bed material of the size distribution shown would it move in a one year event. The critical tractive force using Shields relationship is .2 to .23 lbs/ft^2 . The critical velocity is computed simply as:

$$V_{fps} = (D_{mm}/1.88)^{0.5}$$

Bed material was sampled using the Wolman's method. There was a lot of variability in the bed material in the channel bottom. These results represent an average and should not be used for design of individual streams but serves to indicate the general bed material gradation found in the watersheds. Since the bed material was discontinuous in all channels except for perhaps Bedford, no armoring calculations were done in this preliminary survey. For design, more extensive sampling of Bedford Branch is advocated.

Grain Size	D16	D35	D50	D65	D84	D95	Gradation	Geo Mean	Std. Dev.
--------	1.5	7.21	12.1	19	37	61	5.5	7.4	4.9

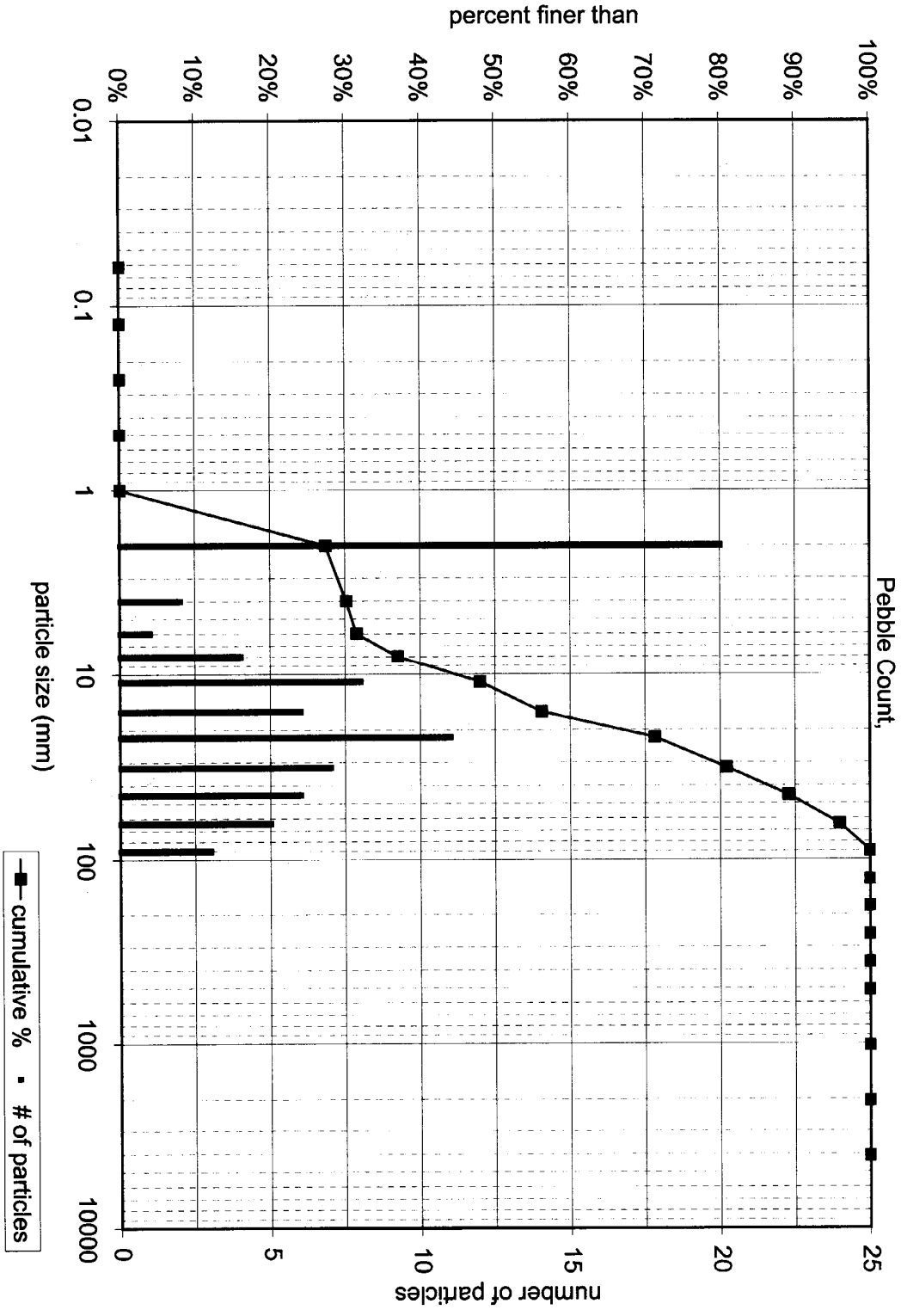
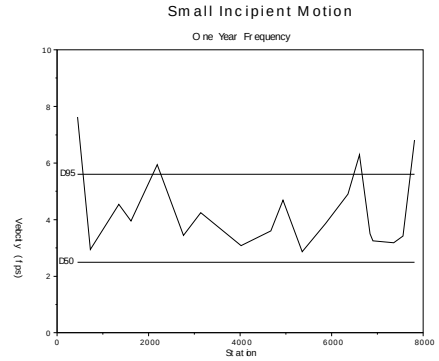
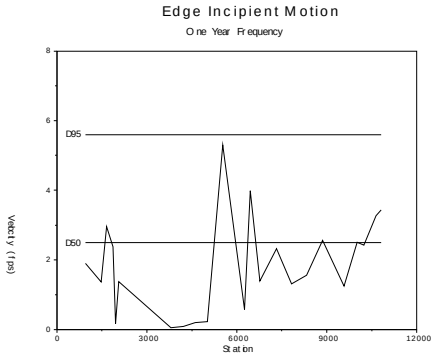


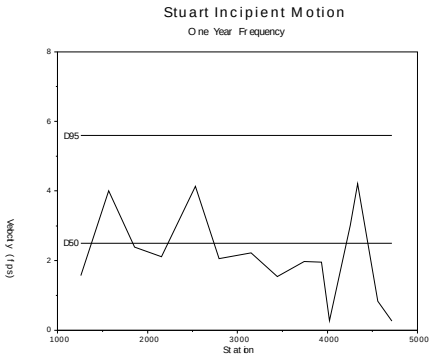
Figure 5. Results of Pebble Count of Bed Material in Joe Pool Streams.

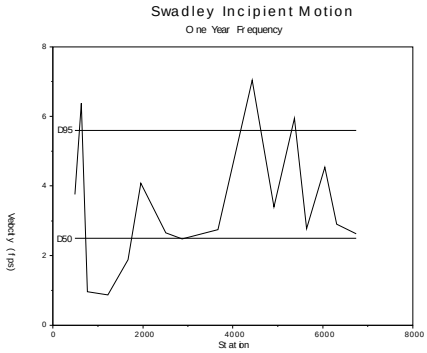
The results of this analysis for each stream for the one year flood indicates that there are areas of the channel that cannot move the D50. This infers that potential armoring may occur in these zones if there is an upstream supply of similarly sized limestone gravels. This will be dependent on the future erosion of the channel and the location of the source of bed material or local limestone beds. Local armoring can lead to local diversion of the channel and shoaling which intern leads to bank erosion, and related slope stability problems.

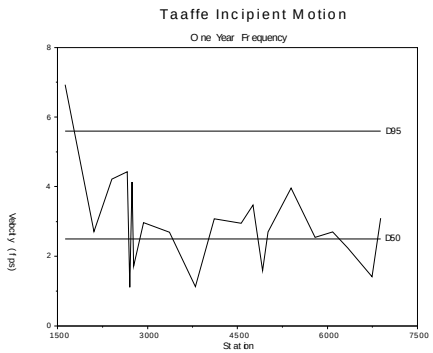
Incipient Motion Assessment

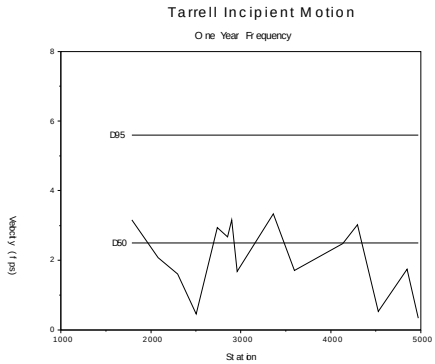




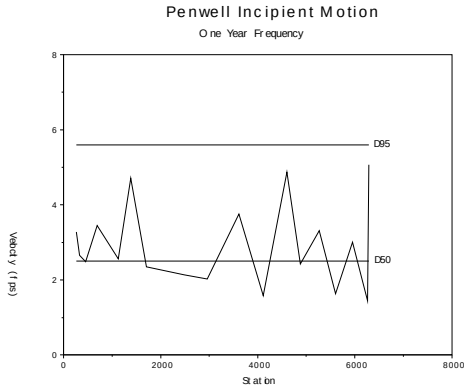


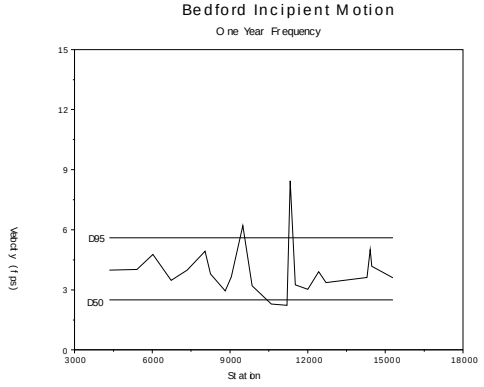






Incipient Motion Assessment





Phase III: Equilibrium Slope

The bed material gradation combined with the channel forming discharge is used to estimate the equilibrium or "ultimate" stable channel slope. Five methods are used to assess stable slope under boundary conditions imposed within the design reach (Appendix). Equilibrium slope is given for each stream in Table 3. Most methods of solving for the equilibrium slopes utilize bed load equations and back solve for slopes at incipient motion. These methods assume that there is insufficient coarse material to form an armored layer, the gradation of the bed material is the same down to the depth of degradation, and the bed material depth is greater than the expected degradation limit.

While all these assumptions are not met (shale bedrock lies below the bed material at depths of less than the depth of degradation), this analysis gives a reasonable point to which the stream would down cut if new bed material is supplied through erosion of the limestone flags and perhaps terrace material. In addition, since the critical tractive force of the weathered bed material is in the range of the tractive force of the bed material, this assumption seems appropriate.

The results of the equilibrium slopes, and discharge are given in Table 3 below.

Stream	**Equilibrium Slope**
Bedford	0.0009
Penwell	0.0014
Small	0.00096
Edge	0.0014
Mill	0.0026
Stuart	0.0024
Swadley	0.0019
Taaffe	0.0015
Tarrell	0.0014

Phase III: Erosion Rates of Alluvial Material by Submerged Jet Testing

Erosion rates in the soil/alluvial zone (channel banks or channel bottom) were previously tested using submerged jet testing (Allen and others,1997,1999, and Hanson, 1990;1991) by Halff and Associates on Kirby Creek.. Tests were made on a representative silty clay/ clay alluvial soils at the Ridgewood Bridge Road. A sample was collected and laboratory tests were done to determine the engineering properties of the material such as Atterberg limits, and bulk density (Allen and others, 1999). Briaud et. al. (1999) has developed the scour rate in cohesive soils method (SRICOS) to predict scour depth versus time at bridges. His method includes testing samples obtained with shelby tubes in the field in an erosion function apparatus (EFA) as a means to establish erosion rates of materials under given shear stresses. Rates established by this method are comparable in magnitude to those obtained for similar cohesive soils by Allen and others (1999). For cohesive soils with moderate to high plasticity (CH-CL Unified Classification) such as are found in the Dallas–Ft. Worth area, Briaud and others (1999) reports a mean rate of scour of 5.2 in/hr/lbs./ft^2 and a range of scour from 0.94 to 14.1 in/hr/lbs./ft^2 . While either method appears suitable for use in the alluvial soil zone, the submerged jet test done for the Kirby Creek Masterplan in Grand Prairie was used in this study.

Submerged Jet Test Dry Conditions	9.9 inches/hr./lbs/ft^2
Submerged Jet Test Saturated	0.01 inches/hr./lbs/ft^2

From the simple assessment of the hydraulics, the following relationships are established for shear and velocity in the channel for the one year flood.

Where: $\text{Shear} = a\ V^{b}$

Stream	**a**	**b**	**R^2**	**Standard Error Estimate**
Bedford	.048	1.95	.97	.109
Mill	.071	2.01	.95	.34
Penwell	.067	2.02	.9	.25
Small	.066	1.87	.92	.15
Stuart	.102	1.79	.98	.98.17
Swadley	.053	2.15	.96	.96.23
Taaffe	.031	2.27	.88	..37
Tarrell	.105	1.94	.97	.23
Edge	.108	1.93	.96	.188

The average values for estimates of channel shear are:

$$\text{Shear (lbs./ft.}^2\text{)} = 0.07\ \text{Velocity(fps)}^{1.99}$$

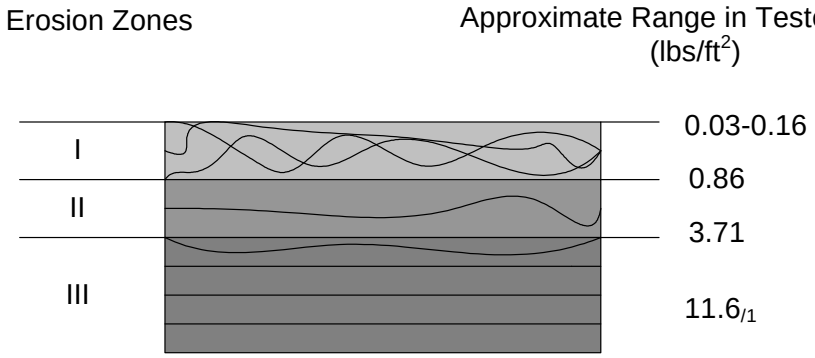
Incipient motion plots indicate areas along the stream which exceed simple thresholds for movement of the bed material. In addition, these plots can be used to indicate areas where the bare (no grass) channel materials and bed material have potential to erode when combined with Figure 6. If the plotted velocities fall above the threshold, then given bare soil conditions the channel has the potential to erode in the one year flood. Basically, depending on weathering, the surficial soils will erode at velocities ranging from .7 to 1.5 fps. The underlying soil zone will erode, depending on antecedent moisture and roots in the range of 3.5 to 7.3 fps. The weathered shale will erode at velocities in the range of 12.9 fps. Highly weathered shale will erode at the upper limits of soil erosion. Tractive power to erode shale may also be estimated with the following equation:

$$\text{Threshold Power} = 2.93\text{EE-7}\ \text{UCC}^{2.52}$$

Where: TP = lbs/ft-sec
UCC = unconfined compressive strength lbs./sq. ft.

(Arizona Dept. of Water Resources; State Standards, 5-96)

Estimated Critical Shear for Channels



General Description

I	Highly weathered soil/shale, flat plates fine material on surface typically less 2 inches thick
II	Soil with less fractures, higher bulk density; can range from inches to feet in thickness
III	Shale bedrock, ranges from highly weathered and fractured to less weathered (darker gray) and less fractured

1/ Allowable Stream Power in $KW/m^2 = 0.866$
Assume Kh = 3.83

Figure 6. Erosion Thresholds

As a general guideline, the U.S. Army recommends the following in terms of local maximum shear:

For straight channel segments: $T_{max} = 1.5\ T$

For Bends: $T_{max} = 2.64\ T(Rc/W)^{-.5}$

Where: T = maximum shear stress
Rc= radius of curvature
W= channel bankfull width

From ERDC TN-EMRRP-SR-29 Fischenich (2001)

Phase III: Erosion Rates Shale by Slake Durability Testing and Field Measurement

The erosion rate in the bedrock slake zone (lower channel bank) has been assessed in previous studies in both the field and laboratory. The field tests consisted of repeated measurements of stream bank profiles in a shale dominated bedrock channel after four flood events (greater than 1 year Return Interval) based on procedures and equipment used by Zonge, Swanson, and Myers (1996). The laboratory tests consisted of performing slake durability tests on the shale bedrock utilizing methods modified from Richardson and Long (1987). The procedure consisted of oven drying the bulk rock samples from the bank (2 X 4 inches) in the oven at 105 C for 12 hours. The samples were then weighed and put in a #12 sieve and immersed in and out of a water bath 200 times in a period of ten minutes. The sample was then oven dried, reweighed and the process repeated for five more cycles. The slake durability index was found by dividing each final dry weight retained on the sieve by the original weight and multiplying the result by 100%. The slope of the plotted relationship between percent loss due to slaking and the number of slake cycles was determined by regression analysis. The average slake rate for the Eagle Ford Shale are given below.

Dry Density	Total Density	2nd Cycle Slake
119 pcf	138 pcf	21 %

In areas where the channels have down cut into the underlying rock, widening of the channel is accomplished through scour of the alluvial material and weathering (slaking) and removal of the exposed rock material. This zone of exposed rock which extends from the mean flow line of the channel taken as the riffle height to the soil/rock interface is termed the slake zone. In the Dallas-Fort Worth area, the slake zone along the channel bank ranges in height from 0-5 feet.

Channel loss rates in this zone range from less than 0.4 to 2 inches a year depending on the number of wet dry cycles per year and flood frequency. This is based on the following assumptions: (1) This lower portion of the bank is subject to high shear stress and numerous wet and dry cycles (Lawler, 1992;1993, Thorne and others, 1982;1998), and (2) the shale and limestone rock in this zone are subject to repeated cycles of slaking and subsequent removal by flooding.

The slake rate equation derived for this zone is based on repeated site surveys on a shale bedrock channel in North Texas and slake testing done on the bedrock samples. The bank scour process in this zone appears related to both the location of the erosion site on the meander and to the exhaustion of slaked material after numerous flood events. Greater erosion is associated with the downstream portion of the meander. Slake durability test data for the site represents the slake loss for each laboratory slake cycle. The equation derived in this study for predicting ultimate bed and bank loss rates due to slaking and subsequent entrainment is based on: (1) assessment of the number of flood flows in this

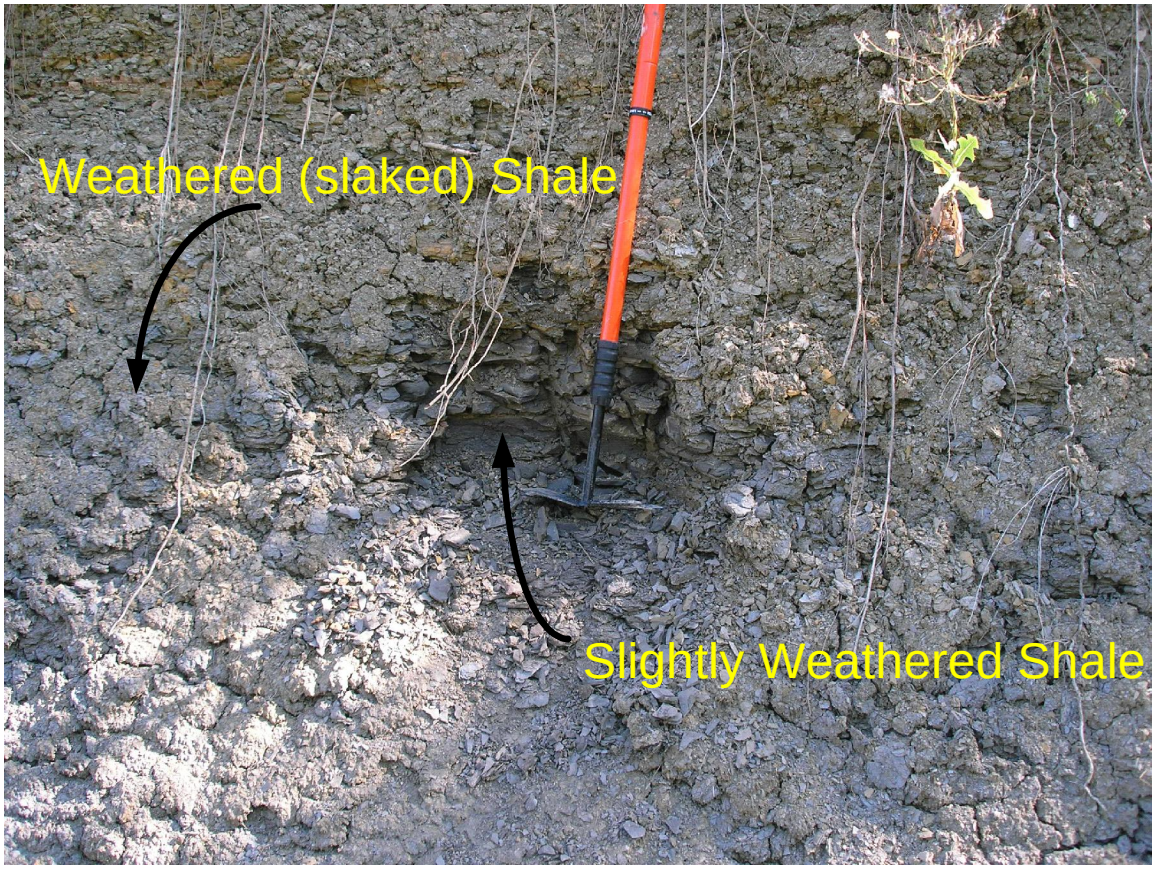
zone per year, (2) slake rates established by the work of Shakoor and Rodgers (1996), and (3) previous suggestions by Howard and Kerby (1983).

$SLR = LR*(1-e^{at})$
where:
SLR = annual slake loss (inches)
LR = maximum annual loss rate (inches)
a = slake rate (slope of slake durability loss per slake cycle range or -0.4 to -0.65)
t = number of floods in slake zone
With an average second cycle slake durability value one can compute the maximum slake loss rate in inches per year based on Shakoor and Rodgers (1996), where:

LR= 3.91 - .0792*SR (For SR less than 30)

LR = 2.10 – 0.0119*SR (For SR greater than 30)
LR = Maximum rate of loss in in/yr.
SR = 2nd Cycle Slake Durability

For example, for a channel with a second cycle slake durability of 21 percent, up to 2 inches could be lost if four floods occurred during that year. Work by Prosser, and others (2000) reinforces these assumptions. They show that erosion can be controlled by subaerial processes such as dessication of clays.



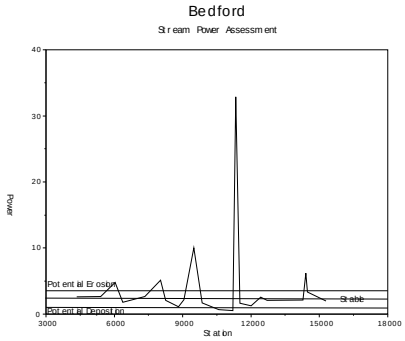
Phase IV Projected Channel Enlargement and Degradation

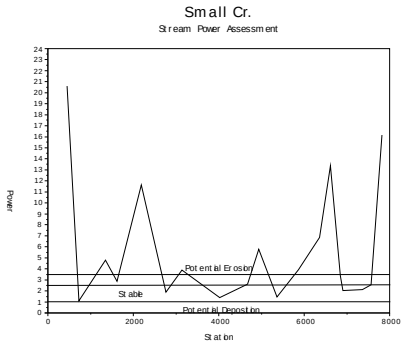
In order to assess the potential changes in channel dimensions, the natural and urban 1 year discharges were used with regression equations to predict channel widening with increased discharge. Results of this analysis are shown in Table 4 below.

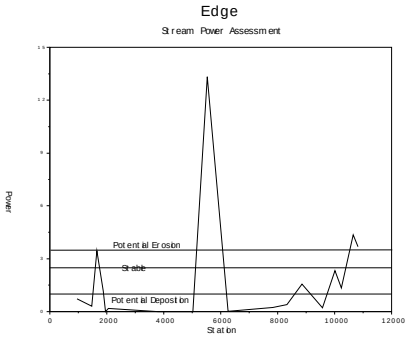
Stream Channel	Projected Widening Ratio(Urban/Existing)
Bedford	1.77-1.92
Penwell	1.14-2.14
Small	2.5-2.75
Edge	0.6-2.36
Mills	1-1.277
Stuart	1-1.21
Swadley	1.39-1.28
Taaffe	1.21-1.22
Tarrell	2.09-3.19

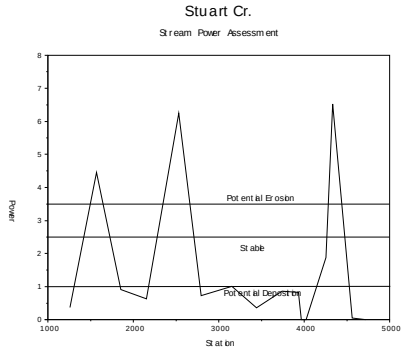
There are several ways to assess the current condition of the channel. The NRCS Stream Corridor Manual cites work by Brooks who, for limited channels, postulated that stream power can be used as an indicator of channel stability. Channels with stream power over 3.4 are prone to erosion and instability; channels below 1 are prone to deposition and aggradation, and channels are stable in the 2.5 range. Units are in lbs/ft-sec. The results of such analysis can provide a general downstream assessment of channel conditions and where, under existing conditions, the channel would be subject to problems.

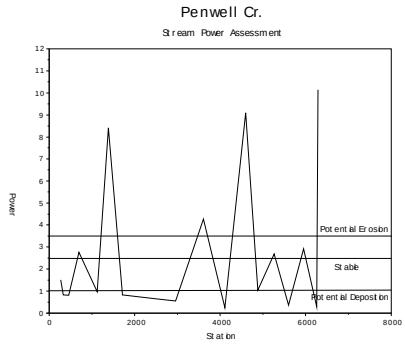
Stream Power Assessment

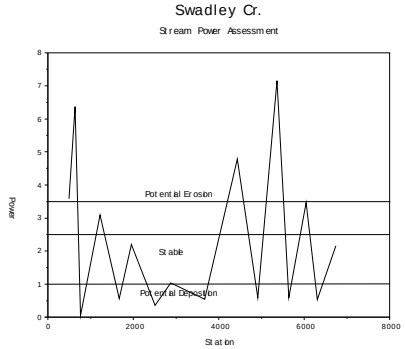




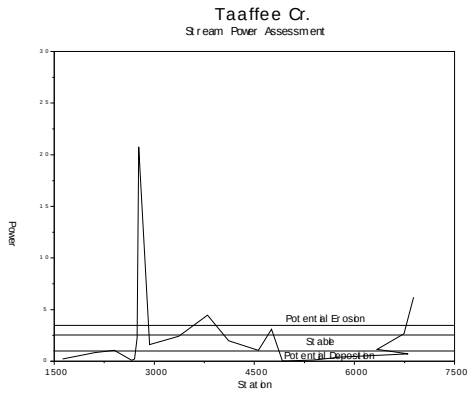


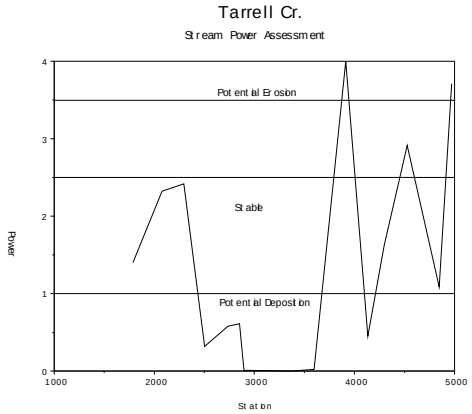


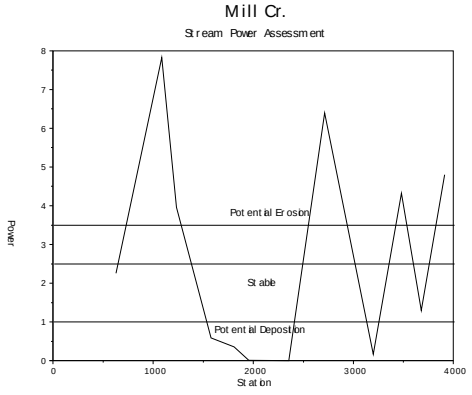




Stream Power Assessment







The stream power assessment indicates that under future conditions, the channel exceeds limits of stream power in numerous areas. This evaluation can serve as a guide to areas of the channel system that may need more extensive channel armoring in terms of high stream power, and perhaps adjustment of design slopes in areas of lower stream power.

SWAT-DEG Model

The rate of bed degradation was assessed with the Soil Water Assessment Tool (Arnold, et. al., 1993) and a simple degradation component SWAT- DEG, (Allen et. al., 1994;1999). SWAT-DEG is a continuous simulation model , which has been developed to predict time series channel erosion and degradation. Input to this model, besides basic watershed parameters (curve numbers or loss rates, time of concentration, routing structure), are channel dimensions, channel slopes, erodibility of the channel bottoms and width depth ratios of the channel. Erodibility is assessed utilizing the submerged jet technique (Hanson, 1990; Allen et. al., 1999). Bed load is assessed using the appropriate bed load equation after Stevens and Yang (1989). Width-depth ratios and general channel dimensions are based on channel surveys. Based on field surveys in the streams, the channel width depth ratios can be predicted with the equation:

$$\text{Top Width} = 3.75 + 3.1135 \text{ Total Depth}$$

This corresponds to a W/D of approximately 4 and was used in the SWAT-DEG model for assessing channel degradation and dimensions over time.

This method has the advantage of giving the time rate of potential degradation and can be used to test the effects of varying land-use and climatic conditions on channel erosion. The modeled climate was the daily rainfall and temperature for Grand Prairie, Texas from 1950-1986. Boundary conditions for design of degradation can utilize the SWAT-DEG results as a general planning tool for assessment of acceptable planning horizons for designing engineering works. It is advocated that a lower boundary condition of 3*Bankfull depth be used as a minimum for design of drop structures to protect the channel from degrading and related side slope problems. This is similar to guidelines used in the Austin area. Results are shown in Tables 5-6 below.

Stream	Minimum Allowable Degradation (ft.)
Bedford	14.1
Edge	8.5
Mills	4.3
Penwell	8.25
Small	12.9
Stuart	4.65
Swadley	6.06
Taaffe	7.53
Tarrell	8.31

Table 5. Maximum degradation for design from three times active channel depth.

Stream	Regression Slope (x)
Bedford	-0.00128
Edge	-0.00199
Mills	-0.00117
Penwell	-0.000582
Small	-0.00122
Stuart	-0.00114
Swadley	-0.0016
Taaffe	-0.00073
Tarrell	-0.000983

Table 6. Results of SWAT-DEG runs on Joe Pool Channels. Slope of regression of change in elevation with time.

Based on the SWAT model runs for the urbanized channels, the following regression slopes can be input into the stream at a station to assess the maximum time rate of down cutting in the stream.

$$\text{Elevation} = \text{Elevation}_{\text{exist}}\ \text{Time}^{(X)}$$

For example, if the initial elevation of Bedford was 1000, then in ten years, the new stream elevation would be ($10^{-.00128}$) * 1000 = 997 or a loss of 3 feet.

Meanders

While the SWAT model infers maximum degradation in the channel, it assumes no meanders. Prediction of local bend scour is based on Soar and Thorne (2001):

$$Dmax/Dm = 1.5 + 4.5(Rc/w)^{-1}$$

Where:

Dmax = maximum depth of pool bend
Dm= mean depth of channel at upstream riffle width
Rc= radius of curvature
W= channel width

Based on a limited time series photographic assessment of channel migration in the Blackland Prairie, the following regression appears appropriate for a first order estimate of potential meander migration rates.

$$\text{Channel Widths/Year} = 0.1346 - 0.0128\ Rc/W - 0.00115\ Da$$

Where: Rc = radius of curvature in feet
W = channel width in feet
Da = drainage area in sq. miles

So, for a five square mile drainage area with a channel width of 40 feet and a radius of curvature of 100, the channel bend loss rate could be .097 widths a year or 3.8 feet. The same channel with less of a radius, say 160 feet, would have a migration rate of .0773 widths a year or 3 feet. This indicates on meanders, some form of bank protection will be needed to arrest lateral migration.

Conclusions

- The channels flow in CH-CL soils and are underlain by Eagle Ford Shale Bedrock in some areas.
- The shale as well as soil is subject to slope instability owing to high plasticity and low shear strength. Post mortem of failures in the shale have shown strength values approaching residual values.
- The soils are prone to shrink and swell with varying moisture conditions which enhances erodibility of the materials upon drying. Use of allowable velocity approaches in such material are fine for moist conditions but upon drying the material is far more erosive.
- Drying and stress in vertical cut slopes can aid in creation of tension cracks and bank failure, cracks in side slopes can enhance shallow or infinite slope failures on steeper slopes and smaller cantilever failures on small cut-banks.
- The channel bottoms are covered in places with a diverse size range of bed material owing to the location of outcropping limestone ledges and formerly deposited gravel in terraces. More extensive assessment of bed material is advocated prior to any design of channel restoration projects.
- Where the shale is exposed it will be subject to slaking. Slaking will result in easily entrainable particles and erosion. Rates are given in the text.
- The channel banks are predominantly covered with grass except in areas where the channel is entrenched or on steep cut banks.
- Incipient motion assessment using an average bed material sample indicates areas which may be prone to deposition of the bed material which could cause local shoaling or braiding and erosion of side-slopes as is found on portions of Bedford Branch.
- Stream Power assessment of future conditions indicates that many channel segments may exceed simple erosion thresholds while others are areas are shown to be prone to deposition. Such analysis may serve as a general guide to channel design and maintenance considerations.
- Field assessment of stream channels indicates a former cycle of higher runoff during more intensive pasture and cattle operations.
- Future land use changes will cause greater runoff and re-initiate many of the past processes such as headward gully erosion, slumping on steeper shale side slopes, and bank and channel bed erosion and downcutting.
- Channels will widen up to 2 times natural conditions
- Channel degradation, if uncontrolled could result in downcutting of up to 14 feet in some of the streams in around 50 years thus indicating the need for some form of degradation control performance standards on all the channels.
- SWAT-DEG runs were done for each watershed to indicate the approximate rate of degradation.
- Most channel dimensions and processes are controlled by the frequency and magnitude of discharge, channel bed and bank lithologies, and bank vegetation. Urbanization is shown to double or in cases triple discharge for the study watersheds.

Channel widths will increase, meander geometry will change, and related pool riffle spacing.

- Previous studies have indicated that a bimodal flow regime may occur as a result of storm sewer systems and surface runoff. This should be considered in future channel design. Often this creates a two stage channel with the smaller inner channel related to high frequency storm sewer discharge and the larger channel to the less frequent bankfull flows.

Bibliography

Allen, P.M., Arnold, J.G., and Byars, B.W., 1994. Downstream Channel Geometry for Use in Planning Level Models. Water Resources Bulletin, 30, pp. 663-671.

Allen, P.M., Arnold, J.G., and Jakabowski, E., 1997. Design and Testing of a Simple Submerged Jet Device for Field Determination of Soil Erodibility. Journal of Environmental and Engineering Gesosciences, 3, pp. 579-584.

Allen, P.M., Arnold, J.G., and Jakabowski, 1999. Prediction of Stream Channel Erosion Potential. Journal of Environmental and Engineering Geoscience, 5, pp. 339-351.

Allen, P.M., and Flannigan, B., 1985. Geology of Dallas, Texas. In: Cities of the World, Eds. Hathaway, A.: Bulletin of the Association of Engineering Geologists, 23, pp. 363-416.

Allen, P.M. 1977. Analysis of an Escarpment Landform for Land Use Planning, Mountain Creek Basin, Dallas –Ellis Counties, Texas. PhD. Dissertation, Southern Methodist University, 391p.

Allen, P.M. and Narramore, R.L., 1985. Bedrock Controls on Stream Channel Enlargement with Urbanization, North Central Texas. Water Resources Bulletin, 21, pp. 1037-1048.

Andrews, E.D. and Nankervis, J.M., 1995. Effective Discharge and the Design of Channel Maintenance Flows for Gravel Bed Rivers. (in) Natural and Anthroprogenic Influences in Fluvial Geomorphology., Geophysical Monograph 89, AGU, pp. 151-164.

Annandale, G.W., 1995. Erodibility. Journal of Hydraulic Research, vol 333, No. 4, pp. 471-494.

Annandale, G.W. and Smith, S.P., 1996. Scour in Erodible Rock I: the Erodibility Index. North American Water and Environment Congress, American Society of Civil Engineers, Anaheim, California, pp. 1342-1348.

Arnold, J.G., Allen, P.M., and Bernhardt, G., 1993. A Comprehensive Surface/Groundwater Flow Model. Journal of Hydrology, 142, p. 47-69.

Arnold, J.G., Allen, P.M., Ramanaraynan, T.S., Srinivasan, R, and Muttiah, R., 1997. The Geographical Distribution of Freeze/Thaw and Wet/Dry Cycles in the United States. Journal of Environmental and Engineering Geosciences, 4, pp. 596-603.

Asquith, W.H., and Slade, R.M. Jr., 1997. Regional Equations for Estimation of Peak Streamflow Frequency for Natural Basins in Texas. U.S. Geological Survey, Water Res. Inves. Rept. 96-4307, 53p.

Ayres and Associates, 2004. Erosion Setback and Stabilization Criteria for City of Austin Streams. Draft Document. Misc. Pages.

Booth, D.B., 1990. Stream Channel Incision Following Drainage Basin Urbanization. Water Resources Bulletin, 26, pp. 407-418.

Bledsoe, B.P. and Watson, C.C. 2001. Effects of Urbanization on Channel Stability. J. Amer. Water Resources Association, 37:255-270.

Briaud, J.L., Ting, C.K., Chen, H.C., Gudavalli, R., Perugu, S., Wei, G., 1999. SCICOS: Prediction of Scour Rate in Cohesive Soils at Bridge Piers. Journal of Geotechnical and Environmental Engineering, ASCE, 125, pp. 237-246.

Dempster, G.R., 1974. Effects of Urbanization on Floods in the Dallas, Texas metropolitan area. U.S. Geological Survey Water Resources Investigation, 60-73, 51p.

Font, R. G., 1976. Relationship Between the Geologic History and Engineerig Properties of Two Cretaceous Shales. Texas Journal of Science, Vol. 27, No. 2., pp. 267-284.

Hammer, T.R. ,1972. Stream Channel Enlargement due to Urbanization. Water Resources Research, Vol. 8, pp. 1530-1540.

Hanson, G.J., 1990. Surface Erodibility of Earthen Channels at High Stresses. Part II-Developing an In-Situ Testing Device. Trans. American Soc. Ag. Engineers, 33, pp. 132-137.

Hanson, G.J., 1991. Development of a Jet Index Method to Characterize Erosion Resistance of Soils in Earthen Spillways. Trans. Amer. Soc. Agricultural Engineers., 34, pp. 2015-2020.

Howard, A.D. and Kirby, G., 1983. Channel Changes in Badlands. Geol. Soc. Amer. Bull., 94, pp. 739-52.

Lawler, D.M., 1992. Process Dominance in Bank Erosion Systems. In: Lowland Floodplain Rivers: Geomorphological Perspectives. (Eds.) P.A. Carling and G.E. Petts, John Wiley, pp. 117-143.

Lawler, D.M., 1993. Measurement of River Channel Erosion and Lateral Changes:A Review. Earth Surface Processes and Landforms, Vol. 18, pp. 777-821.

Millar, R.G. and Quick, M.C., 1998. Stable Width and Depth of Gravel Bed Rivers with Cohesive Banks. Journal of Hydraulic Engineering, 124, pp. 1005-1013.

Pemberton, E.L. and Lara, J.M., 1984. Computing Degradation and Local Scour. Bureau of Reclamation Tech. Guideline, Engineering and Research Center, Denver, Colorado, 48p.

Prosser, I.P., Hughes, A.O. and Rutherfurd, I.D., 2000. Bank Erosion of an Incised Upland Channel by Subaerial Processes: Tasmania, Australia. Earth Surface Processes and Landforms, 25, pp. 1085-1101.

Simon, A., 1995. Adjustment and Recovery of Unstable Alluvial Channels: Identification and Approaches for Engineering Management. Earth Surface Processses and Landforms. 20, pp. 611-628.

Simon, A., Curini, A., Darby, S.E., and Langendoen, E., 2000. Bank and Near Bank Processes in an Incised Channel. Geomorphology, 35, pp. 193-207.

Schumm, S.A. , Harvey, M.D., and Watson, C.C., 1984. Incised Channels: Morphology, Dynamics and Control. Water Resources Publications, Littleton, CO. 200p.

Sklar, L. and Dietrich, W.E., 1998. River Longitudinal Profile and Bedrock Incision Models: Stream Power and the Influence of Sediment (In) Rivers over Rock: Fluvial Processes in Bedrock Channels, Amer. Geophysical Monograph 107.

Soar, P.J., Thorne, C.R. ,2001. Channel Restoration Design for Meandering Rivers. U.S. Army Corps ERDC/CHL CR-01-1

Stauffer, P.A., and Wright, S.G., 1984. An Examination of Earth Slope Failures in Texas. Center for Trans. Res., Rept. 353-3F, Univ. of Texas, Austin.

Shakoor, A., and Rodgers, J.P., 1996. Predicting the Rate of Shale Undercutting Along Highway Cuts. Bulletin Association of Engineering Geologists, 29, pp. 61-75.

Task Committee on River Widening, 1998. River Width Adjustment I. Processes and Mechanisms. J. of Hydraulic Eng., 124:881-902.

Thorne, C.R., 1982. Processes and Mechanisms of River Bank Erosion. In:Gravel Bed Rivers, (eds.)R.D. Hey, J.C. Bathurst, and C.R. Thorne, Wiley, pp. 227-259.

Thorne, C.R., Hey, R.D., and Newson, M.D., 1997. Applied Fluvial Geomorphology for River Engineering and Management. Wiley, 376p.
Thorne, C.R., 1982. Processes and Mechanisms of River Bank Erosion. In:Gravel Bed Rivers, (eds.)R.D. Hey, J.C. Bathurst, and C.R. Thorne, Wiley, pp. 227-259.

Thorne, C.R., Hey, R.D., and Newson, M.D., 1997. Applied Fluvial Geomorphology for River Engineering and Management. Wiley, 376p.

Thorne, C.R., 1998. Stream Reconnaissance Handbook. John Wiley, N.Y., 133p.

Tinkler, K.J., and Parish, J., 1998. Recent Adjustments to the Long Profile of Cooksville Creek, an Urbanized Bedrock Channel in Mississauga, Ontario. In: Rivers Over Rock:Fluvial Processes in Bedrock Channels. AGU Monograph 107, pp. 167-187.

Wolman, M.G., 1959. Factors Influencing Erosion of a Cohesive River Banks. Amer. Journ. of Science, 257, pp 204-216.

Zonge, K.L., Swanson, S., and Myers, T., 1996. Drought Year Changes in Streambank Profiles on Incised Streams in the Sierra Nevada Mountains. Geomorphology, vol. 15, pp. 47-56.

Appendix Stable Slope

1. **Meyer Peter Muller Formula**:

S = .19*((n/(d90**1/6))**1.5)dm/R

Where:
Dm = effective size of bed material expressed as a weighted mean diameter or d50 in mm
D90= particle size of bed material at 90 percent finer in mm
R = hydraulic radius, for width depth ratio greater than 40 use water depth in feet
N = manning n factor

2. **Schoklitsch Formula**

S = ((.00021*dm*B/Q)**0.75

Where:
B= Channel width
Q = dominant discharge

3. **Shields/DuBoys**

S = tau-cr /(gma*R)

Where:
Gma = specific weight of water in lbs./cuft.
Tau-cr = critical bed shear stress in lbs/sq. ft. using dm

4. **Regional Regression for North Texas**

S = 0.01576*Q**-.3534

Where:
Q = dominant discharge in cfs.

Represents lower prediction interval for USGS gage sites in Region 7 (North Texas) of channel slope versus discharge.

5. **Beldsoe et. al.**

S = 0.000246*Cs**.559*Q**-.336
Where:
Q = dominant discharge in cfs
Cs = concentration in ppm

Appendix I
CD-ROM