Hydraulic Report

Fishers Canyon Apartments Channel Improvements El Paso County, Colorado

Prepared for:
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Prepared by:
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Project #: 196825001

PCD Filing No.: CDR246

Prepared: September 15, 2024

CERTIFICATION

DESIGN ENGINEER'S STATEMENT

The attached hydraulic report was prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said hydraulic report has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparation of this report.

SIGNATURE (Affix Seal): ______________________________
Frans Lambrechtsen, P.E.
Colorado P.E. No. 54350 Date

OWNER/DEVELOPER'S STATEMENT

I, the developer, have read and will comply with all of the requirements specified in this Drainage Report and Plan.

____
CS 2005 Investment LLC

____
Authorized Signature Date

____
Chad Ellington

____
Principal

____
Address:
1480 Humboldt Street
Greenwood Village, CO 80111

EL PASO COUNTY

Filed in accordance with the requirements of the Drainage Criteria Manual, Volumes 1 and 2, El Paso County Engineering Criteria Manual and Land Development Code as amended.

______________________________ ____________________
Joshua Palmer, P.E. Date
County Engineer/ECM Administrator

Conditions:

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INTRODUCTION

PURPOSE AND SCOPE

The purpose of this Channel Design Report is to summarize the design of the channel improvements to an unnamed tributary of Fishers Canyon Creek and improvements to the main stem of Fishers Canyon Creek. The channel improvements are being made as a part of the Fishers Canyon Apartments ("the Project") multi-family residential project for Thompson Thrift and CS 2005 Investment LLC. Fishers Canyon Creek will be referred to as the "main stem" and the unnamed tributary of Fishers Canyon Creek will be referred to as "the tributary" throughout the report. The proposed channel improvements include three (3) grouted boulder drop structures and 800-ft of constructed riffle drop structures. The proposed channel improvements begin approximately 1,050 feet upstream of the confluence of the tributary with the main stem and end at the confluence with main stem. The Project is located within the jurisdictional limits of El Paso County ("the County"), in unincorporated Colorado Springs ("the City"). Therefore, the hydrologic and hydraulic design is based on the County's criteria which is described in further detail within the report.

LOCATION

The Project is located approximately 5 miles south of downtown Colorado Springs within Section 4, Township 15 South, Range 66 West of the 6th Principal Meridian, County of El Paso, State of Colorado ("the Site"). The Site is located on a parcel which is bounded by College View Estates Filing No. 1 on the west, South Academy Boulevard on the south, Venetucci Boulevard to the east, and several commercial lots along B Street to the north. A vicinity map has been provided in the **Appendix A** of this report.

The Site is currently owned by CS 2005 Investment LLC and will be rezoned and replatted through a partnership between Peak Development LLC and Thompson Thrift. The rezoning and replat efforts, otherwise known as the "onsite" development, are being submitted and coordinated separately with the County, and is considered a separate project under the County's Electronic Development Application Review Program (EDARP).

Relative to the regulatory floodplain, a portion of the proposed improvements are located inside a designated Zone AE Special Flood Hazard Area (SFHA) floodway and floodplain. The effective Flood Insurance Rate Map is panel number 08041C0743G with an effective date of December 7, 2018. A discussion of floodplain permitting will be discussed near the end of this report.

DESCRIPTION OF PROPERTY

The Site is approximately 64 acres consisting of undeveloped land with native vegetation and is classified as "Open Space" per Table 5-4 of the Drainage Criteria Manual of El Paso County. Vegetation within the site is characterized primarily by prairie grasses along with some area of scrub brush and a limited occurrence of hardwood trees directly adjacent to the tributary and main stem of Fishers Canyon Creek. The existing land use is undeveloped vacant land. There are no existing irrigation ditches on the Site.

The existing topography consists of slopes ranging from 1% to 33%, with slopes adjacent to creek near vertical where historic erosion and channel migration has occurred. The unnamed tributary of Fishers Canyon Creek runs from the southwest corner of the site to the northern portion of the site, where it joins the Fishers Canyon Creek main stem in flowing from west to east across the Site.

PROJECT BACKGROUND

The Project is located within the Fishers Canyon Creek drainage basin. The most recent Drainage Basin Planning Study for the basin was completed by Muller Engineering Company in September 1991 (DBPS). The watershed is generally located in southwest central El Paso County near the unincorporated community of Stratmoor.

The watershed has some minor tributaries through the Stratmoor and Stratmoor Hills community and has an overall area of approximately 6.5 square miles where the basin confluences with Fountain Creek. The headwaters of the watershed are heavily developed suburban neighborhoods and commercial developments, with some undeveloped areas for parks, open space, and natural channels.

The DBPS identified drainage improvements within the project site. These improvements included grade control structures within the channel to help stabilize the channel invert as well as keeping the channel as natural as possible. Additional water quality improvements beyond the vertical channel stabilization included preemptive flattening of slopes to avoid sediment migration into the channel. See **Appendix A** for excerpts from the DBPS.

The recommend channel improvements in the DBPS included grouted boulder drop structures with channel armoring through the use of riprap, which is now referred to as constructed riffle drop structures; this also includes armoring at the toe of slopes. The DBPS, however, is vague on how and where the typical protection section is applied to the channel reaches. On the main stem of Fishers Canyon Creek, there is one grouted boulder drop structure downstream of the confluence with the Tributary. There are several more recommended drop structures on the Tributary with heights ranging from 4’ to 11’ tall. The recommended channel slope through the Main Stem and Tributary are 0.008 (ft/ft) and 0.012 (ft/ft) respectively.

EXISTING SUB-BASIN DESCRIPTIONS

The channel improvements are located in the bottom third of the Fishers Canyon Creek Basin. Main Stem flows come from the west portion of the watershed which make up the majority of the drainage area. Flow along the Main Stem generally flows from west to east as it makes its way beneath Interstate 25 to Fountain Creek. Tributary flows come from the south from the community college and upper portions of this subbasin from the south. Flow along the Tributary primarily flows in a northerly direction until it confluences with the main stem of Fishers Canyon Creek. Near the project site, the channels are characterized with shallow bedrock of mud rock or shale material with near vertical banks in most places. The DBPS describes this area as a “point [that] used to [have] a series of ponds the rest of the way to Interstate 25” where these dams were later breached and the channel meanders through these old structures. Both drainage areas are heavily developed with a mix of dense commercial and residential, with the occasional open space and park.

PROPOSED SUB-BASIN DESCRIPTIONS

For the channel improvements, the proposed subbasins will maintain historic flow patterns for the main stem and tributary of Fishers Canyon Creek. The improvements will be influenced by off-site improvements from a development to the south along the Tributary. The off-site basins are considered a separate project but are being closely coordinated with that consultant team to determine the best outfall location to minimize impacts to the stream and maintain stability within the channel.

PREVIOUS REPORTS

The following is a complete list of the existing reports pertaining to the Fishers Canyon Apartments site.

1. Fishers Canyon Drainage Basin Planning Study Selected Plan Report (DBPS), prepared by Muller, September 1990.

DBPS DRAINAGE IMPROVEMENTS

The DBPS improvements recommended improvements along the main stem of Fishers Canyon Creek, near the proposed drop structure upstream of Venetucci Blvd, of one 4-foot drop structure designed for a discharge of 3,200 cfs, with a longitudinal slope upstream and downstream of 0.8%. The proposed channel section included a typical section with a multi-stage channel that included an access trail, floodplain bench, 3:1 slopes, and an armored rock low flow channel that extended 2.5' up the side slopes of the low flow channel. The channel bottom width was 8-feet wide, with a 16-foot top width of the armored section.

The improvements along the Tributary channel included a proposed five (5) grouted boulder drop structures with heights of 11-feet, 6-feet, 5- feet, 4-feet, and 4-feet. The longitudinal slope through here was proposed to be 1.2%. The typical low flow channel included an armored rock low flow channel with rock extending 1.5-feet up the side slopes of the channel, with side slopes of 4:1, bottom width of 4-feet, and a top width of the armored section of 10-feet.

HYDROLOGY

The proposed channel design was modeled in HEC-RAS using flow rates based on the DBPS for the 100-year design storm. The 100-year flow rates from the DBPS are provided in Table 1 below.

Table 1. DBPS (1990) Flow Rates.

Design Point | Recurrence Interval	*100-year*
Fishers Canyon Creek Downstream of Confluence with Tributary	3,200 cfs
Fishers Canyon Creek Tributary	290 cfs

The effective Federal Emergency Management Agency (FEMA) hydraulic model was obtained from FEMA. This model only had flow rates for the main stem of Fishers Canyon Creek as the Tributary is an unmapped drainageway. A summary of the effective flow rates at the channel improvements upstream of Interstate 25 is provided in

Table 2.

Table 2. Effective FEMA Flow Rates.

Design Point \ Recurrence Interval	*10-year*	*50-year*	*100-year*	*500-year*
Fishers Canyon Creek Downstream of Confluence with Tributary	1,420 cfs	2,590 cfs	3,090 cfs	4,800 cfs

HYDRAUILC ANALYSIS

The proposed channel improvements were modeled as two separate stream reaches. This was because of the importance to model the Tributary without the influence of the Fishers Canyon Creek main stem on the tributary. Doing this resulted in the most conservative design approach for the lower end of the Tributary channel. A HEC-RAS 1D model was made of the improvements based on the conceptual construction drawings submitted along with this design report. An existing conditions and proposed conditions model were created using topography collected form the United States Geological Survey (USGS) National Map Viewer of bare-earth Light Detection and Ranging (LiDAR) data gathered in 2018.

FISHERS CANYON CREEK

Existing

The model for the main stem of Fishers Canyon Creek was developed using the flows from the effective FEMA model described above. The hydraulic model extends approximately 1,000-feet upstream of the confluence with the Tributary and 300-feet downstream of the Venetucci Blvd bridge. The downstream boundary condition used is a normal depth boundary condition set to the slope of the channel which is approximately 0.011 (ft/ft).

The cross-sections were generated on a 100- to 200-foot spacing, with a cross-section located at the proposed drop crest and drop toe just upstream of Venetucci Blvd. Manning’s n values for the model were generated from the effective FEMA model and based on engineering judgement, with values between 0.05 to 0.08 for the overbanks and 0.03 to 0.045 for the channel.

The Venetucci Blvd bridge is a 123-foot concrete structure spanning Fisher's Creek. According to a survey conducted by Kimley-Horn, the bridge offers a vertical clearance of approximately 15 feet between the channel bottom and the asphalt roadway. The section of Fisher's Creek that passes beneath the Venetucci Bridge is well-vegetated. The bridge will be added to the HEC-RAS model at the next phase of design.

Proposed

The proposed model for the main stem was updated with the proposed channel grading. The Manning’s n values were updated to reflect the proposed stabilization materials and anticipated revegetation along the channel banks.

FISHERS CANYON CREEK TRIBUTARY

Existing

The model for the Tributary to Fishers Canyon Creek was developed based flow rates from the DBPS. As this model is used for design purposes only, the downstream boundary condition used for the model was set to the channel slope of 0.026 (ft/ft) from the main stem downstream of the confluence. The model extends 1,200-feet upstream from the confluence with Fishers Canyon Creek.

The cross-section locations for the proposed hydraulic model are based on the drop crest and drop toe locations from the proposed alignment. This cross-section spacing was frequent enough between the primary drops, with cross-sections spaced between 100- to 200-feet. Some realignment of the stream centerline was necessary to safely fit a minimum of a 3:1 slope with the limited space of the Tributary channel. This will be discussed further in the channel improvement section below. Manning's n values similar to the effective FEMA model were considered and engineering judgement was applied to set overbank Manning's n values between 0.05 and 0.08, with values between 0.03 to 0.045 for the channel.

Proposed

The proposed model for the Tributary was updated to reflect the proposed channel improvements including the grouted boulder drop structures and constructed riffles. The cross-sections in this model now reflect the channel realignment and reflect channel side slopes of no greater than 3:1. Manning's n values were updated as needed to represent the channel improvements and anticipated revegetation of the channel.

PROPOSED CHANNEL IMPROVEMENTS

The proposed channel improvements have been designed in accordance with El Paso County and Mile High Flood District criteria manuals. Areas where the criteria were unable to be met are outlined in detail below. Table 3 below is a summary of some of the applicable design criteria being used for this channel design. The maximum values for the tributary are at cross section locations where the channel is proposed to be armored and will therefore be stabilized. The maximum values for the main stem and tributary are only located on cross-sections within our defined work area.

Table 3. Channel Improvement Design Criteria.

Design Criteria	*Recommended Design Value*	*Maximum Design Value (Tributary)*	*Maximum Design Value (Main Stem)*
Maximum 100-year depth outside of bankfull channel	5 ft	2.8 ft	9.3 ft
Maximum 100-year velocity, main channel	5 ft/s	6.9 ft/s	11.7 ft/s 13.16?
Froude No., 100-year, main channel	0.8	0.81	0.84
Maximum Shear Stress, 100-year, main channel	1.2 lb/sf	9.5 lb/sf	9.0 lb/sf
Minimum bankfull capacity of bankfull channel (based on future development conditions)	70% of 2-year discharge or 10% of 100-year discharge, whichever is greater	10% of 100-year discharge (29 cfs)	10% of 100-year discharge (338 cfs)
Maximum overbank side slope	4(H):1(V)	4(H):1(V)	4(H):1(V)
Maximum bankfull side slope	2.5(H):1(V)	3(H):1(V)	3(H):1(V)
Maximum drop structure height	4 ft	4 ft	4 ft

CHANNEL DESIGN

side(?)

The channel design attempted to maintain a 4:1 slope where possible, and a 3:1 slope where tie-in points would negatively impact adjacent slopes, maintenance roads, or access points. The proposed longitudinal slope of the Tributary channel was held between 0.2% to 0.6% outside of grouted boulder drop structures, non-grouted boulder grade controls, and constructed riffles. The proposed longitudinal slope of the main channel was kept flatter, at less than 0.2%.

The proposed channel alignment on the Tributary approximates the existing centerline of the channel while providing benching in order to reduce velocity, shear, and Froude values as much as possible while not creating excessively steep side slope tie-ins. The maximum tie-in slopes have been set to 3:1 and do not impact adjacent infrastructure such as the existing maintenance access road on the east side of the Tributary.

DROP STRUCTURES

The proposed drop structures are a combination of grouted boulder drop structures, ungrouted boulder grade controls, and constructed riffles made of void-filled riprap. The grouted boulder structures will consist of 3-ft diameter boulders grouted together for additional weight and resistance to erosion. The longitudinal slope of the drops will be no greater than a 4:1 slope with side slopes no steeper than 3:1. The grouted boulder drop structures will not have a height greater than 4-feet from drop crest to drop toe. Three grouted boulder drop structures are proposed and they will have an edge wall with riprap along the edges of the drop structure. The ungrouted boulder grade controls will form part of a proposed step-pool-riffle sequence; the elevation between the crest of the boulder step and the head of a riffle will not exceed 0.5-feet.

A Lane’s Creep seepage analysis was performed for each grouted boulder drop structure to set the embedment depth for the sheet pile cutoff wall; the cutoff depth may be updated in the future as geotechnical information becomes available to help understand the depth of bedrock.

Drop #1

This is a grouted boulder drop structure located on the main stem of Fishers Canyon Creek just upstream of Venetucci Blvd. The drop structure is slightly elevated above existing conditions to help create additional stabilization in the channel upstream of the drop. The proposed slope upstream of the drop structure is 0.10%, which is a little flatter than the minimum to promote additional aggradation above the proposed drop structure. Being elevated above the existing channel invert, the drop structure will allow the channel to backfill with sediment for a short distance, with 10-foot approach void-filled riprap of Type M design designed for the crest, with a sloped edge on the upstream end. The drop structure proposes a stilling basin for energy dissipation. Drop width was set based on the hydraulic modeling results where shear stresses and channel velocities were below design criteria for stable channels.

Drop #2 and Drop #3

These drops are located just upstream of the confluence of the Tributary to Fishers Canyon Creek. They were set here to increase the channel invert height quickly for the remainder of the channel upstream of the drops. Drop heights are approximately 4-feet with drop structure width beyond the 100-year floodplain limit. The maximum limit for channel slope of 0.6% was used elevate the channel invert as much as possible. Both drop structures propose a stilling basin for energy dissipation.

Add information about future (or pre-development) reimbursement request and required Drainage Board approval for any increase above currently "allowable" costs

Drop #4 to Drop #12

Drops 4 through 12 are constructed riffle drop structures that are made from void-filled Type M riprap, with a D50 of 12-inches. A maximum slope of 4% was used for the drops, with the upstream and downstream ends of the material toed into the channel invert 2- to 3-feet for additional stability. Drop heights were generally kept at 1-foot in height, with Drop 9 having a height of 1.2-feet. A sheetpile cutoff wall is proposed immediately upstream of Drop 12.

Upstream Improvements

Upstream of Drops 4 – 12, the channel is proposed to be lined with Type M riprap. This portion of the channel will utilize existing riprap within the channel to provide stability. The riprap will extend upstream to an existing riprap drop structure located at station 60+00. A proposed cutoff wall will be installed at the crest of the existing drop structure to lock the channel invert in place.

MAINTENANCE

Maintenance access for the proposed channel improvements is provided by existing access on a maintenance road at the base of top of slope along the T
Boulevard for the drop structure along the main stem. The main
can be accessed from Venetucci Boulevard near the recently cons

Once construction of the proposed channel improvements is co
channel will be the responsibility of El Paso County.

provide DBPS cost and estimated proposed cost for the channel improvements. the previous assessment provided to staff in 2023 indicated a 2% annual rate increase for fees between 1991-1997. Please provide basis for the proposed annual rate

COST

See **Appendix E** for a draft opinion of probable construction
submittal. This will be updated in preparation for the next submittal based on any additional feedback from the County.

FLOODPLAIN PERMITTING

A few of the proposed improvements are located within the effective floodway and floodplain which triggers the need for a floodplain development permit. The design of the improvements is not expected to cause a rise in the Base Flood Elevation of more than 0.00 feet, will not decrease the BFE by more than 0.30 feet, and will not decrease the floodplain more than 25-feet. A floodplain development permit will be applied for through the Pikes Peak Regional Building Department (PPRBD). A copy of the floodplain development permit and any correspondence with PPRBD will be provided as they are developed.

ENVIRONMENTAL PERMITTING

Based on the current interpretation of the Clean Water Act Section 404, the project will likely have an impact of Waters of the United States (WOTUS) and jurisdictional wetlands. The exact impacts to wetlands will be determined for the next submittal to the County. A 404 permit will be applied for through the Albuquerque District of the United States Army Corps of Engineers (USACE) office. It is anticipated the project may need to apply for an Individual Permit (IP) as the proposed design includes grouted structures inside the Ordinary High Water Mark (OHWM). The permit application and correspondence to USACE has not happened yet as the design may change following the receipt of comments from the County. After the second submittal to the County, the 404 permit will be applied for and the permit, along with any correspondence to USACE, will be provided in an appendix of this report.

(even if USACE says not jurisdictional per new rules, the State's new rules may apply)

CONCLUSION

The Fishers Canyon Apartments development lies within the drainage basin of the Fishers Canyon Creek watershed. This report has been prepared in accordance with El Paso County stormwater criteria. It outlines the proposed channel improvements to stabilize the channel invert. The channel improvements are in general conformance with the DBPS.

REFERENCES

1. City of Colorado Springs “Drainage Criteria Manual (DCM) Volume 1”, dated May 2014

2. El Paso County “Engineering Criteria Manual” Volumes 1 & 2, dated October 31, 2018

3. Urban Storm Drainage Criteria Manuals (USDCM), (Volumes 1, 2 and 3). September 2017.

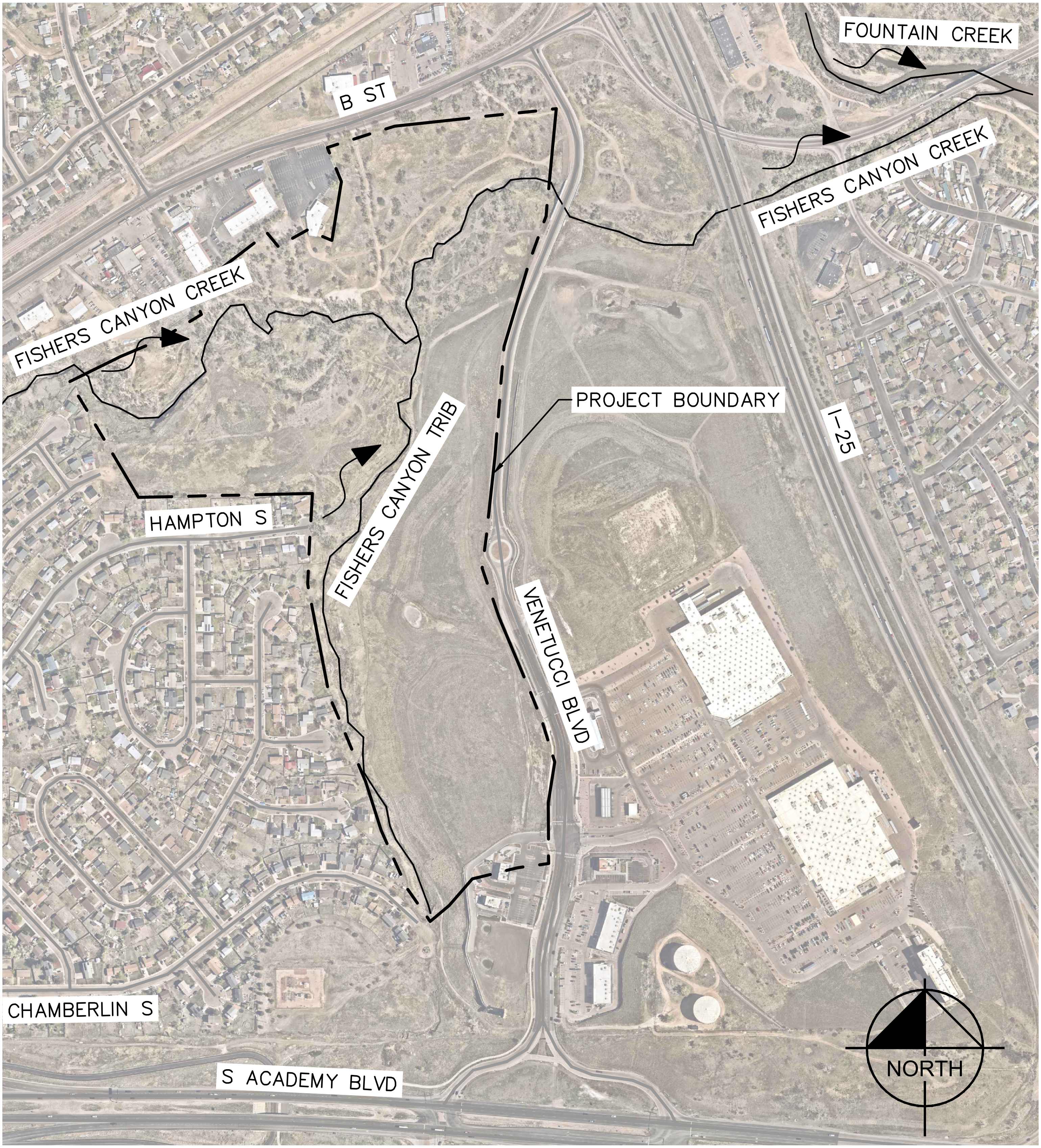
4. Flood Insurance Rate Map, El Paso County, Colorado and Incorporated Areas, Map Number 08041C0743G, Effective Date December 7, 2018, prepared by the Federal Emergency Management Agency (FEMA).

5. Fishers Canyon Drainage Basin Planning Study Selected Plan Report (DBPS), prepared by Muller, September 1990.

APPENDIX

APPENDIX A: FIGURES

FISHERS CANYON CREEK



VICINITY MAP
1" = 500'

104°48'45.46"W 38°46'59.11"N

104°46'52.11"W 38°44'53.43"N

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR DRAFT FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS	🟦	**Without Base Flood Elevation (BFE)** *Zone A, V, A99* **With BFE or Depth** *Zone AE, AO, AH, VE, AR*
	▨	**Regulatory Floodway**
OTHER AREAS OF FLOOD HAZARD	🟧	**0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile** *Zone X*
	▨	**Future Conditions 1% Annual Chance Flood Hazard** *Zone X*
	▨	**Area with Reduced Flood Risk due to Levee See Notes** *Zone X*
	▨	**Area with Flood Risk due to Levee** *Zone D*
OTHER AREAS	**NO SCREEN**	**Area of Minimal Flood Hazard** *Zone X*
	☐	**Effective LOMRs**
	🟧	**Area of Undetermined Flood Hazard** *Zone D*
GENERAL STRUCTURES	- - - - - - -	**Channel, Culvert, or Storm Sewer**
	ı ı ı ı ı ı ı ı ı ı	**Levee, Dike, or Floodwall**
OTHER FEATURES	⬡B —— 20.2	**Cross Sections with 1% Annual Chance**
	17.5 ——	**Water Surface Elevation**
	⑧- - - -	**Coastal Transect**
	-·- -·- -·-	**Coastal Transect Baseline**
	— -- —	**Profile Baseline**
	——	**Hydrographic Feature**
	~~ 513 ~~~	**Base Flood Elevation Line (BFE)**
	——	**Limit of Study**
	——	**Jurisdiction Boundary**

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Basemap information shown on this FIRM was provided in digital format by USDA, Farm Service Agency (FSA). This information was derived from NAIP, dated April 11, 2018.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on **5/3/2024 11:25 AM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at https://www.fema.gov/media-library/assets/documents/118418

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards. This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date.

SCALE

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: NAVD88
For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map, please see the Flood Insurance Study (FIS) Report for your community at https://msc.fema.gov

N

1 inch = 500 feet 1:6,000

0 250 500 1,000 1,500 2,000 Feet

Meters 0 50 100 200 300 400

FEMA
National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

PANEL **743** OF **1275**

Panel Contains:

COMMUNITY	NUMBER	PANEL
EL PASO COUNTY	080059	0743
CITY OF COLORADO SPRINGS	080060	0743
FORT CARSON MILITARY RESERVATION	08FED	0743

MAP NUMBER
08041C0743G
EFFECTIVE DATE
December 07, 2

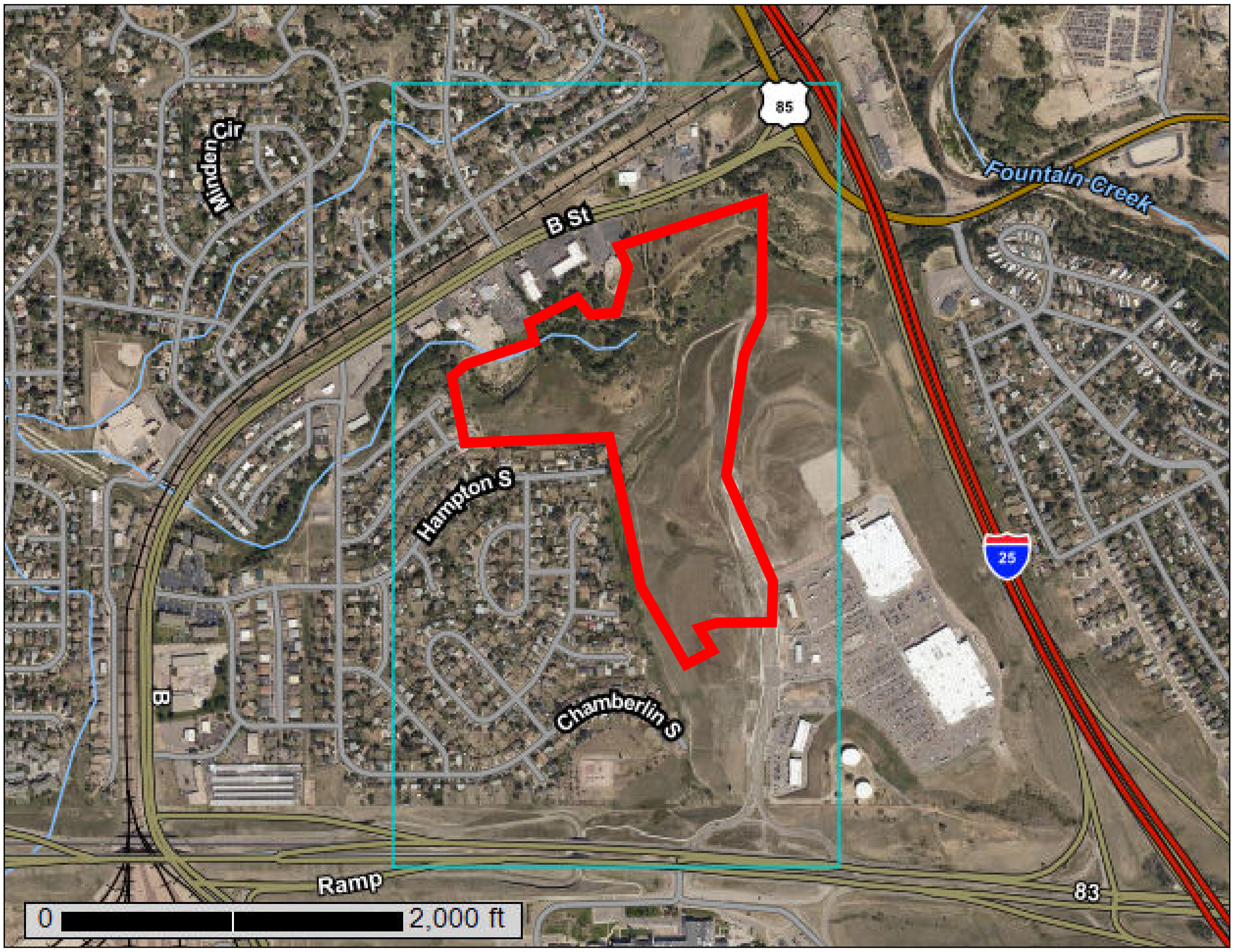
United States
Department of
Agriculture

Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

El Paso County Area, Colorado



May 6, 2024

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

MAP LEGEND

Area of Interest (AOI)

☐ Area of Interest (AOI)

Soils

☐ Soil Map Unit Polygons

〰 Soil Map Unit Lines

■ Soil Map Unit Points

Special Point Features

ʘ Blowout

⊠ Borrow Pit

✱ Clay Spot

◇ Closed Depression

✕ Gravel Pit

∴ Gravelly Spot

⊛ Landfill

Λ Lava Flow

⩛ Marsh or swamp

⚒ Mine or Quarry

◎ Miscellaneous Water

○ Perennial Water

∨ Rock Outcrop

\+ Saline Spot

⁙ Sandy Spot

⊖ Severely Eroded Spot

◈ Sinkhole

⋗ Slide or Slip

ø Sodic Spot

≣ Spoil Area

◊ Stony Spot

⊚ Very Stony Spot

ψ Wet Spot

△ Other

╌ Special Line Features

Water Features

〜 Streams and Canals

Transportation

┼┼┼ Rails

〰 Interstate Highways

〰 US Routes

〰 Major Roads

〰 Local Roads

Background

▨ Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 21, Aug 24, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 19, 2018—Sep 23, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
47	Limon clay, 0 to 3 percent slopes	50.8	18.5%
59	Nunn clay loam, 0 to 3 percent slopes	17.0	6.2%
82	Schamber-Razor complex, 8 to 50 percent slopes	126.4	46.1%
111	Water	5.1	1.9%
127	Midway-Razor clay loams, dry, 1 to 18 percent slopes	74.8	27.3%
Totals for Area of Interest		**274.2**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

El Paso County Area, Colorado

47—Limon clay, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 368p
Elevation: 5,200 to 6,200 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 135 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition

Limon, occasionally flooded, and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Limon, Occasionally Flooded

Setting

Landform: Flood plains, alluvial fans
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey alluvium derived from shale

Typical profile

A - 0 to 4 inches: clay
AC - 4 to 12 inches: silty clay
C - 12 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water supply, 0 to 60 inches: High (about 9.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R069XY033CO - Salt Flat
Hydric soil rating: No

Minor Components

Other soils
Percent of map unit: 4 percent
Hydric soil rating: No

Pleasant
Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

59—Nunn clay loam, 0 to 3 percent slopes

Map Unit Setting
National map unit symbol: 3693
Elevation: 5,400 to 6,500 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 46 to 50 degrees F
Frost-free period: 135 to 155 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition
Nunn and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Nunn

Setting
Landform: Fans, terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile
A - 0 to 12 inches: clay loam
Bt - 12 to 26 inches: clay loam
BC - 26 to 30 inches: clay loam
Bk - 30 to 58 inches: sandy clay loam
C - 58 to 72 inches: clay

Properties and qualities
Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 3c
Hydrologic Soil Group: C
Ecological site: R069XY042CO - Clayey Plains
Other vegetative classification: CLAYEY PLAINS (069AY042CO)
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit: 4 percent
Hydric soil rating: No

Pleasant

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

82—Schamber-Razor complex, 8 to 50 percent slopes

Map Unit Setting

National map unit symbol: 369y
Elevation: 5,500 to 6,500 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 135 to 170 days
Farmland classification: Not prime farmland

Map Unit Composition

Schamber and similar soils: 55 percent
Razor and similar soils: 43 percent
Minor components: 2 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Schamber

Setting

Landform: Breaks
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granite and/or colluvium derived from granite and/or eolian deposits derived from granite

Typical profile

A - 0 to 5 inches: gravelly loam
AC - 5 to 15 inches: very gravelly loam
C - 15 to 60 inches: very gravelly sand

Properties and qualities

Slope: 8 to 50 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R069XY064CO - Gravel Breaks
Hydric soil rating: No

Description of Razor

Setting

Landform: Breaks
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey slope alluvium over residuum weathered from shale

Typical profile

A - 0 to 3 inches: clay loam
Bw - 3 to 9 inches: clay loam
Bk - 9 to 31 inches: clay
Cr - 31 to 35 inches: weathered bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 15.0
Available water supply, 0 to 60 inches: Low (about 5.5 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R069XY047CO - Alkaline Plains
Other vegetative classification: ALKALINE PLAINS (069AY047CO)
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit: 1 percent
Hydric soil rating: No

Pleasant

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

111—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

127—Midway-Razor clay loams, dry, 1 to 18 percent slopes

Map Unit Setting

National map unit symbol: 2t52f
Elevation: 3,700 to 6,400 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 130 to 170 days
Farmland classification: Not prime farmland

Map Unit Composition

Midway, dry, and similar soils: 46 percent
Razor, dry, and similar soils: 44 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Midway, Dry

Setting

Landform: Ridges, hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, crest

Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Slope alluvium and/or residuum weathered from shale

Typical profile

A - 0 to 3 inches: clay loam
AC - 3 to 9 inches: clay
C - 9 to 16 inches: paragravelly clay
Cr - 16 to 79 inches: bedrock

Properties and qualities

Slope: 3 to 18 percent
Depth to restrictive feature: 11 to 20 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.00 to 0.21 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 7.9 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water supply, 0 to 60 inches: Very low (about 2.2 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R069XY046CO - Shaly Plains
Hydric soil rating: No

Description of Razor, Dry

Setting

Landform: Pediments, hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Slope alluvium and/or residuum weathered from shale

Typical profile

A - 0 to 4 inches: clay loam
Bw - 4 to 15 inches: silty clay
Bky - 15 to 30 inches: clay
Cr - 30 to 79 inches: bedrock

Properties and qualities

Slope: 1 to 9 percent
Depth to restrictive feature: 20 to 39 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.00 to 0.21 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 7.9 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water supply, 0 to 60 inches: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R069XY047CO - Alkaline Plains
Hydric soil rating: No

Minor Components

Manzanola

Percent of map unit: 9 percent
Landform: Fan remnants, hillslopes
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY042CO - Clayey Plains
Other vegetative classification: Loamy Plains #6 (069XY006CO_2)
Hydric soil rating: No

Rock outcrop

Percent of map unit: 1 percent
Hydric soil rating: No

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APPENDIX B: HYDROLOGY & HYDRAULICS

Check-out Copy
City Engr. Div.

MULLER

Fishers Canyon Drainage Basin Planning Study

FINAL DESIGN REPORT

Prepared For:
El Paso County
Department of Public Works

Prepared By:
Muller Engineering Company

September, 1991

SECTION V

HYDROLOGIC ANALYSIS

Methodology

Storm runoff hydrographs for the Fishers Canyon Basin were generated using the Soil Conservation Service Technical Release 20 Computer Program (TR-20). Use of the TR-20 model is in compliance with the El Paso County and City of Colorado Springs Drainage Criteria Manual (Criteria). Several sub-basins which did not require the generation of hydrographs for design purposes, and which were under 90 acres in area, were modelled using the Rational Method.

Hydrographs were developed for existing and future development conditions, with an initial storm recurrence interval of 10 years and a major storm recurrence interval of 100-years. Storms of both 2-hour and 24-hour rainfall duration were modelled, in accordance with the Criteria.

Previous Studies

The Fishers Canyon Basin was the subject of previous hydrologic analyses. Portions of the Fishers Canyon Basin were studied by Drexel, Barrell and Company for the Gates Land Company. The summary reports were entitled "Final Drainage Report for Portions of Broadmoor Bluffs and Cheyenne Meadows South at Cheyenne Mountain Ranch " (Cheyenne Mountain Ranch Report) and "FEMA Map Revision for Spring Run, Cheyenne Meadows Drainage Channel (Cheyenne Meadows Report). The Colorado Department of Highways recently performed a hydrologic analysis of the Fishers Canyon Basin to size a culvert under Interstate 25. More recently, Resource Consultants has investigated Fishers Canyon basin hydrology under contract to the Federal Emergency Management Agency (FEMA Report).

Basin information from the previous studies was checked for reasonableness and, where appropriate, was used in the current hydrologic analysis. Using existing information avoided unnecessary differences in basin modelling and facilitated the comparison of model results.

Sub-Basin Delineation

The Fishers Canyon Basin includes twenty-one sub-basins. Sub-basins and flow paths are indicated in Figure V-1. The sub-basins west of the City/County boundary were modelled as shown in the FEMA Report and the Cheyenne Mountain Ranch Report. The basin designation system used in the FEMA Report was utilized, and extended to include those sub-basins located east of the City/County boundary and south of Academy Boulevard.

Portions of the drainage basin within the City, which is primarily the Gates Land Company annexation, were not included in the detailed study area, as that area is not a part of the drainage fee system and are not reimbursed for drainage project construction. No evaluation was made of the adequacy of hydraulic structures within the City.

USGS quadrangle maps, in combination with basin maps from the Cheyenne Mountain Center Report, were used to verify the sub-basin boundaries of the FEMA Report. Additional sub-basins were delineated within El Paso County based on one-inch equals 200 feet, 2-foot contour interval mapping dated February 9, 1990.

Sub-basins 1 through 4D, 6A through 6D, and SH2 were modelled using TR-20. Runoff from sub-basins 5A through 5D, 6E, and 7A through 7C was calculated using the Rational Method.

Curr Reservoir, a large existing detention facility in the Fishers Canyon basin, was included in the TR-20 model. Stage/storage/discharge information was referenced from the FEMA report and verified using record drawings for Curr Reservoir. The future basin condition model included a diversion of historic flow rates from sub-basin 3A into Fort Carson, in accordance with the Cheyenne Mountain Ranch Report. This diversion is part of a future development plan by the Gates Land Company as approved by the City and Ft. Carson, and is not a part of this drainage basin master plan.

Land Use

Existing land use was determined using aerial photography of the basin dated November 10, 1989. The basin is currently about two thirds developed. At the time of this study approximately twenty percent of the total basin area, more or less, could expect to be developed in the immediate future. Future land use was estimated based on City and County zoning maps and land use planning information. Future land use information is shown in Figure V-2.

Soils Information

Soils types were identified using the SCS "Soil Survey of El Paso County Area, Colorado", dated 1981. Soils for the basin are categorized as loamy, but with significant percentages of clay in some areas. Substantial rock outcrops exist at the highest elevations up on the mountain side. In general, the steep upper sections of the basin are type "C" soils. The remainder of the basin falls in either the type B or type C category of soils. Soils information is shown in Figure V-2.

SCS Curve Numbers

SCS curve numbers representative of sub-basin land use and soils types were interpolated from Table 5-5 (24-hour storm) and Table 5-7 (2-hour storm) of the City/County Criteria. Curve number calculations and other TR-20 input data are shown in the technical appendix.

TABLE 5-5
RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL-COVER COMPLEXES URBAN AND SUBURBAN CONDITIONS[1]

(For Antecedent Moisture Condition II)
(From: U.S. Department of Agriculture,
Soil Conservation Service, 1977)

NOTE: THIS TABLE TO BE USED FOR 24-HOUR STORM ONLY.

Land Use		Hydrologic Soil Group			
		A	B	C	D
Open spaces, lawns, parks, golf courses, cemeteries, etc.					
Good condition: Grass cover on 75% or more of the area		39*	61	74	80
Fair condition: Grass cover on 50% to 75% of the area		49*	69	79	84
Commercial and business areas (85% impervious)		89*	92	94	95
Industrial districts (72% impervious)		81*	88	91	93
Residential:[2]					
Acres per Dwelling Unit	Average % impervious[3]				
1/8 acre or less	65	77*	85	90	92
1/4 acre	38	61*	75	83	87
1/3 acre	30	57*	72	81	86
1/2 acre	25	54*	70	80	85
1 acre	20	51*	68	79	84
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers		98	98	98	98
gravel		76*	85	89	91
dirt		72*	82	87	89

[1] For a more detailed description of agricultural land use curve numbers, refer to in the National Engineering Handbook (U.S. Dept. of Agriculture, Soil Conservation Service, 1972).

[2] Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[3] The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

* Not to be used wherever overlot grading or filling is to occur.

TABLE 5-7
RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL-COVER COMPLEXES URBAN AND SUBURBAN CONDITIONS[1]

(For Antecedent Moisture Condition III)
(From: U.S. Department of Agriculture,
Soil Conservation Service, 1977)

NOTE: THIS TABLE TO BE USED FOR 24-HOUR STORM ONLY.

Land Use		Hydrologic Soil Group			
		A	B	C	D
Open spaces, lawns, parks, golf courses, cemeteries, etc.					
Good condition: Grass cover on 75% or more of the area		59*	78	88	91
Fair condition: Grass cover on 50% to 75% of the area		69*	84	91	93
Commercial and business areas (85% impervious)		96*	97	98	98
Industrial districts (72% impervious)		92*	95	97	98
Residential:[2]					
Acres per Dwelling Unit	Average % impervious[3]				
1/8 acre or less	65	89*	94	96	97
1/4 acre	38	78*	88	93	95
1/3 acre	30	75*	86	92	94
1/2 acre	25	73*	85	91	94
1 acre	20	70*	84	91	93
Paved parking lots, roofs, driveways, etc.		99	99	99	99
Streets and roads:					
paved with curbs and storm sewers		99	99	99	99
gravel		89*	94	96	97
dirt		86*	92	95	96

[1] For a more detailed description of agricultural land use curve numbers, refer to in the National Engineering Handbook (U.S. Dept. of Agriculture, Soil Conservation Service, 1972).

[2] Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[3] The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

* Not to be used wherever overlot grading or filling is to occur.

Rainfall

Ten-year and 100-year recurrence interval hyetographs were developed for 2-hour and 24-hour storm durations. Figures 5-4a to 5-4e of the Criteria were used to derive the following rainfall depths:

	2-Hour		24-Hour	
	10-year	100-year	10-year	100-year
Rainfall Depth, inches	2.06	3.05	3.20	4.50

Estimates of Peak Discharge

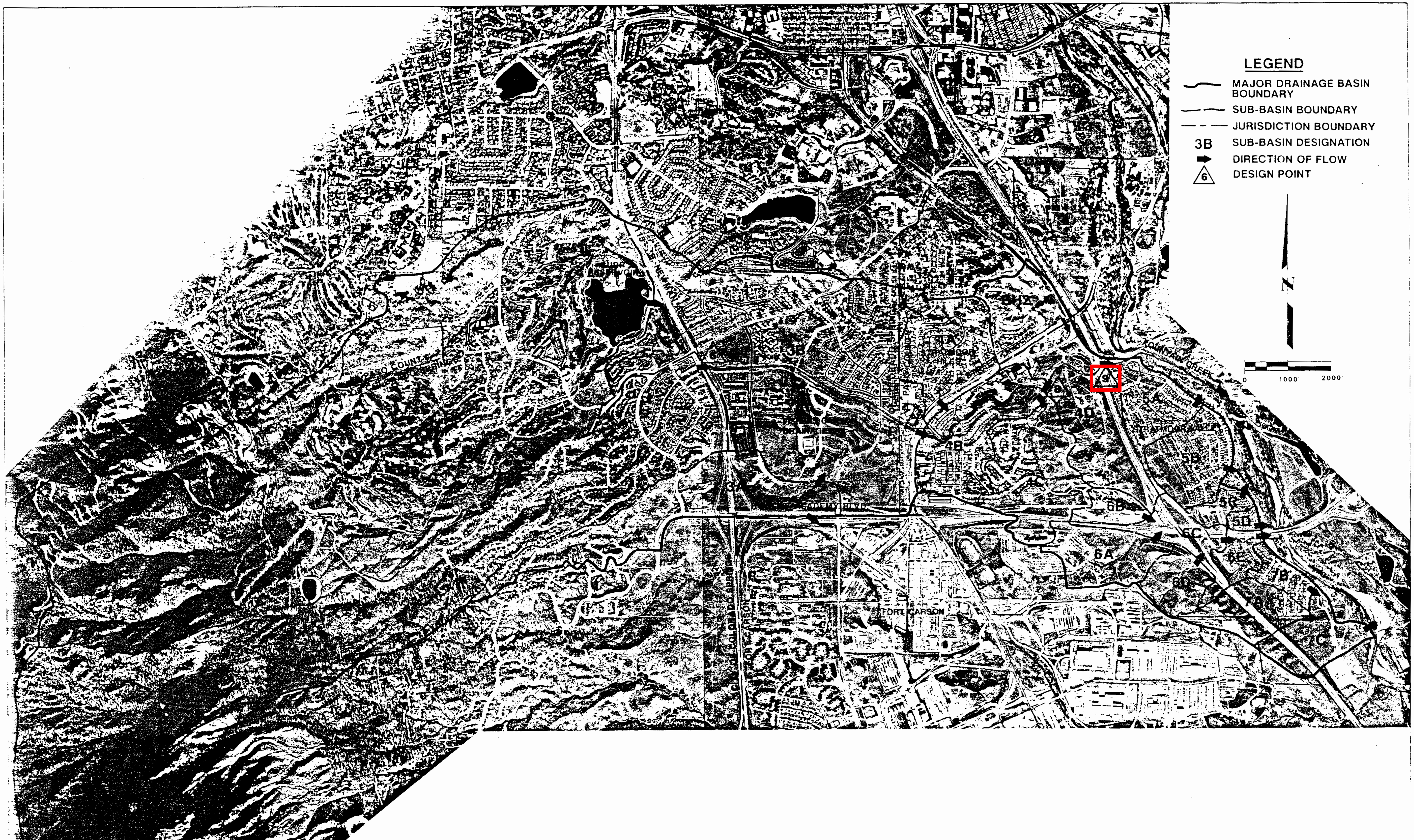
Table V-1 provides a comparison between 100-year existing condition flow rates estimated in the FEMA Report and existing and future development condition flow rates estimated in the current study. The flow rates in Table 2 are generated from the 2-hour storm, which in all cases creates higher peaks than the 24-hour storm. Peak flow rates are indicated at Design Points shown on Figure V-1.

TABLE V-1
FISHERS CANYON BASIN 100-YEAR PEAK FLOW COMPARISON
(all flows in cfs)

	FEMA Report	Current Study	
Design Point	(Existing Conditions)	(Existing Conditions)	(Future Conditions)
6	1,640	1,640	1,640
7	2,490	2,690	2,590
8	2,870	3,000	3,020
9	3,090	3,090	3,170

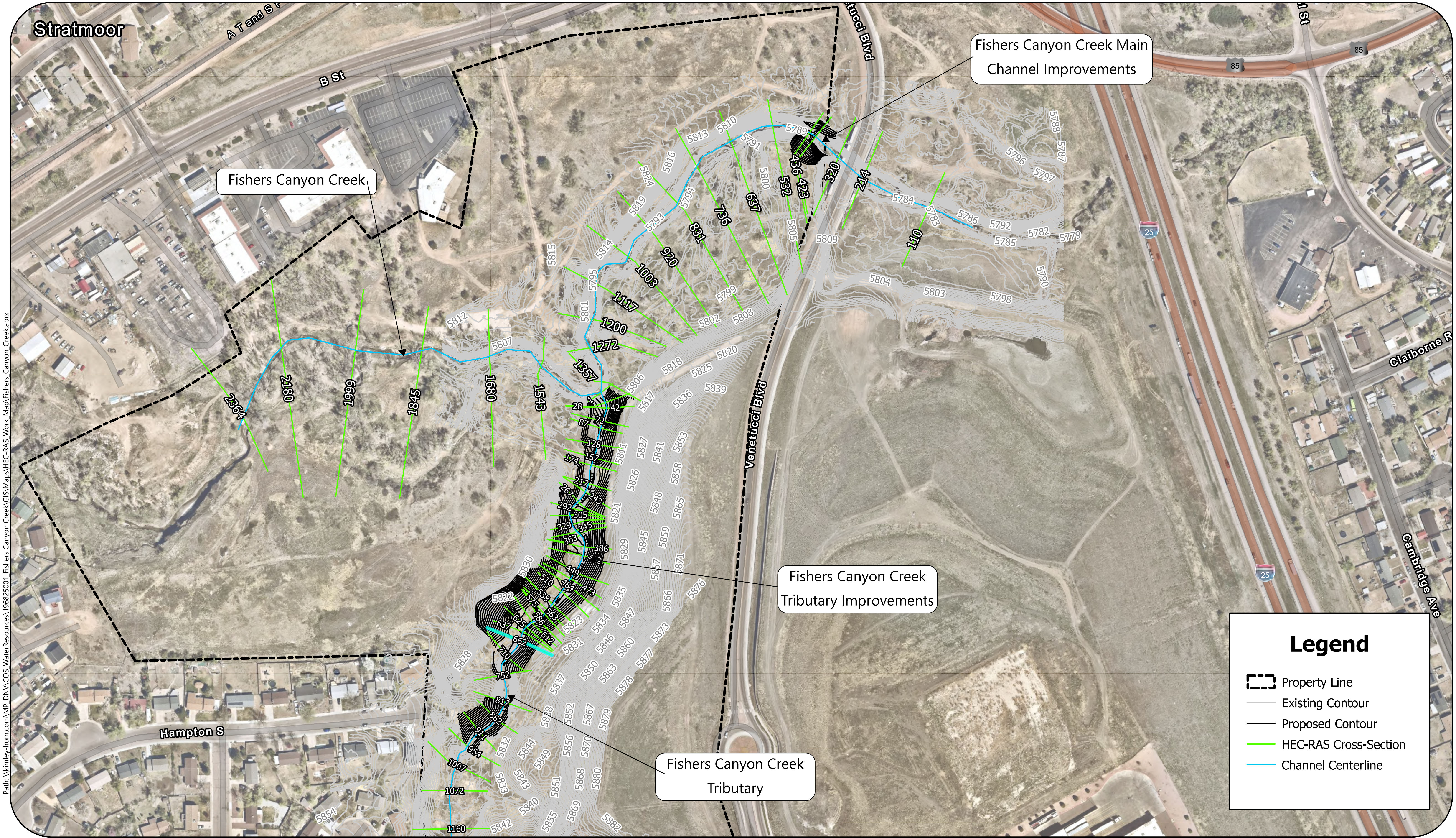
Design Point 7 represents the Fishers Canyon drainageway at the City/County boundary. The peak flow estimated at Design Point 7 in the current study is slightly greater than the flow estimated in the FEMA Report. The difference in peak flow is attributed to the inclusion of Sub-basin 3A in the current study, but not in the FEMA Report. The future condition flow rate is lower than the existing condition flow at Design Point 7 due to the planned diversion of "historic" flows from Sub-basin 3A into Fort Carson, in accordance with the Cheyenne Mountain Ranch Report for the Gates Land Company. At present, the culvert under Highway 83, which is necessary to divert historic flows into Fort Carson, has not been constructed. Therefore the existing condition case does not reflect the diversion. Design Point 9 represents the Fishers Canyon drainageway at Interstate 25. The FEMA Report and the current study correlate well at Design Point 9, with each analysis predicting a 100-year peak flow of 3090 cfs for existing development conditions.

Design peak discharges for storm sewer systems are shown on Figure VIII-1 through VIII-4. These discharges have been calculated at each inlet using the Rational method.



Project No.: 8933
Date: Dec. 1991

AERIAL PHOTOGRAPHY BY: ANALYTICAL SURVEYS, INC. DATE FLOWN: 11/10/89	MULLER ENGINEERING COMPANY, INC. CONSULTING ENGINEERS SOUTH WADSWORTH BOULEVARD SUITE 500 LAKEWOOD COLORADO 80226-3118 (303) 937-3500	EL PASO COUNTY DEPARTMENT OF PUBLIC WORKS 3170 CENTURY STREET COLORADO SPRINGS, COLORADO 80907 (719) 520-6460	FISHERS CANYON DRAINAGE BASIN PLANNING STUDY	SUB-BASIN MAP	FIGURE V-1



Path: \\kimley-horn.com\MP_DNV\COS_WaterResources\196825001_Fishers Canyon Creek\GIS\Maps\HEC-RAS Work_Map\Fishers Canyon Creek.aprx

Esri Community Maps Contributors, © OpenStreetMap, Microsoft, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS

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www.kimley-horn.com

N

0 100 200 400
Feet

NOTES:
1.

Fishers Canyon Creek Channel Improvements

Floodplain Work Map

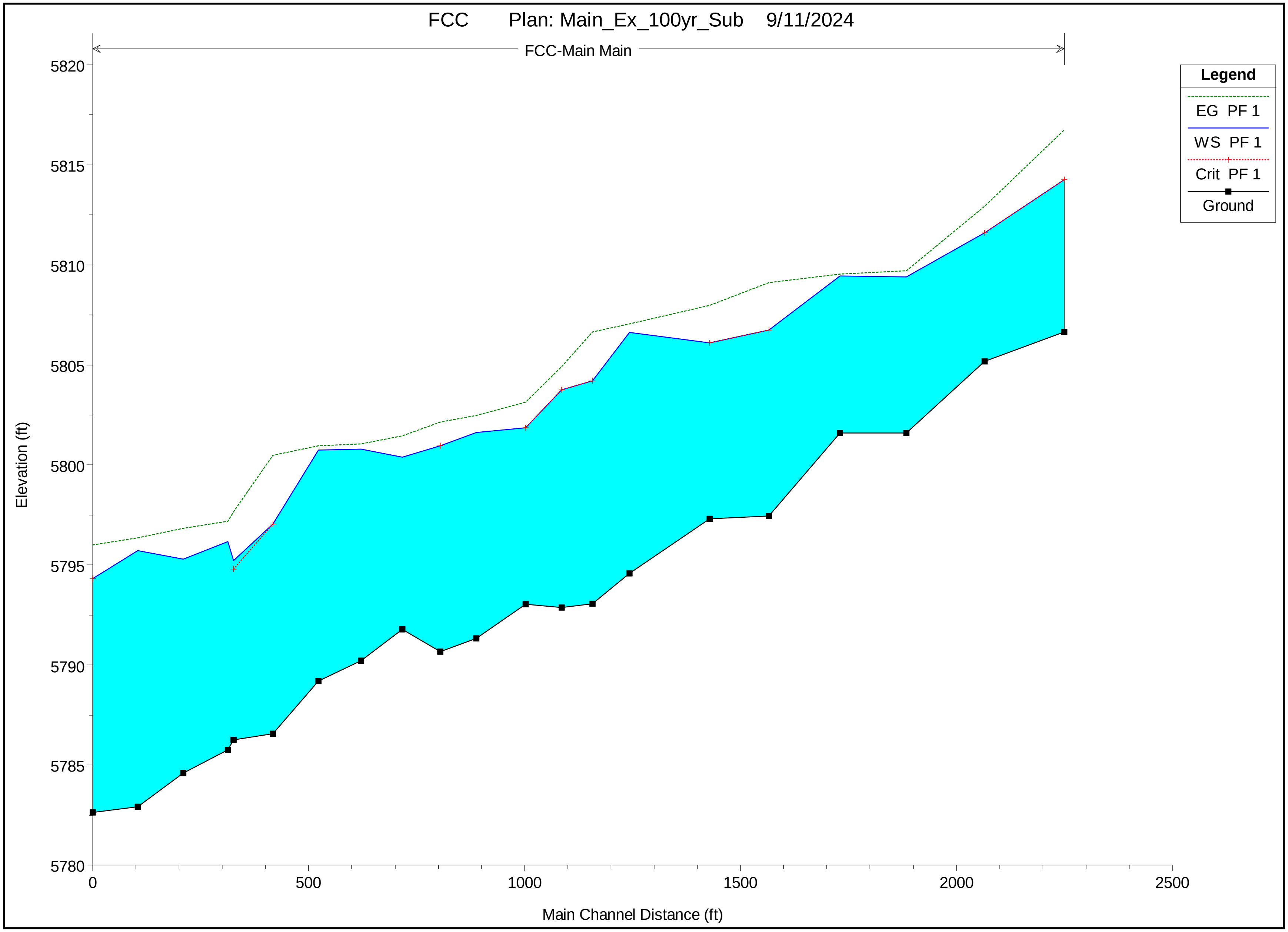
EXISTING CONDITIONS RESULTS

HEC-RAS Plan: Main_Ex_100yr_Sub   River: FCC-Main   Reach: Main   Profile: PF 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	Shear Total
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Main	2364	PF 1	3090.00	5806.66	5814.27	5814.27	5816.76	0.008557	14.03	272.12	56.77	0.94	2.44
Main	2180	PF 1	3090.00	5805.19	5811.61	5811.61	5812.94	0.009389	11.44	386.41	146.26	0.92	1.51
Main	1999	PF 1	3090.00	5801.59	5809.40		5809.70	0.001244	5.61	737.86	170.19	0.36	0.33
Main	1845	PF 1	3090.00	5801.60	5809.46		5809.53	0.000411	3.00	1500.18	346.35	0.21	0.11
Main	1680	PF 1	3090.00	5797.46	5806.73	5806.73	5809.12	0.007936	14.74	295.90	65.26	0.90	2.10
Main	1543	PF 1	3090.00	5797.30	5806.10	5806.10	5807.98	0.006275	13.43	346.57	92.82	0.83	1.41
Main	1357	PF 1	3380.00	5794.58	5806.62		5807.04	0.001243	7.14	781.94	154.31	0.38	0.38
Main	1272	PF 1	3380.00	5793.06	5804.20	5804.20	5806.64	0.005883	15.20	345.44	71.82	0.82	1.62
Main	1200	PF 1	3380.00	5792.87	5803.75	5803.75	5804.92	0.003680	11.70	577.71	199.11	0.64	0.65
Main	1117	PF 1	3380.00	5793.03	5801.86	5801.86	5803.15	0.004498	11.51	541.88	221.57	0.70	0.68
Main	1003	PF 1	3380.00	5791.34	5801.63		5802.48	0.002698	9.70	629.06	195.35	0.55	0.53
Main	920	PF 1	3380.00	5790.66	5800.97	5800.97	5802.16	0.004434	11.71	565.68	237.28	0.68	0.65
Main	831	PF 1	3380.00	5791.78	5800.40		5801.45	0.003904	10.45	529.83	163.67	0.65	0.77
Main	736	PF 1	3380.00	5790.22	5800.79		5801.06	0.000964	5.94	1107.72	327.11	0.33	0.20
Main	637	PF 1	3380.00	5789.21	5800.74		5800.97	0.000678	5.11	1216.03	330.41	0.28	0.15
Main	532	PF 1	3380.00	5786.56	5797.05	5797.05	5800.48	0.007715	15.80	257.30	41.63	0.90	2.59
Main	436	PF 1	3380.00	5786.26	5795.23	5794.79	5797.67	0.006826	13.16	294.45	51.19	0.84	2.19
Main	423	PF 1	3380.00	5785.75	5796.18		5797.19	0.002718	9.27	447.19	61.38	0.54	1.10
Main	320	PF 1	3380.00	5784.59	5795.29		5796.84	0.003010	10.64	395.18	68.09	0.59	1.00
Main	214	PF 1	3380.00	5782.91	5795.72		5796.56	0.001381	7.98	580.74	77.59	0.40	0.58
Main	110	PF 1	3380.00	5782.64	5794.31	5794.31	5796.01	0.004645	12.85	434.34	123.07	0.71	0.98

OUTSIDE PROJECT AREA

OUTSIDE PROJECT AREA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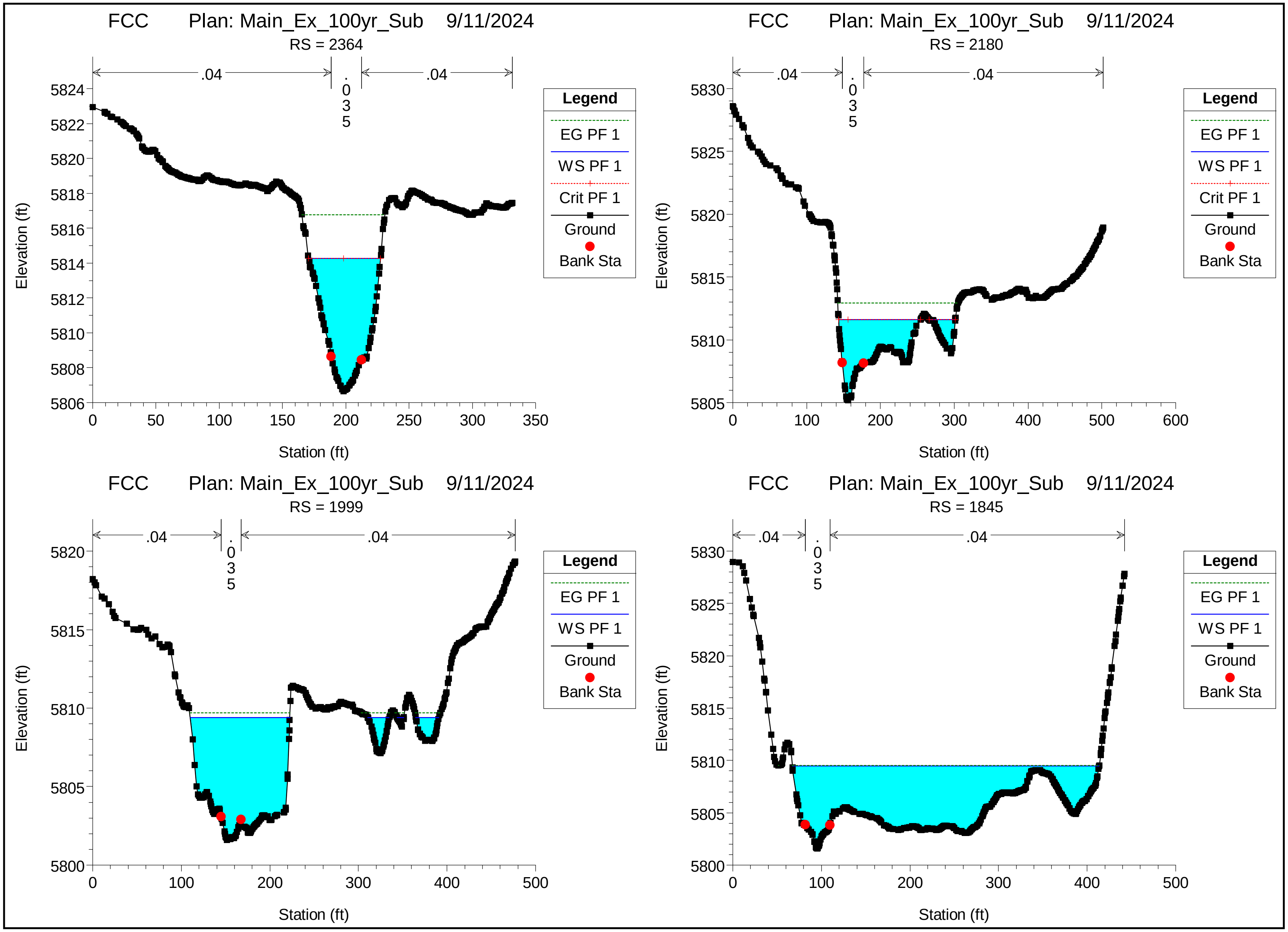
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Bank Sta
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5830
Station (ft)
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500
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WS PF 1
Crit PF 1
Ground
Bank Sta
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Station (ft)
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Legend
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WS PF 1
Ground
Bank Sta
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5830
Station (ft)
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300
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Ground
Bank Sta

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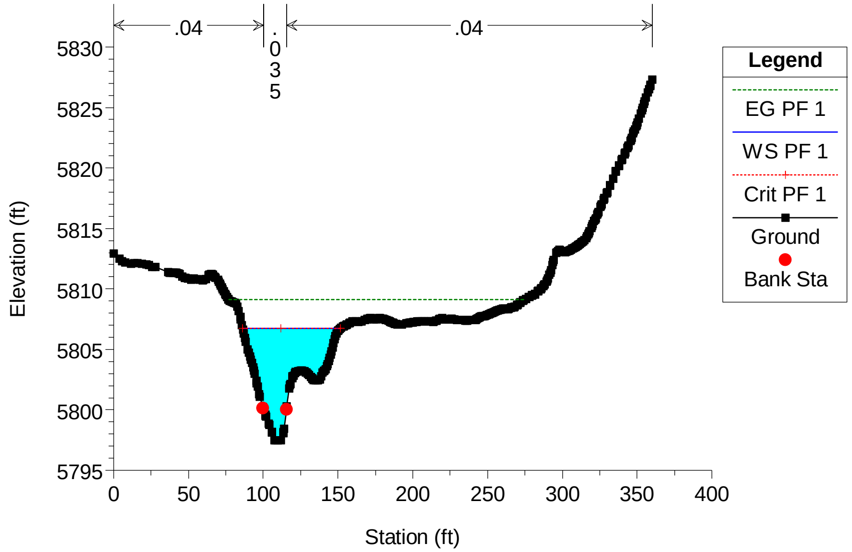

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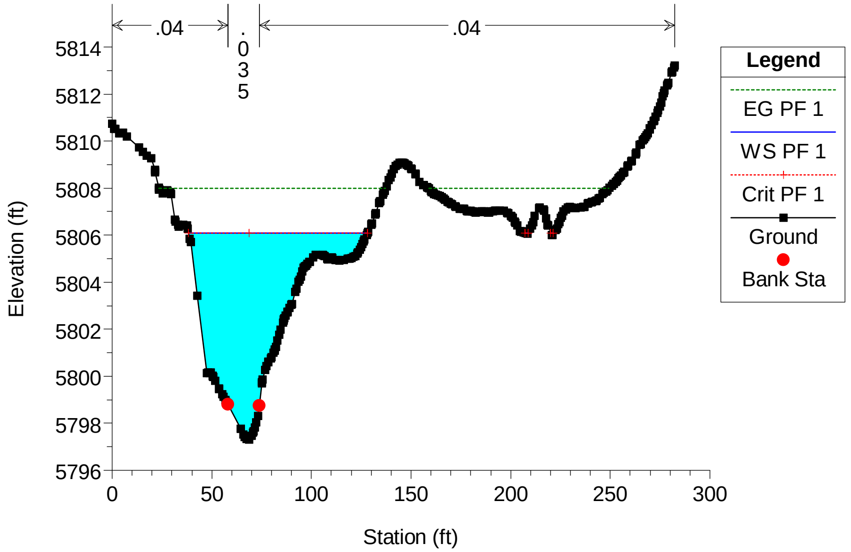

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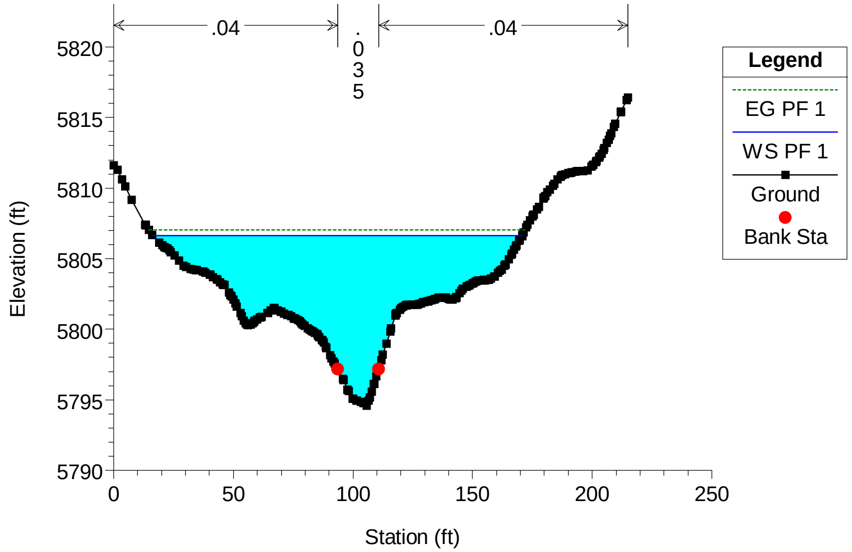

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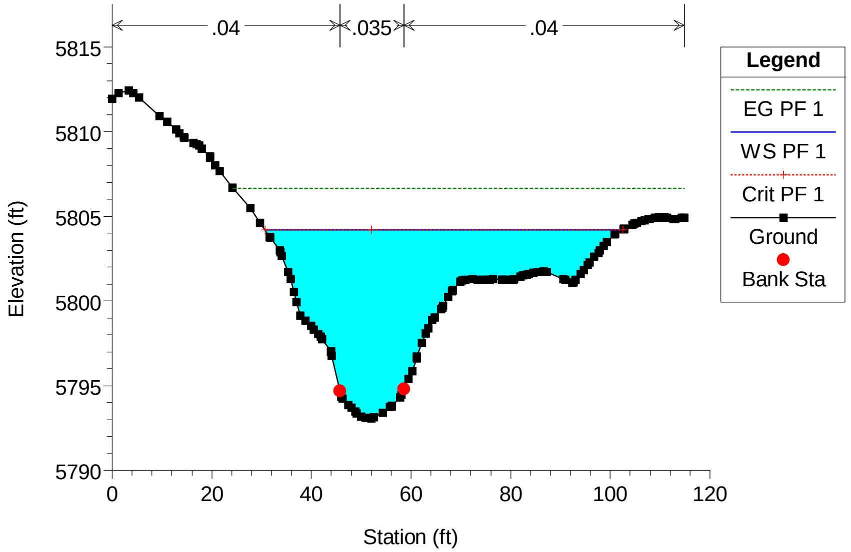

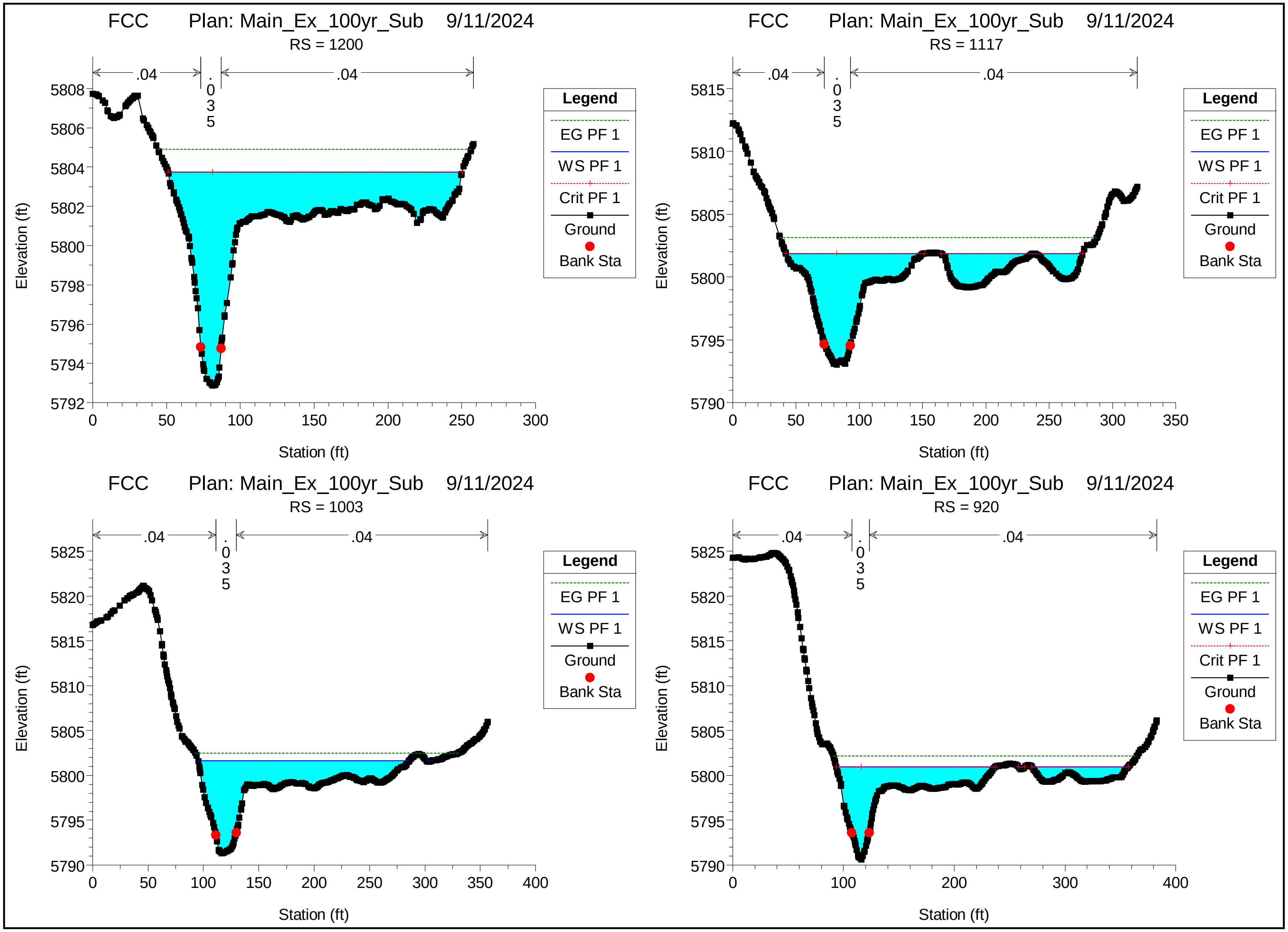
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5794
5792
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250
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Legend
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WS PF 1
Crit PF 1
Ground
Bank Sta
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Station (ft)
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100
150
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300
350
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
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Legend
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WS PF 1
Ground
Bank Sta
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Elevation (ft)
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Station (ft)
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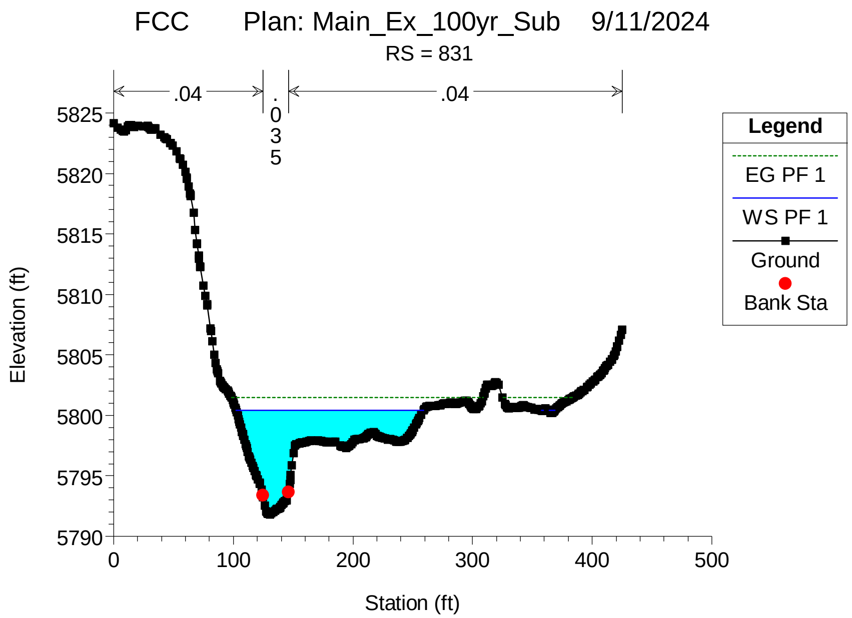
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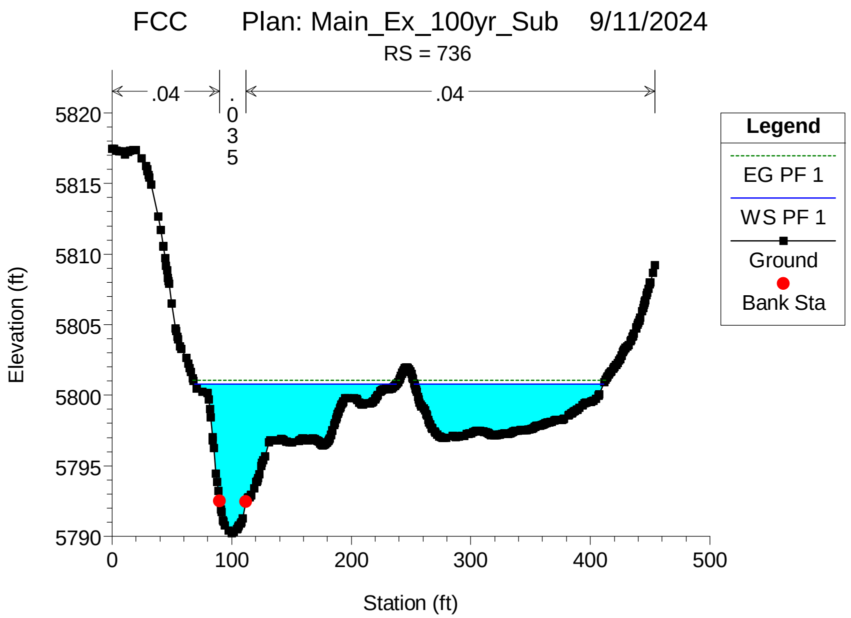
Bank Sta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Legend
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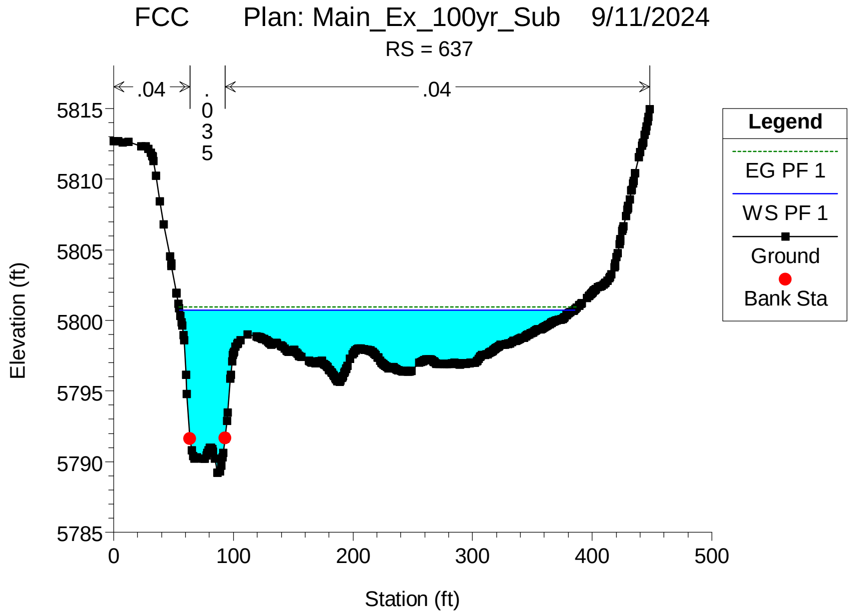
Ground
Bank Sta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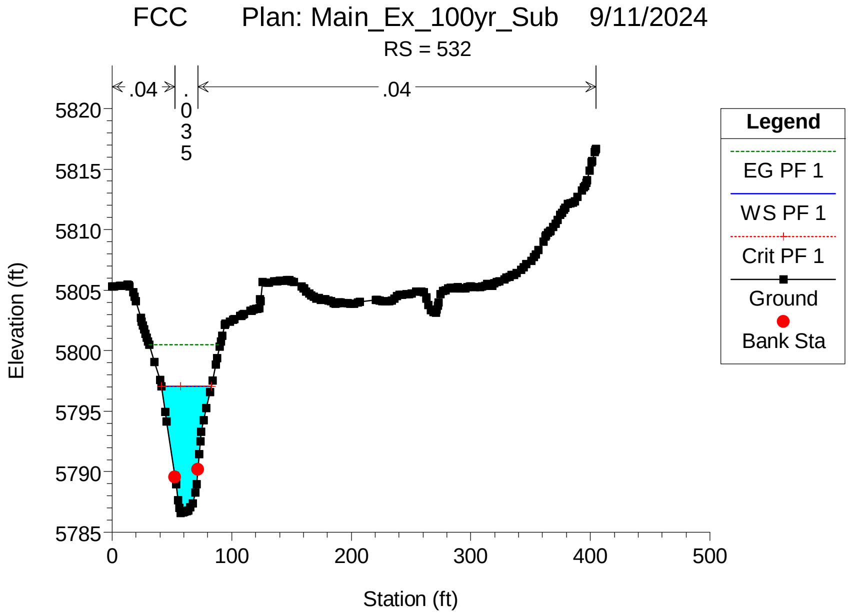
Bank Sta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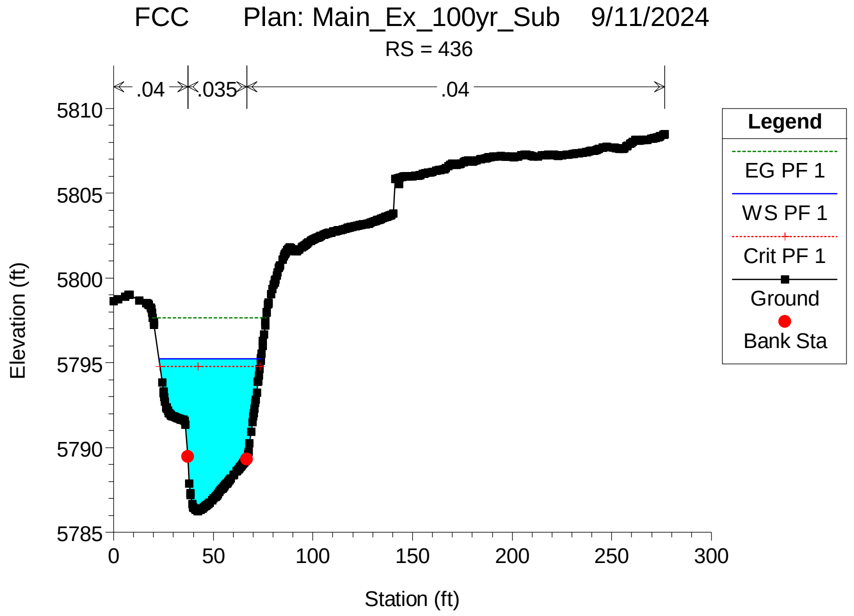
Ground
Bank Sta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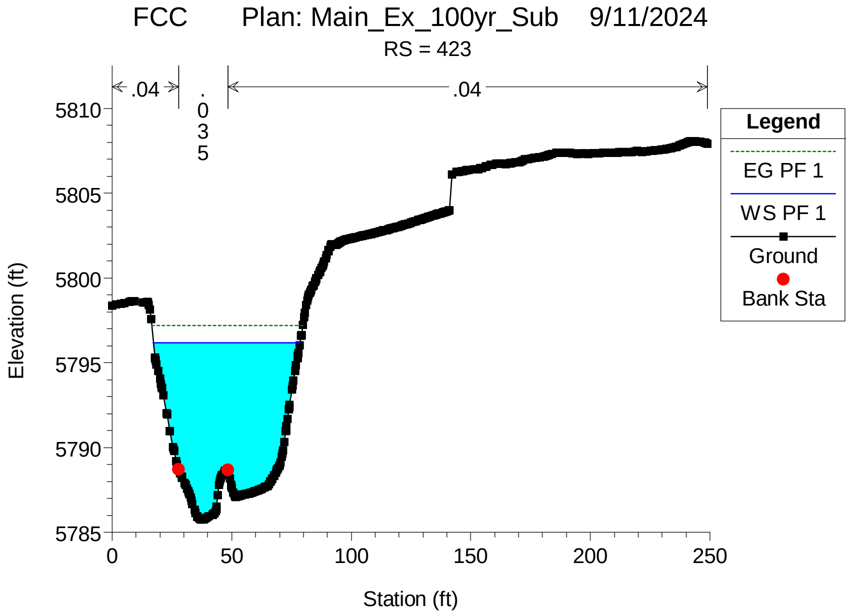
Crit PF 1
Ground
Bank Sta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WS PF 1
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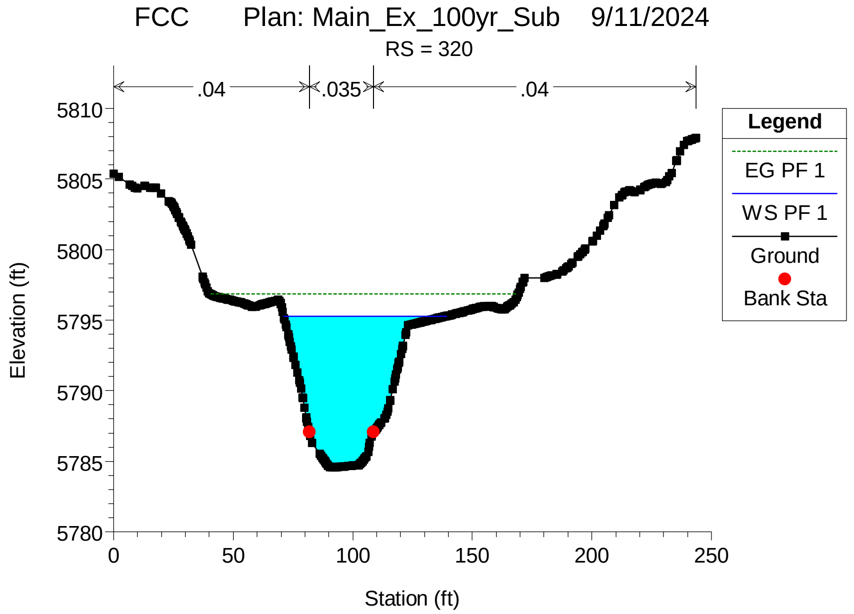
Bank Sta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Station (ft)
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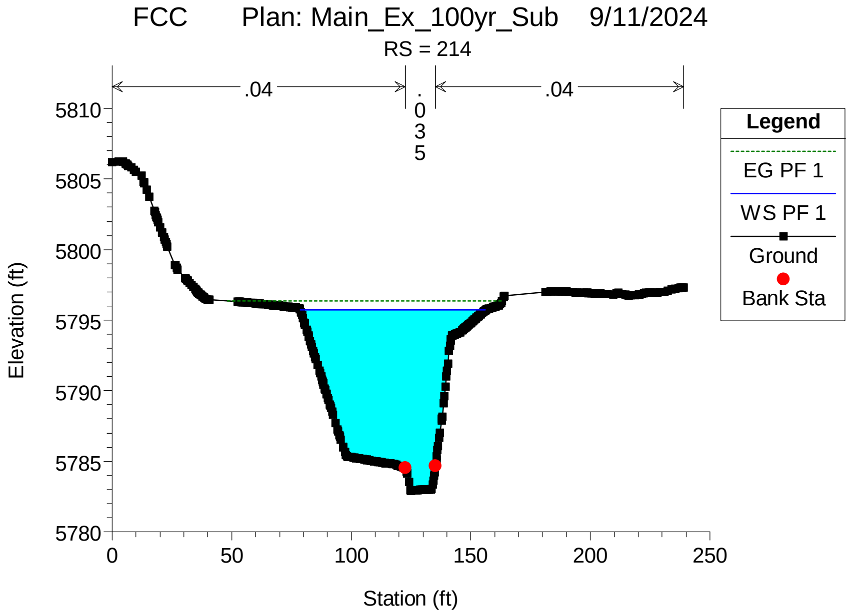
Ground
Bank Sta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Station (ft)
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EG PF 1
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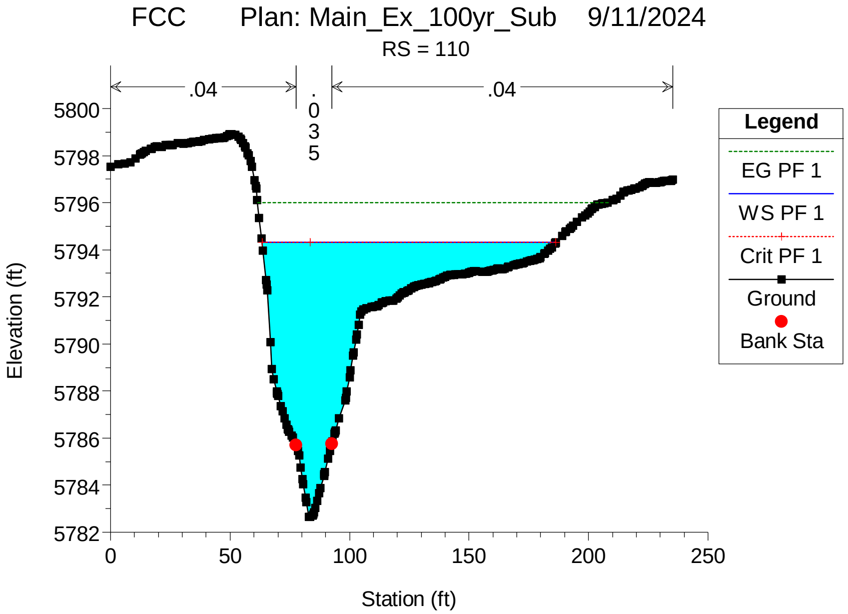
Ground
Bank Sta



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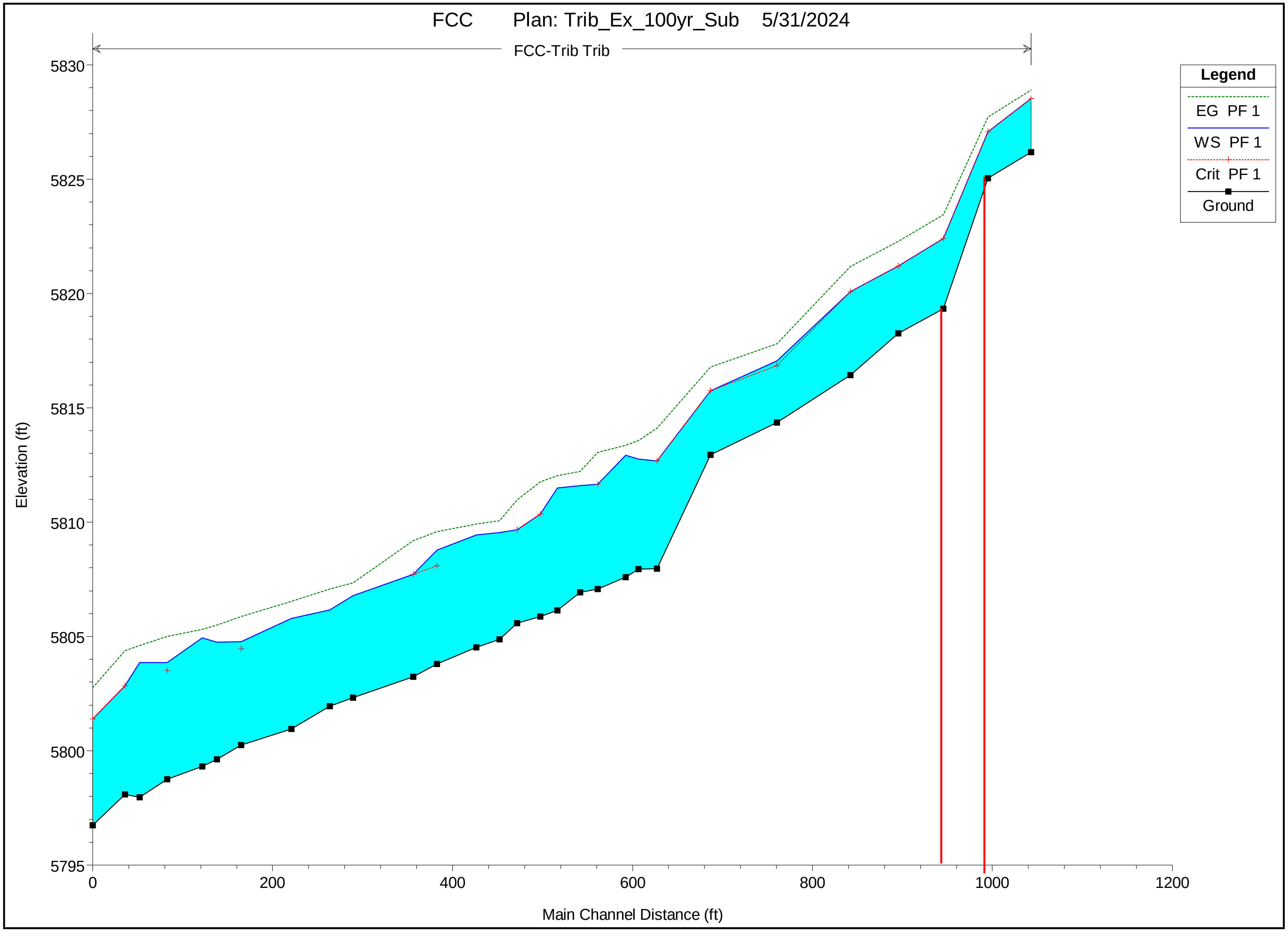
5788
5786
5784
5782
0
50
100
150
200
250
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

EXISTING CONDITIONS RESULTS

HEC-RAS Plan: Trib_Ex_100yr_Sub   River: FCC-Trib   Reach: Trib   Profile: PF 1

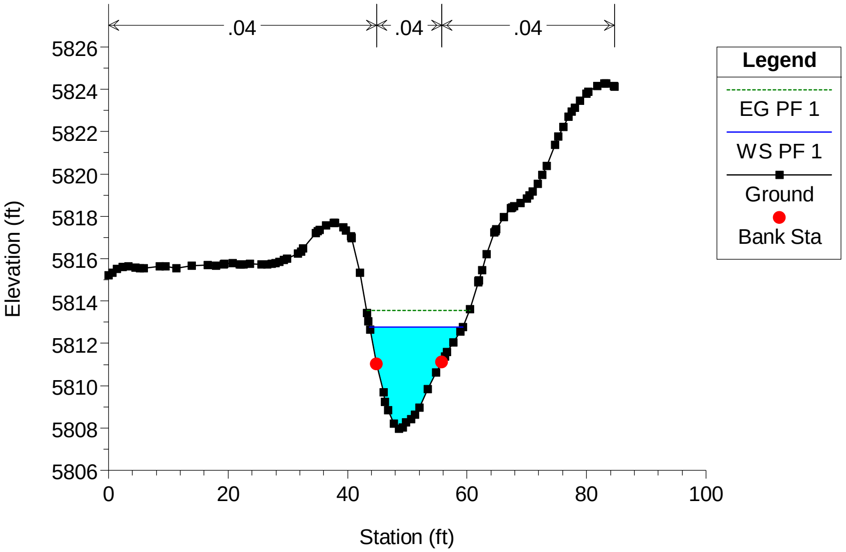
OUTSIDE PROJECT AREA

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	Shear Total
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Trib	1079	PF 1	290.00	5826.18	5828.52	5828.52	5828.91	0.011909	6.07	68.39	76.92	0.78	0.66
Trib	1031	PF 1	290.00	5825.05	[illegible]	[illegible]	[illegible]	0.017087	7.16	50.31	48.46	0.94	1.10
Trib	981	PF 1	290.00	5819.33	5822.41	5822.41	5823.45	0.016122	8.41	37.10	18.75	0.94	1.85
Trib	931	PF 1	290.00	5818.25	5821.20	5821.20	5822.27	0.017982	8.38	35.70	17.56	0.97	2.08
Trib	878	PF 1	290.00	5816.43	5820.08	5820.08	5821.19	0.016988	8.58	35.38	16.98	0.95	2.01
Trib	796	PF 1	290.00	5814.35	5817.06	5816.85	5817.81	0.011744	7.20	44.14	23.15	0.82	1.34
Trib	722	PF 1	290.00	5812.94	5815.75	5815.75	5816.78	0.015626	8.45	37.77	19.34	0.94	1.78
Trib	663	PF 1	290.00	5807.97	5812.67	5812.67	5814.10	0.020331	9.68	30.99	12.02	0.95	2.52
Trib	642	PF 1	290.00	5807.95	5812.76		5813.56	0.008883	7.27	42.31	15.56	0.68	1.25
Trib	628	PF 1	290.00	5807.60	5812.93		5813.37	0.004036	5.52	57.44	18.64	0.48	0.65
Trib	597	PF 1	290.00	5807.07	5811.65	5811.65	5813.04	0.019250	9.53	31.63	12.32	0.94	2.42
Trib	577	PF 1	290.00	5806.92	5811.59		5812.22	0.007514	6.64	49.11	20.95	0.64	0.98
Trib	552	PF 1	290.00	5806.15	5811.50		5812.03	0.005043	5.90	51.18	15.57	0.51	0.83
Trib	533	PF 1	290.00	5805.87	5810.36	5810.36	5811.76	0.023354	9.50	30.58	11.32	1.00	3.00
Trib	507	PF 1	290.00	5805.59	5809.67	5809.67	5810.98	0.019358	9.22	32.13	13.21	0.97	2.45
Trib	488	PF 1	290.00	5804.87	5809.54		5810.07	0.005284	5.88	52.04	18.24	0.55	0.82
Trib	462	PF 1	290.00	5804.52	5809.43		5809.92	0.005124	5.62	53.01	17.82	0.53	0.82
Trib	418	PF 1	290.00	5803.79	5808.78	5808.08	5809.59	0.009111	7.37	42.11	15.49	0.67	1.26
Trib	392	PF 1	290.00	5803.24	5807.72	5807.72	5809.19	0.020534	9.77	30.71	11.76	0.95	2.56
Trib	325	PF 1	290.00	5802.33	5806.78		5807.35	0.007071	6.07	48.18	16.77	0.60	1.09
Trib	299	PF 1	290.00	5801.94	5806.15		5807.07	0.014060	7.68	37.78	13.29	0.80	2.02
Trib	256	PF 1	290.00	5800.95	5805.79		5806.53	0.009231	6.94	42.86	16.10	0.67	1.27
Trib	200	PF 1	290.00	5800.24	5804.77	5804.46	5805.87	0.014252	8.44	35.53	13.59	0.83	1.89
Trib	174	PF 1	290.00	5799.62	5804.76		5805.50	0.007069	7.04	44.16	13.95	0.61	1.09
Trib	157	PF 1	290.00	5799.31	5804.94		5805.31	0.003345	5.31	66.82	26.36	0.44	0.48
Trib	118	PF 1	290.00	5798.76	5803.85	5803.50	5805.00	0.012574	8.81	35.78	12.48	0.79	1.73
Trib	88	PF 1	290.00	5797.96	5803.85		5804.61	0.006701	7.21	44.48	13.09	0.58	1.03
Trib	71	PF 1	290.00	5798.10	5802.83	5802.83	5804.37	0.017335	10.31	31.67	12.08	0.91	2.14
Trib	35	PF 1	290.00	5796.75	5801.39	5801.39	5802.76	0.018902	9.51	31.97	12.76	0.94	2.34


FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
FCC-Trib Trib
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Elevation (ft)
5830
5825
5820
5815
5810
5805
5800
5795
0
200
400
600
800
1000
1200
Main Channel Distance (ft)

FCC Plan: Trib_Ex_100yr_Sub 5/31/2024

RS = 642



FCC Plan: Trib_Ex_100yr_Sub 5/31/2024

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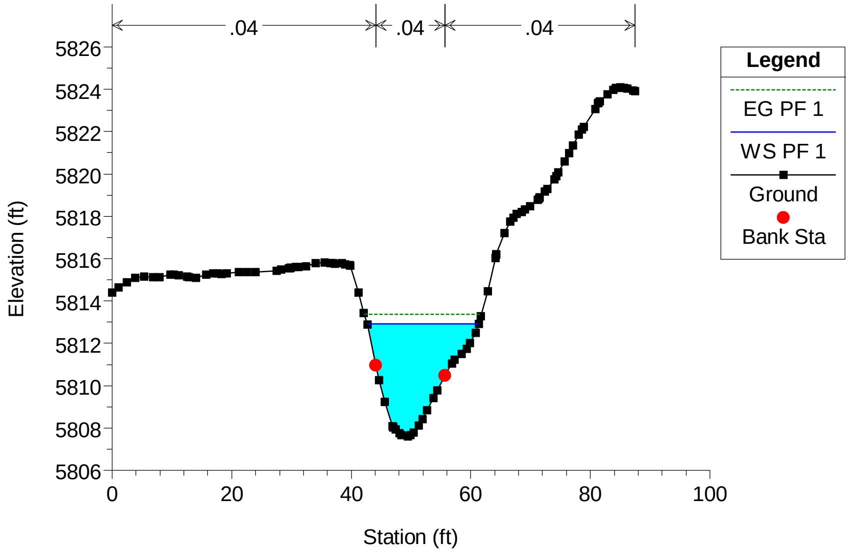

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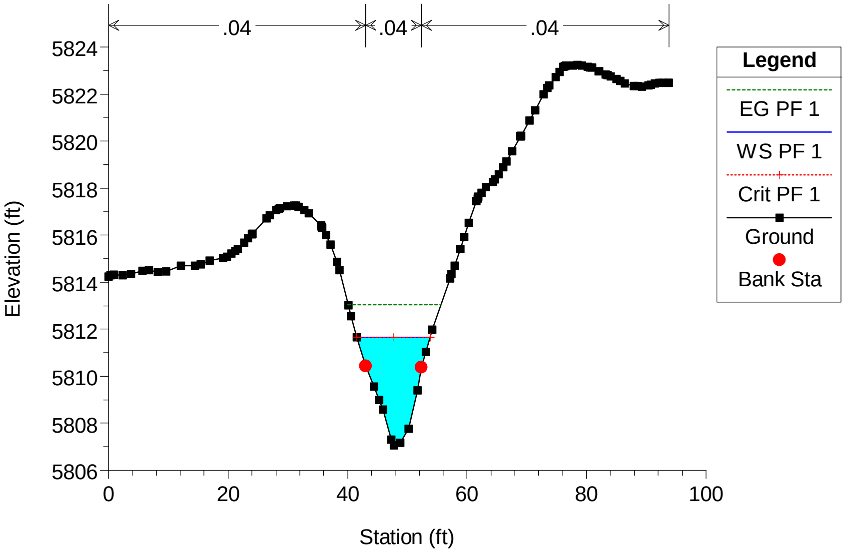
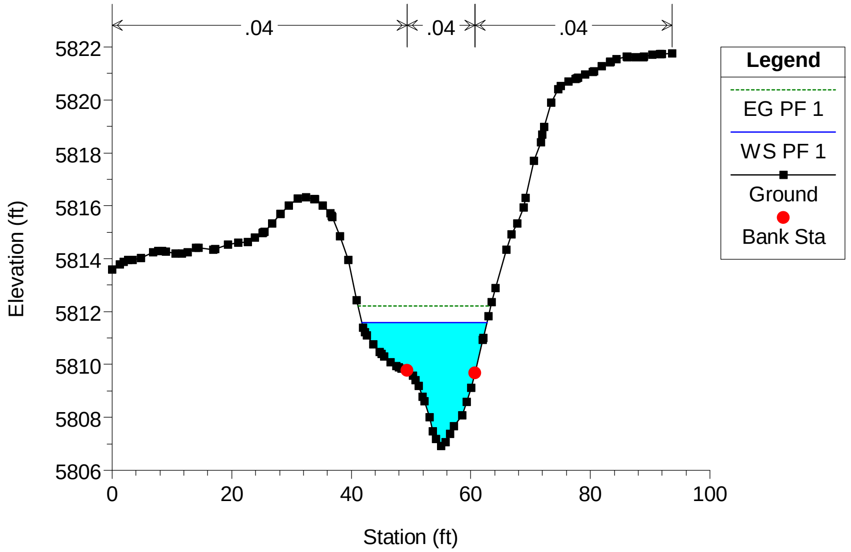
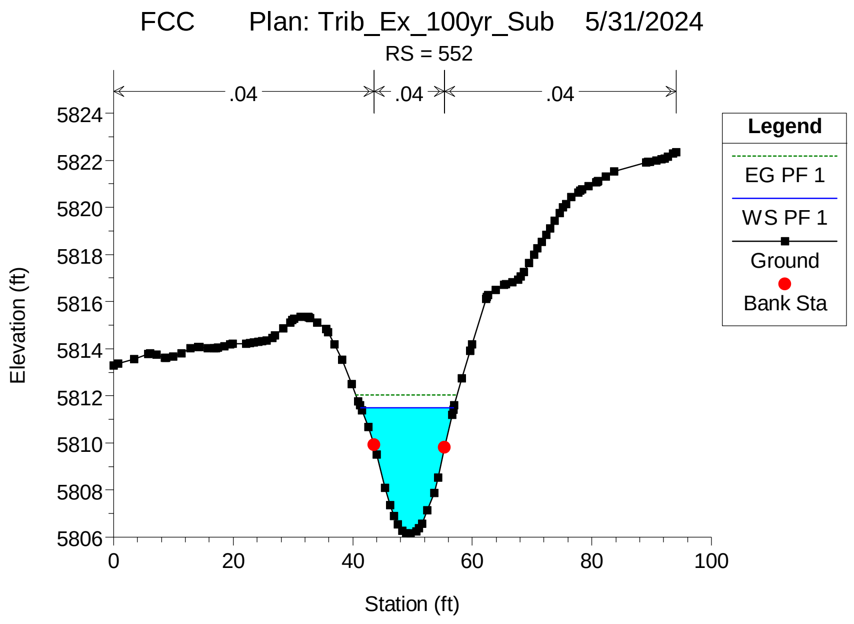
RS = 597



FCC Plan: Trib_Ex_100yr_Sub 5/31/2024

RS = 577

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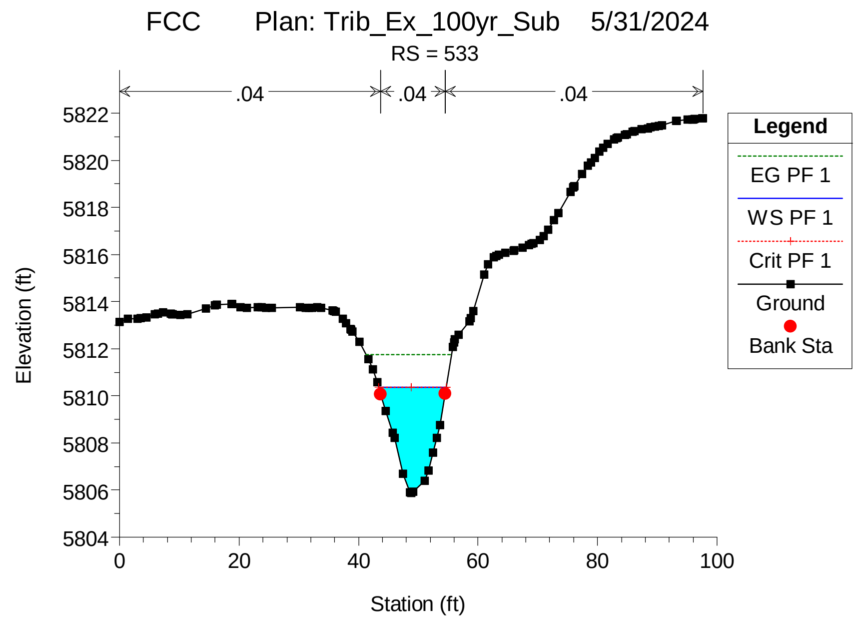
RS = 552
.04
.04
.04
5824
5822
5820
5818
5816
5814
5812
5810
5808
5806
Elevation (ft)
0
20
40
60
80
100
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta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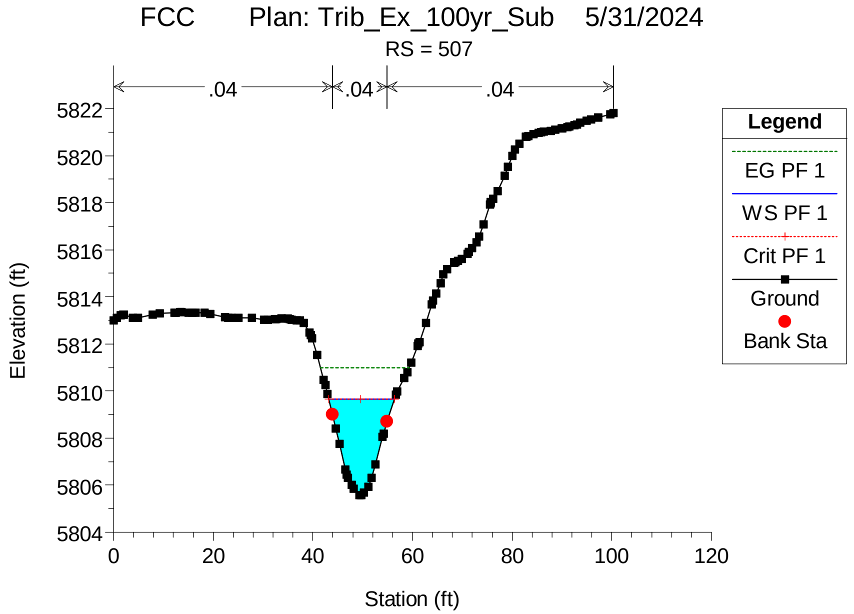
RS = 533
.04
.04
.04
5822
5820
5818
5816
5814
5812
5810
5808
5806
5804
Elevation (ft)
0
20
40
60
80
100
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta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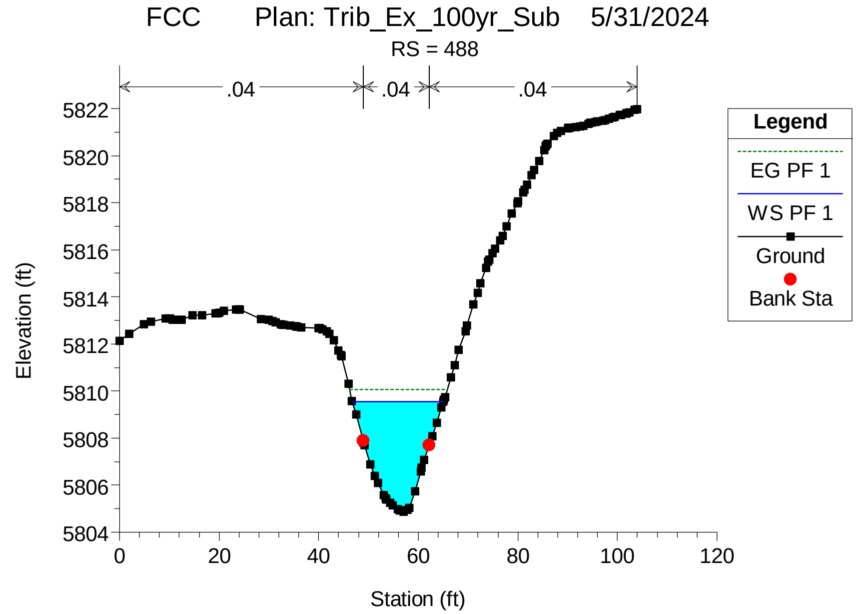
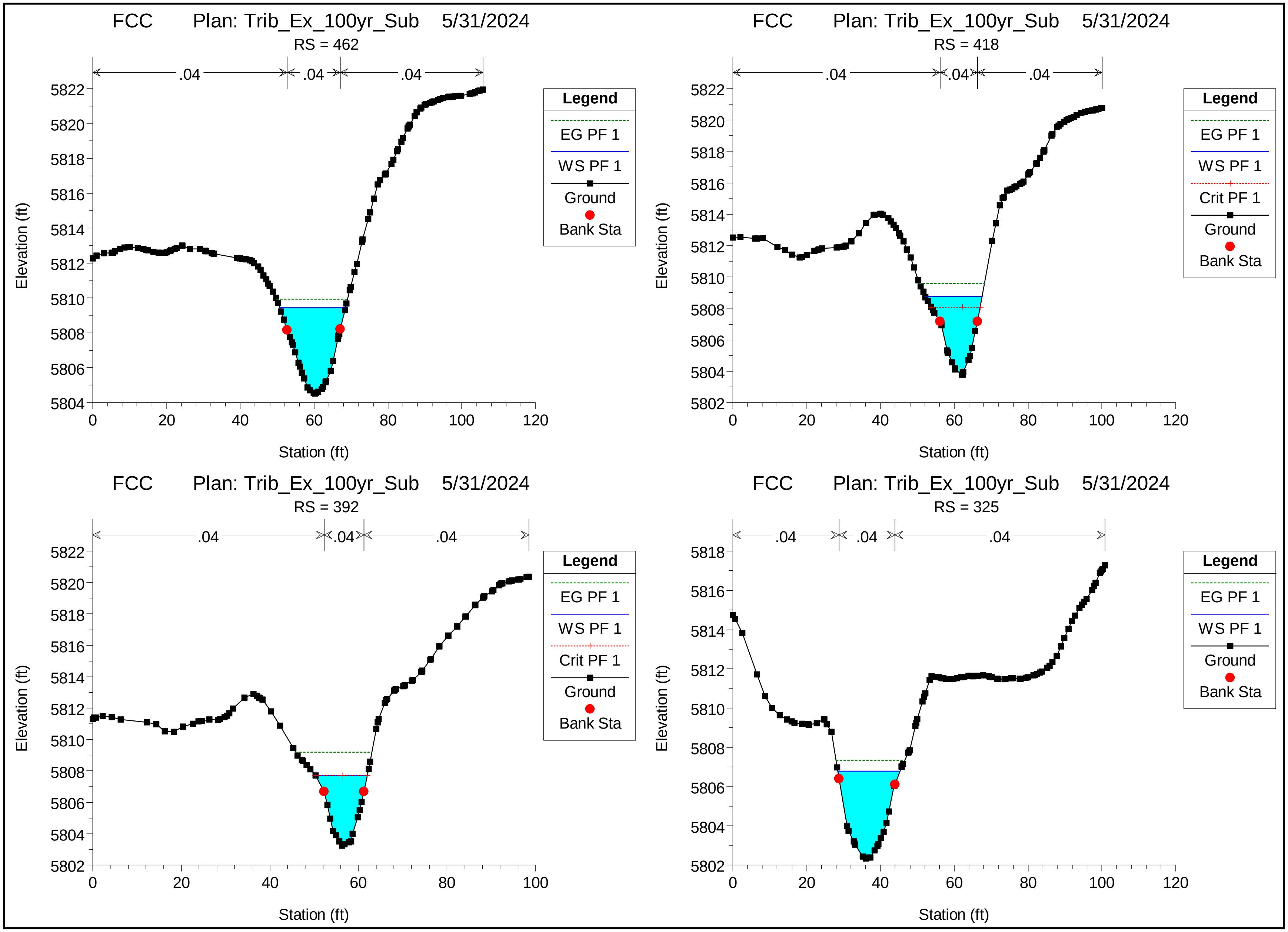
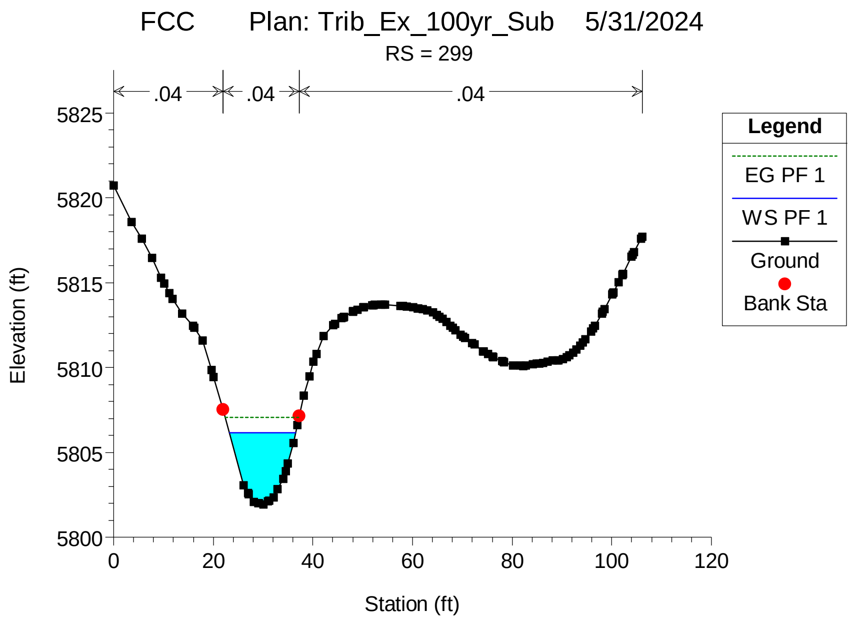
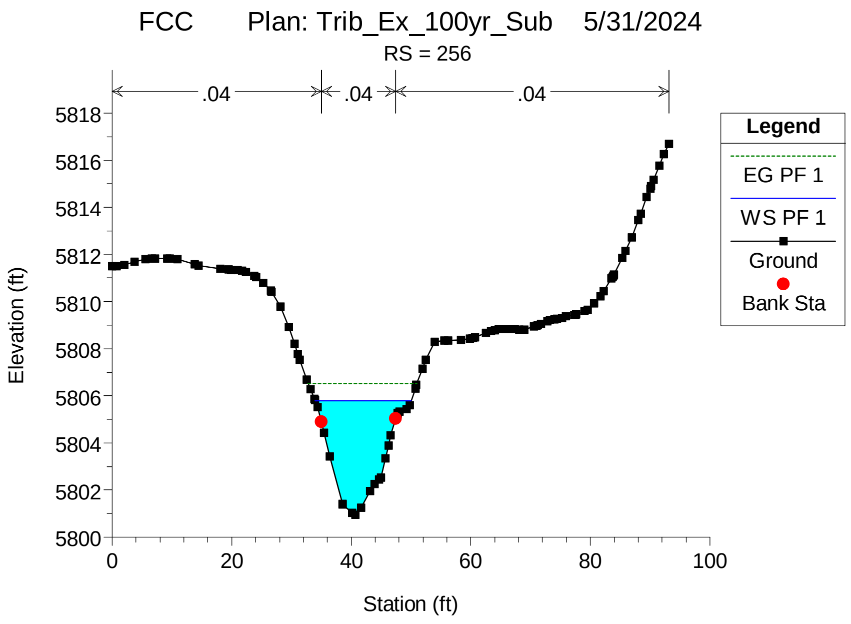
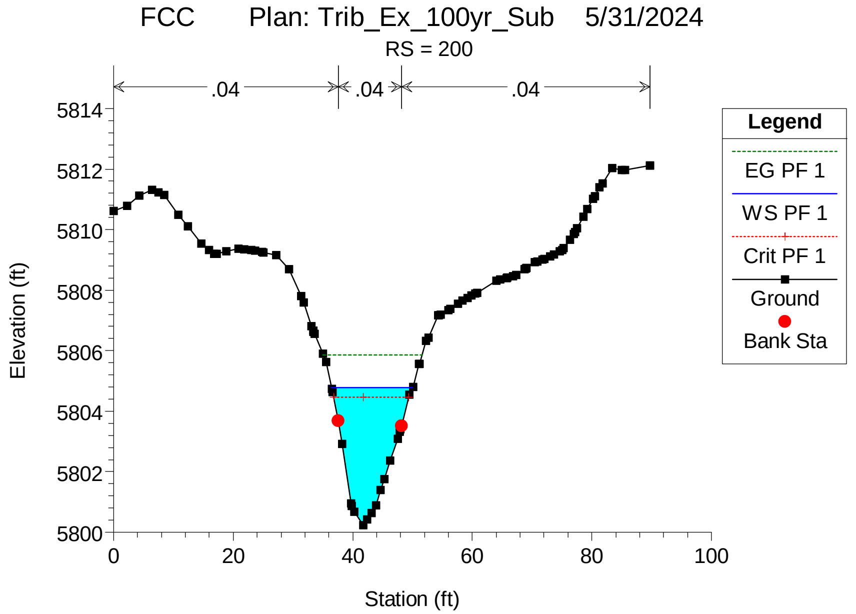
.04
.04
.04
5822
5820
5818
5816
5814
5812
5810
5808
5806
5804
Elevation (ft)
0
20
40
60
80
100
120
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

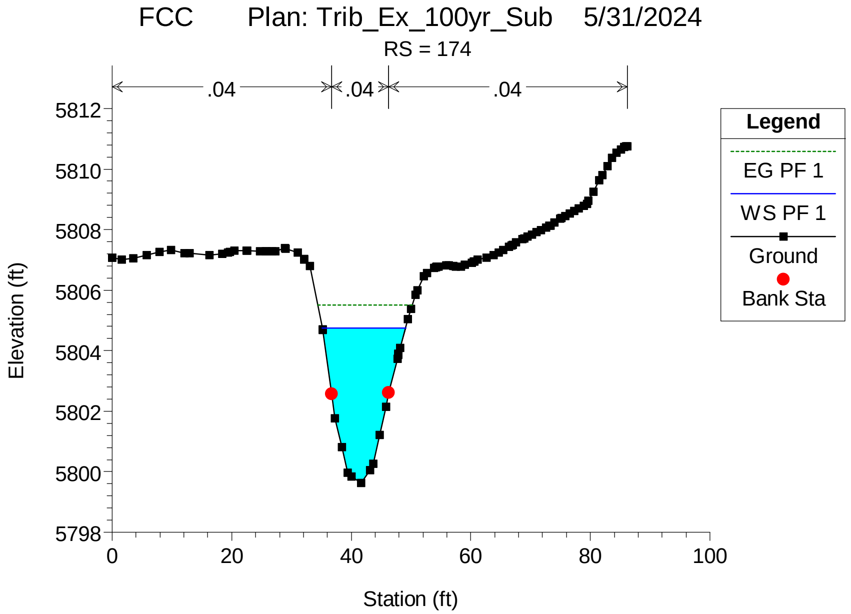

FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 488
.04
.04
.04
5822
5820
5818
5816
5814
5812
5810
5808
5806
5804
Elevation (ft)
0
20
40
60
80
100
120
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta

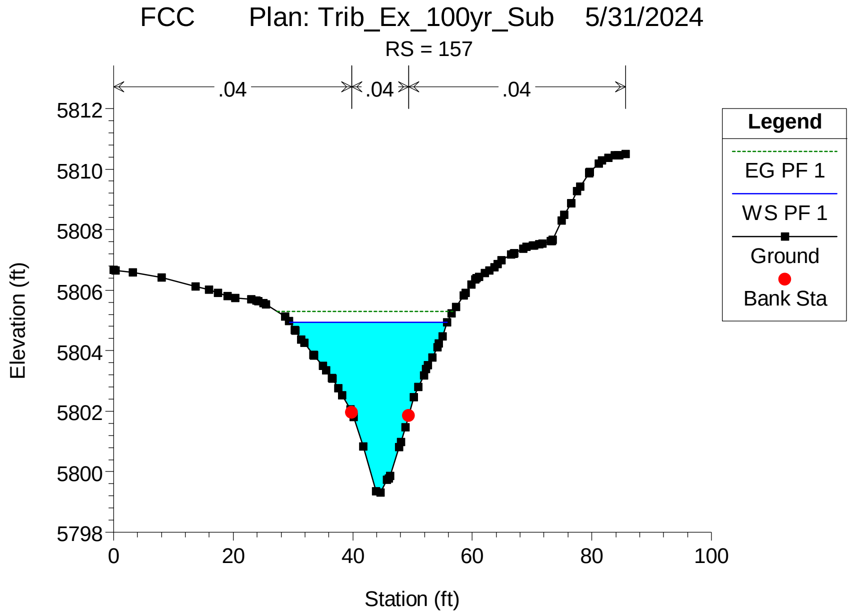

FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 462
.04
.04
.04
Elevation (ft)
5804
5806
5808
5810
5812
5814
5816
5818
5820
5822
Station (ft)
0
20
40
60
80
100
120
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 418
.04
.04
.04
Elevation (ft)
5802
5804
5806
5808
5810
5812
5814
5816
5818
5820
5822
Station (ft)
0
20
40
60
80
100
120
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 392
.04
.04
.04
Elevation (ft)
5802
5804
5806
5808
5810
5812
5814
5816
5818
5820
5822
Station (ft)
0
20
40
60
80
100
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 325
.04
.04
.04
Elevation (ft)
5802
5804
5806
5808
5810
5812
5814
5816
5818
Station (ft)
0
20
40
60
80
100
120
Legend
EG PF 1
WS PF 1
Ground
Bank Sta

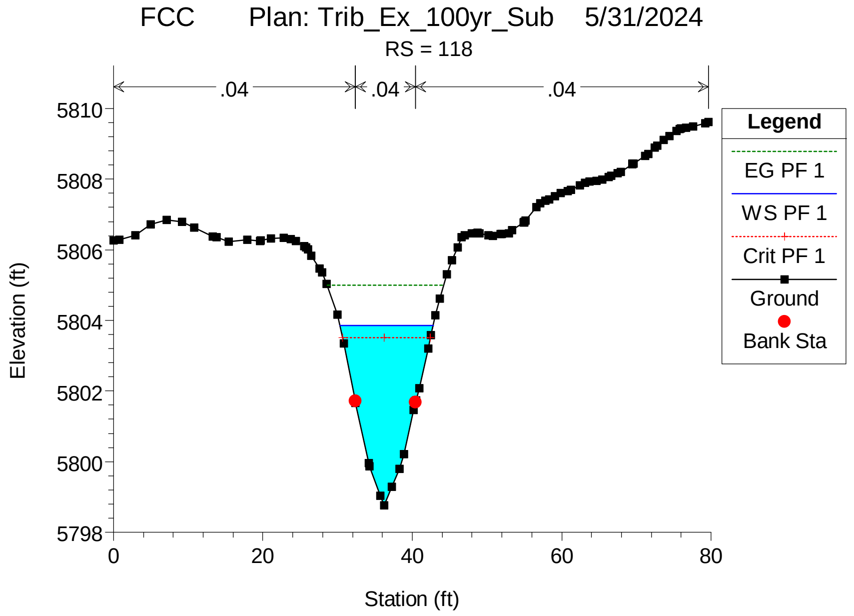

FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 299
.04
.04
.04
Elevation (ft)
5800
5805
5810
5815
5820
5825
Station (ft)
0
20
40
60
80
100
120
Legend
EG PF 1
WS PF 1
Ground
Bank Sta

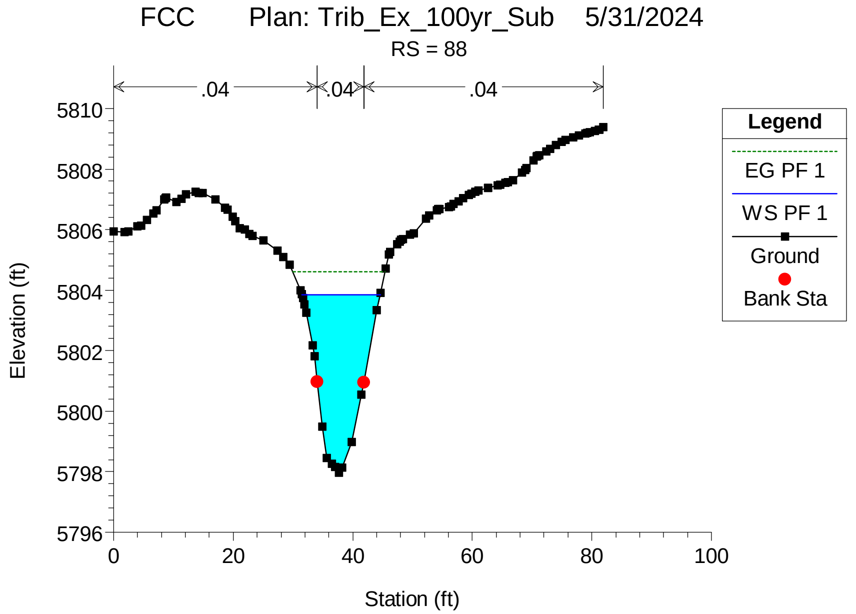

FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 256
.04
.04
.04
Elevation (ft)
5800
5802
5804
5806
5808
5810
5812
5814
5816
5818
Station (ft)
0
20
40
60
80
100
Legend
EG PF 1
WS PF 1
Ground
Bank Sta


FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 200
.04
.04
.04
Elevation (ft)
5800
5802
5804
5806
5808
5810
5812
5814
Station (ft)
0
20
40
60
80
100
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta


FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 174
.04
.04
.04
Elevation (ft)
5798
5800
5802
5804
5806
5808
5810
5812
Station (ft)
0
20
40
60
80
100
Legend
EG PF 1
WS PF 1
Ground
Bank Sta


FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 157
.04
.04
.04
5812
5810
5808
5806
5804
5802
5800
5798
Elevation (ft)
0
20
40
60
80
100
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta


FCC Plan: Trib_Ex_100yr_Sub 5/31/2024
RS = 118
.04
.04
.04
5810
5808
5806
5804
5802
5800
5798
Elevation (ft)
0
20
40
60
80
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta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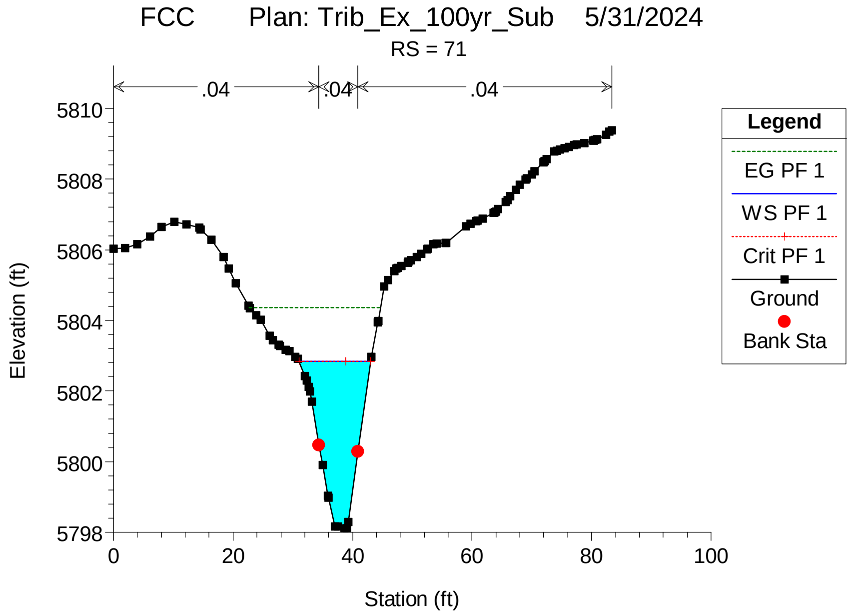
RS = 88
.04
.04
.04
5810
5808
5806
5804
5802
5800
5798
5796
Elevation (ft)
0
20
40
60
80
100
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta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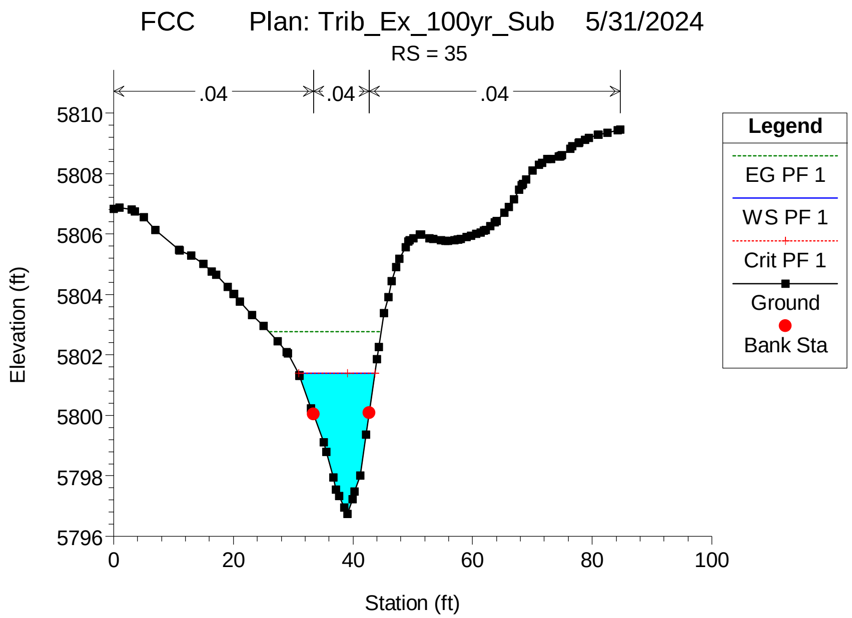
RS = 71
.04
.04
.04
5810
5808
5806
5804
5802
5800
5798
Elevation (ft)
0
20
40
60
80
100
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta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RS = 35
.04
.04
.04
Elevation (ft)
5810
5808
5806
5804
5802
5800
5798
5796
0
20
40
60
80
100
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

Proposed Condition Results

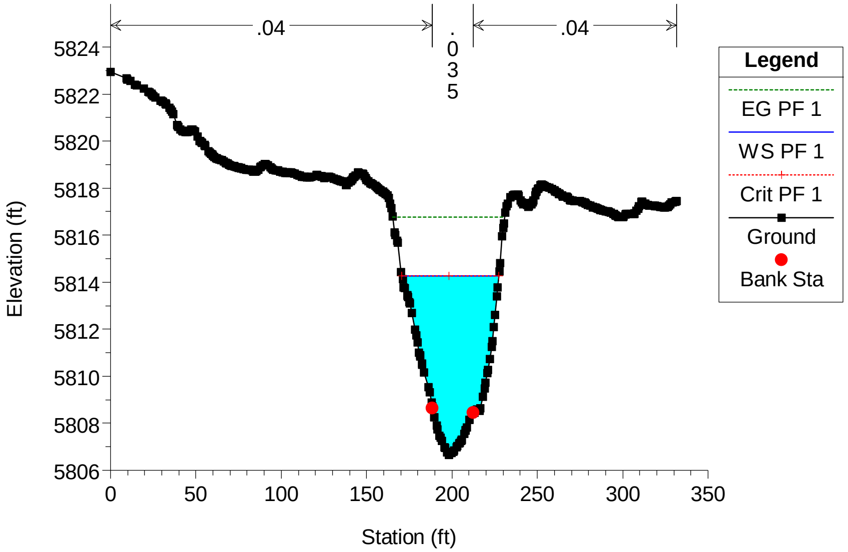
HEC-RAS Plan: Main_Pr_100yr_Sub   River: FCC-Main   Reach: Main   Profile: PF 1

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	Shear Total
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Main	2364	PF 1	3090.00	5806.66	5814.27	5814.27	5816.76	0.008557	14.03	272.12	56.77	0.94	2.44
Main	2180	PF 1	3090.00	5805.19	5811.61	5811.61	5812.94	0.009389	11.44	386.41	146.26	0.92	1.51
Main	1999	PF 1	3090.00	5801.59	5809.40		5809.70	0.001244	5.61	737.86	170.19	0.36	0.33
Main	1845	PF 1	3090.00	5801.60	5809.46		5809.53	0.000411	3.00	1500.18	346.35	0.21	0.11
Main	1680	PF 1	3090.00	5797.46	5806.73	5806.73	5809.12	0.007936	14.74	295.90	65.26	0.90	2.10
Main	1543	PF 1	3090.00	5797.30	5806.10	5806.10	5807.98	0.006275	13.43	346.57	92.82	0.83	1.41
Main	1357	PF 1	3380.00	5794.58	5806.62		5807.04	0.001243	7.14	781.94	154.31	0.38	0.38
Main	1272	PF 1	3380.00	5793.06	5804.20	5804.20	5806.64	0.005883	15.20	345.44	71.82	0.82	1.62
Main	1200	PF 1	3380.00	5792.87	5803.75	5803.75	5804.92	0.003680	11.70	577.71	199.11	0.64	0.65
Main	1117	PF 1	3380.00	5793.03	5801.86	5801.86	5803.15	0.004498	11.51	541.88	221.57	0.70	0.68
Main	1003	PF 1	3380.00	5791.34	5801.63		5802.48	0.002698	9.70	629.06	195.35	0.55	0.53
Main	920	PF 1	3380.00	5790.66	5800.97	5800.97	5802.16	0.004434	11.71	565.68	237.28	0.68	0.65
Main	831	PF 1	3380.00	5791.78	5800.40		5801.45	0.003904	10.45	529.83	163.67	0.65	0.77
Main	736	PF 1	3380.00	5790.22	5800.79		5801.06	0.000964	5.94	1107.72	327.11	0.33	0.20
Main	637	PF 1	3380.00	5789.21	5800.74		5800.97	0.000678	5.11	1216.03	330.41	0.28	0.15
Main	532	PF 1	3380.00	5786.56	5797.05	5797.05	5800.48	0.007715	15.80	257.30	41.63	0.90	2.59
Main	436	PF 1	3380.00	5789.81	5796.30	5796.30	5798.26	0.024344	11.67	303.26	76.18	0.84	5.93
Main	423	PF 1	3380.00	5787.33	5796.67		5797.33	0.004901	6.72	520.24	85.79	0.40	1.79
Main	320	PF 1	3380.00	5784.59	5795.27		5796.85	0.003084	10.84	393.65	67.61	0.60	1.03
Main	214	PF 1	3380.00	5782.91	5795.72		[illegible]	0.001381	7.98	580.74	77.59	0.40	0.58
Main	110	PF 1	3380.00	5782.64	5794.31	5794.31	5796.01	0.004645	12.85	434.34	123.07	0.71	0.98

OUTSIDE PROJECT AREA

OUTSIDE PROJECT AREA

provide missing profile



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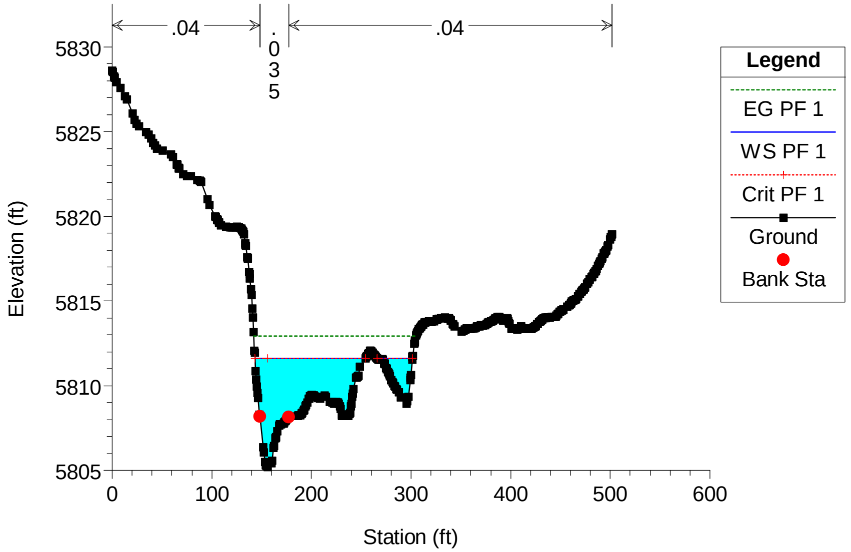
RS = 2364



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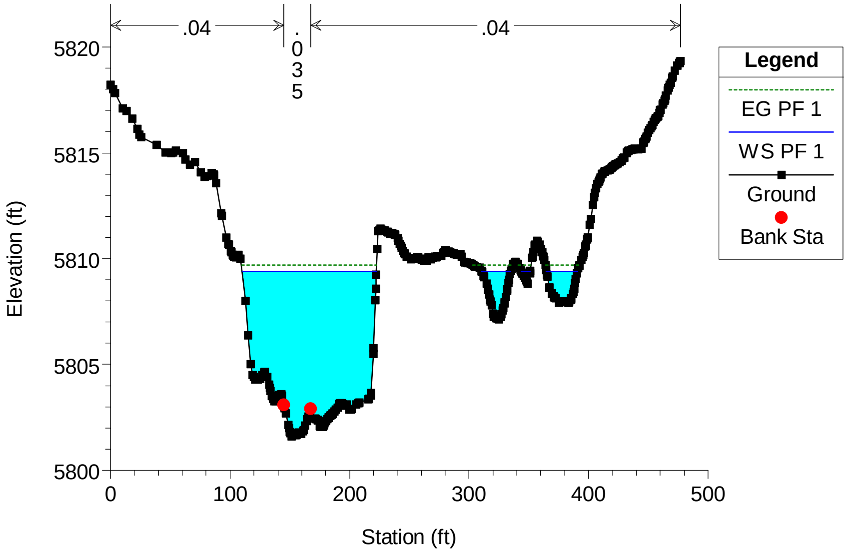
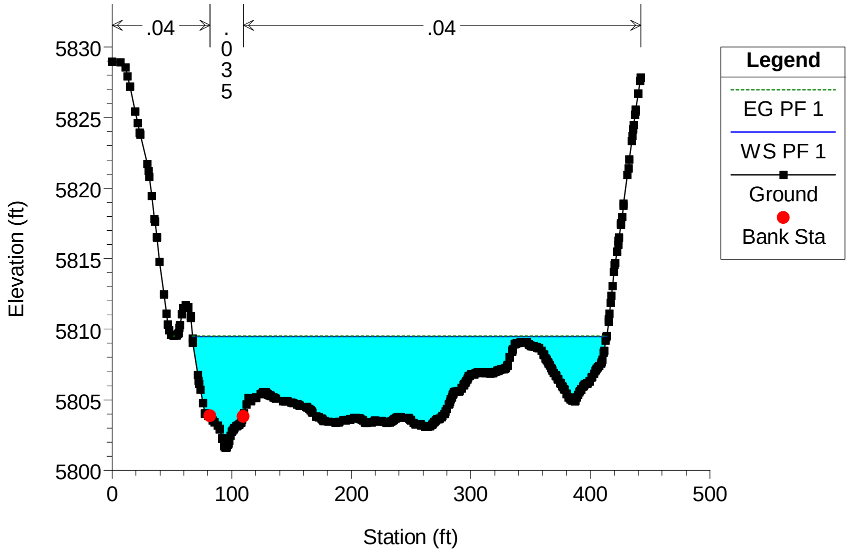
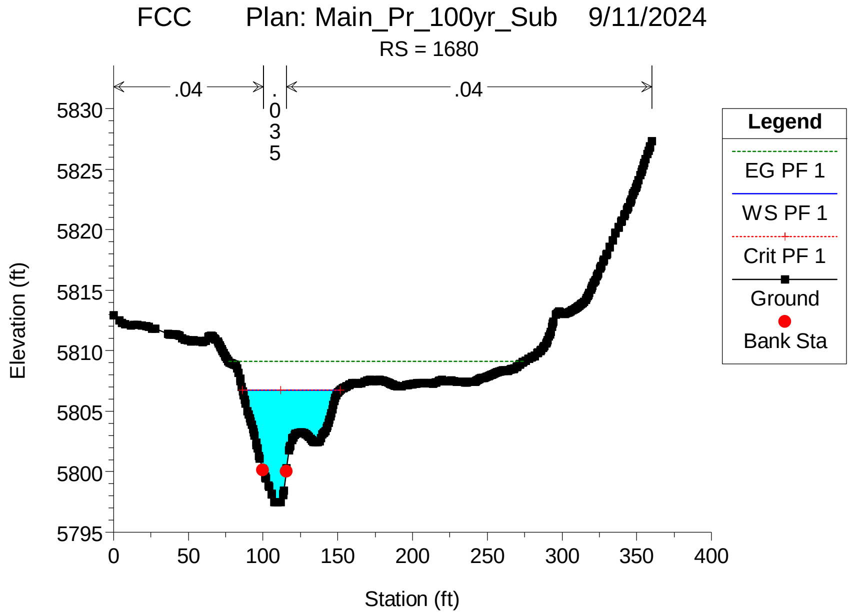
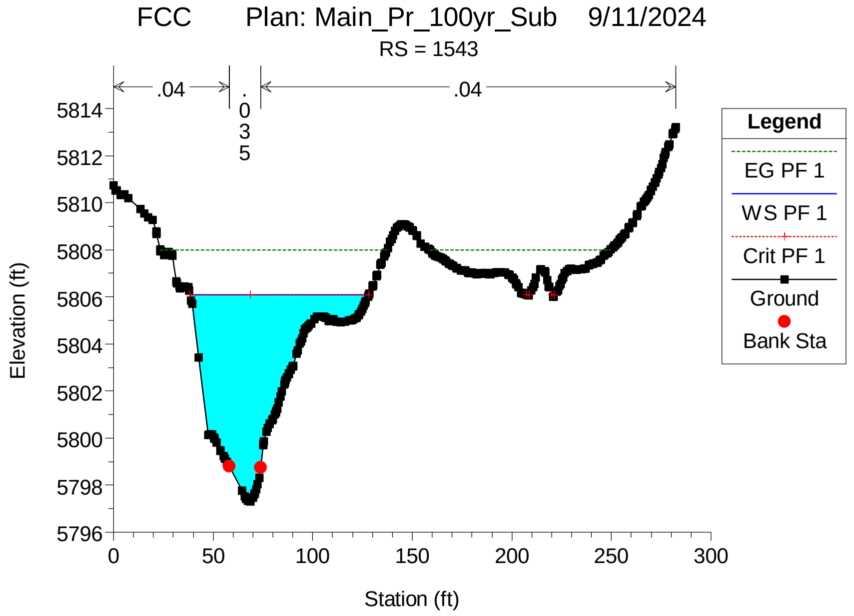


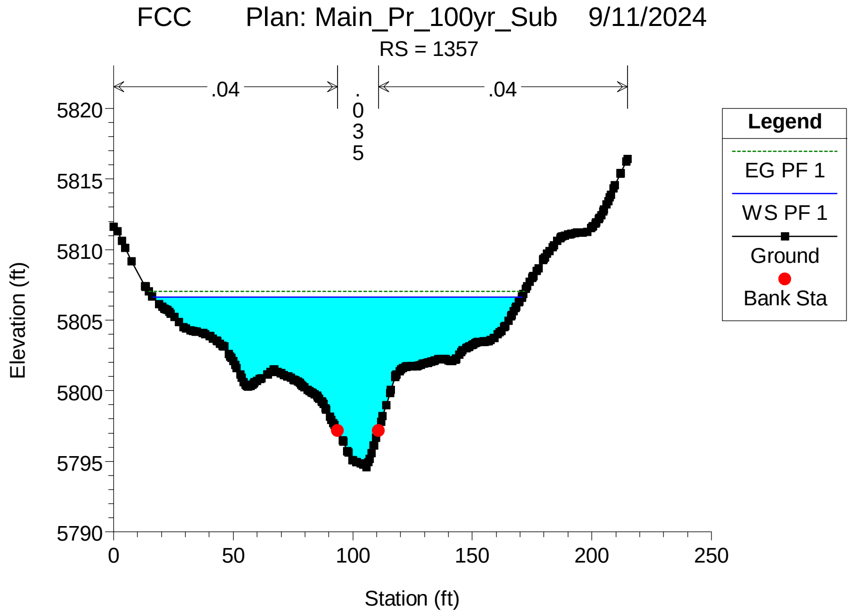
FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 1999

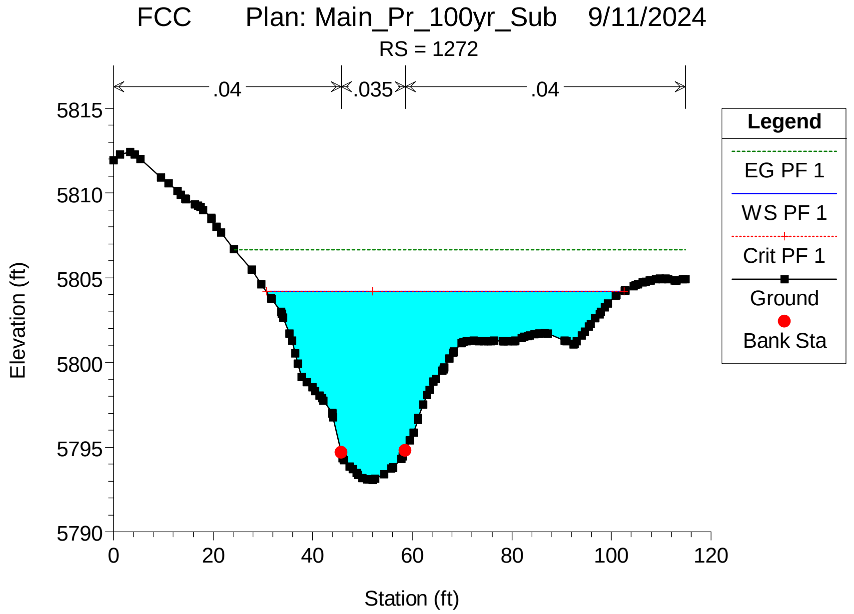


FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 1845

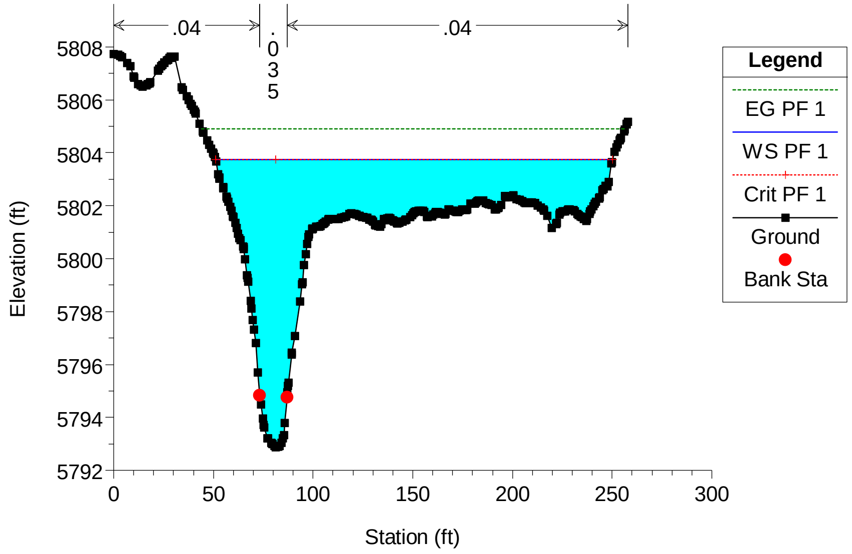

FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 1680
.04
.035
.04
Elevation (ft)
5830
5825
5820
5815
5810
5805
5800
5795
0
50
100
150
200
250
300
350
400
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta


FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 1543
.04
.035
.04
Elevation (ft)
5814
5812
5810
5808
5806
5804
5802
5800
5798
5796
0
50
100
150
200
250
300
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

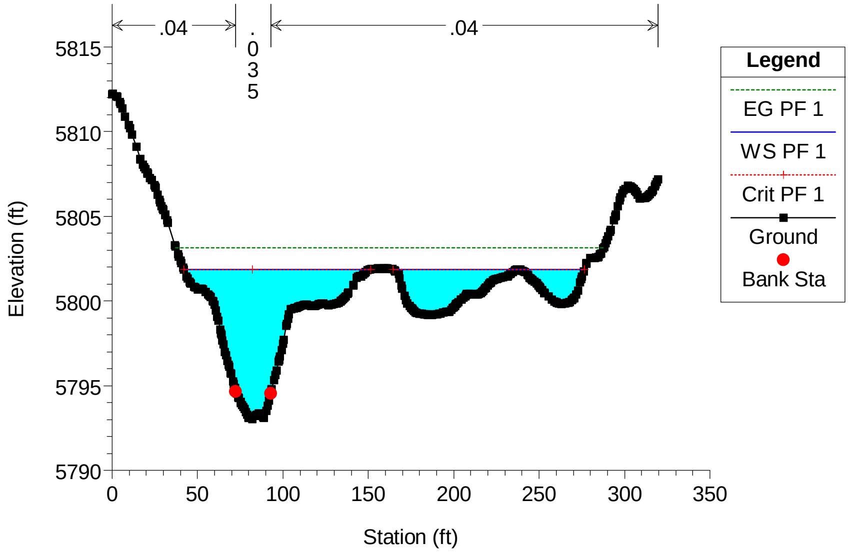

FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 1357
.04
.035
.04
Elevation (ft)
5820
5815
5810
5805
5800
5795
5790
0
50
100
150
200
250
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta


FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 1272
.04
.035
.04
Elevation (ft)
5815
5810
5805
5800
5795
5790
0
20
40
60
80
100
120
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

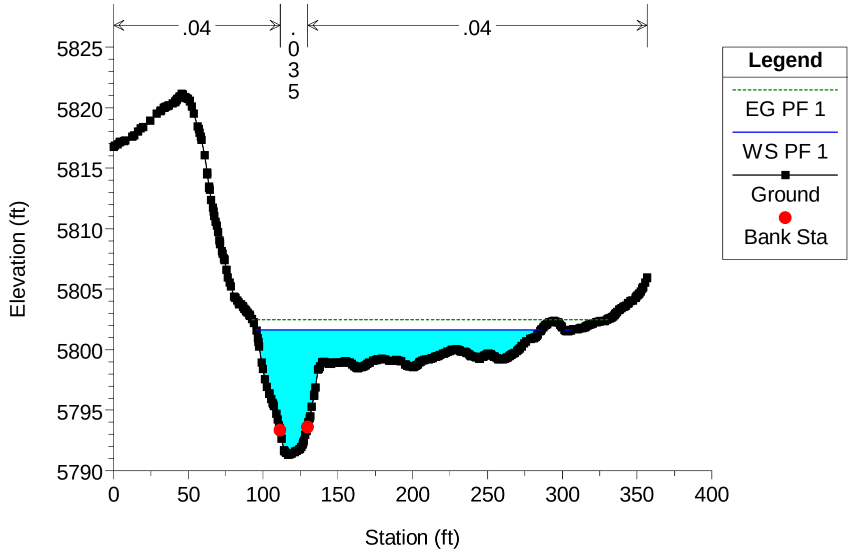
FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 1200



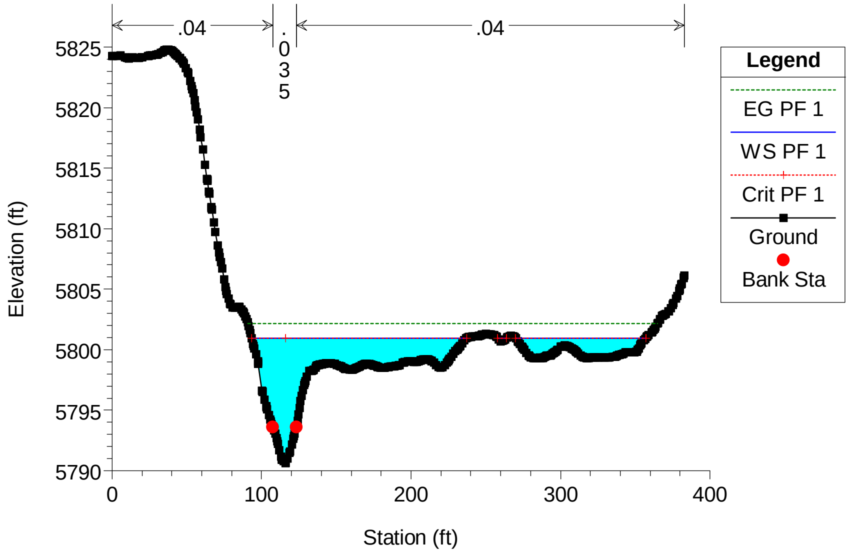
FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 1117

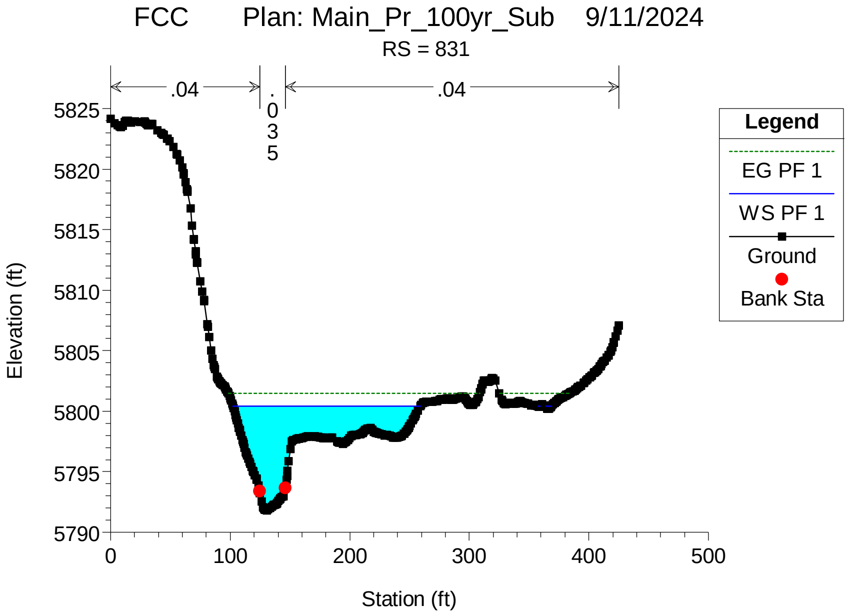


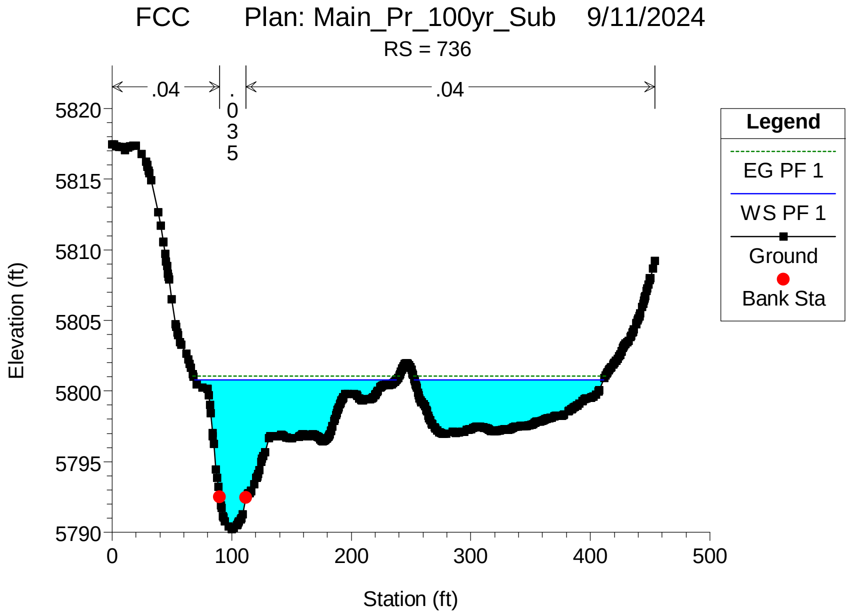
FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 1003

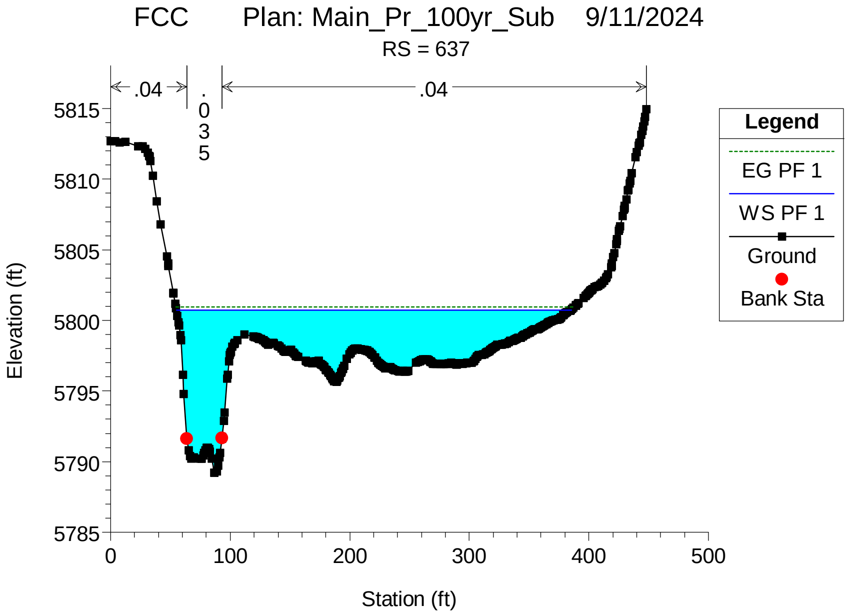


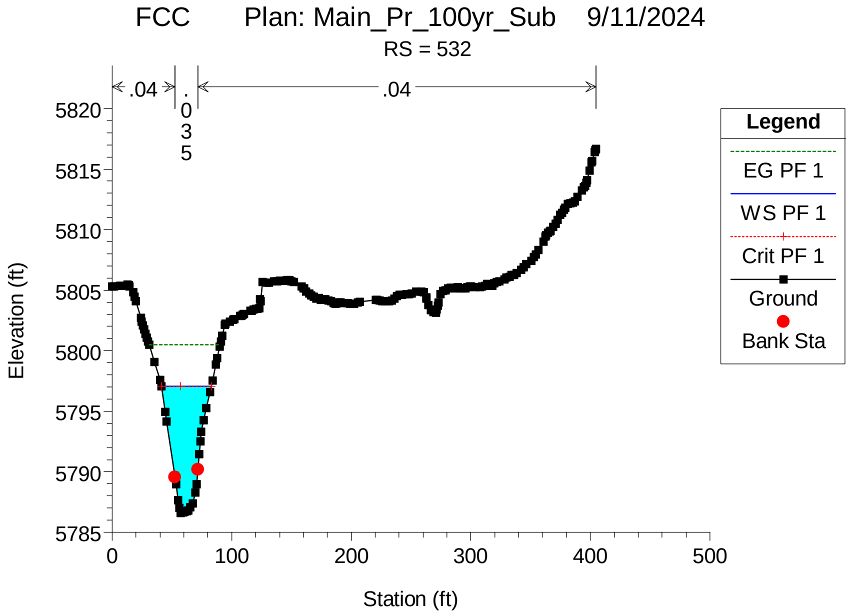
FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 920



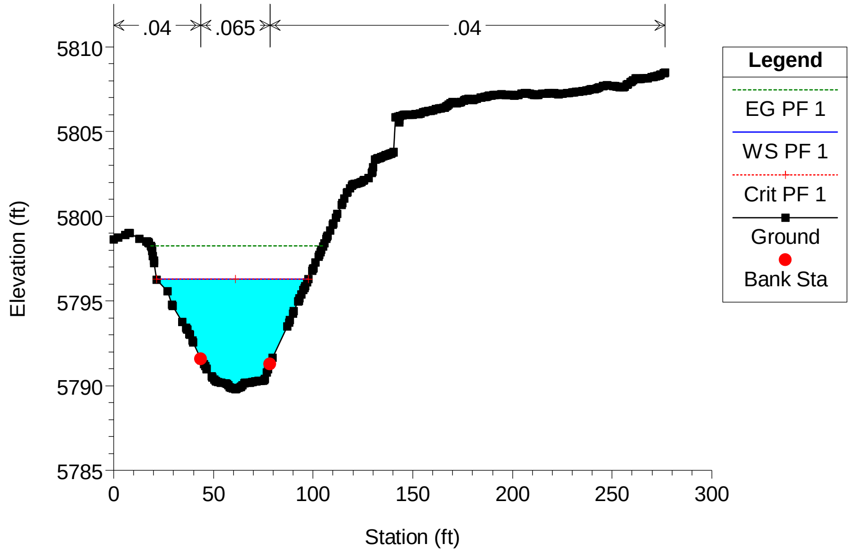

FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 831
.04
.035
.04
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
5825
5820
5815
5810
5805
5800
5795
5790
Station (ft)
0
100
200
300
400
500


FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 736
.04
.035
.04
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
5820
5815
5810
5805
5800
5795
5790
Station (ft)
0
100
200
300
400
500

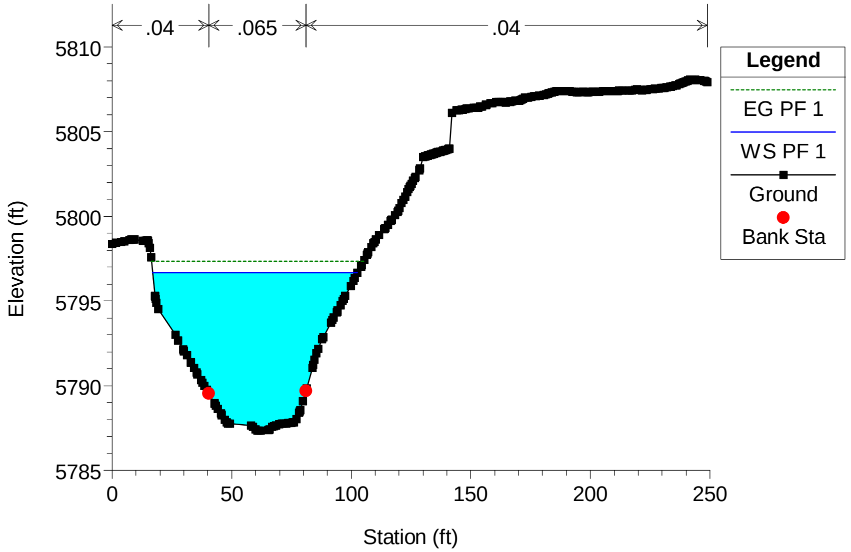

FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 637
.04
.035
.04
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
5815
5810
5805
5800
5795
5790
5785
Station (ft)
0
100
200
300
400
500


FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 532
.04
.035
.04
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
5820
5815
5810
5805
5800
5795
5790
5785
Station (ft)
0
100
200
300
400
500

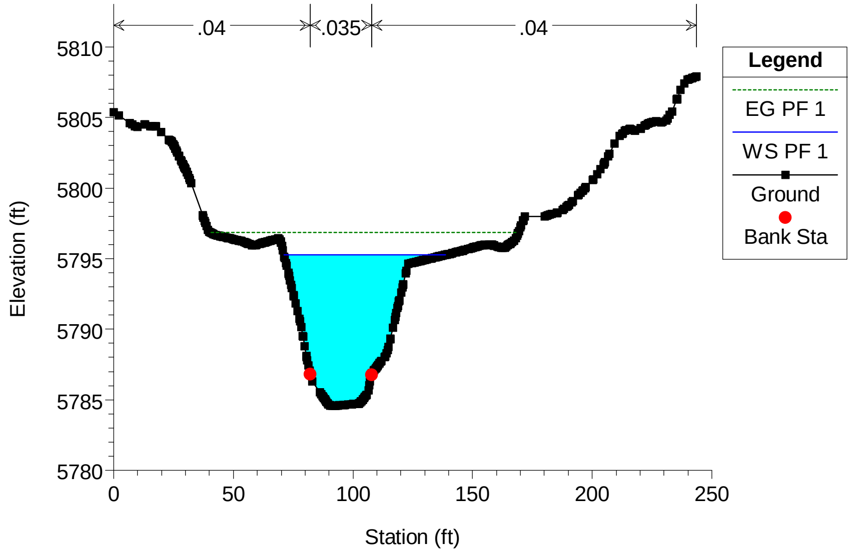
FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 436



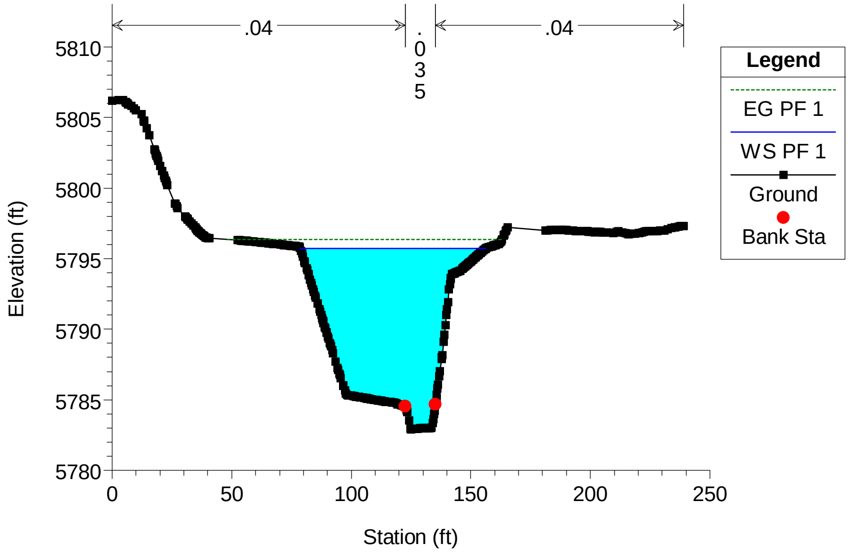
FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 423

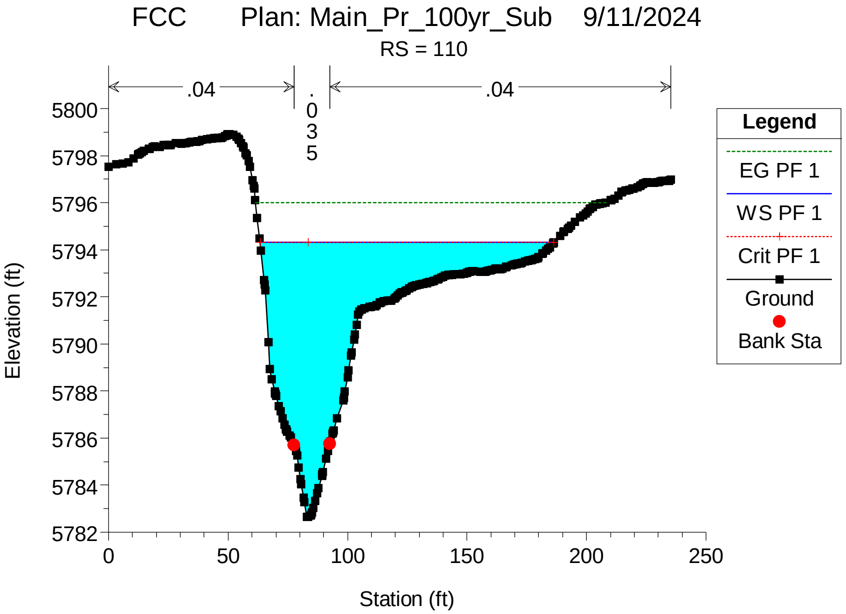


FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 320



FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 214



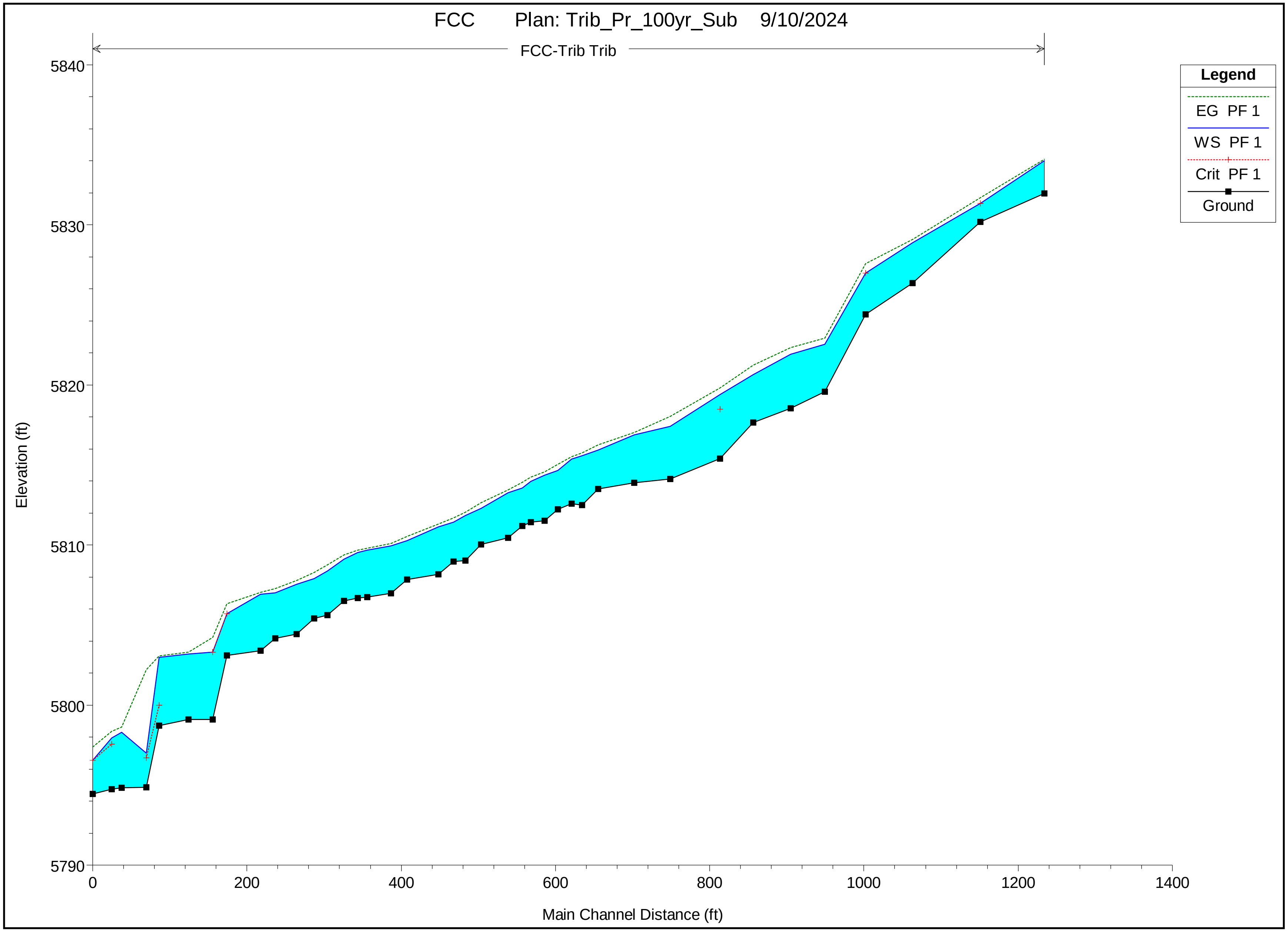

FCC Plan: Main_Pr_100yr_Sub 9/11/2024
RS = 110
.04
.035
.04
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
5800
5798
5796
5794
5792
5790
5788
5786
5784
5782
0
50
100
150
200
250
Station (ft)

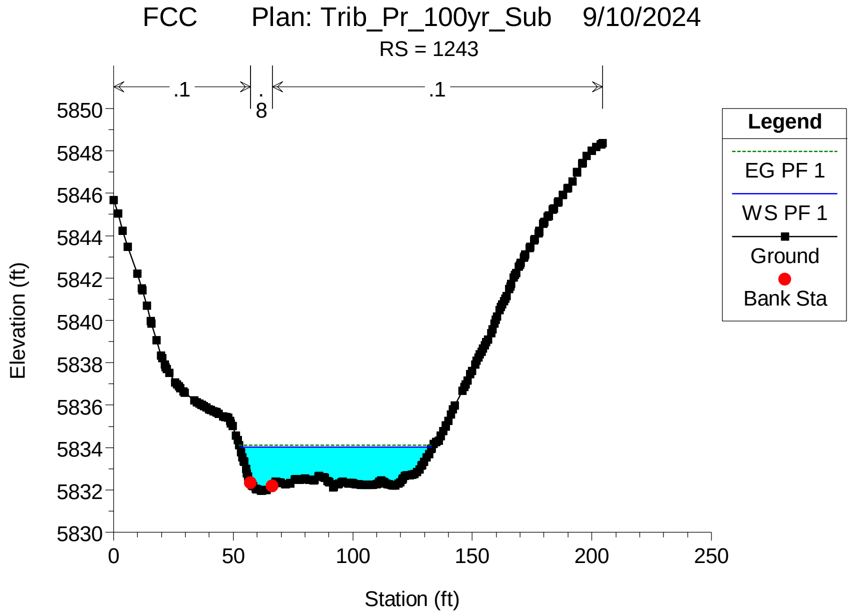
Proposed Condition Results

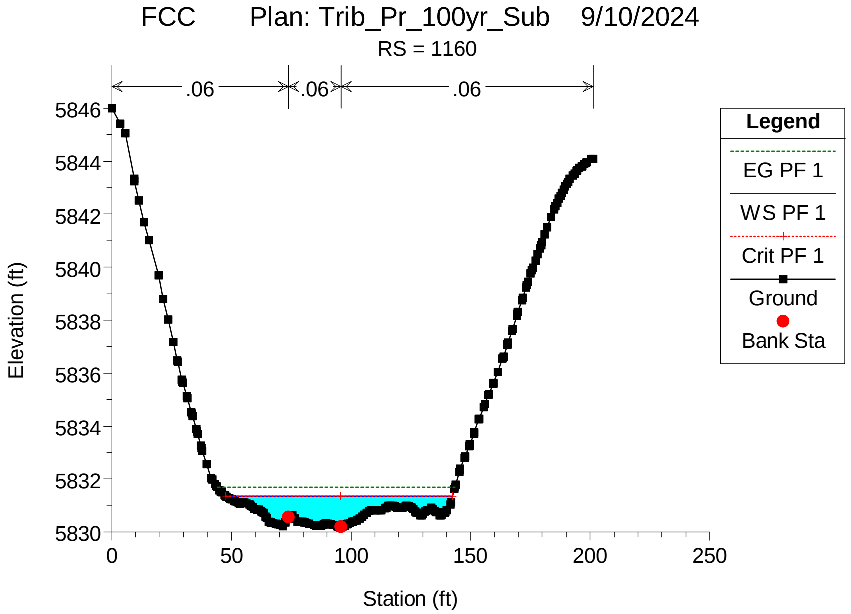
HEC-RAS Plan: Trib_Pr_100yr_Sub   River: FCC-Trib   Reach: Trib   Profile: PF 1

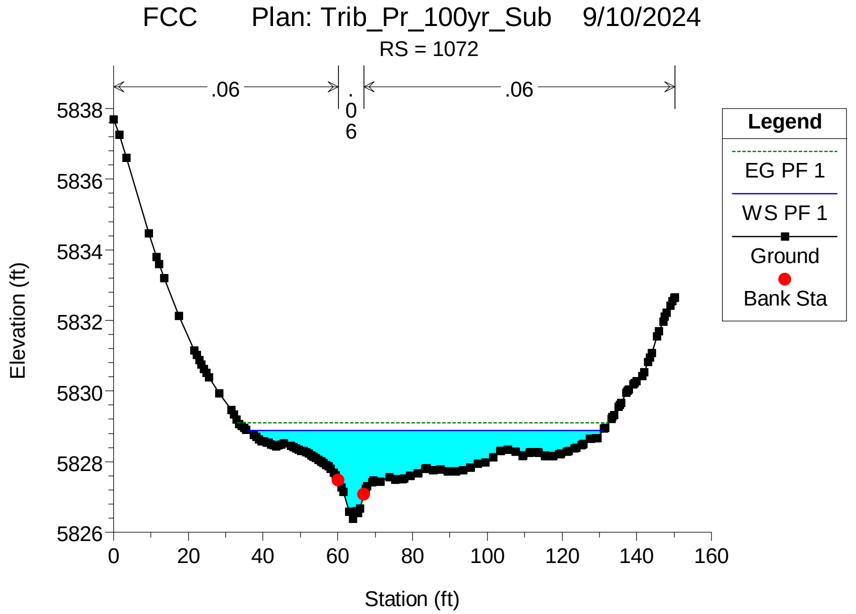
OUTSIDE PROJECT AREA

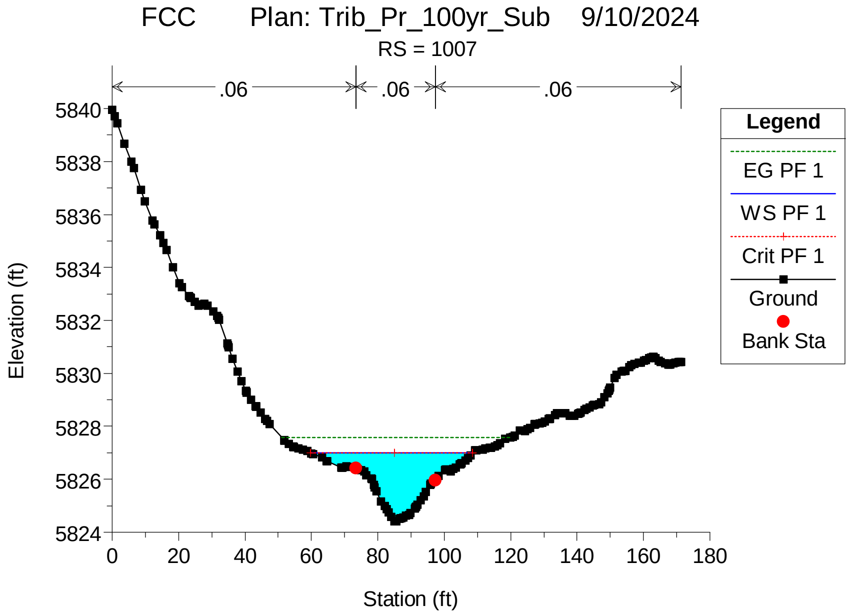
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Total
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Trib	1243	PF 1	290.00	5831.96	5834.01		5834.12	0.019019	0.40	123.41	80.47	0.05	1.81
Trib	1160	PF 1	290.00	5830.18	5831.35	5831.35	5831.69	0.048422	5.53	65.64	94.73	0.96	2.09
Trib	1072	PF 1	290.00	5826.38	[illegible]		[illegible]	0.019066	5.42	84.96	94.98	0.66	1.06
Trib	1007	PF 1	290.00	5824.40	5827.00	5827.00	5827.58	0.033548	6.40	51.70	48.78	0.87	2.20
Trib	954	PF 1	290.00	5819.59	5822.55		5822.94	0.015538	5.82	62.90	37.63	0.63	1.59
Trib	911	PF 1	290.00	5818.54	5821.93		5822.33	0.012215	5.69	62.04	30.37	0.57	1.50
Trib	862	PF 1	290.00	5817.65	5820.65		5821.25	0.049223	6.54	47.24	27.89	0.71	5.07
Trib	817	PF 1	290.00	5815.39	5819.40	5818.49	5819.80	0.022731	5.28	57.60	24.19	0.49	3.10
Trib	752	PF 1	290.00	5814.12	5817.42		5818.04	0.032949	6.92	47.76	21.95	0.70	4.15
Trib	710	PF 1	290.00	5813.88	5816.88		5817.03	0.010410	3.64	97.11	59.46	0.39	1.05
Trib	662	PF 1	290.00	5813.50	5815.93		5816.27	0.040288	5.13	63.42	51.52	0.62	3.06
Trib	637	PF 1	290.00	5812.49	5815.56		5815.76	0.013986	4.00	85.62	54.11	0.44	1.36
Trib	625	PF 1	290.00	5812.59	5815.37		5815.53	0.012535	3.63	95.16	64.88	0.42	1.14
Trib	612	PF 1	290.00	5812.23	5814.67		5815.06	0.049579	5.50	59.52	50.80	0.68	3.59
Trib	586	PF 1	290.00	5811.53	5814.37		5814.56	0.015153	4.10	85.93	58.16	0.46	1.38
Trib	575	PF 1	290.00	5811.43	5813.97		5814.26	0.026059	5.09	70.44	53.54	0.60	2.12
Trib	563	PF 1	290.00	5811.19	5813.57		5813.91	0.041004	5.14	62.93	51.25	0.62	3.11
Trib	538	PF 1	290.00	5810.44	5813.28		5813.46	0.013378	3.90	88.14	55.66	0.43	1.31
Trib	510	PF 1	290.00	5810.05	5812.30		5812.65	0.049946	5.22	61.85	55.94	0.67	3.42
Trib	484	PF 1	290.00	5809.03	5811.86		5812.05	0.016553	4.30	85.15	61.11	0.48	1.43
Trib	473	PF 1	290.00	5808.98	5811.43		5811.70	0.034748	4.77	70.28	60.48	0.57	2.50
Trib	449	PF 1	290.00	5808.18	5811.15		5811.30	0.011839	3.75	95.37	63.19	0.41	1.10
Trib	412	PF 1	290.00	5807.83	5810.26		5810.55	0.037318	4.93	67.88	58.55	0.59	2.68
Trib	386	PF 1	290.00	5806.99	5809.94		5810.11	0.012866	3.91	91.60	60.66	0.43	1.20
Trib	363	PF 1	290.00	5806.75	5809.68		5809.81	0.009138	3.25	104.61	63.67	0.36	0.93
Trib	345	PF 1	290.00	5806.68	5809.53		5809.68	0.011546	3.61	94.28	58.34	0.40	1.15
Trib	329	PF 1	290.00	5806.50	5809.12		5809.38	0.026489	4.35	71.05	48.22	0.51	2.41
Trib	305	PF 1	290.00	5805.61	5808.38		5808.77	0.029615	5.71	60.58	40.05	0.64	2.75
Trib	292	PF 1	290.00	5805.40	5807.91		5808.28	0.034472	4.93	59.80	38.04	0.58	3.31
Trib	267	PF 1	290.00	5804.42	5807.52		5807.78	0.016737	4.62	73.46	40.99	0.49	1.84
Trib	243	PF 1	290.00	5804.17	5806.82		5807.15	0.032367	4.84	63.87	42.20	0.56	3.02
Trib	217	PF 1	290.00	5803.39	5806.66		5806.81	0.008899	3.53	95.89	49.71	0.36	1.06
Trib	174	PF 1	290.00	5803.11	5805.29	5805.29	5805.86	0.096874	6.27	47.94	43.21	0.81	6.64
Trib	157	PF 1	290.00	5799.09	5803.10		5803.41	0.022549	4.74	65.44	28.40	0.44	3.10
Trib	128	PF 1	290.00	5799.09	5802.55		5802.82	0.015536	4.84	75.62	45.51	0.49	1.59
Trib	87	PF 1	290.00	5798.72	5801.02	5801.02	5801.58	0.099071	6.16	48.91	45.51	0.81	6.57
Trib	72	PF 1	290.00	5794.86	5798.94		5799.23	0.022370	4.52	68.04	28.58	0.43	3.18
Trib	42	PF 1	290.00	5794.84	5798.30		5798.61	0.017746	5.11	69.86	40.70	0.52	1.86
Trib	28	PF 1	290.00	5794.75	5797.94	5797.56	5798.36	0.026142	5.80	60.96	39.26	0.62	2.49
Trib	1	PF 1	290.00	5794.46	5796.56	5796.56	5797.39	0.065619	7.62	40.35	24.75	0.94	6.48

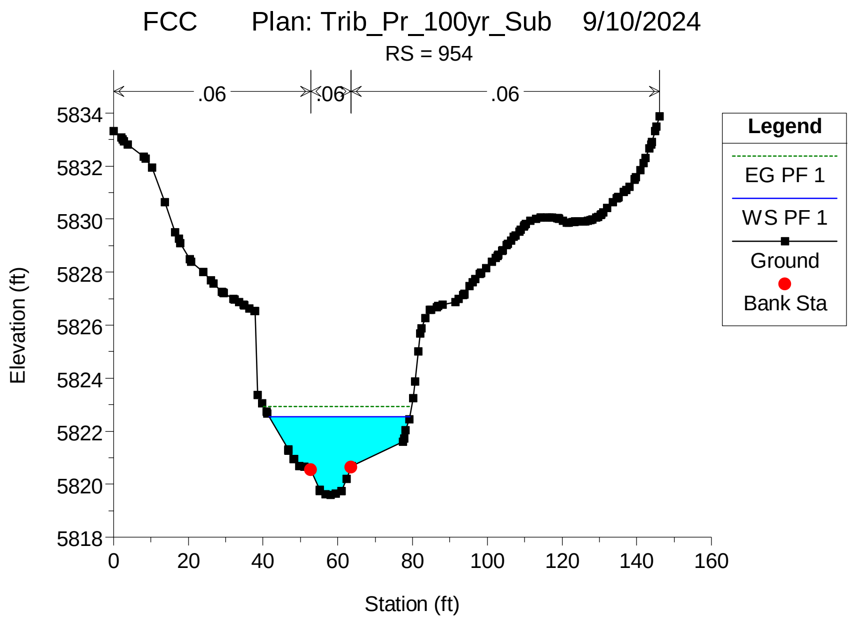

FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
FCC-Trib Trib
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Elevation (ft)
5840
5830
5820
5810
5800
5790
0
200
400
600
800
1000
1200
1400
Main Channel Distance (ft)


FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 1243

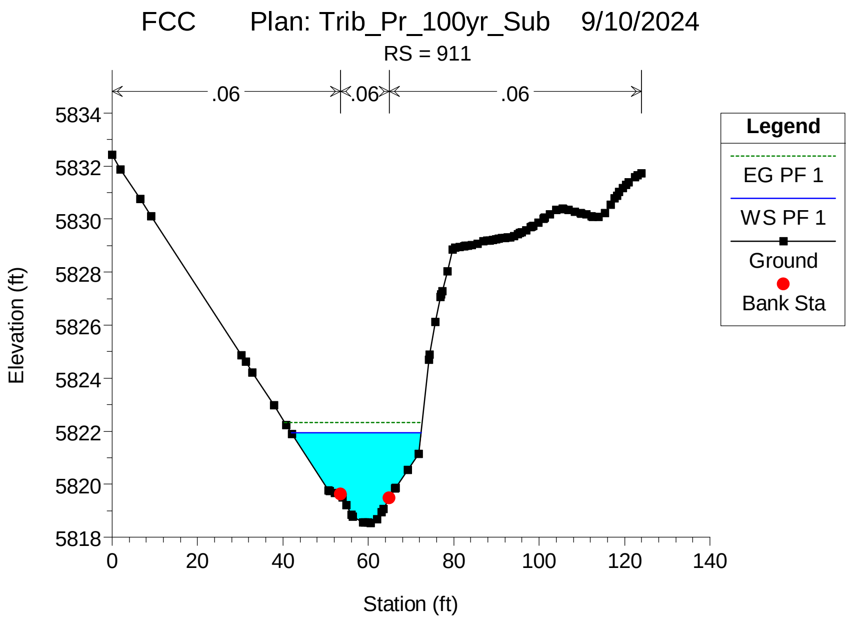

FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 1160


FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 1072

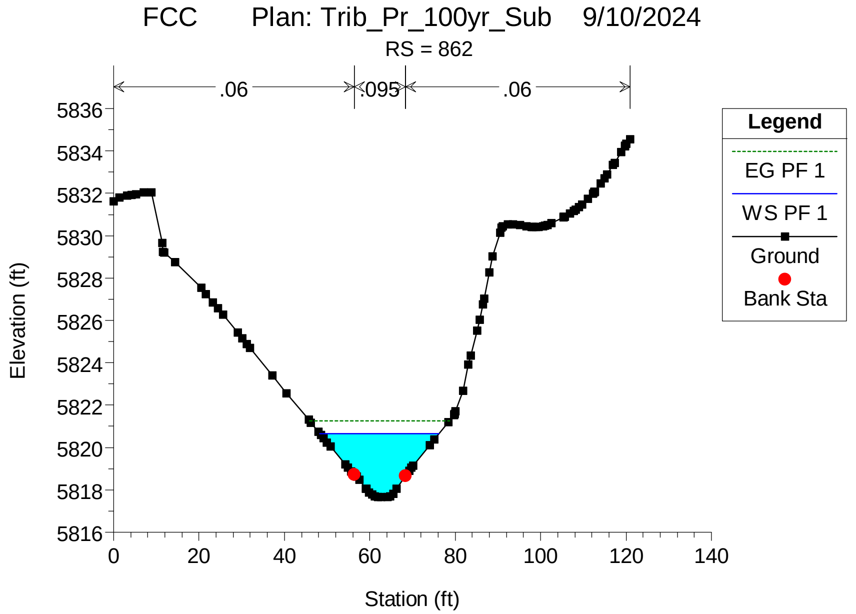

FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 1007


FCC Plan: Trib_Pr_100yr_Sub 9/10/2024

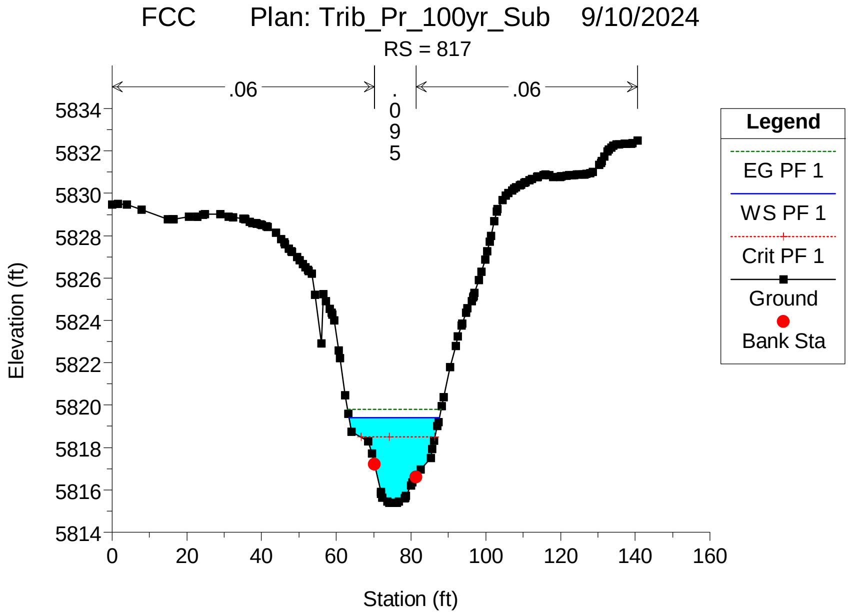
RS = 954


FCC Plan: Trib_Pr_100yr_Sub 9/10/2024

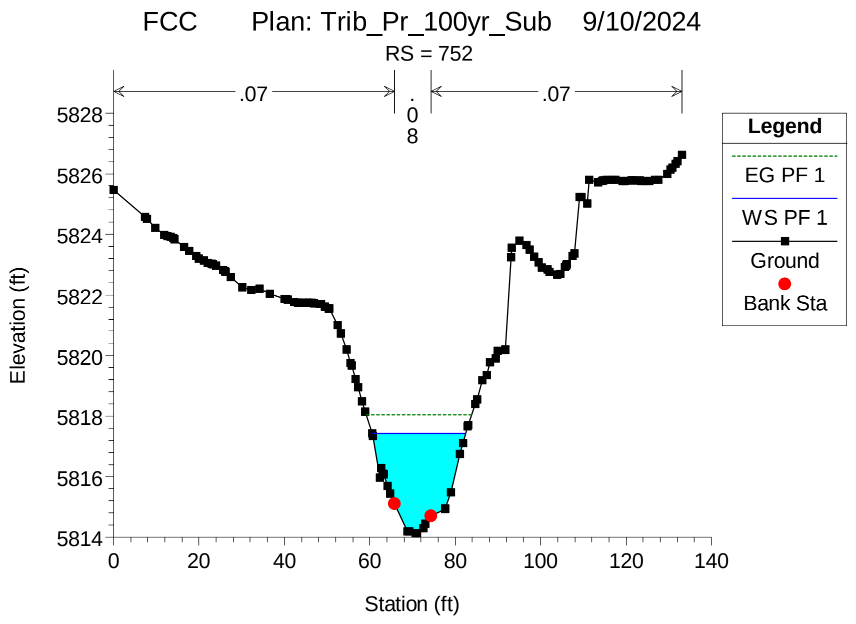
RS = 911

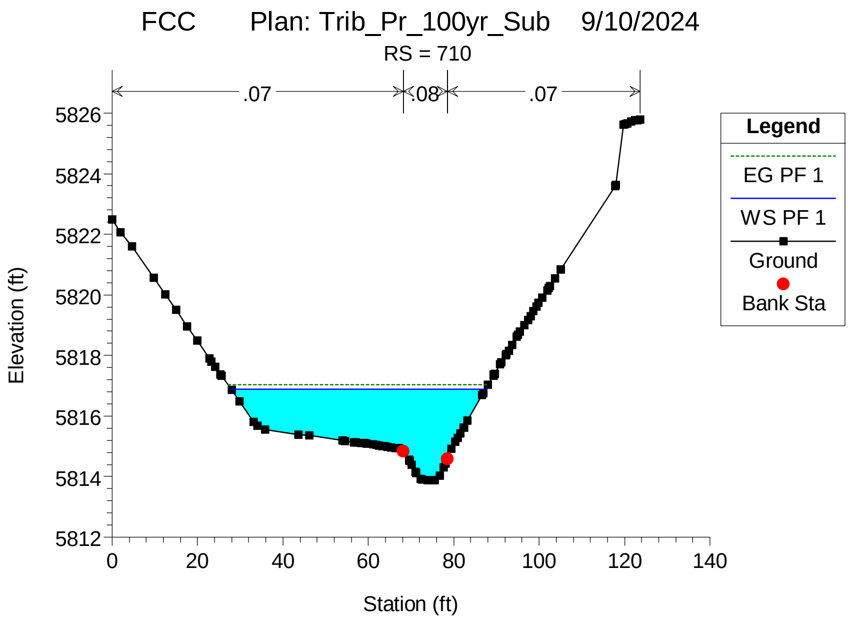

FCC Plan: Trib_Pr_100yr_Sub 9/10/2024

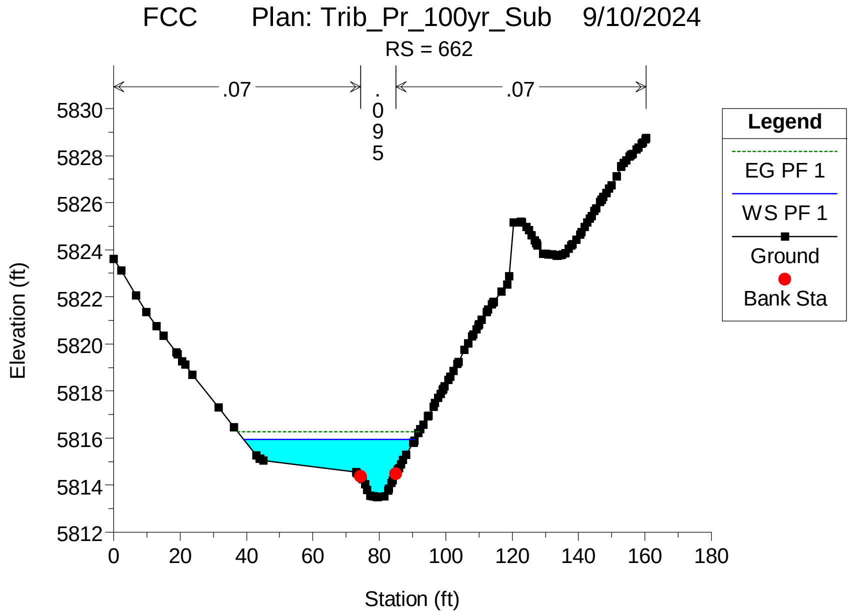
RS = 862

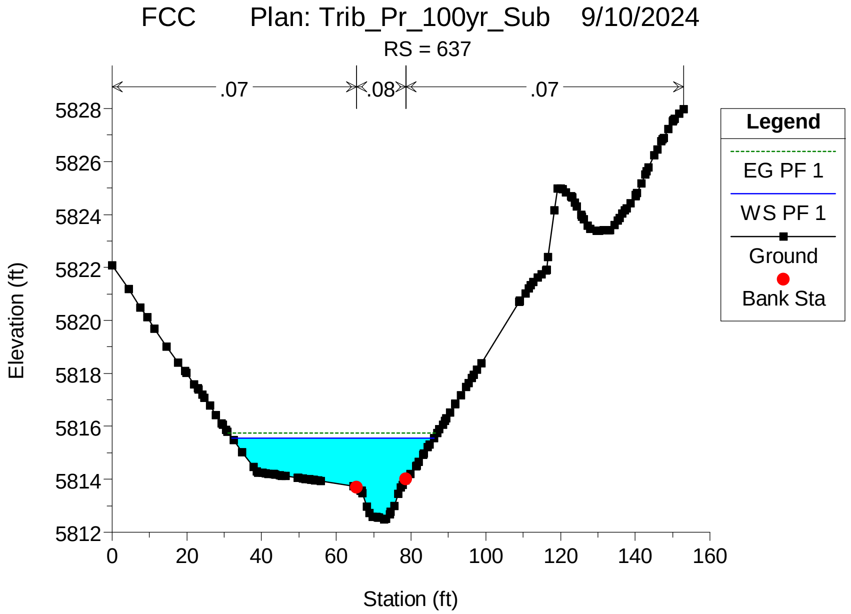

FCC Plan: Trib_Pr_100yr_Sub 9/10/2024

RS = 817

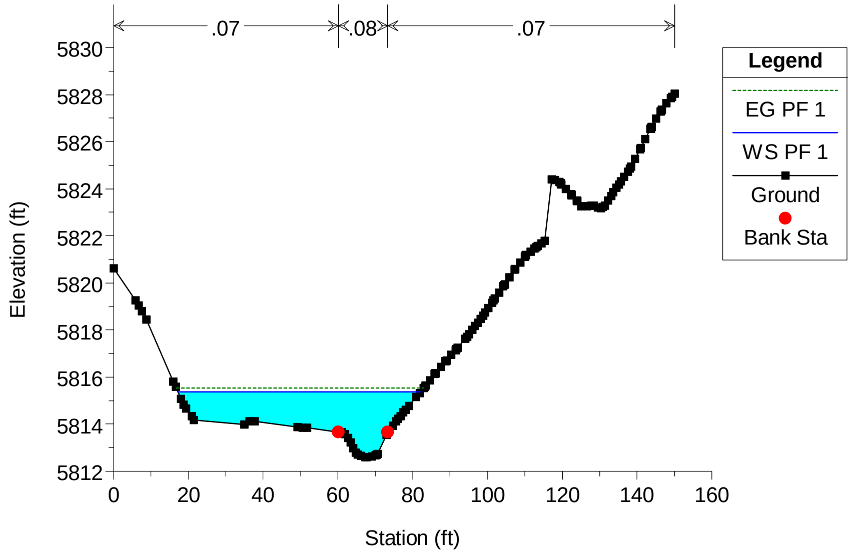

FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 752
.07
.
0
8
.07
Elevation (ft)
5828
5826
5824
5822
5820
5818
5816
5814
Station (ft)
0
20
40
60
80
100
120
140
Legend
EG PF 1
WS PF 1
Ground
Bank Sta


FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 710
.07
.08
.07
Elevation (ft)
5826
5824
5822
5820
5818
5816
5814
5812
Station (ft)
0
20
40
60
80
100
120
140
Legend
EG PF 1
WS PF 1
Ground
Bank Sta

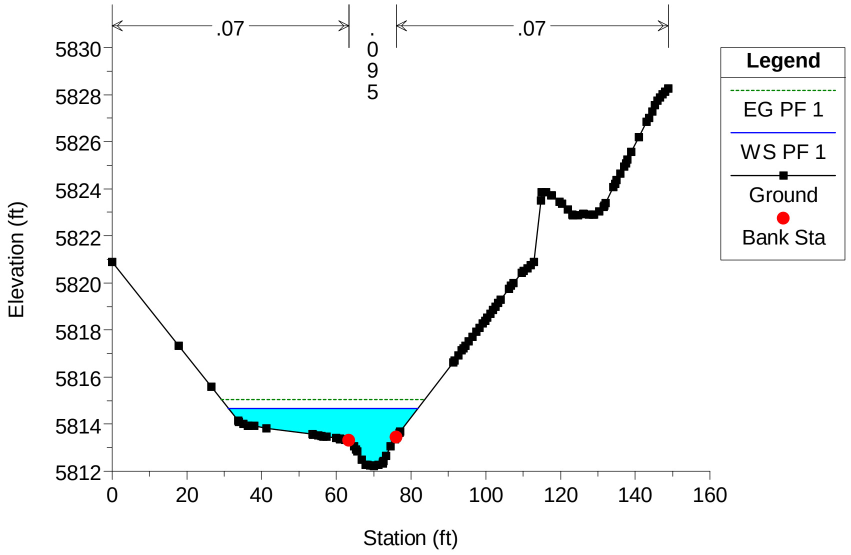

FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 662
.07
.
0
9
5
.07
Elevation (ft)
5830
5828
5826
5824
5822
5820
5818
5816
5814
5812
Station (ft)
0
20
40
60
80
100
120
140
160
180
Legend
EG PF 1
WS PF 1
Ground
Bank Sta


FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 637
.07
.08
.07
Elevation (ft)
5828
5826
5824
5822
5820
5818
5816
5814
5812
Station (ft)
0
20
40
60
80
100
120
140
160
Legend
EG PF 1
WS PF 1
Ground
Bank Sta

FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 625



FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
RS = 612



FCC Plan: Trib_Pr_100yr_Sub 9/10/2024
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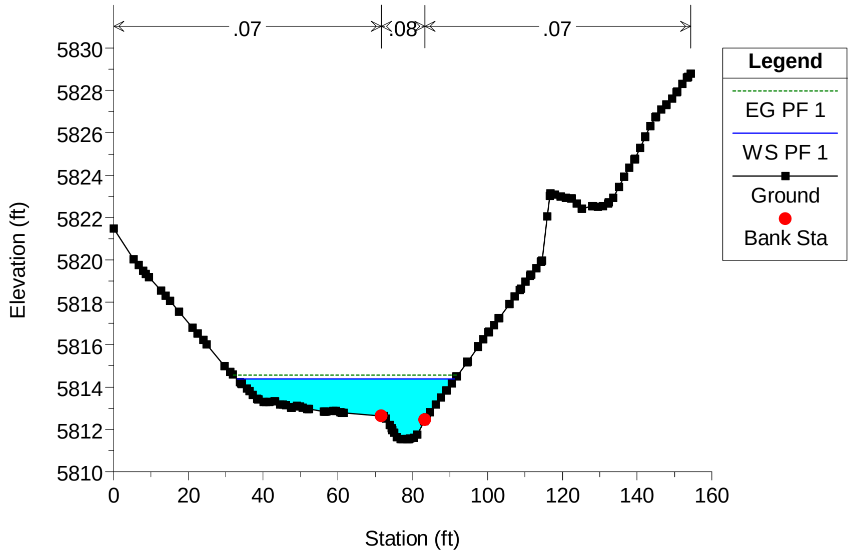

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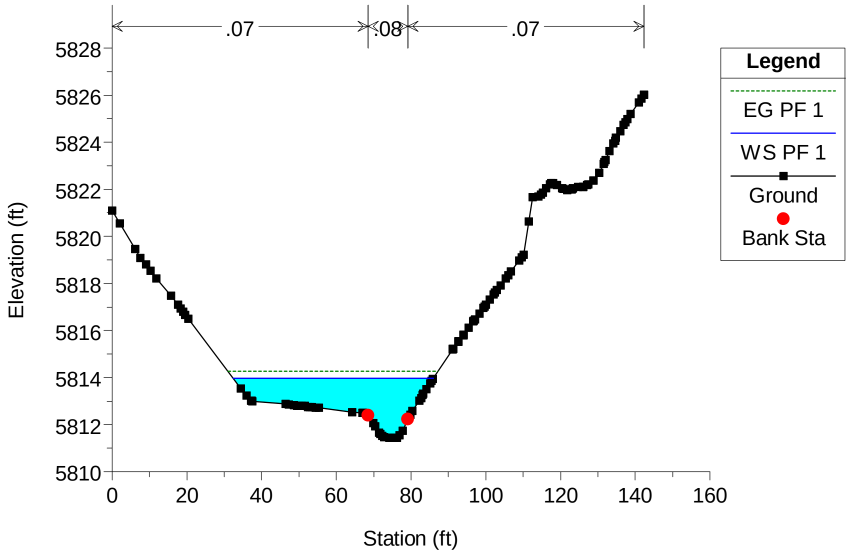

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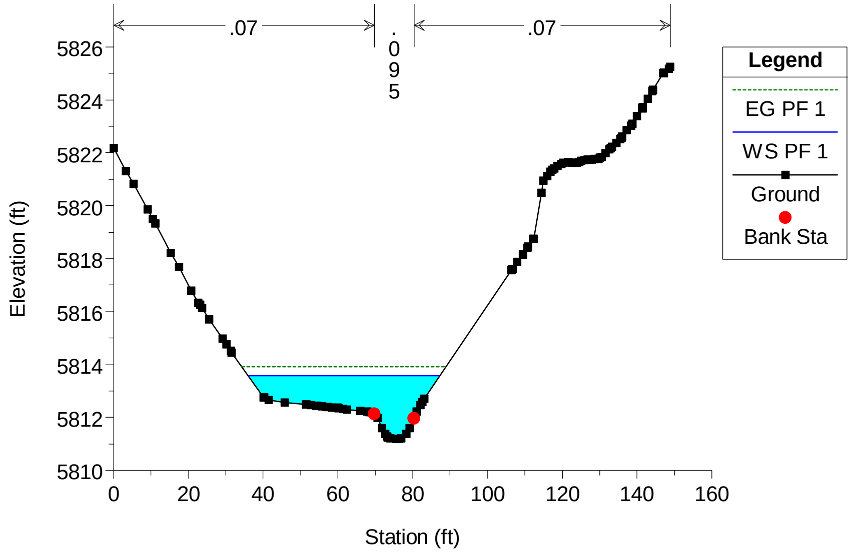

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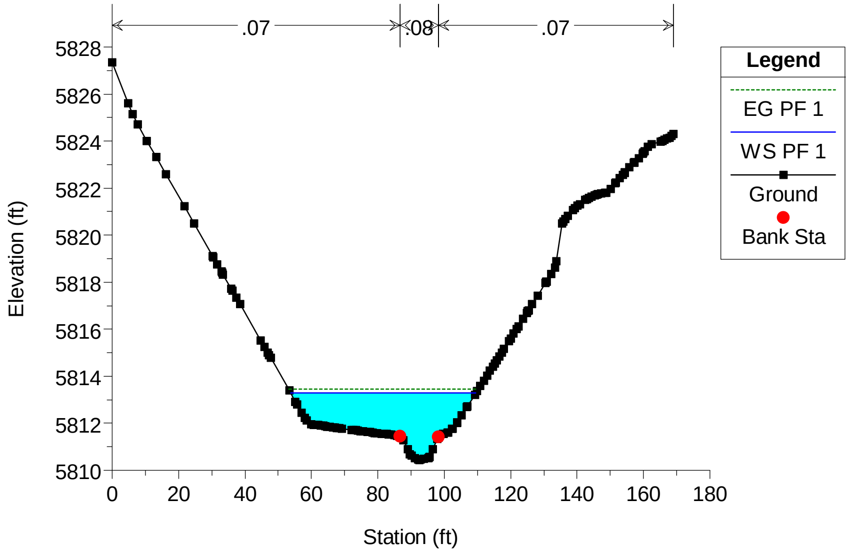

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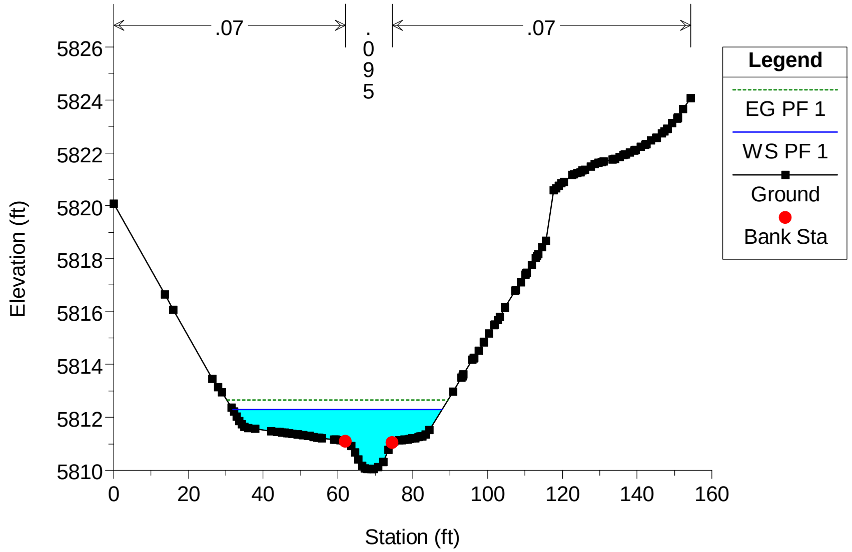

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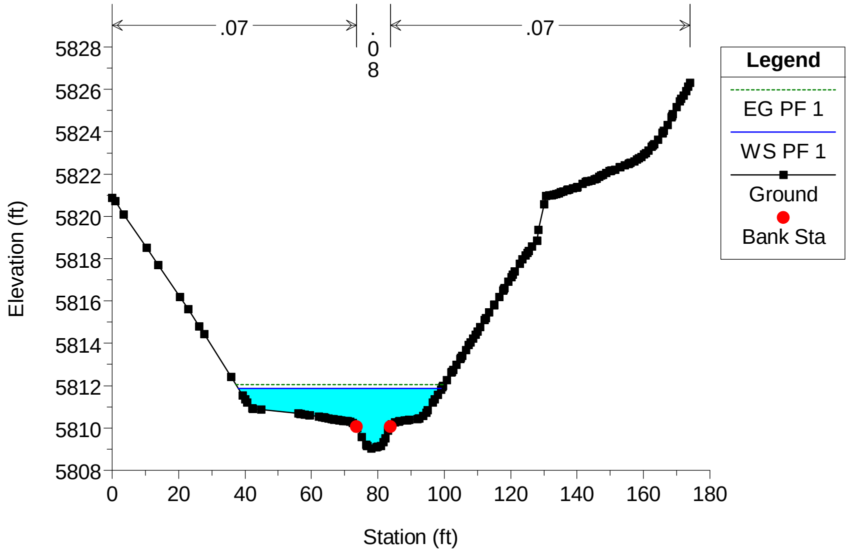

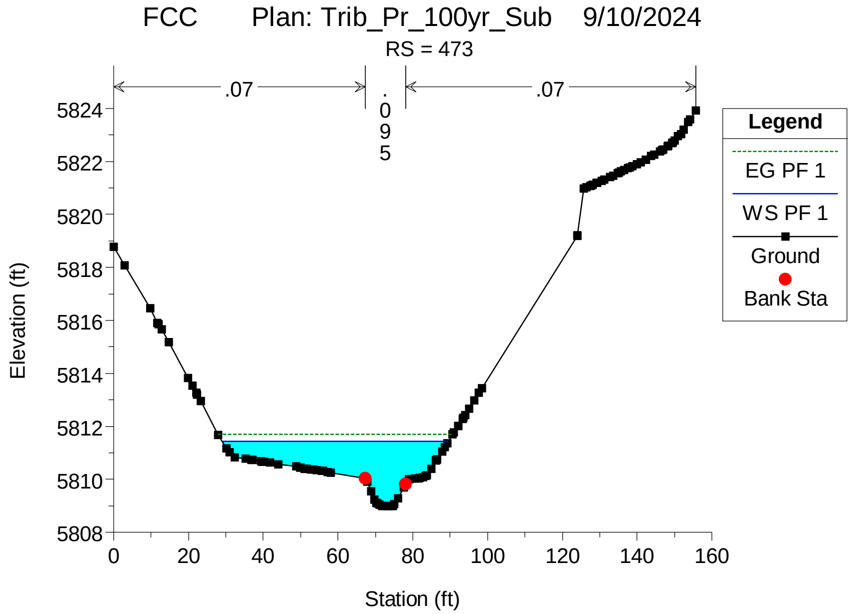
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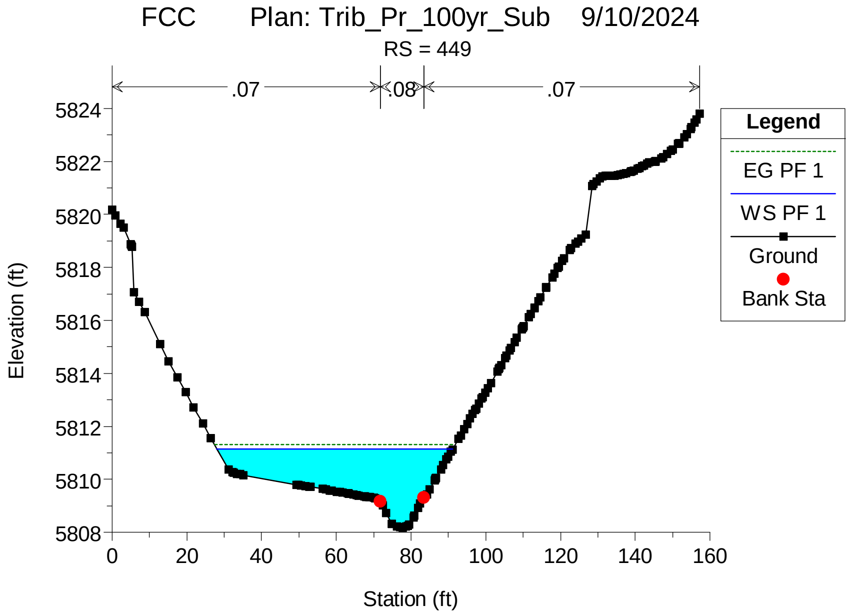
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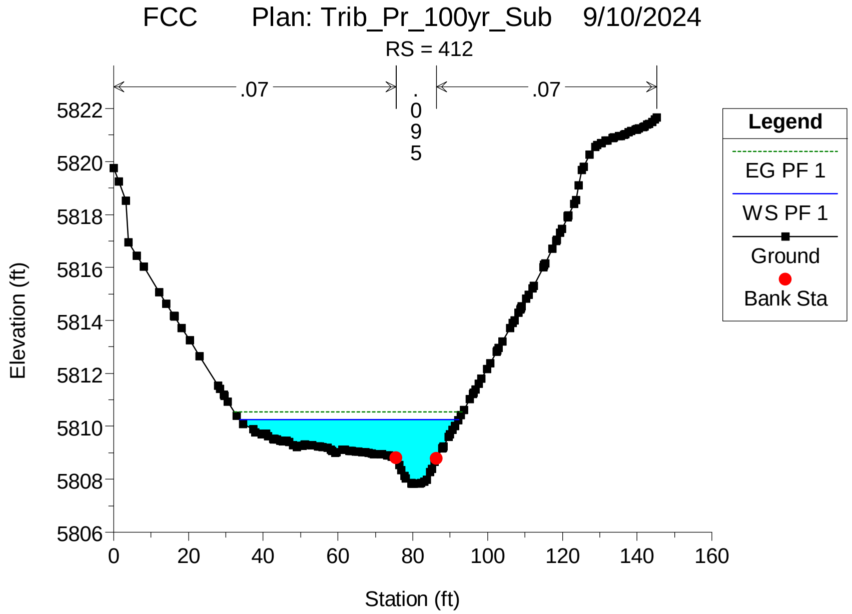
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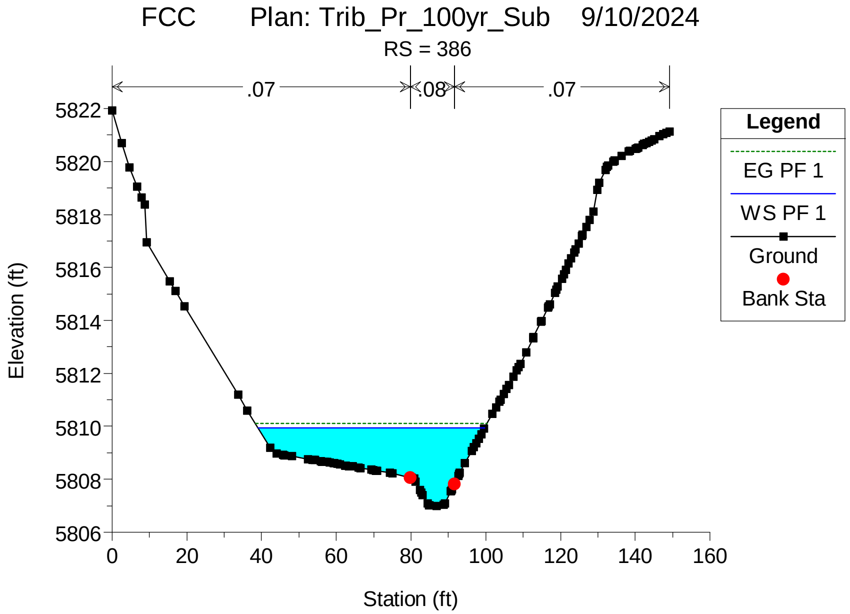
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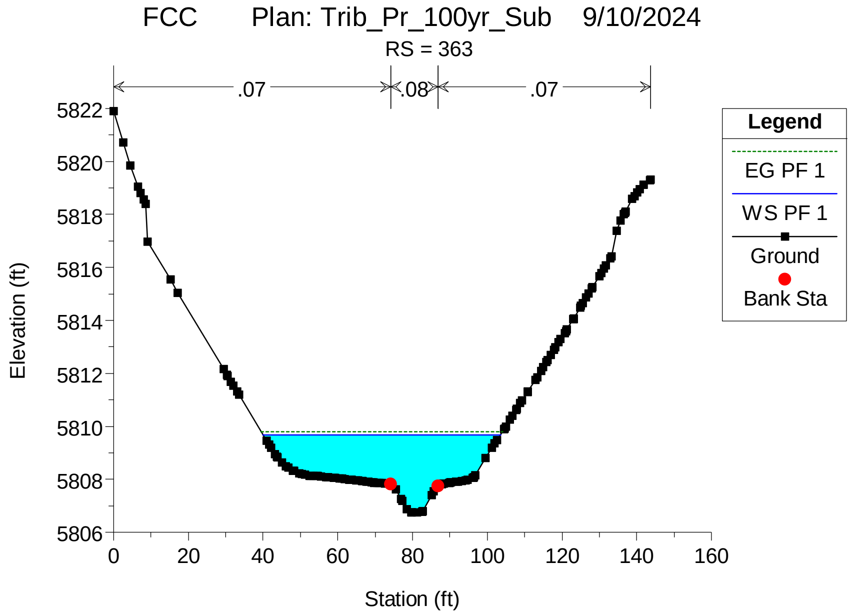
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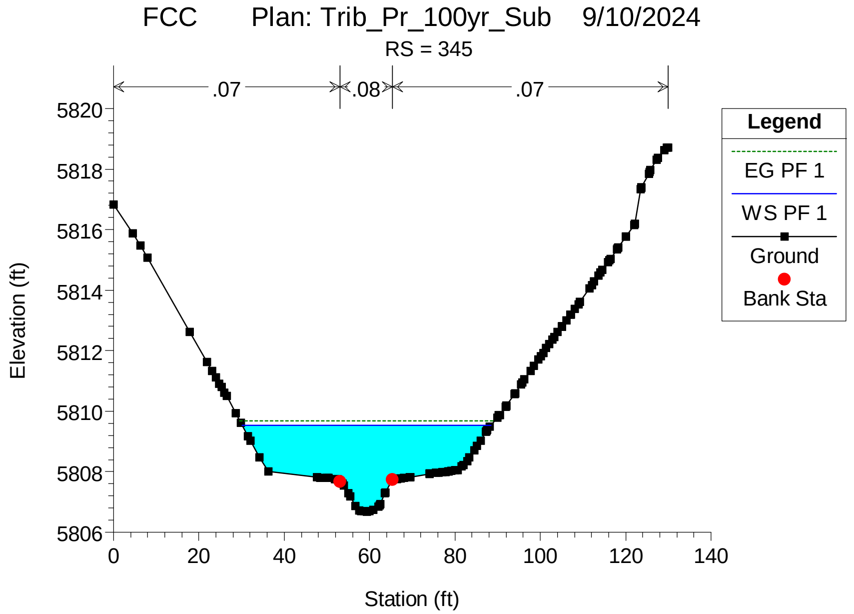
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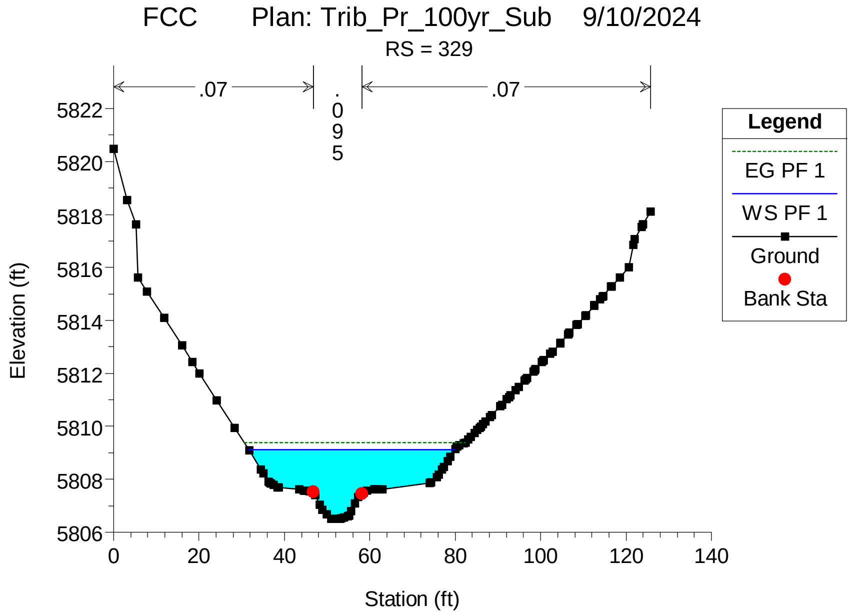
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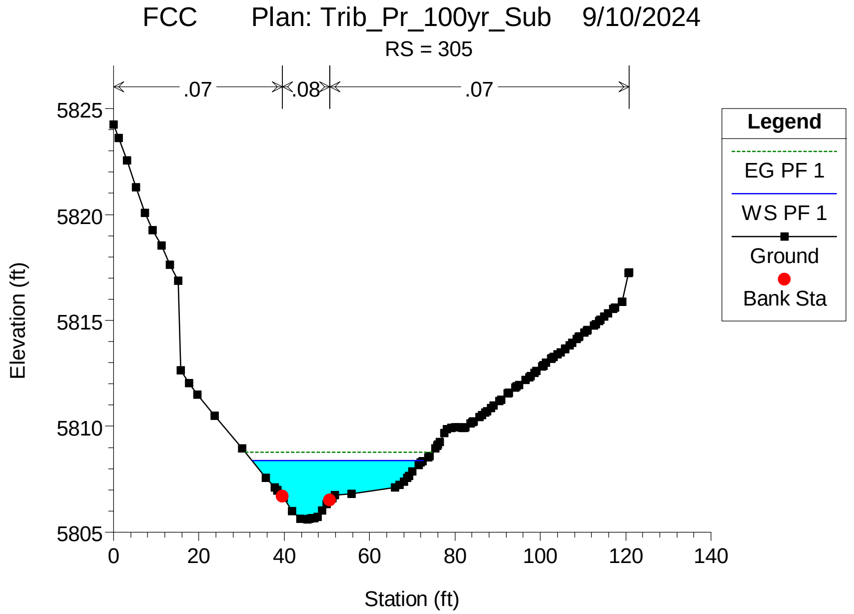
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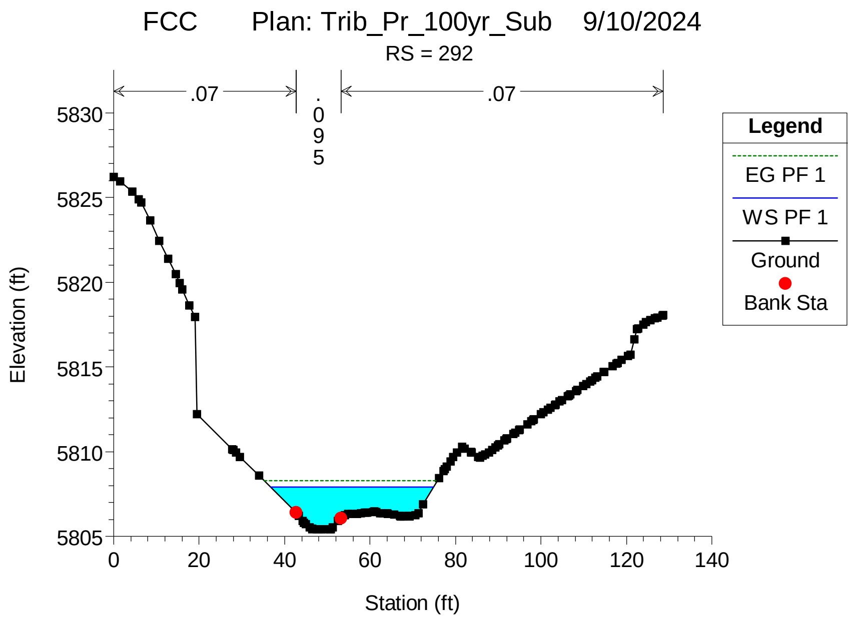
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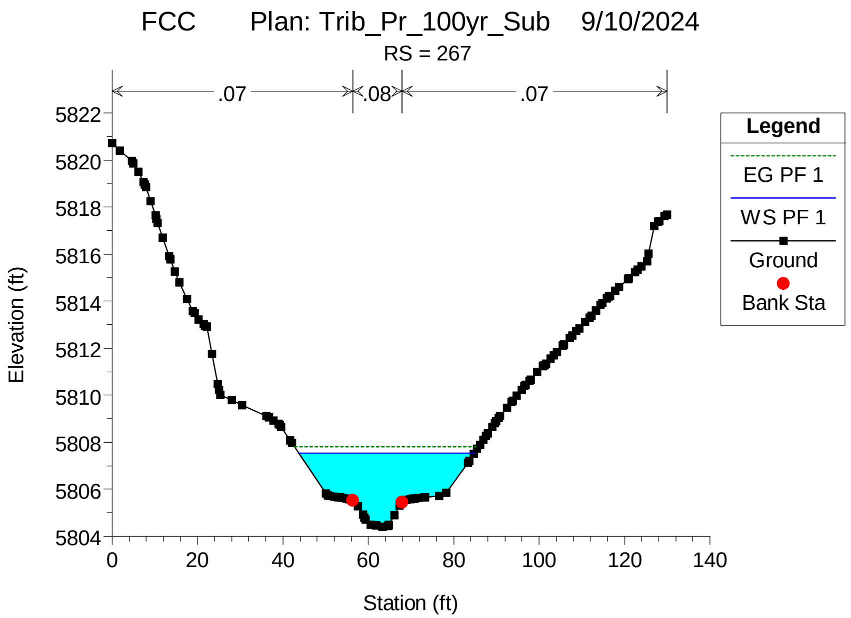
Bank Sta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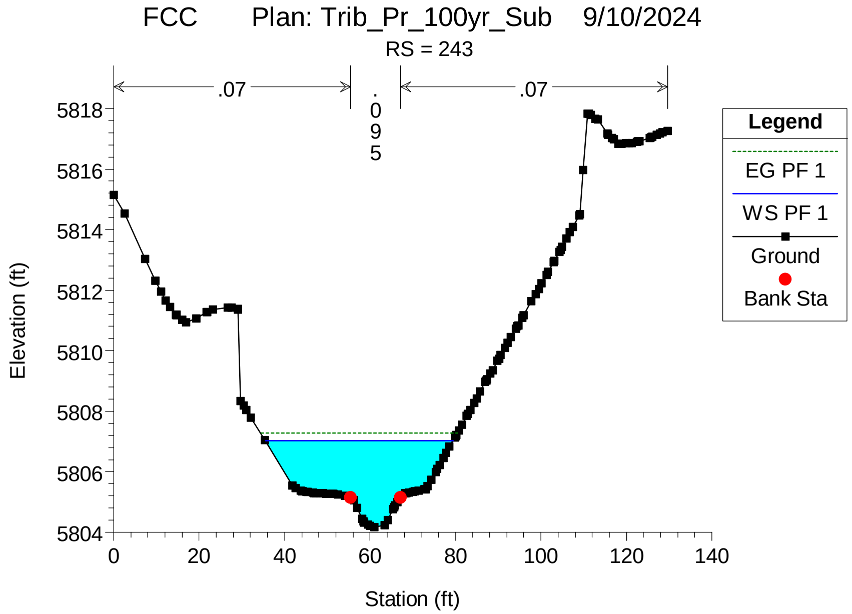
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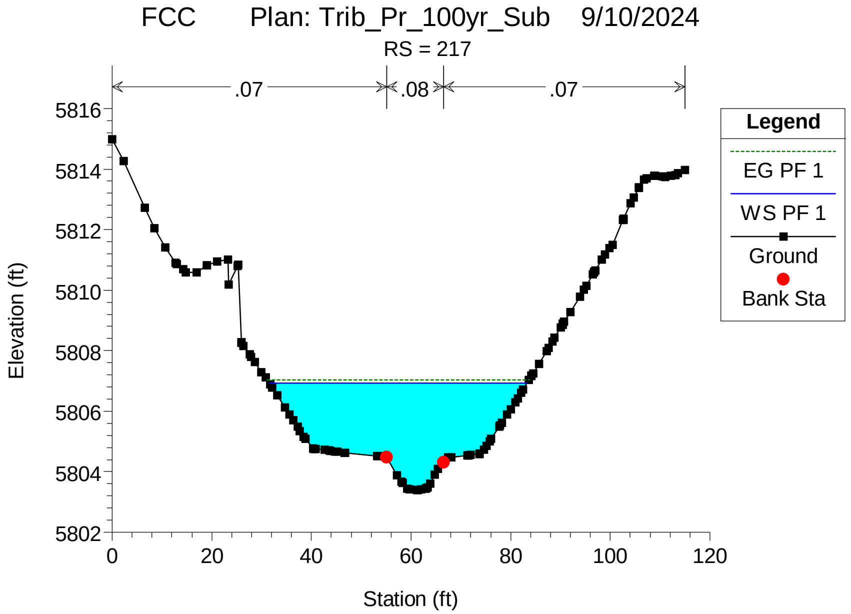
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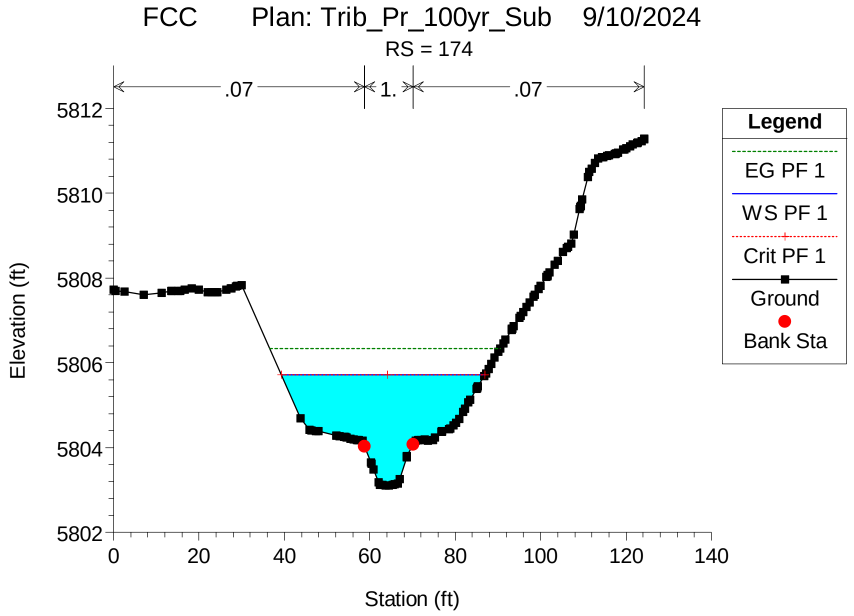
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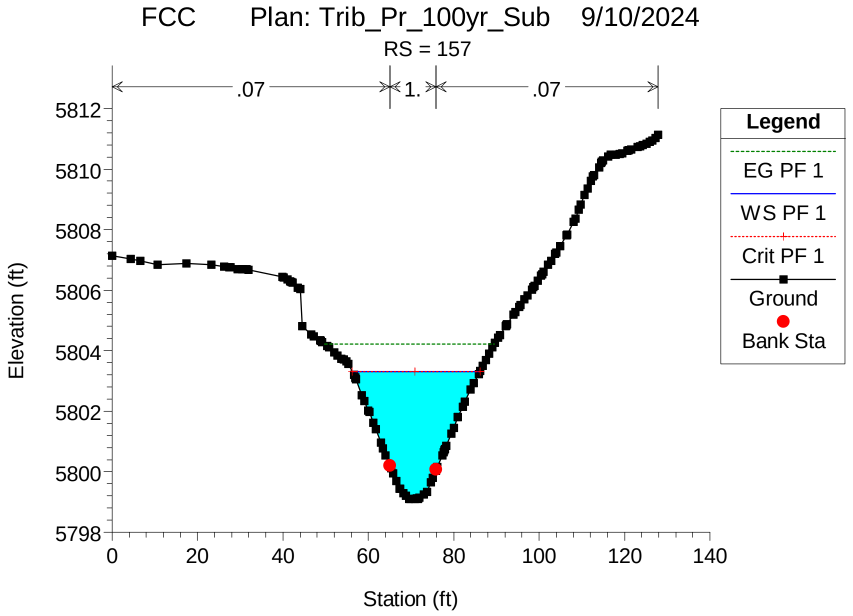
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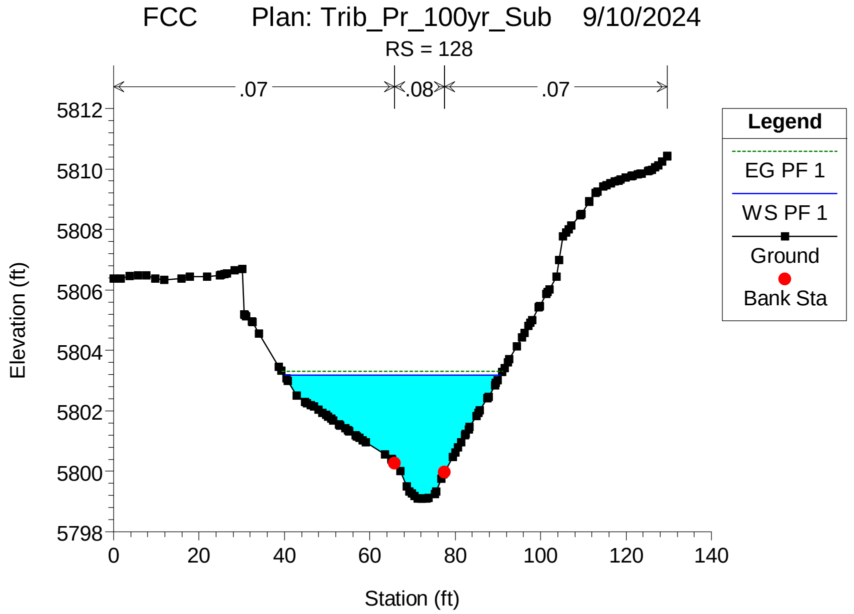
Station (ft)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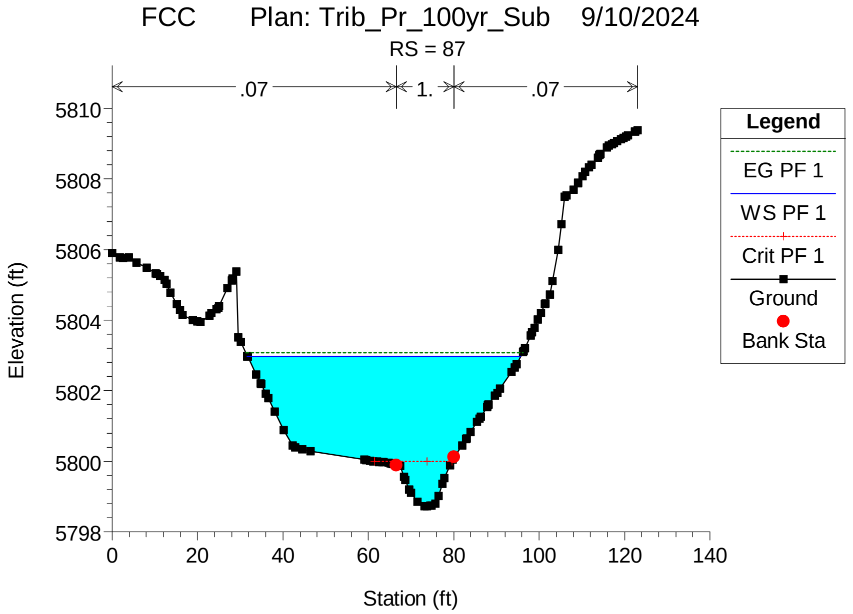
Station (ft)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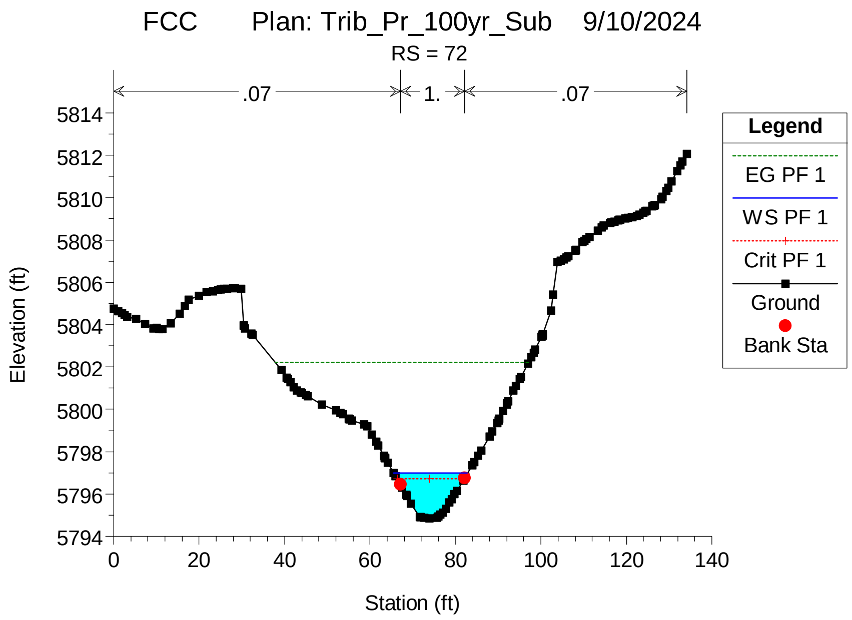
Station (ft)



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Station (ft)
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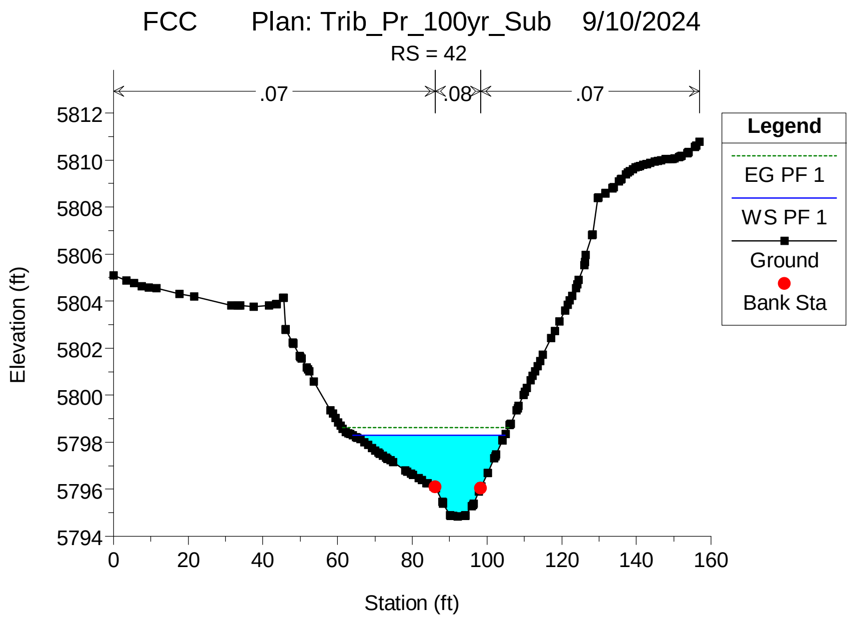
Ground
Bank Sta



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Station (ft)
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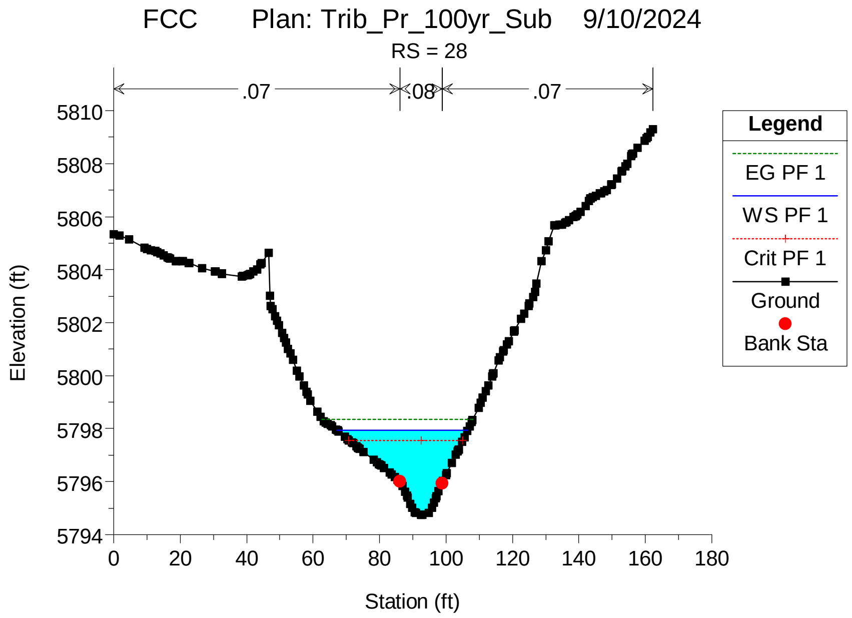
WS PF 1
Ground
Bank Sta



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Station (ft)
Legend
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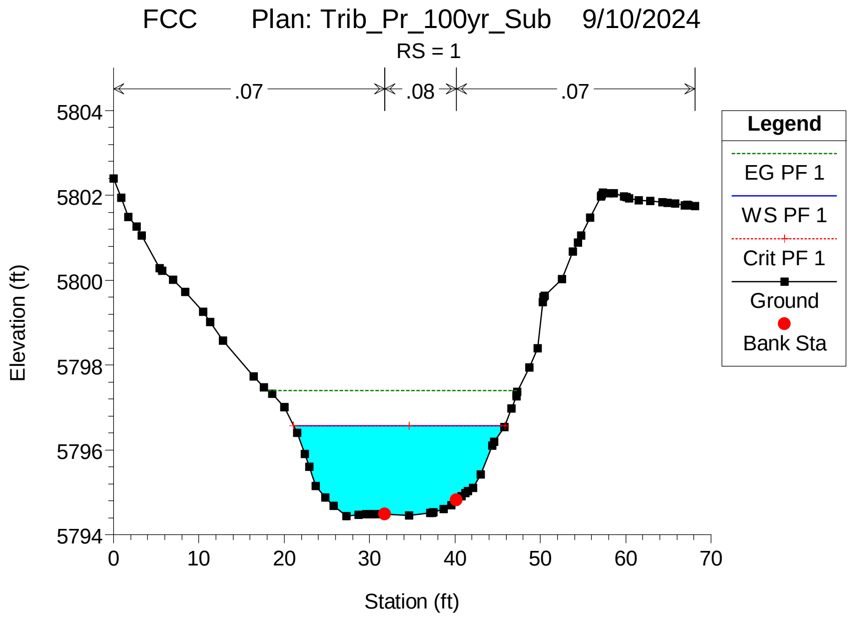
Bank Sta



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20
30
40
50
60
70
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

APPENDIX C: CONSTRUCTION DOCUMENTS

Construction drawings are submitted separately. They will be attached to this report after it has been approved with final signatures and stamps.

APPENDIX D: REFERENCES

Check-out Copy
City Engr. Div.

MULLER

Fishers Canyon Drainage Basin Planning Study

FINAL DESIGN REPORT

Prepared For:

El Paso County
Department of Public Works

Prepared By:

Muller Engineering Company

September, 1991

SECTION VII

DESCRIPTION OF ALTERNATIVE PLANS

Initial Alternative Formulation

The alternative formulation process started with brainstorming possible solutions to the drainage concerns existing in the basin. The objective of this phase was to approach the existing problems in a broad, complete manner to ensure that all types of possible solutions were considered. Ideas considered for Stratmoor Hills and Stratmoor Valley included various configurations of detention, development of open channel conveyances, acquisition of residential structures, regrading streets, and installation of various sizes of storm sewer systems. Concepts examined for the Fishers Canyon Drainageway and Fishers Canyon Tributary included conveying flows in a closed conduit, constructing concrete lined, riprap lined, or grass-lined channel sections, adding a limited number or a large number of drop structures, constructing small check structures and expecting some erosion when their capacity is exceeded, and installing rock low flow channels of various sizes. The do-nothing alternative was also considered throughout the basin.

After the initial formulation of alternatives, the least favorable concepts were eliminated based on negative impressions regarding cost, adverse environmental impact, effectiveness and maintenance requirements. The remaining alternative concepts were refined into two general plans.

Description of Alternative 1 and Alternative 2

Stratmoor Hills: Alternative 1 - Storm Sewer Improvements with No Detention. The residential area north of B Street has experienced frequent nuisance flooding during storm events. The area is developed on a hillside, with runoff typically being conveyed down slopes between houses instead of remaining in streets and gutters. The presence of Clover Ditch, no longer in use for irrigation purposes, exacerbates flooding problems by collecting stormwater runoff and releasing it over low banks toward houses below. The ditch has too flat of a longitudinal slope to be useful in coveying runoff out of the area.

A system of storm sewer improvements is proposed to collect runoff in Stratmoor Hills and minimize flooding problems. The plan is shown in Figure VII-1. The plan generally consists of storm sewers sized for a 10-year return period upstream of Clover Ditch and for a 100-year return period downstream of the ditch. This sizing strategy satisfies design criteria promulgated in the City of Colorado Springs/El Paso County Drainage Criteria Manual. The ditch itself is proposed to be graded toward inlets near each road crossing which would be designed to drain the ditch and eliminate overtopping in the 100-year storm. Additional information regarding Alternative 1, including quantification of areas of riparian vegetation potentially impacted, is shown in Table VII-1.

Stratmoor Hills: Alternative 2 - Storm Sewer Improvements with Detention. Alternative 2 is similar to Alternative 1, but incorporates a detention facility upstream in the basin in order to reduce flows and required pipe sizes. The plan is depicted in Figure VII-1. Additional information is shown in Table VII-1.

TABLE VII-1
STRATMOOR HILLS ALTERNATIVE COMPARISON

Consideration	Alternative 1 Storm Sewer Improvements With No Detention	Alternative 2 Storm Sewer Improvements With Detention
1. Probable Cost (including construction, R.O.W., engineering)	$2.15 Million	$ 2.22 Million
2. Existing Wetland/Riparian Vegetation	1 acre* of herbaceous/shrub wetlands on side tributary. 5 acres (2,800 l.f.) of grass overbank with shrubs and trees along Fisher's Canyon.	1 acre* of herbaceous/shrub wetlands on side tributary. 5 acres (2,800 l.f.) of grass overbank with shrubs and trees along Fisher's Canyon
3. Wetland/Riparian Impacts	Preserves wetlands on side tributary at location of detention pond. Minor loss of grass/shrub/tree riparian overbank at isolated outfalls on Fisher's Canyon.	Loss of wetlands on side tributary at location of detention pond. Minor loss of grass/shrub/tree riparian overbank at isolated outfalls on Fisher's Canyon.
4. Compensation Mitigation Opportunities	Opportunity for on-site replacement of grass/shrub overbank.	Opportunity for on-site wetland replacement at location of detention pond. Opportunity for on-site grass/shrub overbank.
5. Maintenance Requirements	Periodic maintenance is required to keep Clover Ditch inlets clear.	Periodic maintenance is required to keep Clover Ditch inlets clear. Periodic maintenance of detention pond is required.
6. Right-of-Way Requirements	Easement is required for Crestridge Avenue outfall to Fishers Canyon drainageway.	Easement is required for Crestridge Avenue outfall to Fishers Canyon drainageway. R.O.W. is required for detention pond.
7. Constructability	Three pipe crossings of railroad are required. Outfalls to Fishers Canyon drainageway require adequate scour protection.	Three pipe crossings of railroad are required. Outfall to Fishers Canyon drainageway require adequate scour protection.

*all acreages of vegetation are estimates

Stratmoor Valley: Alternative 1 - Storm Sewer Improvements with No Detention. Like Stratmoor Hills, Stratmoor Valley was developed without an adequate initial drainage system. A plan of storm sewer improvements is proposed and is shown in Figure VII-1. Proposed storm sewers are sized to convey 10-year flows from the currently developed area and 100-year flows from upstream areas that may develop in the future. Table VII-2 shows additional information regarding Alternative 1.

Stratmoor Valley: Alternative 2 - Storm Sewer Improvements with Detention. Alternative 2 is similar to Alternative 1, but proposes detention ponds to limit runoff from future upstream developing areas to historic levels. The plan is depicted in Figure VII-1. Additional information is shown in Table VII-2.

Fishers Canyon Drainageway and Tributary: Alternative 1 - Vegetated Channel with a Rock Low Flow Channel. The Fishers Canyon drainageway and its tributaries between B Street and Interstate 25 are currently experiencing significant bed and bank erosion. The erosion discourages the establishment of wetland vegetation along the channel and is contributing to sediment deposition in the culvert under Interstate 25 and in the downstream channel.

Alternative 1 consists of a system of stabilization improvements including a rock low flow channel, a number of drop structures, selected riprap bank protection, and widening of constricted areas. The plan is shown in Figure VII-1. Typical cross sections and details are shown in Figure VII-2. The improvements would encourage the formation of wetland vegetation along the channel. Additional information regarding Alternative 1 improvements is shown in Table VII-3.

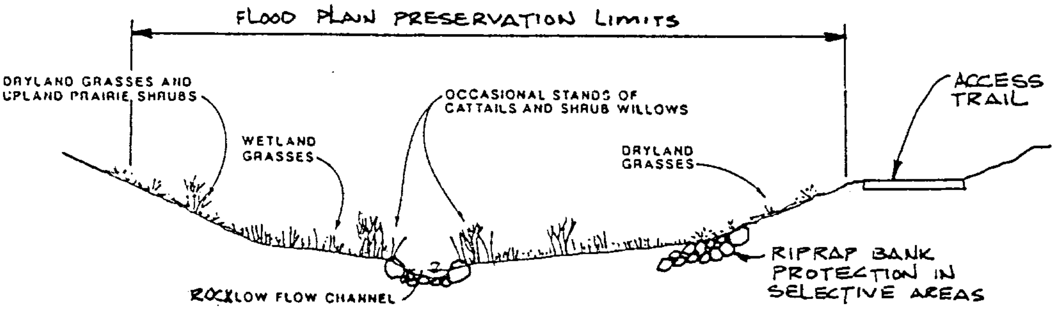
TABLE VII-2
STRATMOOR VALLEY ALTERNATIVE COMPARISON

Consideration	Alternative 1 Storm Sewer Improvements With No Detention	Alternative 2 Storm Sewer Improvements With Detention
1. Probable Cost (including construction, R.O.W., engineering)	$1.35 Million	$1.42 Million
2. Existing Wetland/Riparian Vegetation	110 acres (8,000 l.f.) of riparian woodland along Fountain Creek.	110 acres (8,000 l.f.) of riparian woodland along Fountain Creek.
3. Wetland/Riparian Impacts	Disturbance/loss of riparian woodland at isolated locations for pipeline and outfall structure within riparian area.	Disturbance/loss of riparian woodland at isolated locations for pipeline and outfall structure within riparian area.
4. Compensation Mitigation Opportunities	On-site replacement of riparian woodland.	On-site replacement of riparian woodland.
5. Maintenance Requirements	Periodic clearing of inlets may be required.	Periodic clearing of inlet may be required. Periodic maintenance of detention pond is required.
6. Right-of-Way Requirements	Easement is required for Kensington Drive outfall.	Easement is required for Kensington Drive outfall. R.O.W. is required for detention pond.
7. Constructability	Outfalls to Fountain Creek require adequate scour protection.	Outfalls to Fountain Creek require adequate scour protection

TABLE VII-3
FISHERS CANYON DRAINAGEWAY ALTERNATIVE COMPARISON

Consideration	Alternative 1 Vegetated Channel with Rock Low Flow Channel	Alternative 2 Vegetated Channel with Periodic Check Structures
1. Probable Cost (including construction, R.O.W., engineering)	$ 2.74 Million	$2.64 Million
2. Existing Wetland/Riparian Vegetation	5 acres (2,800 l.f.) of grass overbank with shrubs and trees along portions of Fisher's Canyon.	5 acres (2,800 l.f.) of grass overbank with shrubs and trees along portions of Fisher's Canyon.
3. Wetland/Riparian Impacts	Proposed improvements stabilize eroding channel and promote growth of wetland vegetation. Loss of minimal grass/shrub/tree riparian overbank.	Proposed improvements stabilize eroding channel and promote growth of wetland vegetation. Loss of significant grass/shrub/tree riparian overbank.
4. Compensation Mitigation Opportunities	On-site replacement of riparian grass and shrubs within grass-lined channel.	On-site replacement of riparian grass and shrubs within grass-lined channel.
5. Maintenance Requirements	Periodic channel maintenance is required	"Soft" low flow channel requires greater maintenance effort than rock low flow channel
6. Right-of-Way Requirements	Management of regulatory flood plain is recommended	Management of regulatory flood plain is recommended
7. Constructability	Control of water is required during construction	Control of water is required during construction. May require regrading of eroded low flow channel banks.

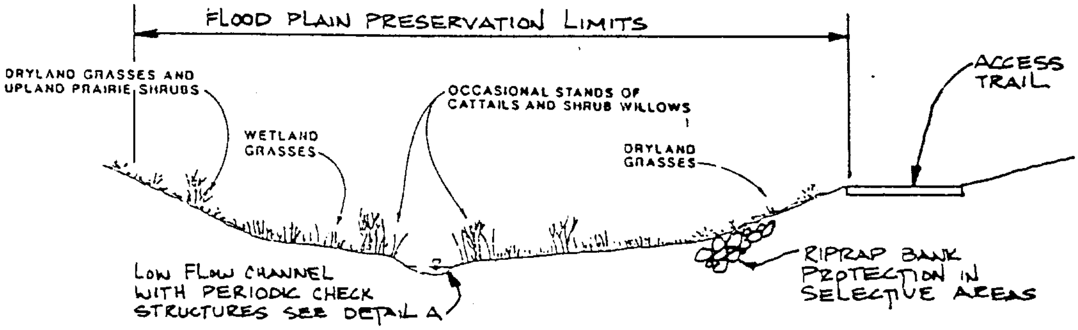
NOTE: PERIODIC CHANNEL DROP STRUCTURES MAY BE REQUIRED.



ALTERNATIVE 1 VEGETATED CHANNEL

N.T.S

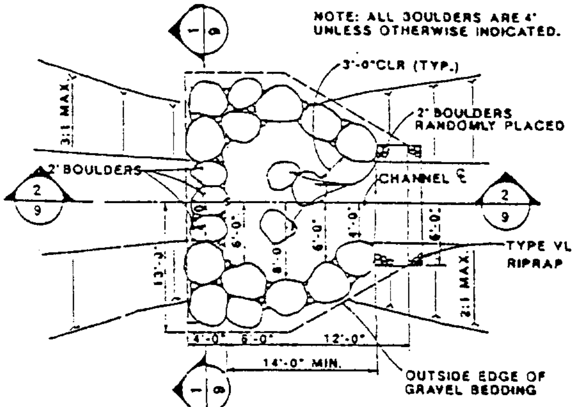
NOTE: PERIODIC CHANNEL DROP STRUCTURES MAY BE REQUIRED



ALTERNATIVE 2 VEGETATED CHANNEL

N.T.S.

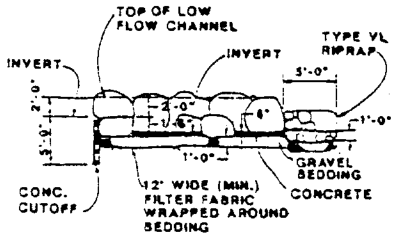
NOTE: ALL BOULDERS ARE 4' UNLESS OTHERWISE INDICATED.



DETAIL A

TYPICAL CHECK STRUCTURE

N.T.S.



SECTION 2/9

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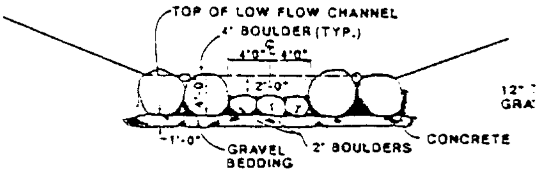

SECTION 1/9

N.T.S.

FISHERS CANYON
DRAINAGE BASIN PLANNING STUDY

TYPICAL CHANNEL SECTIONS

FIGURE
VII-2

Fishers Canyon Drainageway and Tributary: Alternative 2 - Vegetated Channel with Periodic Check Structures. This concept is similar to Alternative 1 but proposes the use of small periodic check structures instead of a continuous rock low flow channel. Between check structures the low flow channel would be unlined and would be allowed to erode and flatten over time to a stable equilibrium slope. Additional information comparing Alternative 2 to Alternative 1 is shown in Table VII-3.

Public Comments Regarding Alternative Plans

Review comments regarding the Alternative 1 and Alternative 2 plans were solicited from varous public agencies. Written comments were received rom the EPA, Colorado Division of Wildlife, and Colorado Department of Highways. In addition, a public meeting was held near the study area on September 18, 1990 to explain the alternative plans to interested citizens and to seek feedback. In general, support was expressed for constructing a system of drainage improvements in the basin to address existing concerns. Specific comments regarding Alternative 1 and Alternative 2 were varied, although the Alternative 1 plans were generally favored over the Alternative 2 plans. A summary of comments made at the public meeting, as well as copies of written comments received from public agencies, appear in Appendix A.

SECTION VIII

SUMMARY OF SELECTED PLAN

Plan Refinements

After a review of the public comments received concerning the alternative plans, as well as an evaluation based on County objectives such as constructibility and long term maintenance, El Paso County staff provided direction regarding the selected alternative to undergo preliminary design. This direction is summarized below:

Stratmoor Hills and Stratmoor Valley. Alternative 1, storm sewer improvements with no detention was selected with the one modification; namely, that downsizing or elimination of some of the less critical storm sewer laterals be considered in order to optimize the system and reduce the total cost of the improvements relative to benefits received.

Fishers Canyon Drainageway and Tributaries. Alternative 1, vegetated channel with a rock low flow channel was selected with several modifications. First, an attempt was to be made to lay out the rock lining in the incised, eroding channel in such a way that disturbance to the adjacent natural riparian vegetation would be minimized. Second, consideration was to be given to a detention facility upstream of Interstate 25 to reduce the anticipated 100-year discharge to the capacity of the existing box culvert under the highway.

The selected plan was to address a number of concerns expressed by public agencies associated with the Letter of Permission (LOP) process, including the Environmental Protection Agency (EPA), and the Colorado Division of Wildlife (CDOW). These concerns and the actions recommended in the selected plan to respond to the concerns are summarized below:

1. Stratmoor Hills and Stratmoor Valley

	LOP Agency Input	Action
A.	Storm sewer outfalls to Fishers Canyon Drainageway and Fountain Creek create potential for serious local scour and bank erosion problems.	Plan will identify measures to provide adequate scour protection at outfalls and to avoid or mitigate impacts to riparian habitats.
B.	(From CDOW) Detention is recommended to reduce peak storm water discharges at outfalls to Fishers Canyon Drainageway and Fountain Creek.	In these specific applications, there would be no peak flow reduction from detention by the time the Stratmoor Hills storm sewer reaches the Fishers Canyon Drainageway and little reduction by the time the Stratmoor Valley system reaches Fountain Creek. Consequently, detention is not an effective way to reduce impacts to downstream receiving waters. For the detention alternative the cost advantages of smaller pipes immediately downstream of the detention ponds are outweighed by the costs of the ponds themselves. In addition, avoiding the construction of these small detention ponds avoids disturbance to the existing Stratmoor Hills wetland (avoidance is preferred to mitigation) and minimizes ongoing maintenance requirements. Energy dissipation structures are proposed at the storm sewer outfalls to protect downstream receiving waters.

2. Fishers Canyon Drainageway and Tributaries

	LOP Agency Input	Action
A.	Existing riparian vegetation along the drainageway should be protected.	The existing riparian vegetation is located on overbanks adjacent to an incised channel which is actively eroding and is generally devoid of vegetation. The selected alternative is designed to stabilize the incised channel through the construction of a rock lining and to avoid, as much as possible, disturbance to the adjacent riparian vegetation between B Street and Interstate 25. Because of the steep gradient of the existing drainageway (as high as 1.6 percent), maintaining an unlined bottom would require significant channel regrading between frequent check structures. The unlined approach would cause more disturbance to the riparian vegetation and be more costly to construct and maintain than the selected alternative.
B.	Impacted areas of wetland and riparian vegetation should be quantified.	The summary report for the drainage basin planning study includes estimates of impacted areas of wetland and riparian vegetation (shown in Tables VII-2 through VII-3 for alternative concepts and in this section for the selected plan).

3. General

Both the EPA and CDOW have expressed concerns regarding the procedural aspects of the Letter of Permission process. These concerns are not specifically addressed by the Fishers Canyon Drainage Basin Planning Study; however, it is expected that future communications among the LOP agencies will lead toward the goal of an effective and efficient 404 process.

Preliminary Design

Preliminary design drawings of the selected drainage plan for the Fishers Canyon Basin are shown in Figures VIII-1 through VIII-4. The selected plan is depicted on aerial photography of the basin at a scale of 1-inch equals 200 feet superimposed with 2 foot contour interval topographic information. The photography for the mapping was taken on February 9, 1990. A legend for the preliminary design depiction is shown on Figure VIII-3. Sheet indexing is indicated on Figure VII-2. Profiles of the selected plan improvements are shown on Figures VIII-5 and VIII-6.

Storm sewer profiles shown on Figure VIII-6 in Stratmoor Hills, Westmark, and Stratmoor Valley are preliminary in nature. Refinements to the profiles will be required during the final design phase to avoid conflicts with the sanitary sewer system and other major utilities. The existing sanitary sewer system is shown in plan view in the vicinity of proposed storm sewer improvements. This information was transferred from mapping obtained from Stratmoor Hills Water and Sanitation District. Sanitary sewer crossings are indicated in profile on Figure VIII-6; however, the depths of the sanitary sewers are unknown at this time.

At the encouragement of the County, proposed storm sewer improvements in Stratmoor Hills and Stratmoor Valley reflect some downsizing of laterals from the 10-year level of protection shown in Alternative 1. This downsizing reflects a shift in strategy from meeting standard drainage design criteria for new developments to installing the minimum system necessary to eliminate, as much as possible, the inundation of houses during the 100-year event. The approximate design recurrance interval of these downsized laterals, which would function in large runoff events in combination with a certain amount of sheet flow between houses, is 2 years. The maximum quanitity of sheet flow assumed to pass between houses during a 100-year event is 1.0 cubic feet per second per foot of width. Flows in excess of this amount would be designed to be conveyed in the proposed storm sewer.

Typical channel sections of Fishers Canyon Drainageway and Fishers Canyon Tributary are shown on Figure VIII-5. The selected plan for Fishers Canyon Drainageway is designed to stabilize the bed and banks of the eroding active channel in a manner which preserves, as much as possible, the adjacent riparian vegetation. Six drop structures are proposed to reduce the steep existing stream gradient and decrease flood velocities. A side channel detention pond is proposed upstream of Interstate 25 to reduce the estimated future development condition 100-year flow from 3170 cfs to 2900 cfs, which is the design capacity of the culverts under Interstate 25 and Maxwell Street. A drop structure and channel enlargement downstream of Maxwell Street, in conjunction with fill placed south of the channel between Interstate 25 and Maxwell Street, would enable the Fishers Canyon 100-year flood plain to be confined to the channel instead of spilling south to inundate houses in Stratmoor Valley.

The selected plan for Fishers Canyon Tributary would fill and stabilize the steep, deeply incised channel. A rock low flow channel and three drop structures are proposed.

Environmental Impact Mitigation Guidelines

The Fishers Canyon Drainageway, although in a deteriorating condition, has the potential to be a valued local resource providing natural beauty and a diversity of vegetation and wildlife habitat. The proposed improvements, while necessary to address serious erosion problems and flood hazards, must not in themselves alter the stream from a natural to an "engineered" character. The proposed improvements are intended to be designed to blend in with the natural stream environment.

In developing the selected plan for Fishers Canyon Drainageway and Tributary, the following objectives were considered. The first priority was to minimize if not avoid disturbance to the existing riparian vegetation adjacent to the eroding active channel. Accordingly, the proposed improvements would leave much of the existing overbank vegetation intact. Preserving the existing vegetation maintains the stream's hydraulic roughness and resistance to erosion provided by vegetal root structures, and minimizes disturbance to existing wildlife habitat. Where avoidance was not possible, the next priority was to minimize disturbance to existing riparian vegetation. The selected plan minimizes disturbance to adjacent riparian vegetation by confining the width of rock stabilization improvements to approximately the same width as the active channel, which is eroding and generally devoid of vegetation. It is recommended that relatively narrow construction limits be specified during the final design of channel improvements to minimize disturbance to overbank vegetation. Zones where disturbance to vegetation is unavoidable are to be replanted with riparian species selected for their habitat value and suitability to local conditions.

Positive environmental impacts are planned as part of the proposed improvements. The crests of proposed drop structures could be extended above the existing channel invert to encourage the formation of new backwater wetland areas. The rock low flow channel would be designed to be pervious to allow lateral passage of water for support of adjacent vegetation. The improvements would stabilize the channel against bed and bank erosion which is currently hindering the establishment of channel vegetation.

Of the estimated five acres of riparian vegetation along Fishers Canyon Drainageway, made up primarily of dryland grasses, shrubs and trees, approximately 60 percent, or three acres, are to be left undisturbed. Approximately thirty percent, or 1.5 acres, are estimated to be disturbed during construction and subsequently replanted for no net loss of vegetation. Approximately ten percent of the dryland vegetation, or 0.5 acres, is estimated to be lost due to the installation of a gravel trail along the drainageway for maintenance and pedestrian access.

APPENDIX E: OPCC

DRAFT COPY – FOR REVIEW

Report of Geotechnical Engineering Evaluation

Venetucci Boulevard Channel Improvements
Venetucci Boulevard
Colorado Springs, Colorado

Prepared for

Peak Development
1480 Humboldt Street
Denver, Colorado 80218
ATTN: Mr. Chad Ellington

Prepared by

Professional Service Industries, Inc.
1070 West 124th Avenue
Suite 800
Westminster, Colorado 80234

July 26, 2024

PSI Project No. 05322860

PSI Project No. 05322860
July 26, 2024

Professional Service Industries, Inc.
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Mr. Chad Ellington
Peak Development
1480 Humboldt Street
Denver, Colorado 80218

Re: Report of Geotechnical Engineering Evaluation
Venetucci Boulevard Channel Improvements
Thompson Thrift Residential
Colorado Springs, Colorado

Dear Mr. Ellington:

Professional Service Industries, Inc (PSI), an Intertek Company, is pleased to transmit our Report of Geotechnical Engineering Evaluation for the proposed channel improvements associated with the new multifamily development in Colorado Springs, Colorado. The report includes the field exploration and laboratory testing results, as well as site preparation and foundation design recommendations.

If you have questions pertaining to this report, or if we may be of further service, please contact us at your convenience. PSI thanks you for your business and we look forward to finding ways to grow our partnership, expand our services, and continue Building Better Together.

Professional Service Industries, Inc.

DRAFT COPY – FOR REVIEW

DRAFT COPY – FOR REVIEW

Joshua W. Edin
Staff Engineer

Hannah C. Tawfik, P.E.
Senior Project Engineer

Reviewed by: Lloyd Lasher, P.E.
Principal Consultant

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Site Vicinity Maps (Figures 1a and 1b)
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1.0 INTRODUCTION

Professional Service Industries, Inc. (PSI), an Intertek Company, has conducted a geotechnical engineering evaluation for the site of the proposed channel improvements associated with the new multifamily development in Colorado Springs, Colorado. The purpose of our study was to characterize the subsurface strata at the subject site and to develop recommendations for site preparation and provide geotechnical parameters for the design of retaining walls for the proposed development by others. Our services on this project were provided in general accordance with PSI Proposal Number 426925 dated June 5, 2024, authorized by Mr. Chad Ellington with Peak Development on June 5, 2024.

PSI's scope of services for the geotechnical study did not include an assessment of environmental conditions in the soil, bedrock, surface water, groundwater, or air, on or below, or around this site. Any statements in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes.

The report, which follows, presents a brief review of our understanding of the project, a discussion of the site and subsurface conditions encountered, and our recommended soil properties to assist with the design and construction of retaining walls by others.

2.0 PROJECT INFORMATION

Based on information provided by Mr. Tim Govert with Thompson Thrift Residential, which included a Geotechnical RFP dated May 20, 2024 and a Topographic Survey dated July 2, 2024, PSI understands the project consists of channel improvements to existing creeks adjacent to the proposed multi-family development site. We understand two areas (Channel Area 1 and Channel Area 2) will undergo improvements including grouted boulder grade control structures with a sheet pile cutoff wall and a concrete cap. Additionally, there will be riffle drops which are made of riprap placed in the channel bottom. Some grading of the adjacent slopes may also be necessary. PSI has provided recommended soil properties including lateral earth pressures to aid in design of the proposed improvements by others. PSI did not evaluate for scour.

Local stability should be performed by the wall designer. PSI can perform a check for global stability of the proposed walls following completion of design if cross sections, wall geometry and types are provided at critical locations along the wall alignments. PSI should review the wall design to confirm our recommended soil properties were properly implemented.

The site is currently covered with moderate vegetation. The latitude and longitude of the subject site is approximately 38.7704° North and 104.7859° West. The site is bounded by vacant land to the north, Venetucci Boulevard/Commercial Development to the east, vacant land/Residential Development to the west and vacant to the south. The site significantly slopes around the creeks, however; we understand no structures are immediately adjacent to the slopes or creeks. No services were provided related to an evaluation or assessment of the stability or protection of adjacent structures, pavements or other appurtenances along the project either currently or following the proposed improvements. Borings were generally performed in the area of the requested locations, however, borings were offset due to utility lines and access considerations.

Descriptions of the site are based upon observations made during our field exploration program. The geotechnical recommendations presented in this report are based upon the provided project information and the subsurface materials described in this report. If any of the noted information is incorrect, please inform us so that we may amend the recommendations presented in this report, if needed.

3.0 SUBSURFACE INFORMATION

The following sections provide information relating to subsurface conditions encountered at the boring locations and published geologic information in the general vicinity of the project site. The geology section is based upon the "Geological Map of Colorado" by Ogden Tweto dated 1979 and information relating to subsurface conditions within the property gathered from our current field study.

3.1 Site Geology and Geologic Hazards

Based on the referenced map by Tweto 1979, the site lies in an area mapped as Pierre Shale-Upper unit (Phanerozoic, Mesozoic, Cretaceous) can be described as "Including sedimentary, clastic, mudstone, shale".

Based upon historical aerial photographs, the site has been vacant since prior to 1993, however, the site appears to have undergone significant grading to support adjacent development starting in the early-2010s.

3.2 Subsurface Conditions

As part of PSI's evaluation of this site, three (3) exploratory borings were drilled at the approximate locations as indicated on Figure 2, the Boring Location Map. Three (3) borings were drilled in the areas along the proposed channel improvements to depths of approximately 25 to 35 feet below existing grade.

The borings were advanced using a CME-50 truck mounted drill rig equipped with 4-inch diameter, solid-stem, continuous-flight auger. Soil samples were recovered at selected depths during drilling with the truck-mounted drill rig using a Modified California Sampler (outside diameter- 2.4 inches; inside diameter – 2.0 inches) driven by a 140-lb. weight free falling 30 inches. The number of blows required to drive the sampler 12 inches is designated as the penetration resistance (N-value, blows per foot) and provides an indication of the consistency of cohesive soils and the relative density of granular materials. While the procedure is similar to that employed in the Standard Penetration Test (ASTM D1586), the penetration resistance obtained using the California barrel sampler is generally higher than that obtained using the standard split-spoon sampler. A correction factor of 0.6 for sand and 0.77 for clay is typically used for N-Values collected using the Modified California sampler. The N-values on the attached logs were not corrected.

A representative from our office observed the drilling and prepared borings logs of the subsurface conditions encountered. Individual logs of the borings are presented on Figures 3 through 5. It should be noted that the subsurface conditions presented on the boring logs are representative of the conditions at the specific locations drilled. Variations may occur and should be expected across the site. The soil morphology represents the approximate boundary between subsurface materials and the transitions may be gradual and indistinct. Water level information, if encountered, obtained during our field operations is also shown on the boring logs. Elevations referenced were obtained via Google Earth and should be considered approximations.

3.2.1 Subsurface Profile

The soil profile generally consisted of high plasticity soils with varying amounts of sand overlying claystone bedrock. PSI observed high plasticity soils with varying amounts of sand from the current ground surface to the bedrock elevation in the borings performed. The high plasticity soils with varying amounts of sand can be described as fine to coarse grained sand with trace amounts of gravel, dry to moist, brown to dark brown, gray to dark gray, and orange, and stiff to very stiff in consistency. The high plastic clays may be highly weathered bedrock.

Claystone was encountered approximately 5 feet to 19 feet below existing grade, extending to termination depths of borings and can be described as fine to coarse grained sand with trace amounts of gravel, dry to saturated, brown to dark brown, gray to dark gray, black and blue, and very stiff to hard in consistency. Bedrock depths were variable across the site.

3.2.2 Swell Potential

PSI has reviewed the “Potentially Swelling Soil and Rock in the Front Range Urban Corridor, Colorado” by Stephen S. Hart, dated 1972. Based on this published map, the subject site lies with an area described as having “Low Swell Potential” designation. Low Swell Potential designation is described as “This category includes several bedrock formations and many surficial deposits. The thickness of the surficial deposits may be variable, therefore, bedrock with a higher swell potential may locally be less than 10 feet below the surface.”

PSI performed ASTM D4546 Swell Testing on selected samples of the recovered on-site material from the soil borings. The following table summarizes the results of the Denver Swell tests:

Boring	**Sample Depth (feet)**	**Surcharge (psf)**	**Swell Potential (%)**	**Swell Pressure (psf)**	**Moisture Content (%)**	**Soil Classification**
B1	7 ½	750	**1.7**	3,200	24.7	CH
B2	2 ½	250	**4.4**	2,100	28.1	CH
B2	10	1,000	**0.3**	1,600	25.5	CH(Bedrock)

Based upon the swell test results, the native overburden soils and claystone bedrock encountered are classified as having a "low to high" potential for swell, therefore; mitigation for swell is recommended. In addition, if excessive drying and rewetting of these soils is allowed to occur, the risk of swell will increase. Proper drainage and good maintenance should be followed.

3.2.3 Groundwater Conditions

Free-flowing groundwater was observed at a depth of 16-feet during drilling operations in Boring B2 which was performed approximately 15 feet above the creek level at the time of drilling. Free flowing groundwater was not observed in Borings B1 and B3, however, due to the clay soils, infiltration may be very slow. Based on the provided topographic map, the ground surface at the boring locations were approximately 9 to 20 feet above creek level.

It should be noted that it is possible for the groundwater table to fluctuate during the year depending upon climatic and rainfall conditions and changes to surface topography and drainage patterns. Discontinuous zones of perched water may also exist, or develop, within the overburden materials subsequent to the construction of the proposed development. We recommend the contractor determine groundwater levels at the time of construction.

3.2.4 Laboratory Testing

The soil samples obtained during the field exploration were transported to the laboratory and selected soil samples were tested in the laboratory to measure material properties for our geotechnical evaluation. Laboratory testing was accomplished in general accordance with ASTM and other applicable procedures. Laboratory testing was performed on selected samples to evaluate the classification, swell and other engineering characteristics of the subsurface materials. Laboratory test data along with detailed descriptions of the soils can be found on the logs of borings and in Appendix A. The samples that were not altered by laboratory testing will be retained for 60 days from the date of this report and then will be discarded without further notice.

4.0 GEOTECHNICAL EVALUATION

The primary geotechnical concerns at this site are high swelling and high plastic soils and shallow depths to bedrock. The laboratory results indicated high swell in the shallow overburden soils.

Sheet piling should be constructed in accordance with FHWA (NHI-05-042) and CDOT specifications. Grouted boulder grade control structures and riprap channel should be designed in accordance with City of Colorado Springs Specifications Section 620.

Shallow bedrock depths may limit sheet penetration depths, requiring anchors or preforming.

Excavated claystone bedrock and high plasticity clays should not be reused as structural fill or for use behind walls and should only be placed in non-structural areas. If areas where unsuitable materials are encountered during site grading, we recommend they be completely removed from the site. We recommend a contingency for waste of unsuitable materials and import of suitable materials be included in the construction budget.

Moisture fluctuation of the onsite soils will increase its swell/collapse potential, therefore maintenance of the structure and pavements, as well as controlling water runoff will be critical to the functionality of the facility. Proper moisture control will be imperative at this site during and following construction. The risk of swelling/collapsible soils can be reduced, but not eliminated, by preventing fluctuations in moisture content. Therefore, it is imperative that positive slope away from the addition and foundations is maintained, hardscape is constructed around the addition perimeter, utilities are prevented from transmitting water via trench bedding or broken lines, and pavements are regularly maintained.

Free-flowing groundwater was observed during our exploration at a depth 16-feet below existing grade in Boring B2 which was performed approximately 15 feet above the creek level existing at the time of drilling. However, due to the proposed work within the creek area, water levels may fluctuate, and dewatering is likely required during the proposed construction. We recommend the contractor determine groundwater levels at the time of construction.

The following geotechnical design recommendations have been developed based on the described project characteristics and subsurface conditions encountered. Once final design/grading plans and specifications are available, a general review by PSI is required as a means to check that the recommendations presented in the following sections of this report are properly interpreted and implemented.

5.0 SITE GRADING RECOMMENDATIONS

Prior to site grading or excavation for construction, any debris, vegetation and root systems, and utilities not being used for the new construction should be properly and completely removed from the site. Protection and shoring of existing features, slopes, utilities, and other appurtenances to remain should be made the responsibility of the contractor. Proposed grades can then be reestablished with moisture conditioned and recompacted structural fill. If materials are encountered that differ from those observed in our exploration, PSI should be notified, and the areas will need to be evaluated.

Slopes and grades for channel embankments and slopes should be in accordance with City of Colorado Springs Manual Section 620.

Following rough grading and over-excavation for moisture conditioning and prior to placement of structural fill, a proofroll should be performed. The proofroll should be conducted with a loaded tandem-axle dump truck or similar pneumatic-tired equipment with a minimum weight of 15 tons. Areas that deflect excessively should be further over-excavated, moisture conditioned and recompacted.

Trash and debris, if encountered, should be removed from the site and disposed of in accordance with local and state regulations.

Excavations into the claystone bedrock are expected to require moderate effort with standard excavation equipment. No blasting, chiseling, etc. is anticipated to be needed, based on the soils at the boring locations.

5.1 Structural Fill

Based on PSI's field and laboratory data, the majority of the on-site overburden soils and bedrock do not appear to be suitable for re-use as site grading, backfill soils, or for use as structural fill. High plasticity clays and claystone bedrock should not be reused. If material such as construction debris, trash, or other undesirable material is encountered during construction, they should be removed off site.

Specifications for rip rap materials should be in accordance with City of Colorado Springs Manual Section 620.

Imported structural fill for general site grading, if required, should be free of organic or other deleterious materials, have a liquid limit less than 30, a plasticity index less than 10, and meet the following gradation outlined below. This structural fill criteria is intended as a general guideline. Imported structural fill materials should have a swell potential of less than 1 percent when compacted to 95 percent of maximum dry unit weight (MDUW) and at 2 percent below optimum moisture content (OMC) and tested under a swell test surcharge of 500 psf. The MDUW and OMC should be determined by ASTM D698 (Standard Proctor).

Screen Size	Percent Passing
2 Inch	100
#4	50 – 100
#200	10 - 30

Imported fill material proposed for use on this site that does not meet these criteria should be submitted to the project geotechnical engineer for evaluation and approval. The geotechnical engineer should evaluate the proposed import fill prior to purchase and delivery. Fine-grained soils used for fill require close moisture content control and careful placement by the contractor to achieve the recommended degree of compaction and to address swell potential and settlement issues.

5.2 General Fill Placement and Testing

Fill placement regarding embankments and channel improvements should be performed in accordance with City of Colorado Springs Manual Section 620.

For general fill placement, unless otherwise specified, fill material should be compacted to at least 95 percent of the maximum dry unit weight as determined by the Standard Proctor Test (ASTM D 698). **For fill depths in excess of 5 feet, compaction should be 100 percent maximum dry unit weight.** Each lift of compacted fill should be tested for density by a representative of the geotechnical engineer prior to placement of subsequent lifts. Fill soils should be moisture conditioned to a range from optimum moisture content to 4-percent above optimum moisture content for clay soils, and to a range of 2-percent below to 2-percent above optimum moisture content for sand soils. Fill material should be placed horizontally in maximum eight-inch loose lifts.

A sample(s) of the proposed backfill soil(s) should be obtained for moisture density relationship (proctor test) three to four days prior to backfilling operations to expedite compaction and moisture content testing by the materials testing service provider.

To facilitate compaction, it may be necessary to bench existing slopes along the existing channels and creeks prior to placing new fills. The benched placement of engineered structural fill on slopes steeper than five (5) horizontal to one (1) vertical where the final area will be uncontained is recommended. The placement of fill should begin at the base of the natural slope with benches or terraces. The benches or terraces should be a minimum of eight (8) feet wide laterally and should be cut into the slope every five (5) feet of vertical rise to facilitate the level operation of compaction equipment. The naturally occurring existing soils should be prepared and filled in accordance with the previously described structural fill guidelines. A representative of the geotechnical engineer should monitor the benching and fill placement operations.

Unless specifically designed, temporary slopes shall not exceed steeper than a ratio of two (2) horizontal to one (1) vertical where workers or equipment will occupy space at the toe or of the movement of the excavated slope will jeopardize the stability of an adjacent structure. Temporary slopes exceeding ten (10) feet in vertical height should have a slope stability analysis. Temporary slopes exceeding twenty (20) feet in vertical height should have shear strength testing performed to assess the in-situ strength characteristics.

Permanent cut slopes shall not be constructed to a total height of 5 feet or a final grade steeper than a ratio of three (3) horizontal to one (1) vertical without a specific slope stability analysis. Specific shear strength testing should be performed to assess the in-situ strength characteristics for permanent slopes steeper than four (4) horizontal to one (1) vertical.

Weather conditions in the site area are typically dry in the summer and early fall. Precipitation in the form of snowfall is common from October through March. While grading can be inhibited for short periods during and following times of precipitation, grading can generally be conducted year-round. The major factor that must be considered during the winter months is ground freezing. During extended periods of sub-freezing weather, it can be difficult to properly moisture condition and compact soils. Grading must be conducted during the warmer parts of the day in freezing weather.

6.0 GEOTECHNICAL RECOMMENDATIONS

6.1 Seismic Parameters

The project site is located within a municipality that employs the International Building Code, 2021 edition. As part of this code, the design of structures must consider dynamic forces resulting from seismic events. These forces are dependent upon the magnitude of the earthquake event as well as the properties of the soils that underlie the site. As part of the procedure to evaluate seismic forces, the code requires the evaluation of the Seismic Site Class, which categorizes the site based upon the characteristics of the subsurface profile within the upper 100 feet of the ground surface. To define the Site Class for this project, we have interpreted the expected results of soil test borings drilled with the project site and estimated appropriate soil properties below grade to a depth of 100 feet, as permitted by Chapter 20.3-1 of the code. The estimated soil properties were based upon data available in published geologic reports and our experience with subsurface conditions in the general site area.

Based upon our evaluation, it is our opinion that the subsurface conditions within the site are consistent with the characteristics of Site Class C as defined in Chapter 20.3-1 of the ASCE 7-16 code.

The USGS-NEHRP interpolated probabilistic ground motion values near latitude 38.7704 North and 104.7859 West obtained from the USGS geohazards web page are as follows:

Period (seconds)	2% Probability of Event in 50 years (g)	Site Coefficients	Maximum Spectral Acceleration Parameters	Design Spectral Acceleration Parameters	
0.2 (S_s)	0.199	$F_a = 1.3$	$S_{ms} = 0.259$	$S_{Ds}= 0.173$	$T_0= 0.067$
1.0 (S_1)	0.058	$F_v = 1.5$	$S_{m1} = 0.087$	$S_{D1}= 0.058$	$T_s= 0.335$

$S_{ms} = F_aS_s$ $S_{Ds} = ⅔*S_{ms}$ $T_0= 0.2*S_{D1}/S_{Ds}$
$S_{m1} = F_vS_1$ $S_{D1} = ⅔*S_{m1}$ $T_s= S_{D1}/S_{Ds}$

The Site Coefficients, Fa and Fv presented in the above table were interpolated from Chapter 20.3-1 as a function of the site classification and mapped spectral response acceleration at the short (S_s) and 1 second (S_1) periods.

6.2 Soil Corrosivity

Composite samples obtained in the subsurface profile of the upper 15 feet were tested to evaluate the chemical reactivity of the on-site soils and are shown in the following table. Soil pH was performed using method AASHTO T289-91. Resistivity testing was performed using AASHTO T288-91. Water Soluble Sulfate testing was performed using AASHTO T290-91/ASTM D4327.

Note: Samples were sent to an outside laboratory to test for sulfides, chloride ion content, and resistivity. Results from these tests are pending. PSI will update the report once available.

Summary of Chemical Reactivity Testing

Boring ID	Depth (feet)	Soil pH	Water Soluble Sulfates
B1	5	8.7	0.26%
B3	15	8.6	0.19%

The existing soil has a potential for corrosion issues. Consideration should be given to providing cathodic protection for buried metal surfaces.

Our test results indicated water-soluble sulfate concentrations of 0.19 to 0.26 percent, which are classified in the "severe" sulfate exposure category according to the American Concrete Institute (ACI) Design Manual Section 318, Chapter 4, 2014 Edition. It is our opinion that concrete in contact with the existing soils may be designed for "S2" sulfate exposure. PSI recommends using Type V Portland Cement. A corrosion engineer should be contacted prior to construction.

6.3 Recommended Soil Properties

PSI has provided recommended soil properties including lateral earth pressures for on-site soils, bedrock, typical imported soils, and crushed stone. Design of sheet-pile walls and sloped structures should be performed by others.

Recommended soil properties for on-site soils are as follows:

Recommended Parameters Typical Wall Backfill Materials				
Material Type	Drained Friction Angle (ϕ')			
On-Site Soil/Weathered Bedrock	22°			
Competent Bedrock	26°			
Imported Structural Fill	30°			
Compacted Dense Graded Crushed Stone	42°			
Total Soil Density (pcf)	120			
Total Bedrock Density (pcf)	125			
Maximum Toe Pressure on Structural Fill (psf)	1,500			
Water Elevation	Dependent on location			
Parameters specific to soil type	**On-Site Soil**	**Bedrock**	**Structural Fill**	**Crushed Stone**
Friction Factor for Base	0.27	0.33	0.38	0.47 *
Coefficient of Active Pressure (K_a) **	0.67	0.39	0.33	0.27 *
Coefficient of Passive Pressure (K_p) **	1.47	2.56	3.00	3.7 *
Coefficient of At-Rest Pressure (K_o) **	0.63	0.56	0.50	0.43 *

* These values may be used for design only if the crushed stone backfill extends back from the wall certain distances. These are a horizontal distance approximately equal to or greater than the total height of the wall at the surface, and at least one-foot beyond the heel of the wall footing.

** Earth pressure coefficients valid for level backfill conditions with no surcharge

The values presented above were calculated based on positive drainage and are provided to prevent the buildup of hydrostatic pressure. If surface loads are placed near the walls, such as traffic loads, they should be designed to resist an additional uniform lateral load of one-half of the vertical surface loads. An "equivalent fluid" pressure can be obtained from the above chart by multiplying the appropriate K-factor times the total unit weight of the soil. This applies to unsaturated conditions only. If a saturated "equivalent fluid" pressure is needed, the effective unit weight (total unit weight minus unit weight of water) should be multiplied times the appropriate K-factor and the unit weight of water added to that resultant. However, PSI does not recommend that earth retaining walls be designed with a hydrostatic load and that drainage should be provided to relieve the pressure.

6.4 Excavation Safety

In addition, confined excavations such as utility trenches are more likely to require rock excavation techniques than large open cuts. All excavations should be sloped or shored in accordance with applicable OSHA regulations.

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, Part 1926, Subpart P". This document was issued to better allow for the safety of workers entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavations or footing excavations, be constructed in accordance with the new OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the Contractor could be liable for substantial penalties.

The Contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The Contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the Contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in all local, state, and federal safety regulations.

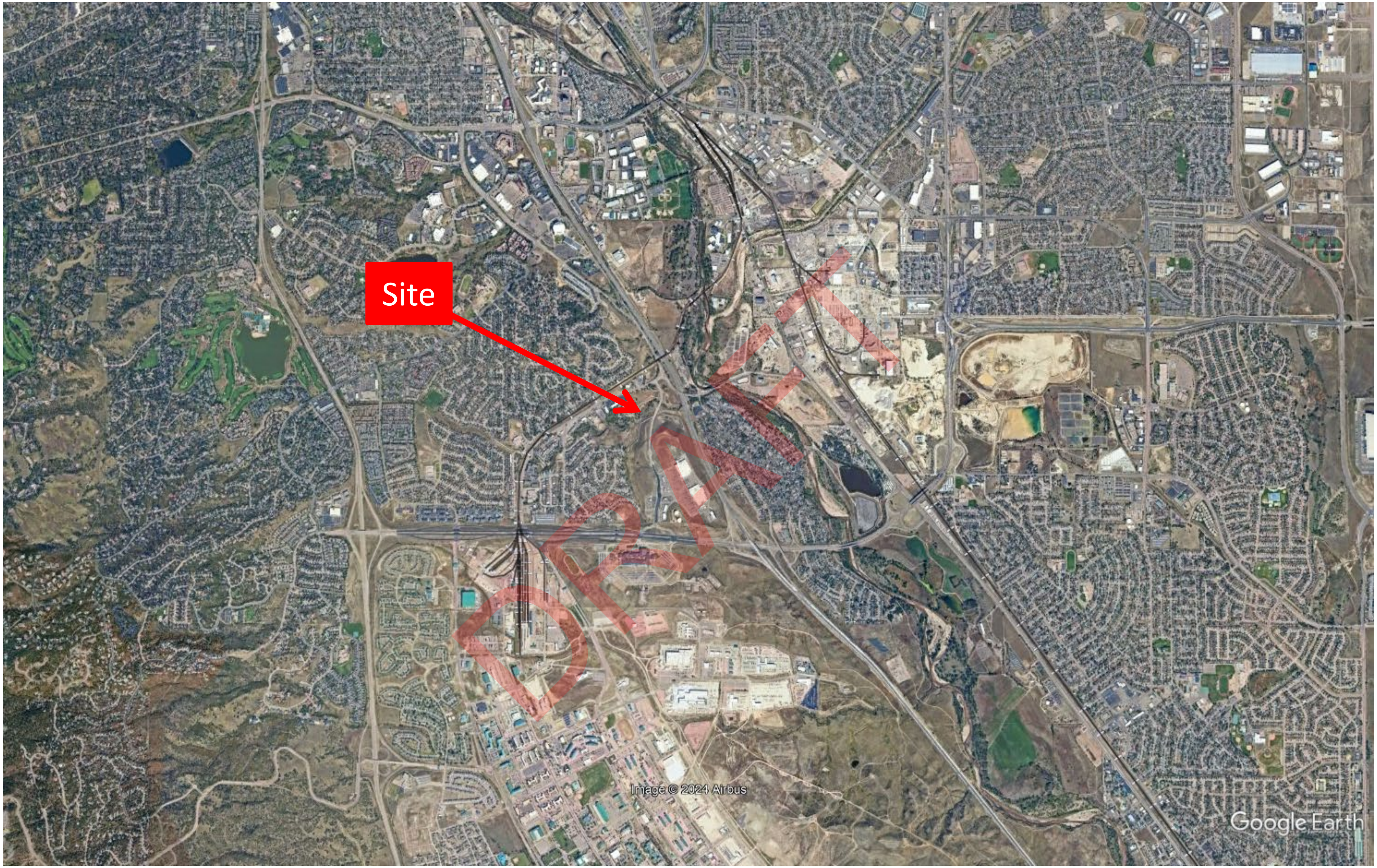
We are providing this information solely as a service to our client. PSI does not assume responsibility for construction site safety or the Contractor's or other parties' compliance with local, state, and federal safety or other regulations. Groundwater control is critical to excavation safety and is described above.

7.0 LIMITATIONS

The recommendations submitted are based on the subsurface information obtained by PSI and design details furnished by Thompson Thrift Residential. If there are revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the foundation recommendations are required. If PSI is not retained to perform these functions, PSI will not be responsible for the impact of those conditions on the project.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are more complete, the geotechnical engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. This report has been prepared for the exclusive use of Peak Development and their consultants for the specific application to the proposed channel improvements associated with the new multifamily development in Colorado Springs, Colorado.



Taken From Google Earth

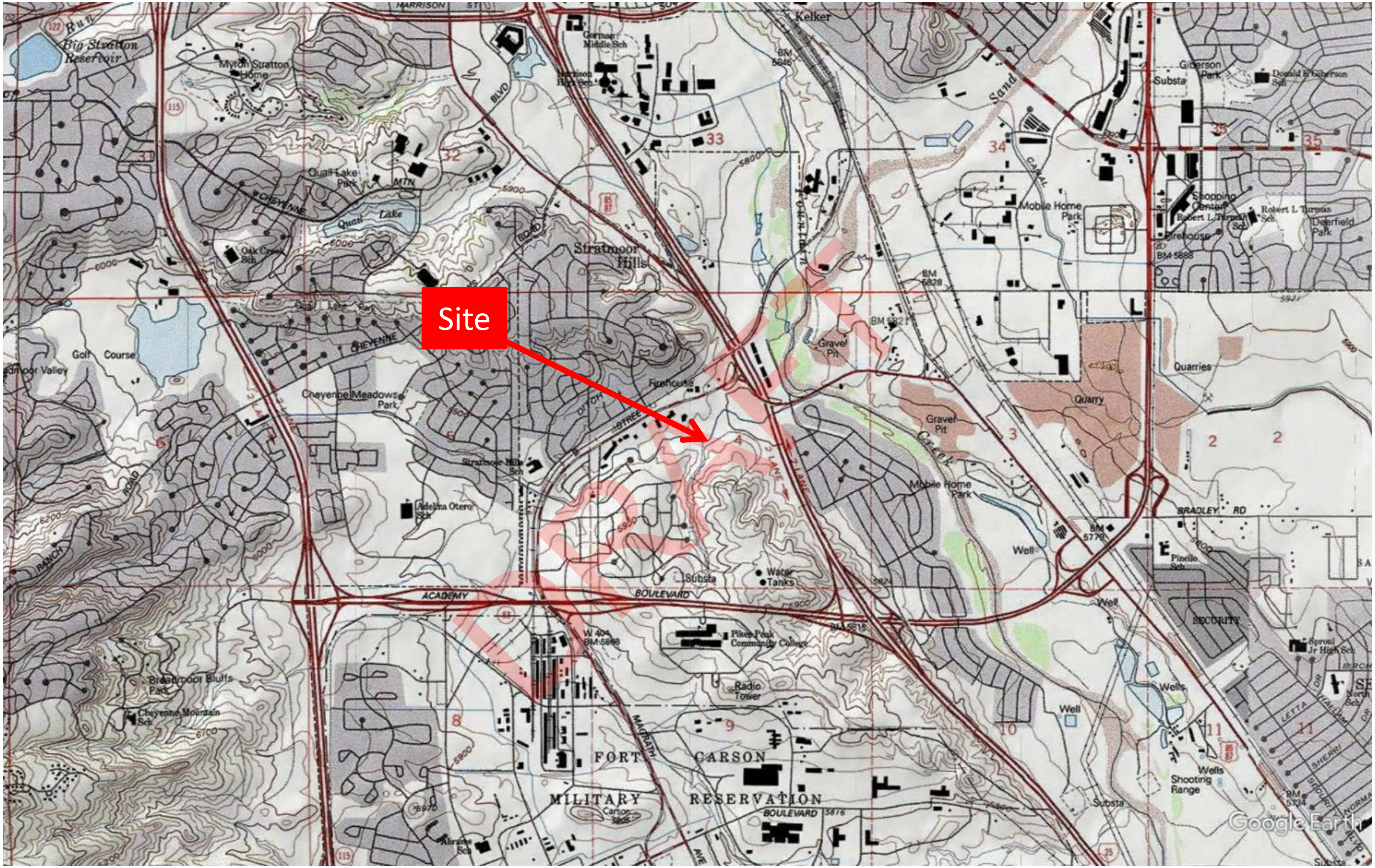
intertek psi

Venetucci Boulevard Channel Improvements

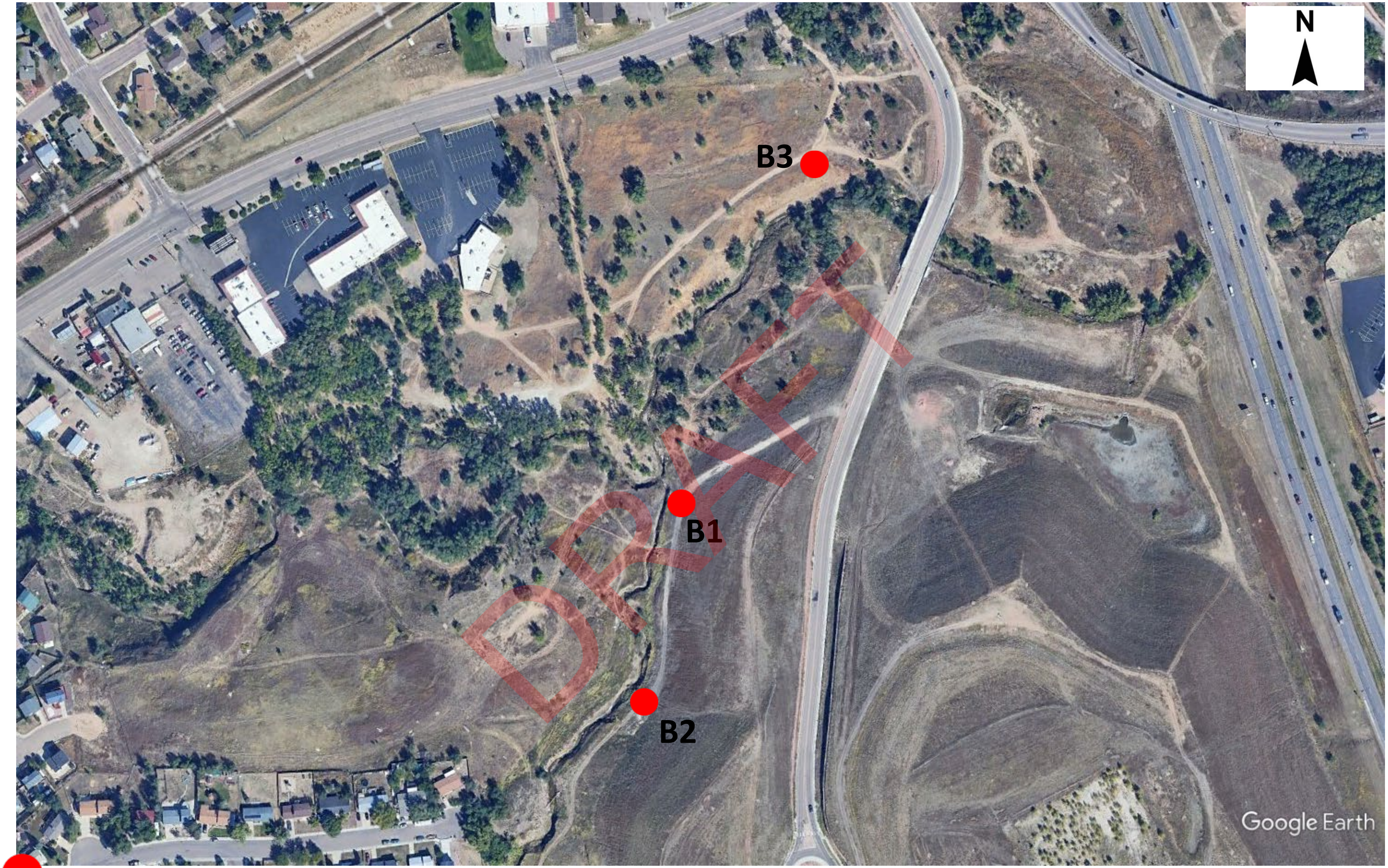
JOB NO.05322860

Site Vicinity Map

FIGURE NO. 1a



Taken From USGS Map -	intertek psi	Venetucci Boulevard Channel Improvements	JOB NO. 05322860
		Site Topographical Map	FIGURE NO. 1b



● Indicates Approximate Location of Boring

Taken From Google Earth	intertek psi	Venetucci Boulevard Channel Improvements	JOB NO. 05322860
		Boring Location Map	FIGURE NO. 2

FIGURE: 3

DATE STARTED: 7/11/24
DATE COMPLETED: 7/11/24
COMPLETION DEPTH 25.0 ft
BENCHMARK: N/A
ELEVATION: 5809 ft
LATITUDE: 38.7704°
LONGITUDE: -104.7859°
STATION: N/A **OFFSET:** N/A
REMARKS:

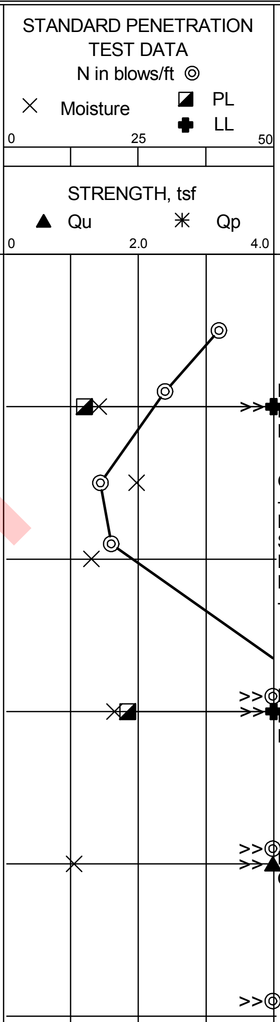
DRILL COMPANY: Dakota Drilling, Inc.
DRILLER: ERC **LOGGED BY:** JW
DRILL RIG: CME-50
DRILLING METHOD: Solid Stem Auger
SAMPLING METHOD: Modified California
HAMMER TYPE: Manual
EFFICIENCY N/A
REVIEWED BY: HT

BORING B1

Water		
▽	While Drilling	Not Observed
▼	Upon Completion	Not Observed
▼	Delay	N/A

BORING LOCATION:
See Figure No. 2

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification		Moisture, %	Additional Remarks
	0					**Fat Clay with Sand:** Fine to coarse grained sand with gravel, dry to moist, brown to dark brown/gray to dark gray, stiff to very stiff.				
				1	12			20-20 N=40		
5805										
	5			2	12			15-15 N=30	18	DD = 105 pcf LL = 53 PL = 15
				3	12		CH	8-10 N=18	25	GRAD -200 = 80.8%
5800										
	10			4	12			10-10 N=20	16	DD = 103 pcf S(750) = 1.7% P = 3.2 Ksf DD = 106 pcf -200 = 62.4%
5795						**Claystone:** Fine to medium grained sand with gravel, dry to moist, brown to dark brown/dark gray/black, stiff to hard.				
	15			5	8			50/8"	21	DD = 106 pcf LL = 61 PL = 23
5790										
	20			6	4			50/4"	13	DD = 113 pcf Q_u = 6.9 tsf
5785						Weatherd Bedrock Zone 10 to 14 Feet				
	25			7	3			50/3"		



Professional Service Industries, Inc.
1070 West 124th Avenue, Suite 800
Westminster, CO 80234
Telephone: (303) 424-5578

PROJECT NO.: 05322860
PROJECT: TTRes Channel Improvement
LOCATION: Venetucci Boulevard
Colorado Springs, CO

The stratification lines represent approximate boundaries. The transition may be gradual.

FIGURE: 4

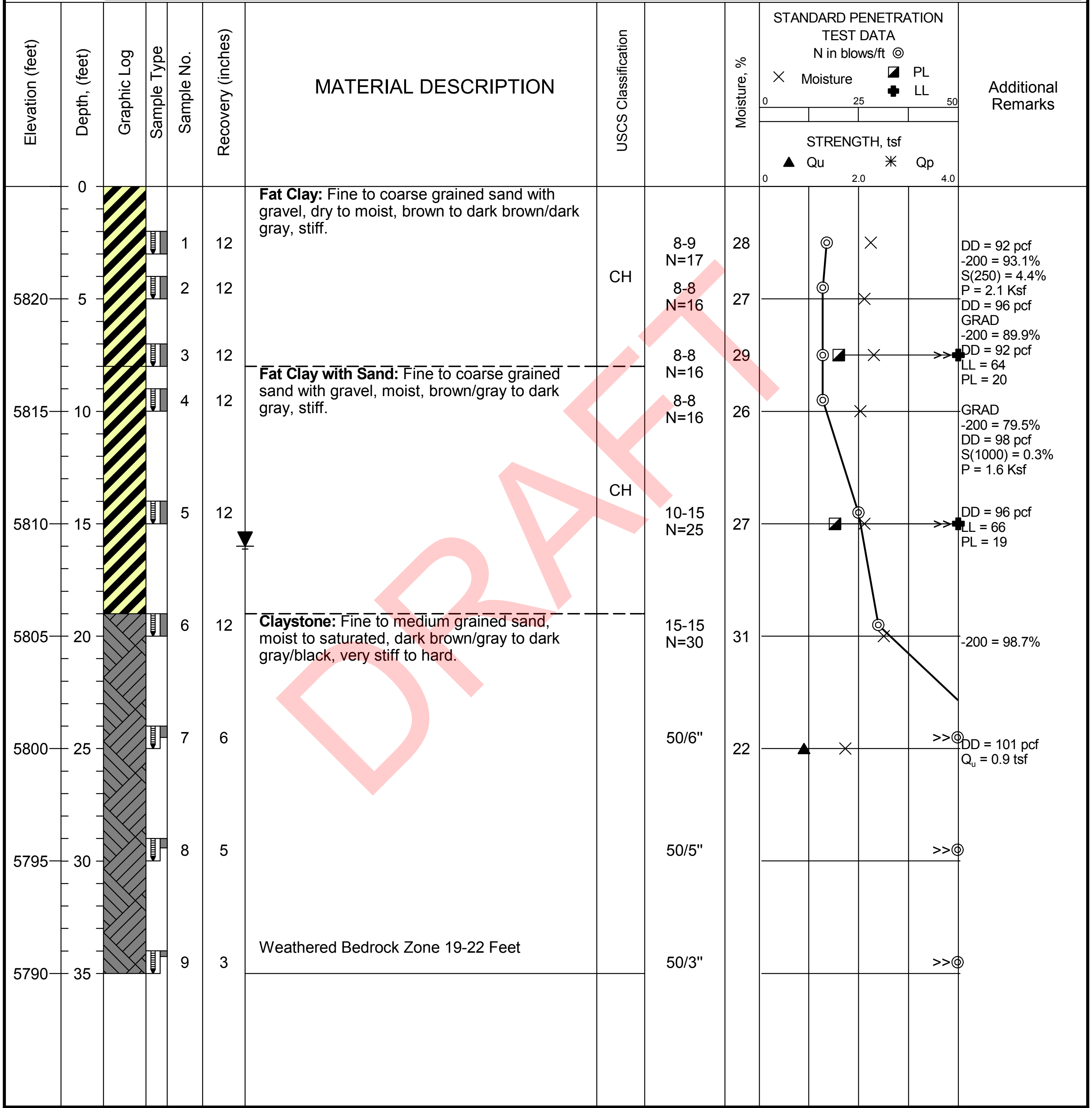
BORING B2

DATE STARTED: 7/11/24
DATE COMPLETED: 7/11/24
COMPLETION DEPTH 35.0 ft
BENCHMARK: N/A
ELEVATION: 5825 ft
LATITUDE: 38.7704°
LONGITUDE: -104.7859°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: Dakota Drilling, Inc.
DRILLER: ERC **LOGGED BY:** JW
DRILL RIG: CME-50
DRILLING METHOD: Solid Stem Auger
SAMPLING METHOD: Modified California
HAMMER TYPE: Manual
EFFICIENCY: N/A
REVIEWED BY: HT

Water		
▽	While Drilling	16 feet
▼	Upon Completion	16 feet
▽	Delay	N/A

BORING LOCATION:
See Figure No. 2



Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification		Moisture, %	Additional Remarks
	0			**Fat Clay:** Fine to coarse grained sand with gravel, dry to moist, brown to dark brown/dark gray, stiff.	CH			
		1	12			8-9 N=17	28	DD = 92 pcf -200 = 93.1% S(250) = 4.4% P = 2.1 Ksf
5820	5	2	12			8-8 N=16	27	DD = 96 pcf GRAD -200 = 89.9%
		3	12			8-8 N=16	29	DD = 92 pcf LL = 64 PL = 20
				Fat Clay with Sand: Fine to coarse grained sand with gravel, moist, brown/gray to dark gray, stiff.	CH			
5815	10	4	12			8-8 N=16	26	GRAD -200 = 79.5% DD = 98 pcf S(1000) = 0.3% P = 1.6 Ksf
5810	15	5	12			10-15 N=25	27	DD = 96 pcf LL = 66 PL = 19
5805	20	6	12	**Claystone:** Fine to medium grained sand, moist to saturated, dark brown/gray to dark gray/black, very stiff to hard.		15-15 N=30	31	-200 = 98.7%
5800	25	7	6			50/6"	22	DD = 101 pcf Q_u = 0.9 tsf
5795	30	8	5			50/5"		
5790	35	9	3	Weathered Bedrock Zone 19-22 Feet		50/3"		

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psi
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PROJECT NO.: 05322860
PROJECT: TTRes Channel Improvement
LOCATION: Venetucci Boulevard
Colorado Springs, CO

The stratification lines represent approximate boundaries. The transition may be gradual.

FIGURE: 5

BORING B3

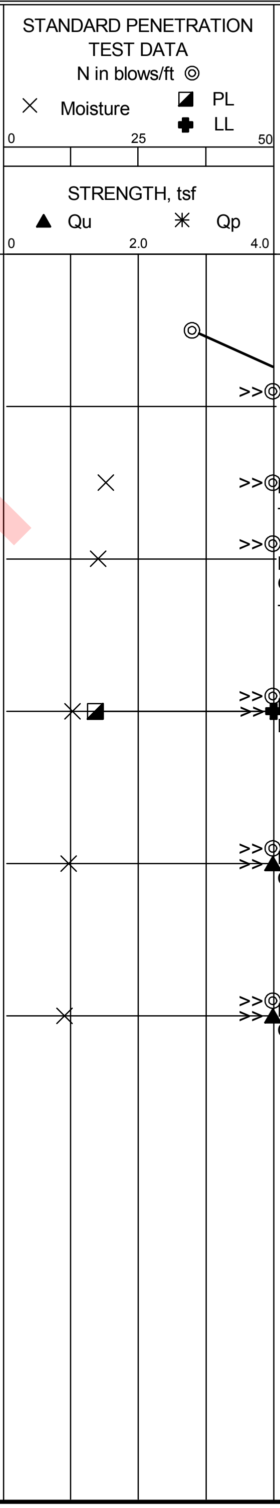
DATE STARTED: 7/11/24
DATE COMPLETED: 7/11/24
COMPLETION DEPTH 25.0 ft
BENCHMARK: N/A
ELEVATION: 5810 ft
LATITUDE: 38.7704°
LONGITUDE: -104.7859°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: Dakota Drilling, Inc.
DRILLER: ERC **LOGGED BY:** JW
DRILL RIG: CME-50
DRILLING METHOD: Solid Stem Auger
SAMPLING METHOD: Modified California
HAMMER TYPE: Manual
EFFICIENCY: N/A
REVIEWED BY: HT

Water		
▽	While Drilling	Not Observed
▼	Upon Completion	Not Observed
▼	Delay	N/A

BORING LOCATION:
See Figure No. 2

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification		Moisture, %	Additional Remarks
	0			**Fat Clay:** Fine to medium grained sand with gravel, dry, brown to dark brown/dark gray/orange, very stiff.	CH			
		1	12			15-20 N=35		
		2	10	**Claystone:** Fine to coarse grained sand with gravel, dry to moist, light brown to dark brown/light gray to dark gray/black/blue, hard.		50/10"		
5805	5							
		3	10			50/10"	19	DD = 107 pcf -200 = 96.1%
		4	8			50/8"		
5800	10						18	DD = 108 pcf GRAD -200 = 94%
5795	15	5	3			50/3"	13	LL = 71 PL = 17
5790	20	6	4			50/4"	12	DD = 108 pcf Q_u = 6.3 tsf
5785	25	7	4			50/4"	11	DD = 110 pcf Q_u = 6.7 tsf



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PROJECT NO.: 05322860
PROJECT: TTRes Channel Improvement
LOCATION: Venetucci Boulevard
Colorado Springs, CO

The stratification lines represent approximate boundaries. The transition may be gradual.

KEY TO SYMBOLS

▨ USCS High Plasticity Clay

▩ Bedrock

SSA = Solid Stem Auger

HSA = Hollow Stem Auger

CFA = Continuous Flight Auger

SPT = Standard Penetration Test

MC - Modified California Sampler

SS = Split-spoon Sampler

ST = Shelby Tube Sampler

RC = Rock Core

DD = Dry Density

MC = Moisture Content

LL = Liquid Limit

PL = Plastic Limit

-200 = Percent Passing the No. 200 Sieve (%)

S(250) = Swell under 250 psf surcharge pressure (%)

S(500) = Swell under 500 psf surcharge pressure (%)

S(1000) = Swell under 1000 psf surcharge pressure (%)

Qu = Unconfined Compressive Strength

RQD = Rock Quality Designation

REC'D = Rock Core Recovery Percentage

PID = Photo Ionic Detector (ppm)

The borings were advanced into the ground using 4-inch solid stem augers. At regular intervals throughout the boring depths, soil samples were obtained with either a 1.4-inch I.D., 2.0-inch O.D., split-spoon sampler or a 2.0-inch I.D., 2.4-inch O.D. Modified California sampler. The samplers were first seated 6-inches to penetrate any loose cuttings and then driven an additional foot where possible with blows of a 140-pound hammer falling 30-inches. The number of hammer blows required to drive the sampler each 6-inch increment is recorded in the field. The penetration resistance "N-value" is redesignated as the number of hammer blows required to drive the sampler the final foot and, when properly evaluated, is an index to cohesion for clays and relative density for sands. N-values recorded on the boring logs are uncorrected. The split-spoon sampling procedures used during this exploration are in general accordance with ASTM Designation D 1586.

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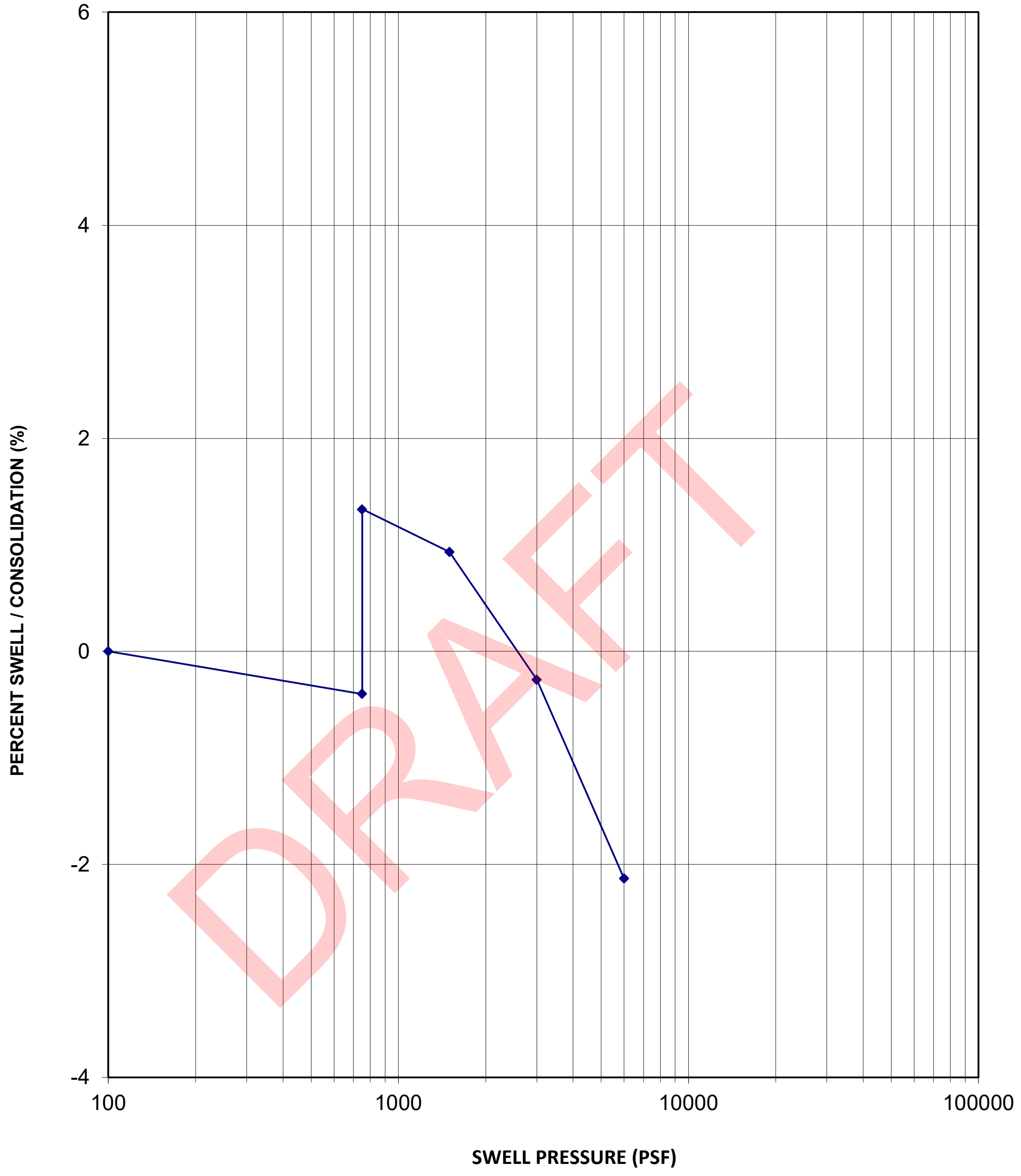
PSI Job No.: 05322860
Project: TTRes Channel Improvement
Location: Venetucci Boulevard
Colorado Springs, CO

Appendix A

Laboratory Test Results

SWELL-CONSOLIDATION TEST

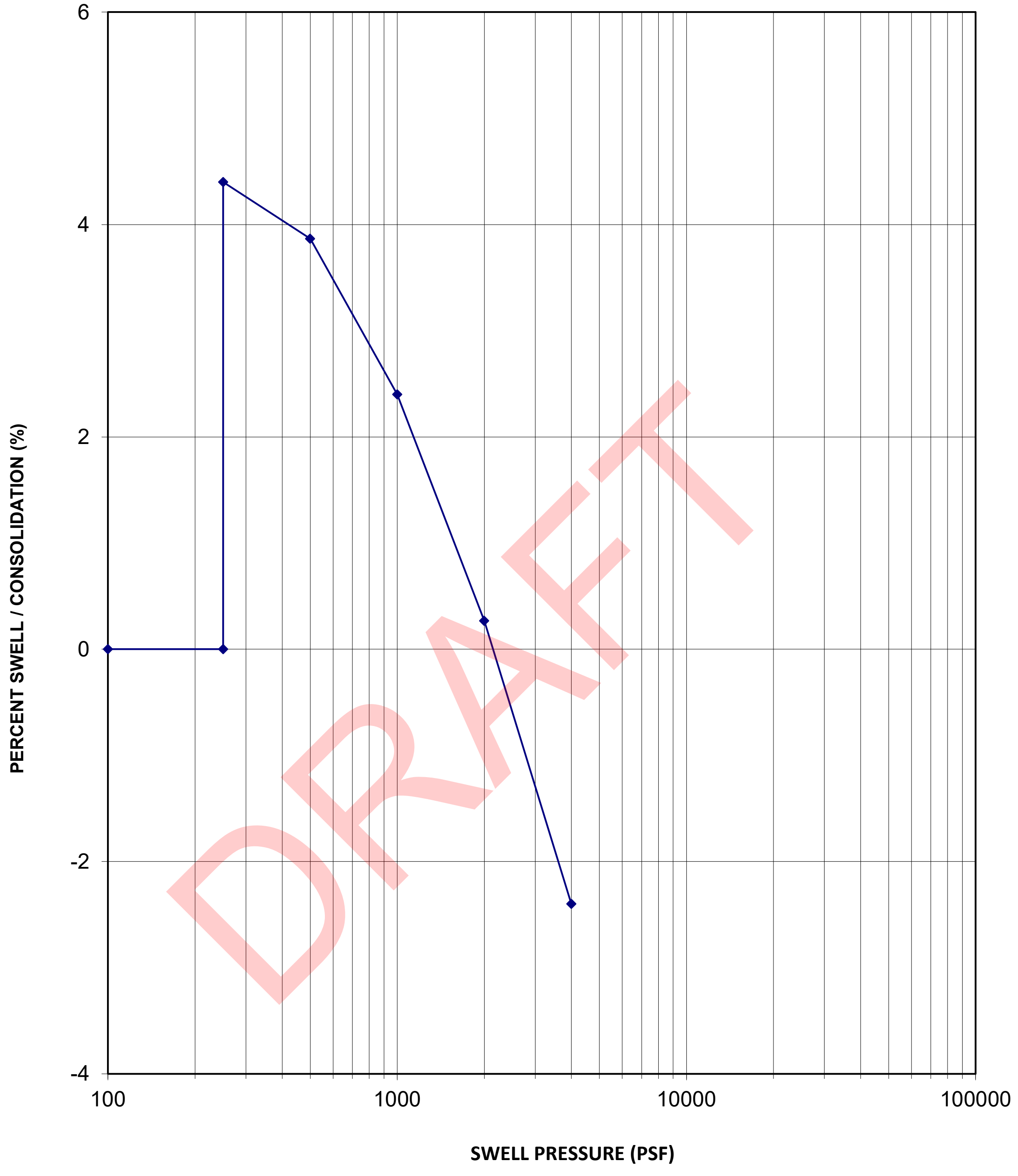


Sample Location	B1
Sample Depth	7.5 feet
Sample Description	Fat Clay with Sand
USCS Classification	CH

Dry Density	103 pcf
In-Situ Moisture Content	24.7 %
Volume Change	1.7 %
Swell Pressure	3,200 psf

intertek psi	**Venetucci Boulevard Channel Improvements**	**JOB NO.**	**05322860**
	SWELL - CONSOLIDATION TEST	**FIGURE NO.**	**A1**

SWELL-CONSOLIDATION TEST

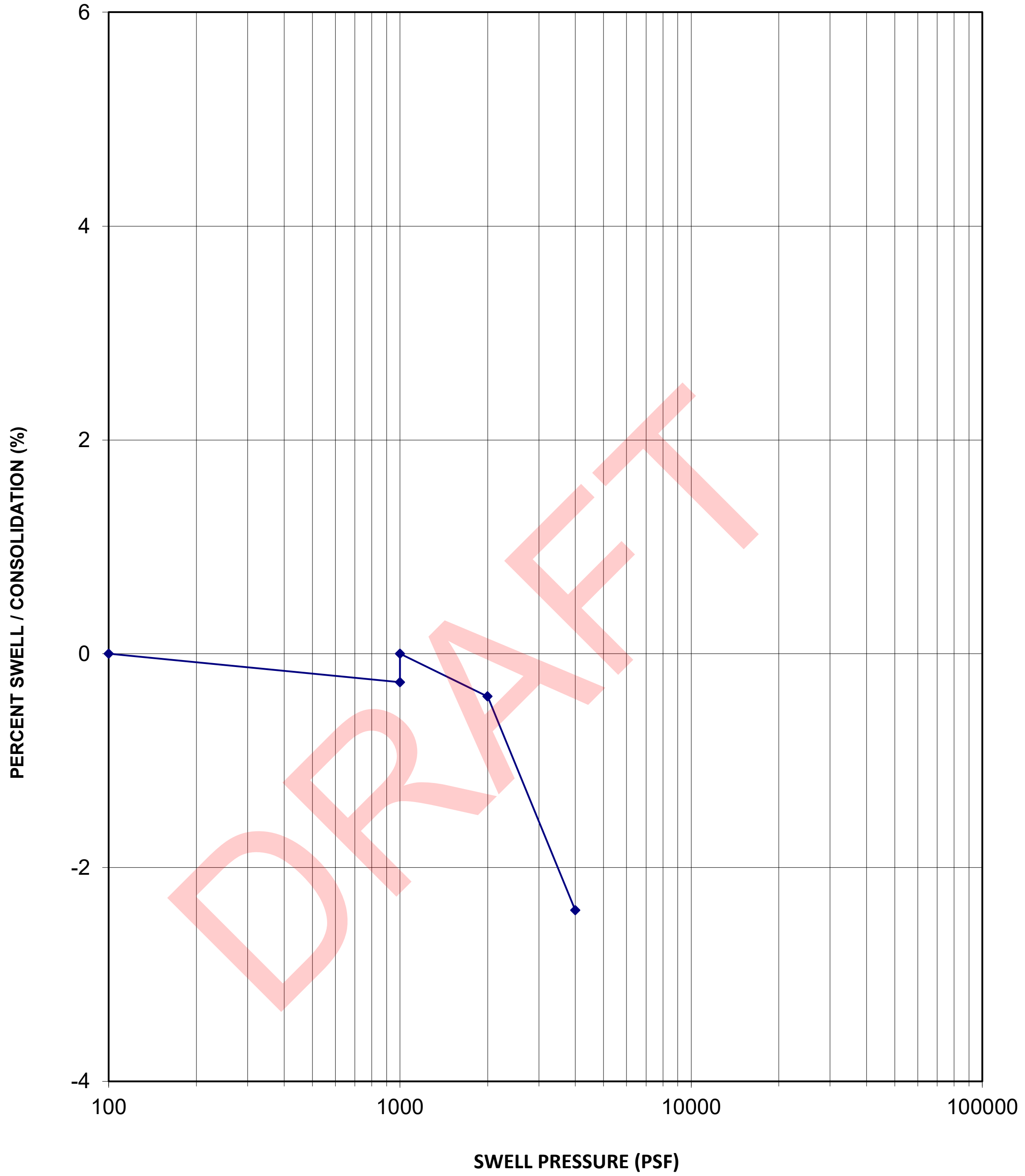


Sample Location	B2
Sample Depth	2.5 feet
Sample Description	Fat Clay
USCS Classification	CH

Dry Density	92 pcf
In-Situ Moisture Content	28.1 %
Volume Change	4.4 %
Swell Pressure	2,100 psf

intertek psi	**Venetucci Boulevard Channel Improvements**	**JOB NO.**	**05322860**
	SWELL - CONSOLIDATION TEST	**FIGURE NO.**	**A2**

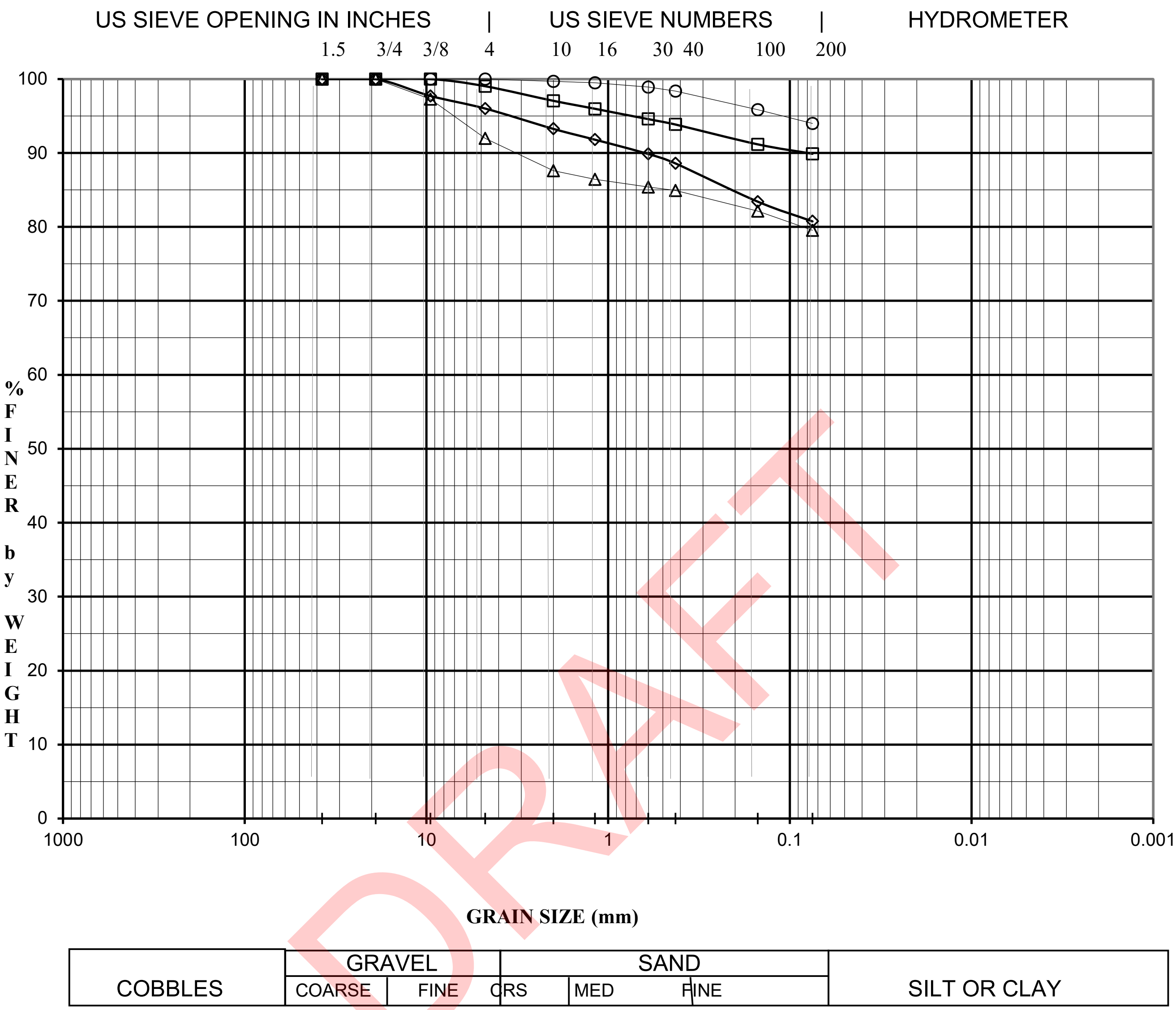
SWELL-CONSOLIDATION TEST



Sample Location	B2
Sample Depth	10 feet
Sample Description	Claystone
USCS Classification	Bedrock

Dry Density	98 pcf
In-Situ Moisture Content	25.5 %
Volume Change	0.3 %
Swell Pressure	1,600 psf

intertek psi	**Venetucci Boulevard Channel Improvements**	**JOB NO.**	**05322860**
	SWELL - CONSOLIDATION TEST	**FIGURE NO.**	**A3**



	Specimen I.D.	Description	USCS	AASHTO	Group Index	LL	PI	PL
◊	B1 @ 7.5 FEET	Fat Clay with Sand	CH	A-7-6	31	53	38	15
□	B2 @ 5 FEET	Fat Clay	CH	A-7-6	46	67	47	20
△	B2 @ 10 FEET	Fat Clay with Sand	CH	A-7-6	36	64	44	20
○	B3 @ 10 FEET	Claystone(Bedrock)	CH	A-7-6	56	71	54	17
+								

	Specimen I.D.	D100	D60	D30	D10	Cc	Cu	%Gravel	%Sand	%Silt&Clay
◊	B1 @ 7.5 FEET	19.00						4	15	81
□	B2 @ 5 FEET	9.50						1	9	90
△	B2 @ 10 FEET	19.00						8	12	80
○	B3 @ 10 FEET	4.75						0	6	94
+										

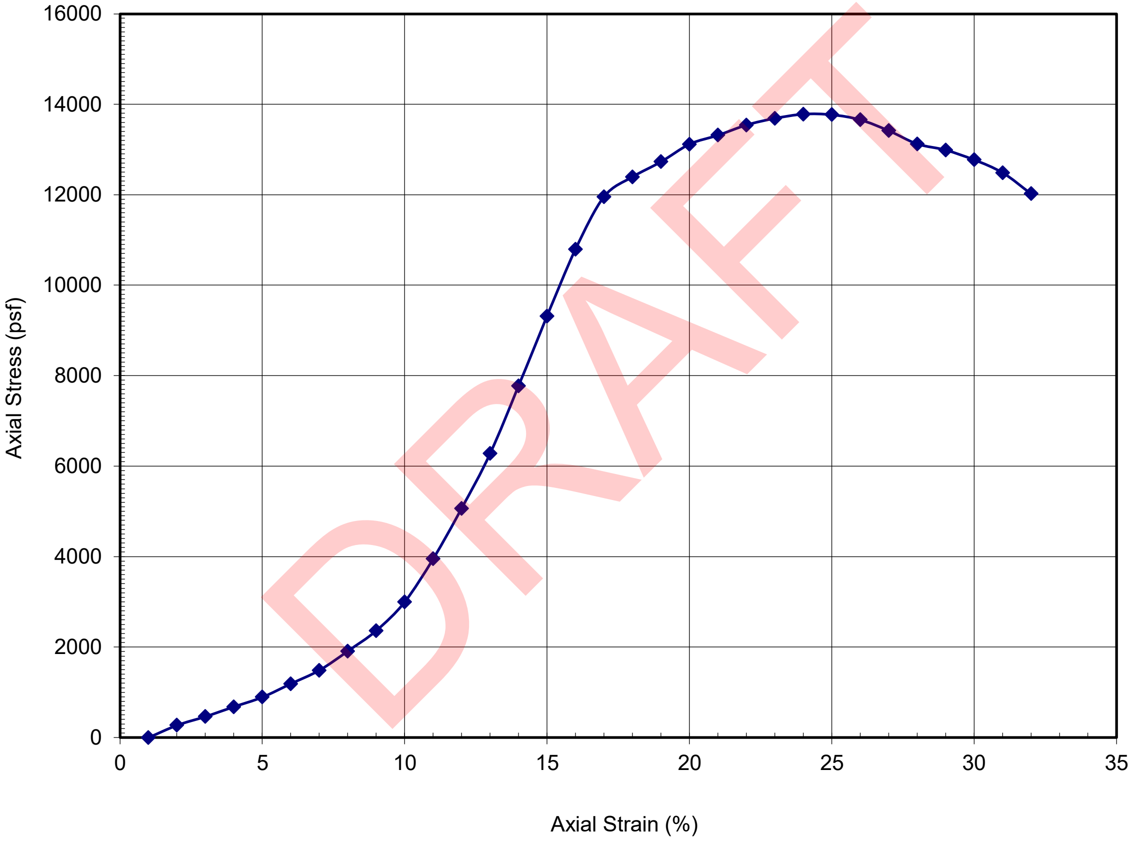
intertek psi

Venetucci Boulevard Channel Improvements	JOB NO.	05322860
GRADATION CURVES	FIGURE NO.	A4

UNCONFINED COMPRESSION REPORT

Tested For:	Peak Development 1480 Humboldt Street Denver, Colorado 80218	Project Name:	TTRes Channel Improvements Venetucci Blvd
		Sample Date:	July 15, 2024
		Project No.	05322860
		Sample No.	B1
		Depth	20

UNCONFINED COMPRESSION TEST: ASTM D2166



Wet Density (pcf)	127.2	**Initial Height (in)**	4.03
Dry Density (pcf)	112.5	**Initial Diameter (in)**	1.93
Moisture Content (%)	13.1	**Relative Compaction (%)**	N/A
Compressive Strength (psf)	13,800	**Deviation From OMC (%)**	N/A

Remarks:

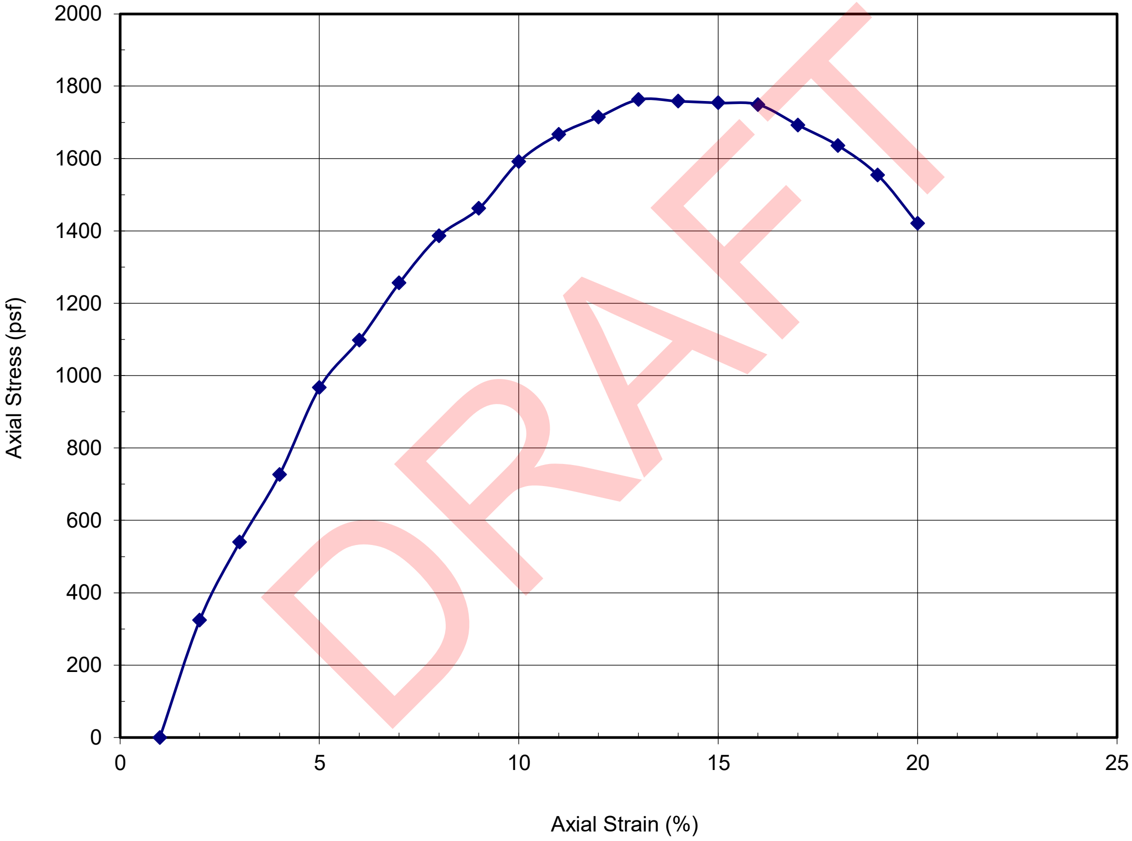
Respectfully Submitted,
Professional Service Industries, Inc.

UNCONFINED COMPRESSION REPORT

Tested For: Peak Development
1480 Humboldt Street
Denver, Colorado 80218

Project Name: TTRes Channel Improvements
Venetucci Blvd
Sample Date: July 15, 2024
Project No. 05322860
Sample No. B2
Depth 25

UNCONFINED COMPRESSION TEST: ASTM D2166



Wet Density (pcf)	122.6	**Initial Height (in)**	3.95
Dry Density (pcf)	100.7	**Initial Diameter (in)**	1.94
Moisture Content (%)	21.7	**Relative Compaction (%)**	N/A
Compressive Strength (psf)	1,800	**Deviation From OMC (%)**	N/A

Remarks:

Respectfully Submitted,
Professional Service Industries, Inc.

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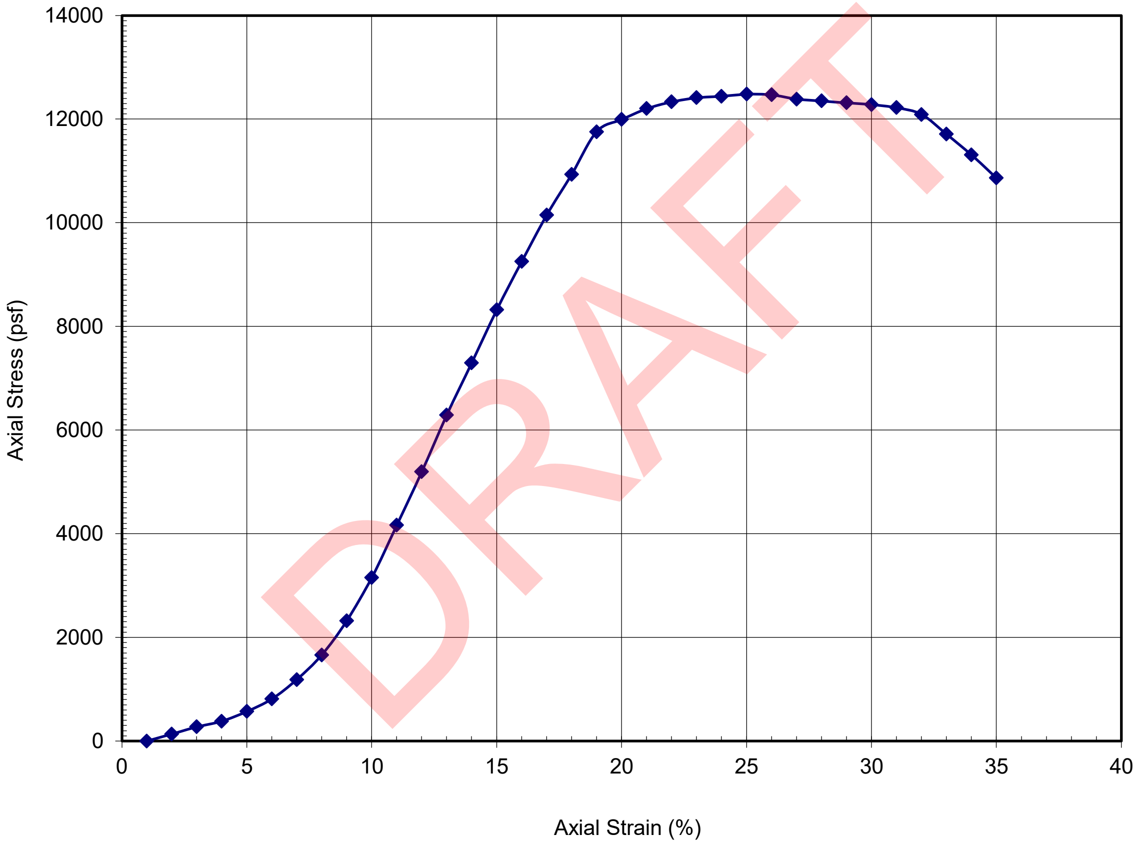
UNCONFINED COMPRESSION REPORT

Tested For: Peak Development
1480 Humboldt Street
Denver, Colorado 80218

Project Name: TTRes Channel Improvements
Venetucci Blvd
Sample Date: July 15, 2024
Project No. 05322860
Sample No. B3
Depth 20

UNCONFINED COMPRESSION TEST: ASTM D2166



Wet Density (pcf)	120.7	**Initial Height (in)**	4.00
Dry Density (pcf)	107.7	**Initial Diameter (in)**	1.92
Moisture Content (%)	12.1	**Relative Compaction (%)**	N/A
Compressive Strength (psf)	12,500	**Deviation From OMC (%)**	N/A

Remarks:

Respectfully Submitted,
Professional Service Industries, Inc.

Information To Build On
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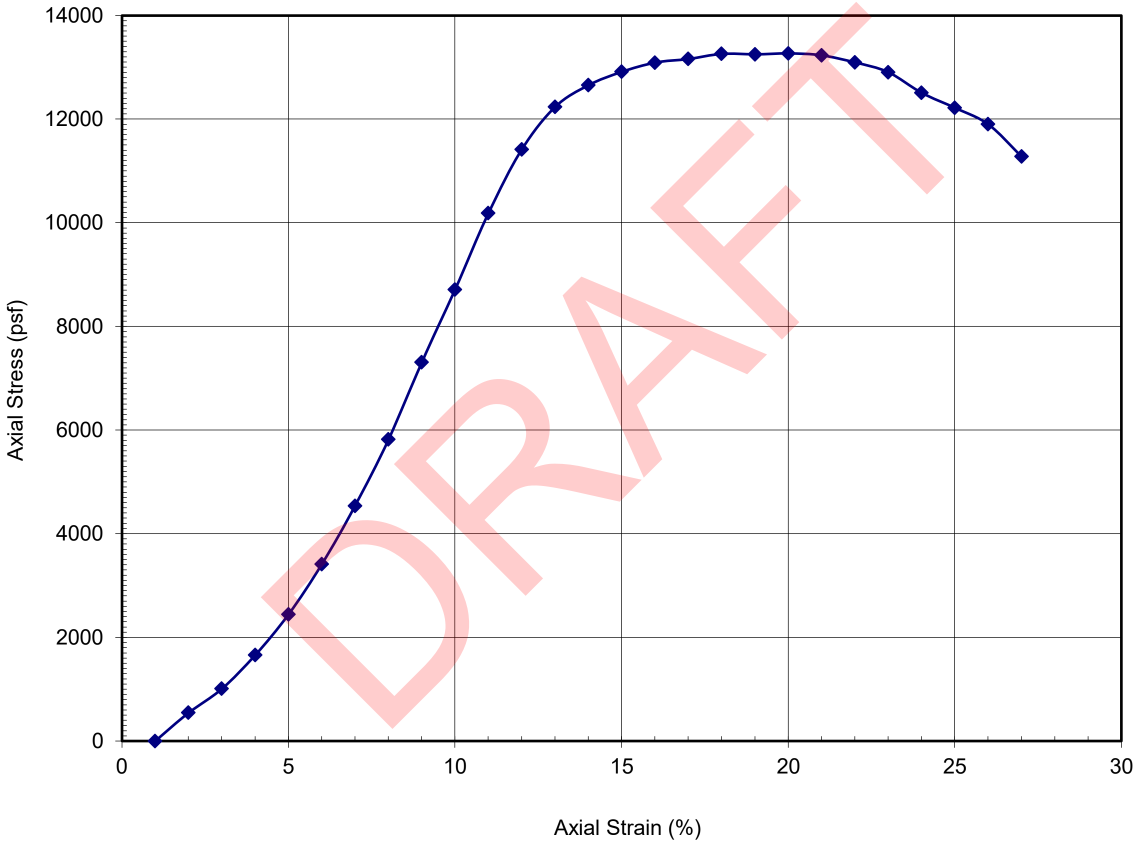
UNCONFINED COMPRESSION REPORT

Tested For: Peak Development
1480 Humboldt Street
Denver, Colorado 80218

Project Name: TTRes Channel Improvements
Venetucci Blvd
Sample Date: July 15, 2024
Project No. 05322860
Sample No. B3
Depth 25

UNCONFINED COMPRESSION TEST: ASTM D2166



Wet Density (pcf)	122.4	**Initial Height (in)**	4.00
Dry Density (pcf)	110.0	**Initial Diameter (in)**	1.93
Moisture Content (%)	11.3	**Relative Compaction (%)**	N/A
Compressive Strength (psf)	13,300	**Deviation From OMC (%)**	N/A

Remarks:

Respectfully Submitted,
Professional Service Industries, Inc.