APPENDIX H

Hydrologic Resources Studies

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APPENDIX H.1

Preliminary Hydrologic and Hydraulic Calculations

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PRELIMINARY HYDROLOGIC AND HYDRAULIC CALCULATIONS

Prepared for the Froom Ranch Specific Plan



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CREATING
ENVIRONMENTS
PEOPLE
ENJOY®

Date: 7-14-2017; Revised 10-31-2018; Revised 02-22-2019
Prepared by RRM Design Group
Prepared for John and Susan Madonna Trust and Villaggio Communities

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Chapter 1

Hydrologic and Hydraulic Analysis

1. Hydrologic and Hydraulic Analysis

1.1 Introduction and Background

This report was prepared to analyze the hydrologic and hydraulic data for the proposed Froom Ranch Specific Plan project and adjacent tributary runoff. The Froom Ranch Specific Plan is primarily a Senior housing development project with a mix of commercial and residential uses near the existing Irish Hills Plaza.

1.2 Location Map/Description

The Froom Ranch property consists of approximately 109.7 acres. The site is composed of two parcels, located immediately west of Los Osos Valley Road within the County of San Luis Obispo's jurisdiction, and adjacent to the City limits (APNs 067-241-030 and 067-241-031).

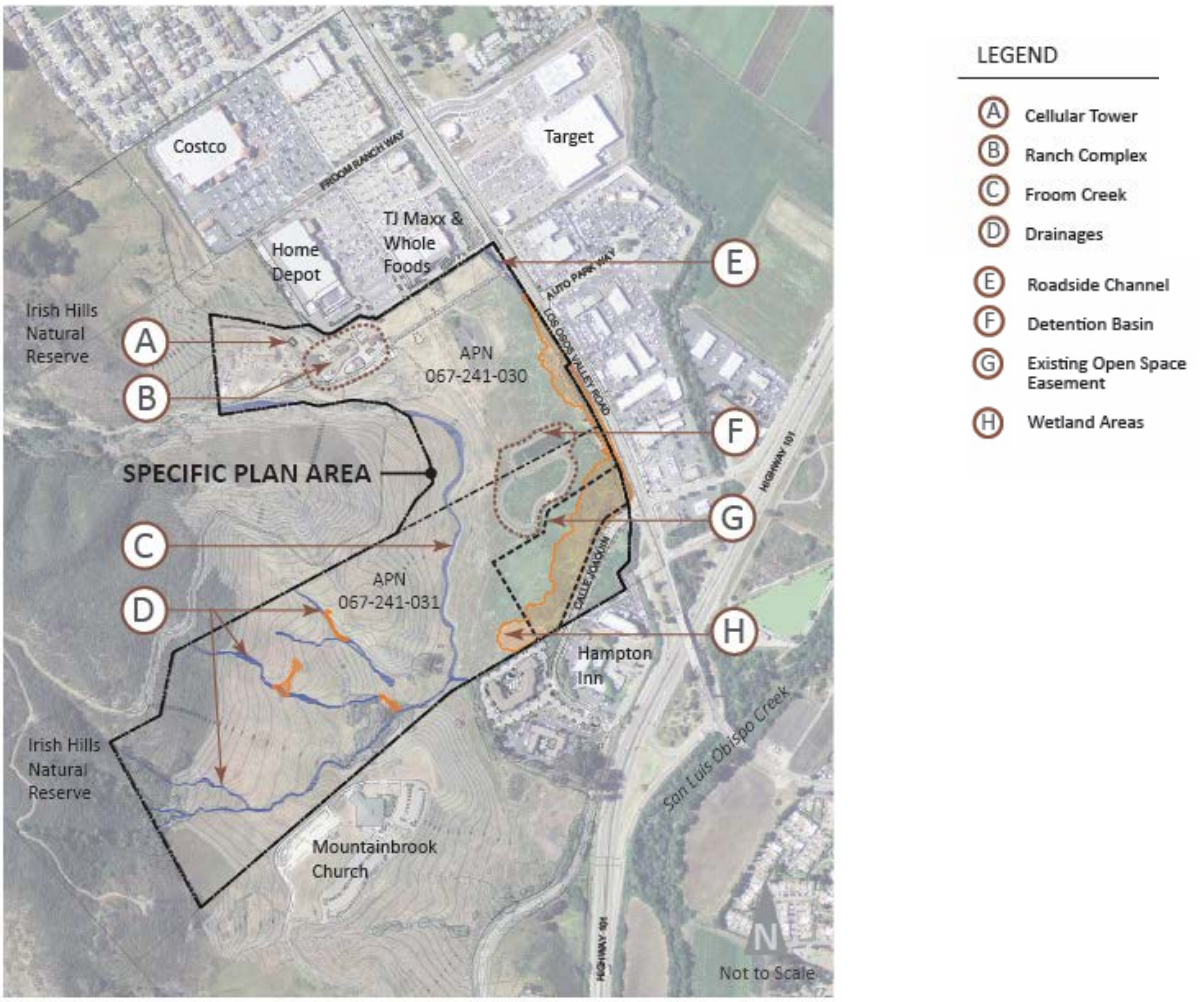


Figure 1-1: Existing location of Froom Ranch Specific Plan Area

The site is characterized by relatively flatter grassland areas which transition to steeper slopes before approaching City open space property at the base of the Irish Hills. The bulk of the property is undeveloped but includes historical ranch and dairy structures on part of the site directly to the south of the Home Depot retail store which is included in the adjacent Irish Hills Plaza. This area of the property is currently used as an office (main ranch house) and equipment storage yard to support John Madonna Construction Co. Inc. The site also includes unimproved roads, staging and materials storage, a quarry area, and a storm water detention facility for the neighboring Irish Hills Plaza (see Figure 1-1).

1.3 Executive Summary

The following sections of this report describe the proposed project and how the proposed condition affects the internal and surrounding hydrological elements. The project is compliant with following design guidelines:

- The project complies with the San Luis Obispo Drainage Design Manual
- The project complies with the San Luis Obispo Waterway Management Plan
- The project complies with the Central Coast Regional Water Quality Control Post Construction Requirements
- The project complies with the FEMA Floodplain Management guidelines

Additionally, the project results in the following conditions:

- The project does not cause significant negative downstream effects
- The project does not negatively affect adjacent or on-site wetland habitat
- The project does not negatively affect groundwater resources

1.4 Watershed Description

The site is bisected by natural drainages in the northeastern flank of the Irish Hills. The existing Froom Creek corridor traverses the Specific Plan area in a mostly north to south direction and joins San Luis Obispo Creek south of the Specific Plan area before flowing towards the Pacific Ocean in Avila Beach. Small areas of wetland habitat occur along the unnamed tributary drainages to Froom Creek in the southwestern area of the site, and a larger contiguous wetland area exists in flat grassland areas where surface and subsurface water is impounded by Los Osos Valley Road and Calle Joaquin. Froom Creek is a relatively narrow channel with incised banks that bisect the Specific Plan area in a north to south direction, and ultimately flows beneath U.S. Highway 101 via two concrete box culverts, heading to its confluence with San Luis Obispo Creek. As stated in the Los Osos Valley Road and US101 Interchange Improvement Project, the box culverts do not support storms above the 10-year event and spill over the top of Calle Joaquin at the box culverts. Due to the lack of dominant wetland vegetation within or adjacent to the channel, Froom Creek was classified as non-wetland waters of the U.S. and State of California subject to U.S. Army Corps of Engineers, Regional Water Quality Control Board and California Department of Fish and Wildlife jurisdiction pursuant to the Clean Water Act (Sections 401 and 404) and California Fish and Game Code (KMA, 2015).

The Specific Plan area includes about 7.25 acres of jurisdictional wetland habitat located on the southwestern part of the site near Los Osos Valley Road and Calle Joaquin. These wetlands are partially within an existing open space easement.

Froom Creek has a history of periodic flooding with estimated overbank flows occurring every five to six years (Balance Hydrologics, 2005). Studies have shown that while some overbank flow contributes to wetland habitat along Calle Joaquin, the primary function of Froom Creek appears to be groundwater recharge, and subsurface maintenance of the Calle Joaquin wetland area (see Figure 1-1). Historically, Froom Creek had a different alignment from what currently exists on the site today (see Figure 1-2). Based on review of an 1895 U.S. Geological Survey topographic map, the creek channel took a more direct northeasterly path as it exited the Irish Hills and ultimately connected with Prefumo Creek and San Luis Obispo Creek.

In consideration of the unique characteristics of the Specific Plan area, a program has been developed to restore Froom Creek closer to its historic alignment on the property, keeping its current hydrologic connection to San Luis Obispo Creek and connection to the wetlands habitat near Calle Joaquin.

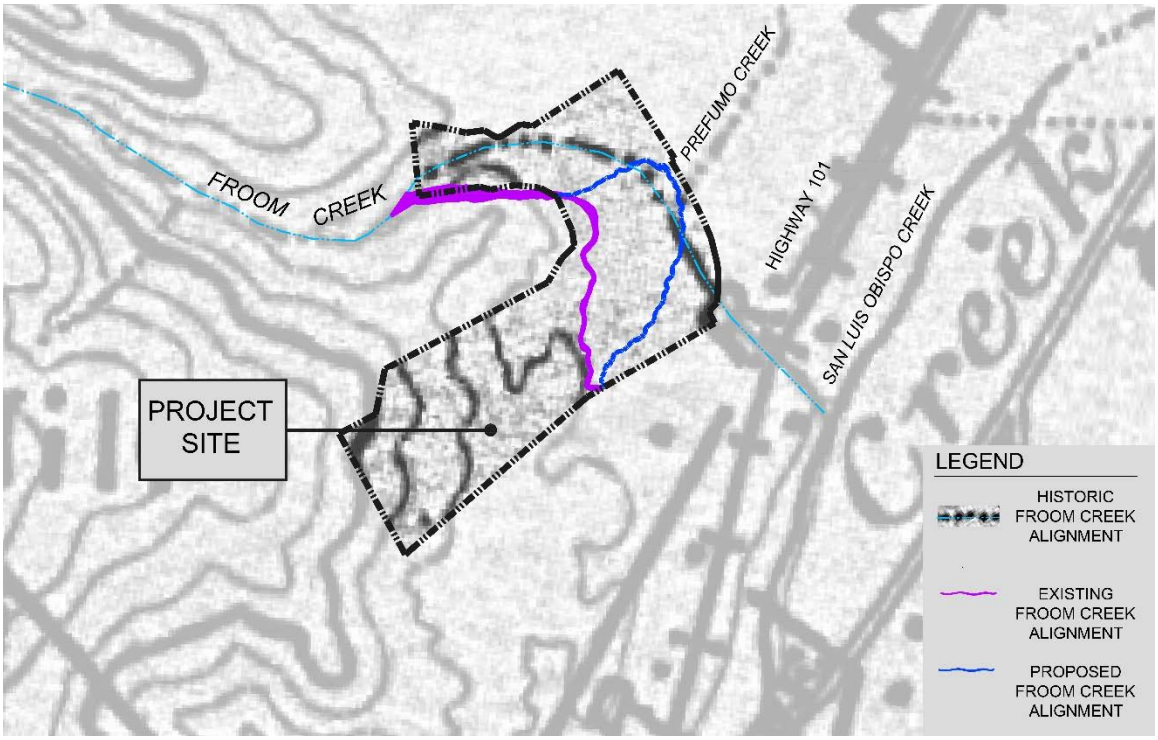


Figure 1-2: Froom Creek Historical Alignment

1.5 Methodology

The project site has been analyzed using several City of San Luis Obispo and FEMA approved methods including: HEC-HMS, HEC-RAS, The Rational Method, and the SCS Runoff Curve Number method. These methods combine in a variety of ways to present the information and tables found in this report. The inputs and assumptions used in each of these methods are included in the corresponding appendix.

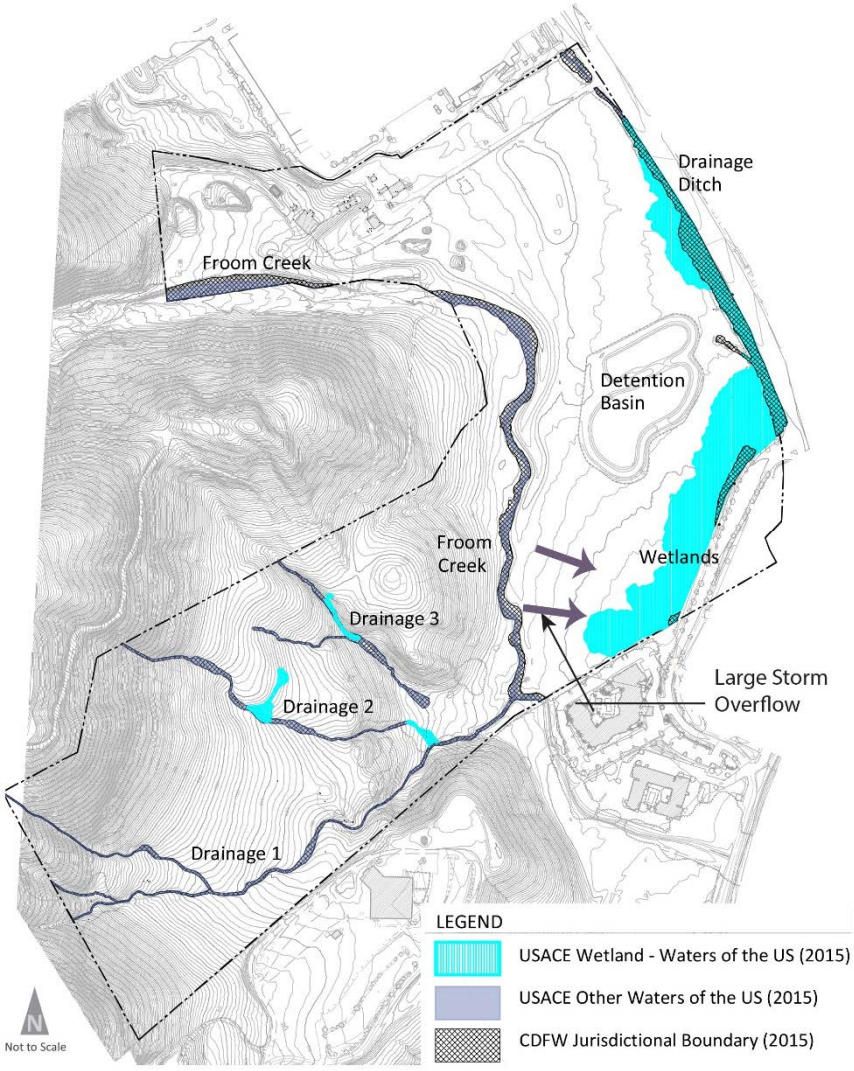


Figure 1-3: Existing Drainage Conditions

1.6 Hydrologic Analysis

The Froom Ranch Planning Area is located within the watershed of Froom Creek which is a relatively small watershed that originates in the Irish Hills.

Existing Drainage Conditions: The existing drainage conditions for the Froom Creek Specific Plan Area include Froom Creek flows across the site in a north to south trajectory ultimately passing through two box culverts beneath Calle Joaquin and US 101 before its confluence with San Luis Obispo Creek. These culverts do not have adequate capacity to pass the 10-year event for the watershed it serves (LOVR/US101 Interchange Improvement Project 2010). Furthermore, the confluence of the San Luis Obispo Creek (a major waterway) and East Fork drainage immediately downstream of the culverts causes a tailwater condition limiting the ultimate efficacy of the existing Froom double box culverts. There are three small

ephemeral tributaries to Froom Creek in the southwestern portion of the site. In addition, there is a man-made drainage ditch that parallels Los Osos Valley Road (LOVR).

An approximately 3.2-acre detention basin currently exists in the southeastern grassland area of the site to receive runoff from the adjacent Irish Hills Plaza development fronting LOVR. It consists of a de-siltation forebay which retains and infiltrates up to 2-year rain events, a main basin and spillway, and was sized to contain runoff from the Irish Hills Plaza. This basin releases water exceeding the 2-year event to the LOVR drainage ditch by a storm drain and swale. During large storm events, the main basin discharges runoff into the wetland area along Calle Joaquin via a concrete spillway. A report conducted by Cleath-Harris Geologists studying the groundwater (provided in Appendix 7) finds that the wetlands adjacent to Calle Joaquin and the Irish Hills detention basin is primarily fed by upward leakage of seasonally shallow groundwater. The report continues to find (based on a 2004 report from Balance Hydrologics) that Froom Creek overflow in high storm events happens infrequently and "may not be sufficient to sustain both seasonal and perennial wetlands". Furthermore, the Irish Hills basin forebay does not source the adjacent wetland in small events as the forebay subdrains do not connect to the outer perimeter drains. The forebay's primary function is to infiltrate runoff directed into the forebay by the diversion weir contained in the upstream manhole.

The existing Froom Creek channel alignment comes down from the hillside easterly where it makes approximately a 90-degree turn where the channel banks recede and make way for a low-lying meandering channel. The existing Froom Creek channel does not have adequate capacity to convey 100-year storm events to the Highway 101 culverts and consequently overtops the existing banks and flows in a sheet flow manner towards LOVR and Calle Joaquin (see Figure 1-3). The resulting condition is that the low-lying area between LOVR and the Irish Hills is designated as a FEMA Flood Insurance Rate Map, Zone A, no base flood elevation is established as shown on FIRM Map Panel Nos. 06079C1331G & 06079C1068G (see appendix 6).

Proposed Drainage Conditions: Development of the Specific Plan area will enhance and restore the historic Froom Creek corridor alignment and allow it to traverse future development areas. The restored creek corridor will be enhanced with native riparian plant communities. This would increase the function and value of the riverine system and resolve the periodic flooding issues.

The creek channel will be sized to handle up to a 100-year storm event with a minimum of one foot of freeboard. The creek corridor is proposed to be developed in a manner consistent with the City of San Luis Obispo Waterways Management Plan.

The San Luis Obispo Waterways Management Plan (WMP) sets forth criteria for drainage design for the Specific Plan areas tributary to San Luis Obispo Creek. The WMP indicates that storm water detention should be used in areas where there are downstream capacity limitations, which has been an issue in this area of the City. As stated above in the Existing Drainage Conditions, the downstream confluence of the San Luis Obispo Creek and the Froom drainage produces a tailwater condition. The WMP identifies this confluence as a problem area; any delay in the peak discharge of the Froom drainage exacerbates the

existing flooding at this confluence. Appendix 8 describes this condition through modeling by the HEC-HMS system which emulates the city-wide hydraulic process.

The drainage plan proposed for the Froom Ranch Area complies with the WMP. The restored Froom Creek corridor conveys flows from the project and the offsite upper reaches of the existing creek to the southeast corner of the property to connect to the existing creek bed that ultimately leads to a double box culvert going under Highway 101. Implementation of the Specific Plan drainage program will remove the site development areas from the FEMA flood plain. The project proposes to formalize the removal of the project development area from the FEMA flood plain through the Conditional Letter of Map Revision (CLOMR)/Letter of Map Revision (LOMR) process.

The proposed Froom Creek corridor includes a low flow channel throughout the reach of the channel and a large overbank area to convey larger flows. The low flow channel will provide a meandering conveyance designed to enhance and restore fish migration patterns on-site through stepped pools and terraces throughout the reach. At the jurisdictional wetlands, adjacent to Calle Joaquin, the overbank area is proposed to be flattened allowing storms larger than a two–year event to migrate into the existing wetland to provide water to sustain this wetland.

The off-site (located on the Mountainbrook Church property) project basin which provides additional "surge" storage for large storm events (see Figure 1-4). The existing box culverts overtop the Calle Joaquin road immediately above the culverts during 10-year events. The proposed basin will allow for storage enough to allow the 25-year event to pass entirely through the culverts. The 50-year and 100-year events are prohibitively large to allow for storage during these events and overtop Calle Joaquin as safe overflow. Appendix 8 provides HEC-HMS modeling showing these storm events and the corresponding peak flows, high water elevations, and storage required. The basin also serves to provide storage pursuant to the post construction requirements 3 (Runoff Retention) and 4 (Peak Management).

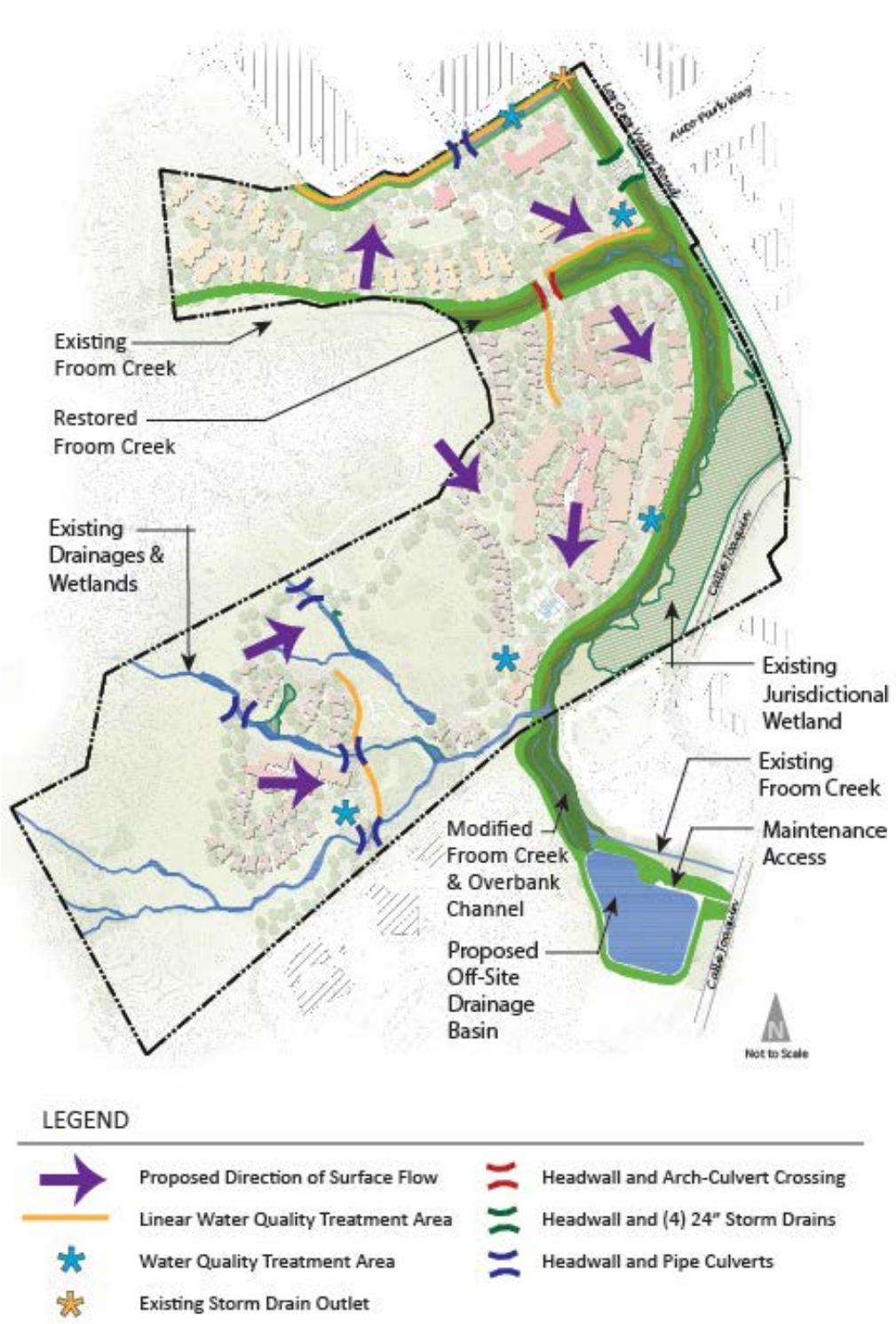


Figure 1-4: Proposed Drainage Conditions

1.7 Hydraulic Analysis

The Storm Water program for the Froom Ranch Specific Plan Area proposes to be consistent with the California Regional Water Quality Control Board, Post Construction Storm Water Management Requirements for Development Projects in the Central Coast Region and the City of San Luis Obispo Waterways Management Plans.

The Froom Ranch Specific Plan area is segmented into varied residential densities and commercial uses. Each of the development areas consist of one or more drainage management areas. Development areas are accessed via public and private roads acting as a backbone circulation system for the project. A series of drainage conveyances and low impact development and storage components, including the restored Froom Creek corridor, serve to provide treatment, filtration and storage for the Specific Plan Area. It should be noted that development of each land use area is conceptual at this juncture however this report intends to provide storm water control directives to be implemented with development of each of the land use areas as well as backbone implementation of the creek corridor, storm water systems, storage and conveyances that will serve the specific plan area at build out. The detailed hydraulic analysis of the drainage management areas, channel flow and storm water systems are contained within Appendices 1 - 6 of this report. The key components of the storm water controls addressing post construction requirements are listed below:

Restored Froom Creek Corridor*:* The Froom Creek corridor is a waterway conveying approximately 1088 cubic feet per second +/-(CFS) at the point of discharge through an existing double box culvert at Highway 101. The restored creek corridor connects to the existing Froom Creek channel at the southwesterly boundary of the project and conveys existing and proposed flows through the site to the point of discharge at Highway 101. The design of the restored corridor includes a low flow conveyance for storm events up to two – year flow and contains 100-year flows with a minimum of one foot of freeboard within the proposed creek banks. A Contech pre – fabricated natural bottom culvert is proposed in the alignment to allow roadway circulation to cross over the creek. The design of the Froom Creek corridor effectively removes the site from the FEMA, Zone A designated flood plain. A letter of map revision (LOMR) to remove development areas from the flood zone is anticipated to be part of the project implementation. The proposed creek corridor provides two key overbank design features along its reach, prior to discharge at Highway 101, one that perpetuates the existing wetland area along Calle Joaquin and a second overbank area that allows larger flows into a proposed storage basin on the adjacent Mountainbrook Church property. The capacity of the restored creek corridor requires bank slope protection measures outlined in the Drainage Design Manual section 3.6. Bank stabilization techniques will be utilized for sections of creek where flow speeds are erosive to naturally reconstructed embankments. Such techniques include but are not limited to: live staking and willow wattling, vegetated geogrids, live rock walls, rock slope protection, and planted gabion baskets.

Los Osos Valley Road (LOVR) ditch*:* The project includes a vegetated drainage ditch adjacent to LOVR ditch to complete the alignment of the existing ditch that fronts the Irish Hills Plaza development that conveys flows of approximately 36 CFS +/- from the Irish Hills Plaza and approximately 155 CFS+/- from the Home Depot ditch to the Froom Creek corridor. The LOVR ditch includes a closed conduit crossing at

the entry road to the project. The LOVR ditch provides point source water quality treatment of development flows that are adjacent to its reach prior to entering the Froom Creek corridor. The LOVR ditch also receives delayed flows from the Costco drainage summarized in Appendix 8.

***The Home Depot ditch**:* The project proposes a vegetated retention basin along the northerly boundary that conveys flows of approximately 155 CFS +/- from a natural swale located behind Home Depot to the LOVR ditch and ultimately into the Froom Creek corridor. This ditch includes a closed conduit crossing at the project roadway connection to the Irish Hills Plaza drive aisle. This ditch provides point source treatment of development flows adjacent to its reach and relocates the Home Depot water quality bio filtration component (post construction requirement #2 — see appendix 6 for storm water control plan exhibit) from the existing position in the open space of Froom Ranch to a location adjacent to the western boundary. This retention basin serves as water quality treatment pursuant to the state adopted post construction requirements for water quality totaling 1.0 acre – feet of runoff treatment storage adjacent to the westerly edge of the project. An overflow bank is provided for larger storm events conveyed into the LOVR ditch at the northwesterly corner of the project.

***Land Use Areas**:* Development areas within the project are required to provide point source water quality treatment of storm water prior to discharge into the creek corridor. When a land use area is proposed for development, each individual project will be responsible for implementation of the state's adopted post construction requirements 1 (Site Design) and 2 (Water Quality). The downstream basin serves to attenuate post development flows for post construction requirements 3 (Runoff Retention) and 4 (Peak Management).

***Backbone Roads**:* The project proposes public and private roads that provide access to each of the land use areas. Impervious surfaces associated with roadways incorporate vegetated swales and bio – filtration to address point source water quality treatment prior to conveyance of runoff to Froom Creek.

***Mountainbrook Church Basin**:* The project addresses PCR 4 peak management through use of a proposed storm water basin located directly adjacent to the Froom Ranch Specific Plan area on the Mountainbrook Church property. The basin is located southeasterly of the property boundary. The basin volume is approximately 28.8 acre - feet (+/-) with a minimum of one foot of freeboard. The storage volume meets or exceeds the Froom Ranch Specific Plan build – out PCR 4 requirement and also includes storage volume relocated from onsite for Home Depot, Irish Hills Plaza and potential future development of facilities on the Mountainbrook Church site. The design of the basin will promote infiltration of runoff and provide outflow controls to attenuate existing capacity issues at the Highway 101 double box culverts.

Post Construction Performance Requirements (PCR's) 1 through 4 for determining the post – development runoff storage volumes and addressing water quality treatment are included in the project storm water management program. As stated in the Land Use Area summary above PCR's 1, 2 & 3 are required for build-out of individual projects in each of the Froom Ranch SP development areas, PCR 4 is addressed through use of the Mountainbrook Church basin and is summarized in the following paragraphs with additional technical data provided in appendix 6 of this report.

The flat areas of the site adjacent to Los Osos Valley Road lie in Watershed Management Zone (WMZ) 1. WMZ 1 requires a 95th percentile storm volume retention. Based on review of the WMZ rainfall mapping, the 95th percentile, 24-hour storm event is equal to 1.9 inches over the WMZ 1 development area. The upper reaches of the planning area are identified as WMZ 9 and require 85th percentile, 24-hour storage equivalent to 1.2 inches over the WMZ 9 development area. The Froom Ranch Planning Area has been segmented into drainage management areas (DMA's) that are tributary to the proposed Froom Creek corridor. Detailed hydrologic calculations can be found in Appendices 1 - 8 of this report, a summary of PCR 3 storage volume requirements for onsite DMA's is listed below.

Table 1-1 identifies each of the land use areas, consistent with the Froom Ranch Specific Plan, and their respective effective impervious area storage volume requirements dictated by the state post construction requirement 3 to be retained and treated on each individual development area.

Drainage Management Area	**Zoning / Land Use Designation**	**Development Area (Acres)**	WMZ	Retention Volume Required (ac-ft)
Residential + Park	R-3, Medium High Density Residential & Park	12.70	1/9	0.90
Commercial	CR-SP, Commercial Retail	10.07	1	1.05
Lower Villaggio	R-3-SP, Medium High Residential (Villaggio-Life Plan Community)	26.94	1	2.32
Upper Villaggio	R-3-SP, Medium High Residential (Villaggio-Life Plan Community)	12.53	9	0.56
Totals		**62.24**		**4.83**

Table 1-1: Froom Ranch SP Development Areas - Storage Volume

Table 1-2 lists other DDM derived basin storage volumes from offsite development areas relocated to the Mountainbrook Church Basin for Home Depot and Irish Hills Plaza and future Mountainbrook Church potential development (pursuant of PCR 4). PCR 2 for these areas will be located on-site near the point of discharge on the northerly border of the site.

Offsite Drainage Areas	**Storm Water Feature**	**Development Area (Acres)**	WMZ	Storage Volume Required (ac-ft)
Home Depot	Relocated Detention Volume	10.14	1	1.27
Irish Hills	Relocated Detention Volume	15.23	1	2.33
Mountainbrook Church	Future development Runoff Retention Volume	3.67	9	0.37
Totals		**32.43**		**3.97**

Table 1-2: Offsite Development – Storage Volume

The Mountainbrook Church basin is designed with approximately 28.8 acre – feet of storage capacity at a water surface elevation of 104.0; the required storage volume is generated from the relocated and future detention from Table 1-2 (3.97 ac-ft) plus the detention volume calculated from Table 1-3 (16.99) which totals 20.96 ac-ft required. The basin has been designed to provide additional capacity for the purposes of attenuating high flow conditions that exceed the capacity of the Highway 101 culverts (565 cfs) pursuant to the San Luis Obispo Drainage Design Manual (DDM). The DDM requires attenuation from 2-yr through 100-yr events such that there are no significant (greater than 5% downstream increase) downstream effects. Appendix 3 tabulates the pre-vs-post conditions and show that the downstream effect is less than 5% with a net decrease in most storm events. The greater volume allows the basin attenuate the high inflow with the constrained double box culvert outflow thereby reducing flood stage elevations for the creek and along the Calle Joaquin wetland. The additional detention storage allows higher storm events to pass through the existing double box culverts without overtopping the above Calle Joaquin spillway. Finally, the existing hydraulically connected wetlands upstream of the project basin provides approximately 11 ac-ft of detention.

	Froom Lower	Froom Dev		Froom Lower	Froom Dev	**Total Storage Req'd (ac-ft)**
Ex-2yr	30.133	20.454	Pro-2yr	36.251	22.909	**8.573**
Ex-10yr	40.954	22.874	Pro-10yr	49.941	26.289	**12.402**
Ex-25yr	51.175	25.161	Pro-25yr	62.137	29.206	**15.007**
Ex-50yr	58.985	26.908	Pro-50yr	71.165	31.333	**16.605**
Ex-100yr	61.092	27.379	Pro-100yr	73.567	31.895	**16.991**

Table 1-3: Pre-Post storage design volumes.

1.8 Risk Assessment/Impacts Discussion

Approximately 35% of the existing Froom Ranch Specific Plan area is in a FIRM map, Zone A designation, no base flood plain elevation. The FIRM Zone A area is in the lower flat land of the project bound on four sides by LOVR, Calle Joaquin, the Irish Hills Plaza and the hillside terrain of the Irish Hills Natural Reserve. Due to the very flat terrain along the LOVR corridor and along Calle Joaquin, runoff from LOVR and overtopping of the existing Froom Creek corridor creek banks localized flooding and ponding have historically been observed on the site. Additionally, the Highway 101 double 5’ x 5’ box culverts overtop at the 10 - year storm event, 547 CFS (WRECO, location hydraulic study, Nov. 2010).

For the reasons stated above the project proposes to implement several flood control components key to minimizing risk associated with potential flooding. The restored Froom Creek corridor design proposes to convey up to 100 - year storm events within its creek banks with an additional minimum of one foot of freeboard. The grading of the project, prior to future individual projects, proposes to raise the elevation of the lower flat area above the projected flood stage so that finish floor elevations can achieve a minimum of one foot above the 100 – year flood. The Mountainbrook Church overbank area and basin are anticipated to provide better channel function and some attenuation of larger peak flows conveyed to the Highway 101 box culverts to assist in minimizing tail - water flooding potential.

1.9 Unusual or Special Conditions

As discussed in previous sections of this report, the Froom Ranch Specific Plan project proposes to remove approximately 2,200 linear feet of the existing, relocated Froom Creek corridor and restore it to its approximate original location. The existing alignment does not provide adequate capacity for large storm events and does not provide an aquatic or riparian habitat. The new alignment provides a unique opportunity to recast the creek in a way that will restore it to a vibrant creek corridor and enhanced fish habitat. The proposed Froom Creek alignment will require permitting through the Army Corps of Engineers, California Fish and Wildlife, the Central Coast Regional Water Quality Control Board and other jurisdictional agencies. Other requirements include removal of the site from the FEMA FIRM map Zone A through processing of a Conditional Letter of Map Revision (CLOMR) and a final Letter of Map Revision (LOMR).

1.10 Conclusions

The Froom Ranch Specific Plan project is a comprehensive plan to create a special environment for people to enjoy. It is included in the City of San Luis Obispo's Adopted Land Use and Circulation Element (2014) as a desired annexation area with development anticipated. The project site provides challenges and opportunities in implementing a storm water program that balances limited development of the site (50% open space required), while enhancing the environmental elements. The findings and conclusions of this report are that restoring the Froom Creek corridor can be accomplished in a manner that meets environmental and flood control goals for the City of San Luis Obispo. The project as designed intends to comply with the City of San Luis Obispo Waterways Management Plan and the Central Coast Regional Water Quality Control Board Requirements for Development Projects in the Central Coast Region (Resolution No. 2013-0032). The project as designed accommodates new development without flood risk and removes the site from FEMA FIRM Map Zone A. And lastly, the project as designed, intends to implement a series of pipes, channels and low impact design features that comply with the City of San Luis Obispo standards for capacity and function.

Chapter 2

Geomorphic Evaluation

2. Geomorphic Evaluation

2.1 Introduction

The Froom Ranch Specific Plan Area proposes to restore the Froom Creek corridor to its approximate original alignment, an important component of the restoration effort includes evaluation of the existing creek corridor constraints and physical nature and provides discussion of the proposed creek corridor design as it relates to the development setting, the opportunities for restoration and the anticipated geomorphic controls.

2.2 Physical Setting

Froom Creek is a tributary to San Luis Creek, it is approximately 1.5 miles long and runs east to west from its upper reach in the Irish Hills Natural Reserve hillside and then turns south to the point of confluence with San Luis Creek. Froom Creek consists of two distinct segments; the lower reach (approx. 4,200 linear feet), which has been significantly altered over time and traverses the Froom Ranch Specific Plan area to a double box culvert discharge conveyance which outlets into San Luis Creek and the upper reach (approx. 3700 linear feet) within the City Irish Hills natural reserve which remains in its existing condition upstream from the connection with the restored alignment onsite.

2.3 Existing Froom Creek Corridor Conditions

The upper reach of Froom Creek, west of the project site, is to remain intact and exists as an intermittent stream. The creek varies in width and contains pools along the creek corridor, significant vegetation and is considered adequate habitat for steelhead. The upper reach dissipates as it enters the site into the altered lower reach. The lower reach of Froom Creek which traverses the site is an incised channel confined by a man – made earthen berm along a portion of the eastern bank of the creek. The creek bed is generally dry and consists of rock washed down from the upper reach of the channel and is devoid of significant vegetation. Soils within the lower reach Froom Creek within the project boundary generally consist of Obispo - Rock outcrop in steeper zones of the creek bed, consisting of black clay to a depth of approximately 18 inches underlain by serpentine rock, and Riverwash consisting of excessively drained, water deposited sand, loamy sand with gravel and cobbles (KMA – Delineation of waters of the U.S., August 2015). Areas of the lower reach channel do not contain large storm events within the creek banks and are prone to moderate erosion and bank cutting due to high velocities during larger storm events. The lower reach does not contain wetland vegetation within or adjacent to the channel.



Photograph of the existing lower reach Froom Creek corridor (Date: January 20th, 2015)

2.4 Proposed Froom Creek Corridor Conditions

The proposed restored Froom Creek corridor joins the existing creek at the northwest corner of the Specific Plan area where it will flow east through the project site toward LOVR before it curves to parallel the Calle Joaquin road corridor on the border of the wetland area. The restored creek then intersects with the original creek bed at the southeast corner of the property. The restored Froom Creek lower reach is a unique opportunity to provide a healthy riparian corridor across the Specific Plan area in replacement of the degraded existing corridor.

The restored Froom Creek corridor design, within the project area boundary will be constructed with imported fill and subject to geotechnical inspection during placement of materials. The hydraulic design criteria are based on the City of San Luis Obispo Waterway Management Plan. Detailed hydraulic analysis of the channel can be found in Appendices 1-3.

A summary of the key hydraulic objectives and design goals are:

1. A low flow channel to handle up to two - year storm events.
2. Varying embankment slopes (maximum 2.5:1) to enable plant shading and minimize mass waste.
3. Upstream sediment capture within new development areas.
4. 100 – year storm containment within the creek corridor with one foot of freeboard.

5. Non – erosive velocities (approx. 2 – 8 feet per second) to minimize potential for undercutting.
6. Armoring of slope banks and culvert locations, in select locations where necessary, will provide openings to allow fish passage.
7. Intersecting tributary ditches or stream beds will be stepped to contain and direct fish within the main Froom Creek corridor.

In addition to the hydraulic design features of the channel, the restored Froom Creek provides new riparian and steelhead habitat based on the City of San Luis Obispo's Waterway Management Plan and the California Salmonid Stream Habitat Restoration Manual including:

1. A natural bottom utilizing existing boulders and cobbles that are relocated from the existing creek corridor.
2. A low-flow meandering channel that allows for pooling, deposition, and load transport.
3. Incorporate stepped pools and terraces to control fish migration patterns.
4. Overbank areas to provide runoff flow into adjacent existing wetlands.
5. Control of light reaching the stream bed.
6. Natural litter and invertebrate fall.
7. Woody debris components.

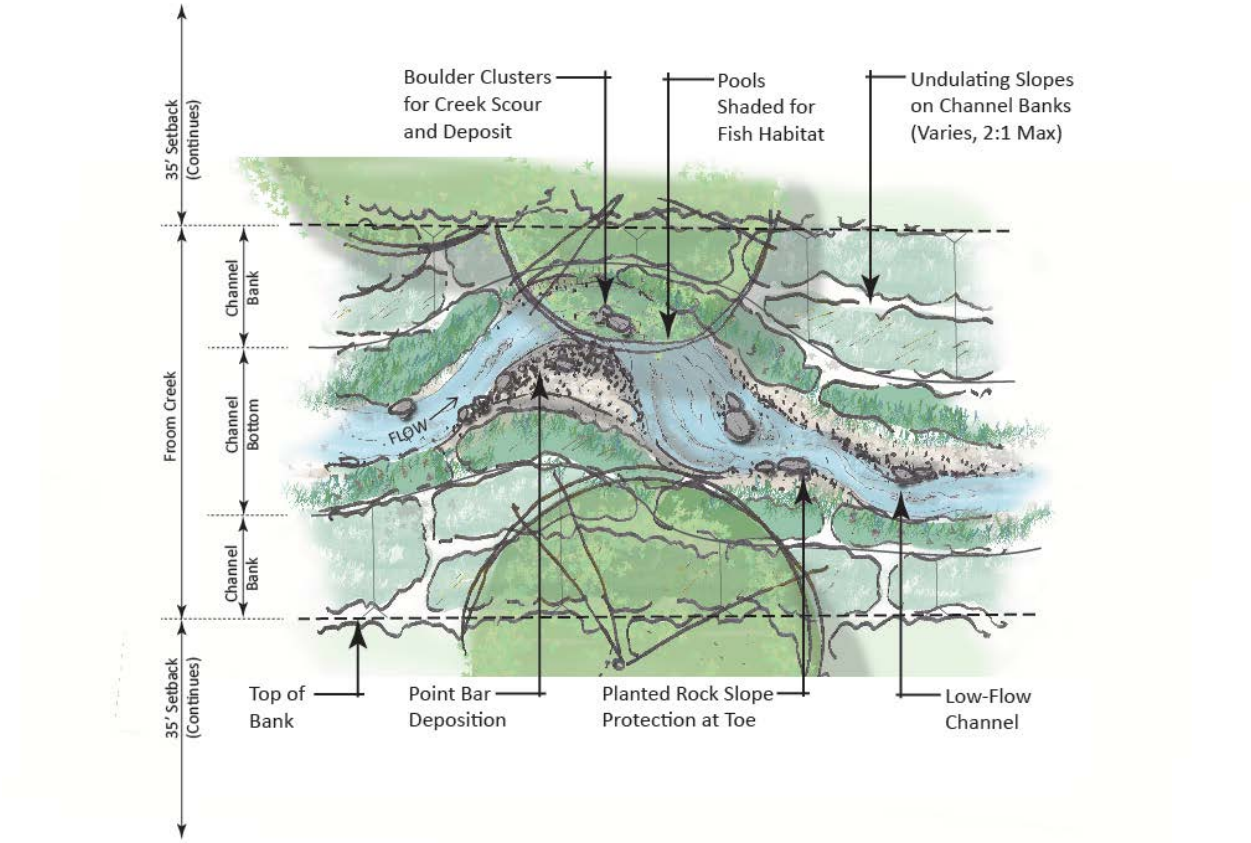


Figure 2-1: Proposed Froom Creek corridor concept

More detailed information regarding the Froom Creek Restoration Program can be found in Section 3 of this report.

2.5 Conclusion

The Froom Creek lower reach located in the Froom Ranch Specific Plan area is currently in a degraded condition and has been altered several times with the ranching uses on the property. The restored Froom Creek corridor meets the objectives of low velocity, minimal sediment transport, low impact design and conforms to the City of San Luis Obispo Waterway Management Plan and the California Salmonid Stream Habitat Restoration Manual.

Chapter 3

Froom Creek Restoration Program

3. Froom Creek Restoration Program

3.1 Introduction

The Froom Creek restoration program is based on the initial grading models, prepared in cooperation with City and other responsible agencies, for the new alignment as shown on the vesting tentative map, and is subject to modification during final design. The restoration program focuses on preparation of preliminary recommendations for creek cross sections, planting schemes and objectives for the design.

3.2 Froom Creek Restoration Objectives

The creek restoration objectives for the Froom Creek corridor are to develop three zones for restoration:

- Riparian Buffer: Zone between the top of bank and edge of setback. A 35' setback is utilized for Froom Creek, and a 20' setback for the drainage ditch along Los Osos Valley Road. The zones are envisioned to be planted with trees at an average of 50' on center, and shrubs at an average of 5' on center. This zone is proposed to be drip irrigated.
- Channel Banks: Zone between the top and toe of bank. These zones are envisioned to include herbaceous species that can tolerate seasonal undulation, and planted at an average of 3' on center spacing. This zone is proposed to be spray irrigated.
- Channel Bottom: Zone below the toe of bank. This area is envisioned to include herbaceous wetland species planted at an average of 3' on center spacing. This zone will not be entirely planted, but is approximated to be 30% of the bottom area and expected to naturalize and fill the flat bottom areas. This zone is proposed to be temporarily spray irrigated to establishment.

3.3 Froom Creek Planting Goals

The planting goals for the Froom Creek corridor were developed utilizing the City of San Luis Obispo's Waterway Management Plan, Volume III, Drainage Design Manual dated February 2003 as a guideline for creek design, cross - sections and plant list.

The study assumes that plants used for creek restoration will meet the following parameters:

- Native non-invasive riparian species
- Mix of evergreen and deciduous varieties
- Vegetation located in naturalistic groupings
- Planting will include plant mitigation areas
- Vegetation will tolerate recycled water for irrigation
- Biotechnical erosion control methods will be utilized

- Adjacent existing wetland will be enhanced

3.4 Froom Creek Enhancement Plan

The conceptual enhancement plan shows the general planting concepts for the Riparian Buffer, Channel Bank, and Channel Bottom zones. Froom Creek restoration will meet the following parameters:

- The Channel Bottom contains a low-flow channel that allows for pooling, deposition and load transport.
- Stepped pools and terraces will be used to control fish migration patterns.
- Existing boulders and cobbles will be relocated from the existing creek corridor.
- Project will explore opportunities in upper reaches of Froom Creek to enhance fish habitat.
- Creek enhancements will be managed and monitored.
- A riparian buffer with pedestrian amenities should be included.

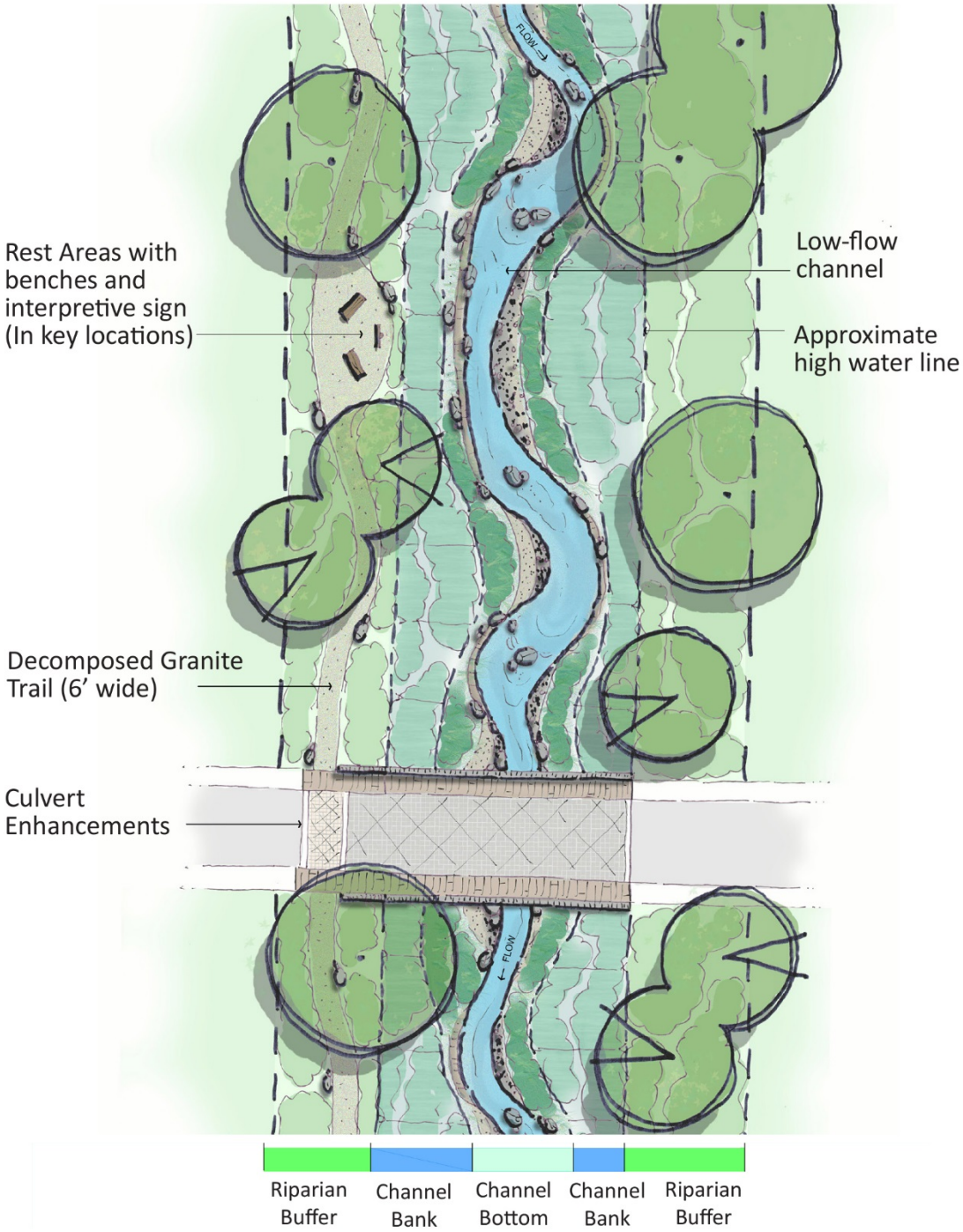


Figure 3.1: Froom Creek enhancement concept

3.5 Froom Creek Restoration Plan

The plan below demonstrates the realigned Froom Creek corridor with the proposed restoration enhancement areas. Consistent with the City of San Luis Obispo Creek Setbacks regulations (Chapter 17.16.025), the plan shows a 35' setback along the Froom Creek corridor, and a 20' setback along the Los Osos Valley Road drainage channel. The realigned creek corridor is proposed to run adjacent to the existing wetlands, and utilize this area for drainage during peak flows. All storm water will be treated prior to entering the creek corridor.

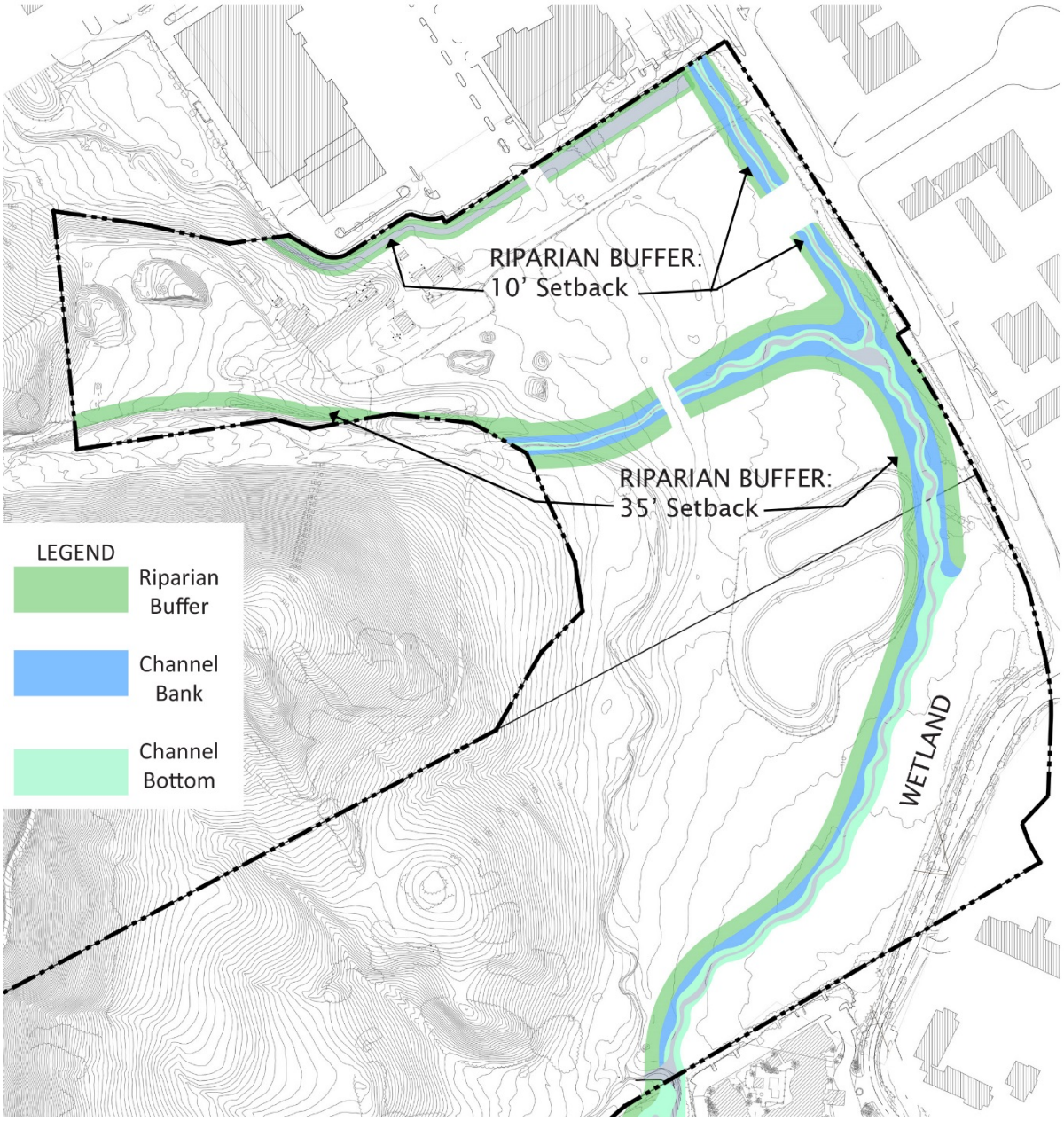


Figure 3.2: Froom Creek restoration plan

3.6 Froom Creek Restoration Plant List

The following list of plants is preliminary, and intended to provide the initial planting recommendations and a potential list of species. Additional species may be included and list revised as the project design is finalized.

Trees: Trees are proposed to primarily 15 gallon containers. Trees are suggested to be planted within the Riparian Buffers, but not on the Channel Banks or Bottom. The creek restoration areas are envisioned to contain a mix of sizes and species. Trees will be clustered to allow view corridors.

Riparian Buffer Trees:

- Acer macrophyllum (Big Leaf Maple)
- Alnus rhombifolia (White Alder)
- Arbutus menziesii (Pacific Madrone)
- Cercis occidentalis (Western Redbud)
- Quercus agrifolia (Coast Live Oak)
- Populus fremontii (Fremont Cottonwood)
- Sycamore (Platanus racemosa)
- Umbellularia californica (California Laurel)

Shrubs and Groundcover: Shrubs and groundcover are proposed to primarily be 1 gallon containers. The creek restoration areas are envisioned to contain a mix of shrub sizes and species, with lower growing species along the trail.

Riparian Buffer Shrubs and Groundcover:

- Artemisia douglasiana (Mugwort)
- Baccharis pilularis (Coyote Brush)
- Ceanothus species (California Wild Lilac)
- Diplacus aurantiacus (Sticky Monkeyflower)
- Garrya elliptica (Coast Silktassel)
- Heteromeles arbutifolia (Toyon)
- Muhlenbergia rigens (Deer Grass)
- Rhamnus californica (California Coffee Berry)
- Ribes speciosum (Fuchsia Flowering Gooseberry)

Channel Bank Shrubs and Groundcover:

- Asclepias fascicularis (Milkweed)
- Eleocharis acicularis (Needle Spikerush)
- Elymus glaucus (Blue Wildrye)
- Hordeum brachyantherum (California Meadow Barley)

- Leymus triticoides (Creeping Wild Rye)
- Mimulus guttatus (Seep Monkeyflower)
- Symphoricarpos mollis (Creeping Snowberry)

Channel Bottom:

- Alisma plantago-aquatica (Water Paintain)
- Cyperus eragrostis (Umbrella Sedge)
- Juncus species (Rush)
- Scirpus species (Bulrush)

3.7 Froom Creek Restoration Sections

The following conceptual sections are intended to show typical areas of creek restoration along the realigned corridor. The sections show the general planting and grading concepts for the Riparian Buffer, Channel Bank, and Channel Bottom zones. The sections also conceptually demonstrate the pedestrian trail and road crossings proposed along the creek corridor.

Section A.1 to A.3: Sections A.1 through A.3 (Figure 3-3, 3-4, 3-5) are intended to represent typical cross sections of the Froom Creek restoration, to demonstrate the proposed undulation and meandering nature of the creek enhancements The Channel Bottom area is proposed to include a meandering low-flow channel that will facilitate the typical drainage for the creek corridor, and the Channel Banks will control seasonal and 100-year flooding (high water line). It is anticipated that boulders, cobbles, logs, and embedded tree roots will be placed in key locations along the Channel Bank and Channel Bottom to provide habitat areas.

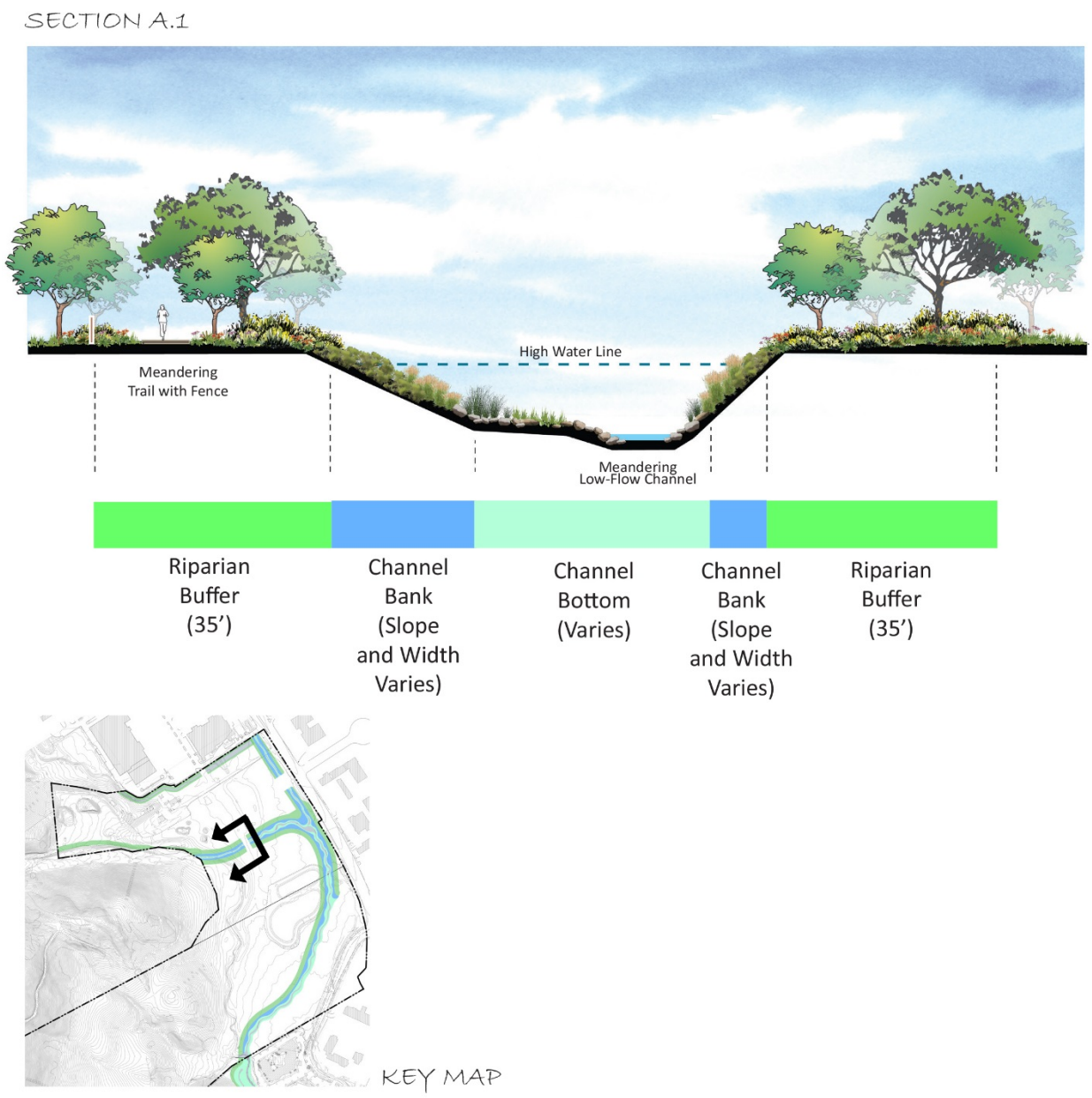
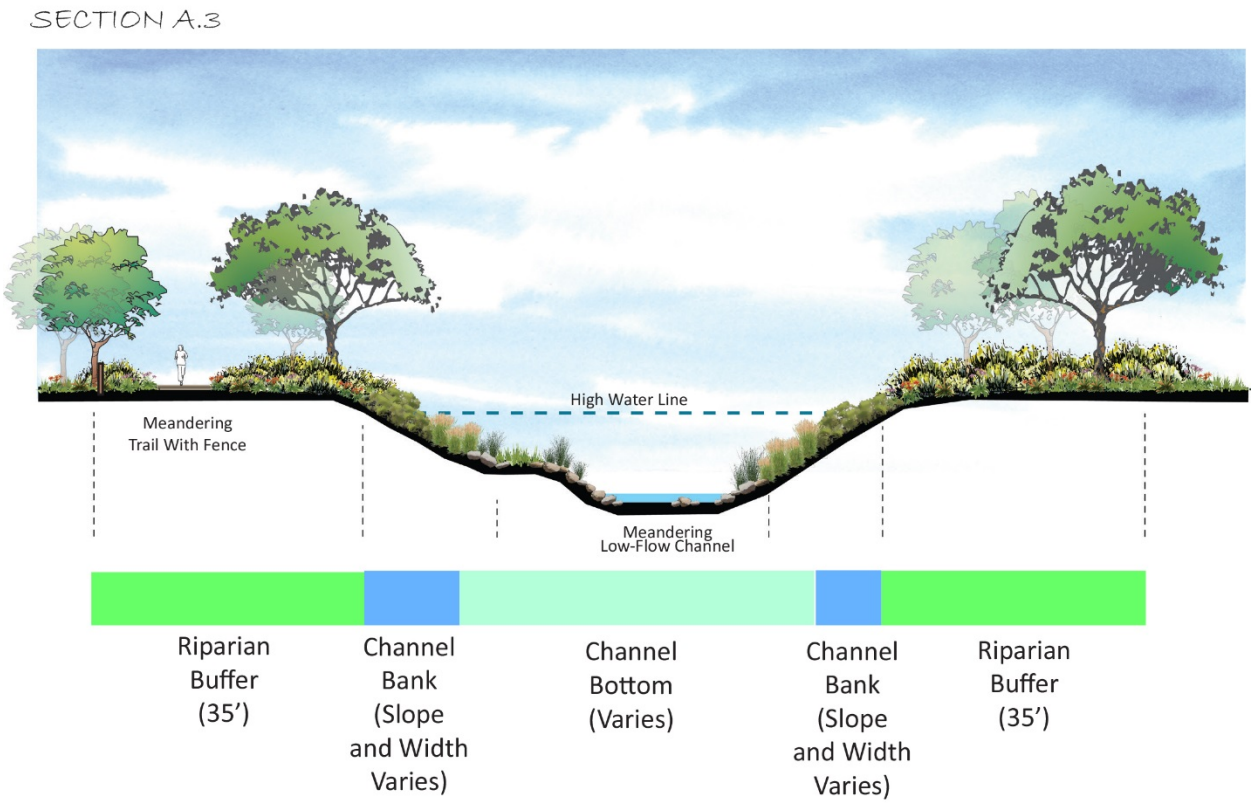


Figure 3.3: Section A-1



Figure 3.4: Section A-2



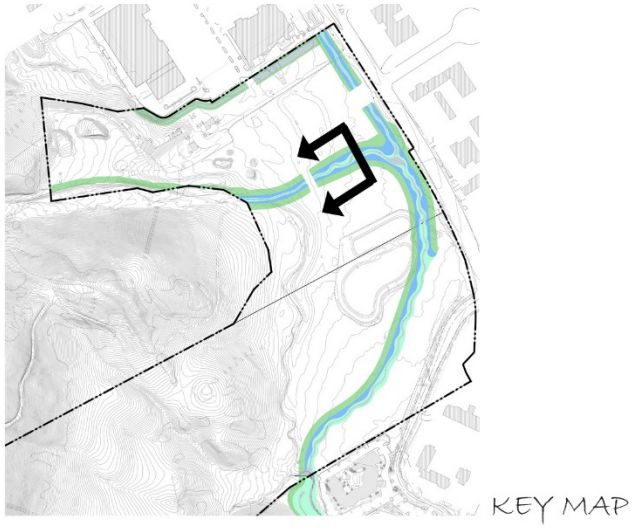


Figure 3.5: Section A-3

Section B: Section B (see Figure 3-6) is intended to represent a typical road crossing at Froom Creek. The Channel Bottom area is proposed to be a natural bottom, and the overhead roadway crossing facilitated with a "Conspan" natural bottom culvert. The culvert is envisioned to be enhanced with a railing and decorative concrete, and armored with boulders, cobble and vegetation. The upper deck of the culvert is proposed to accommodate pedestrians, bicyclists, and vehicles.

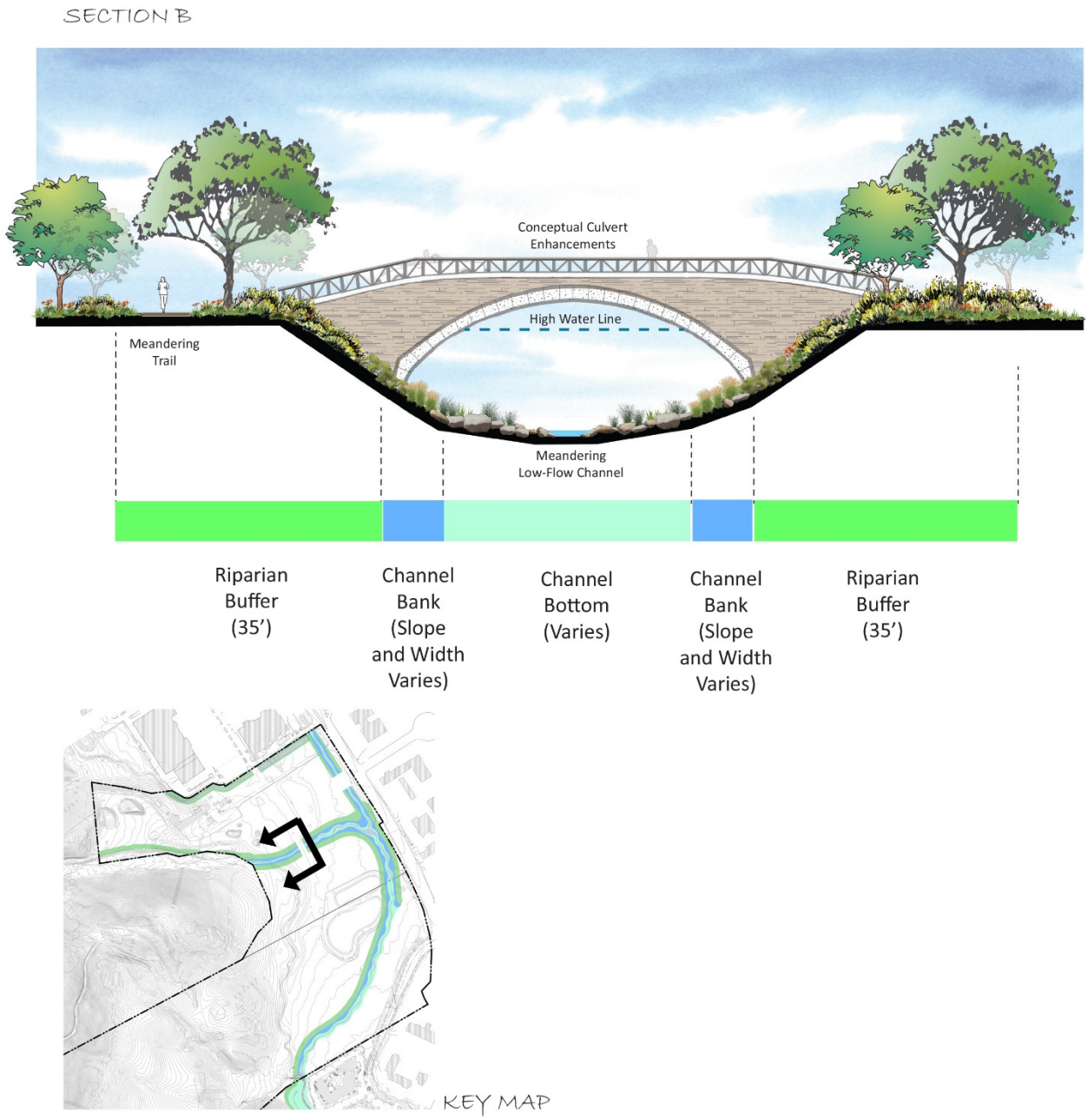
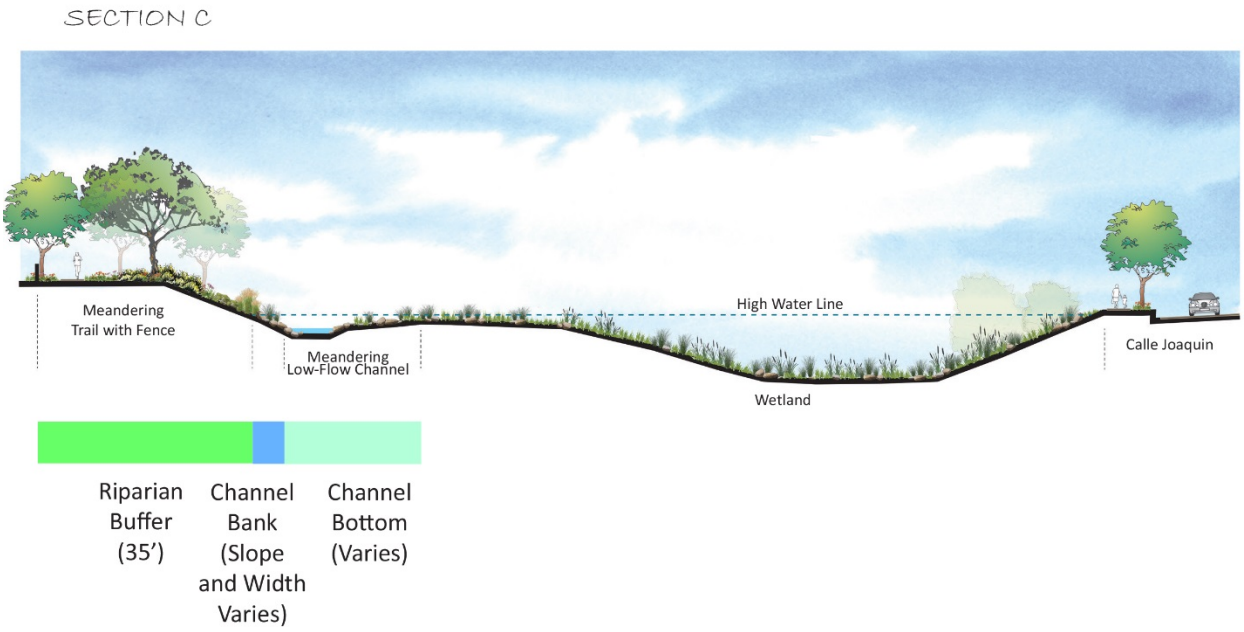


Figure 3.6: Section B

Section C: Section C is intended to represent a typical cross section where Froom Creek is proposed adjacent to the existing wetlands. The Channel Bottom is proposed to be configured so that the creek overbank will flow into the adjacent existing wetlands during storm larger than 2-year events.



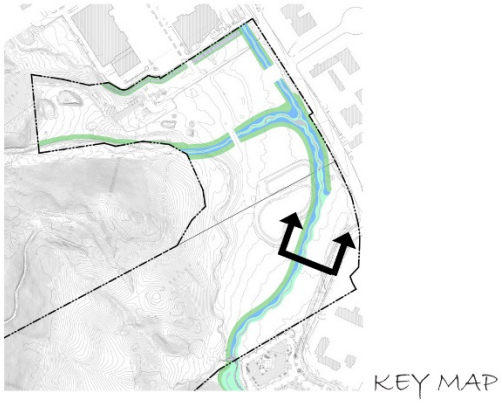


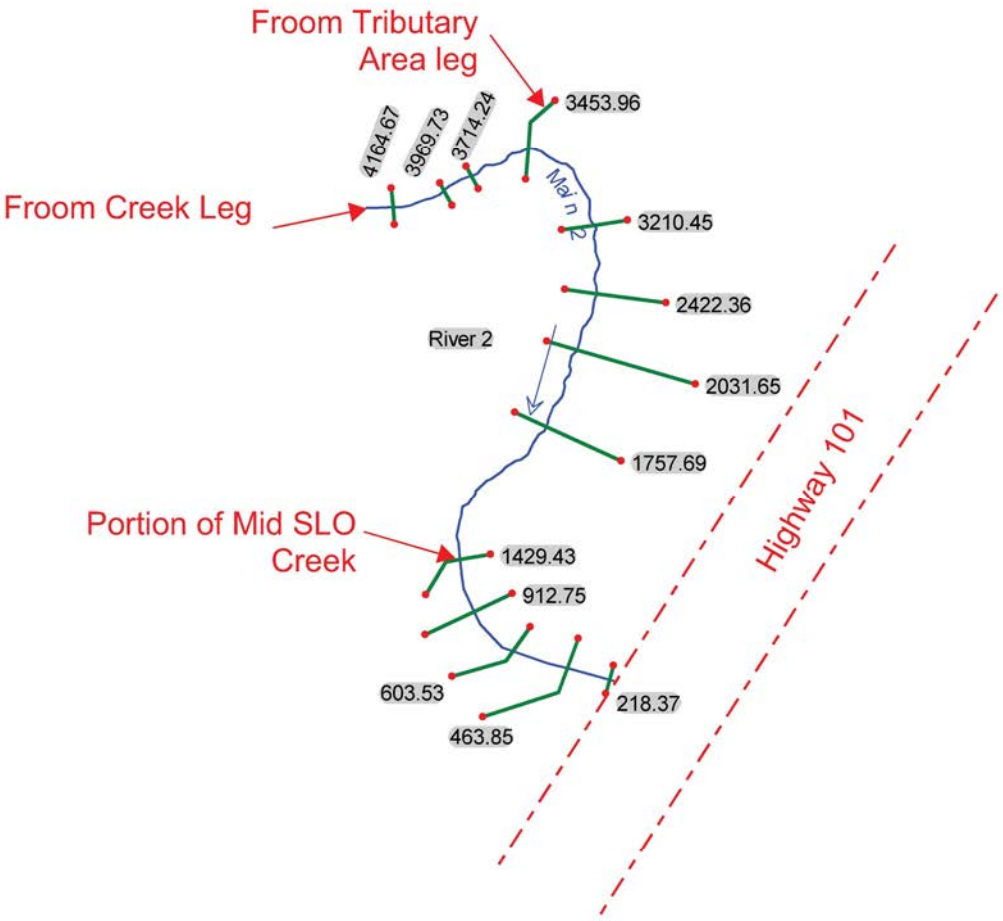
Figure 3.7: Section C

3.8 Conclusion

The Froom Creek Restoration program, as proposed, conforms to guidelines for creek design and planting as outlined by the City of San Luis Obispo's Waterway Management Plan and the California Salmonid Stream Habitat Restoration Manual. The restored lower reach of the Froom Creek corridor will protect and enhance creek, riparian, fish, and wetland habitats in the Froom Ranch Specific Plan area.

Appendix 1

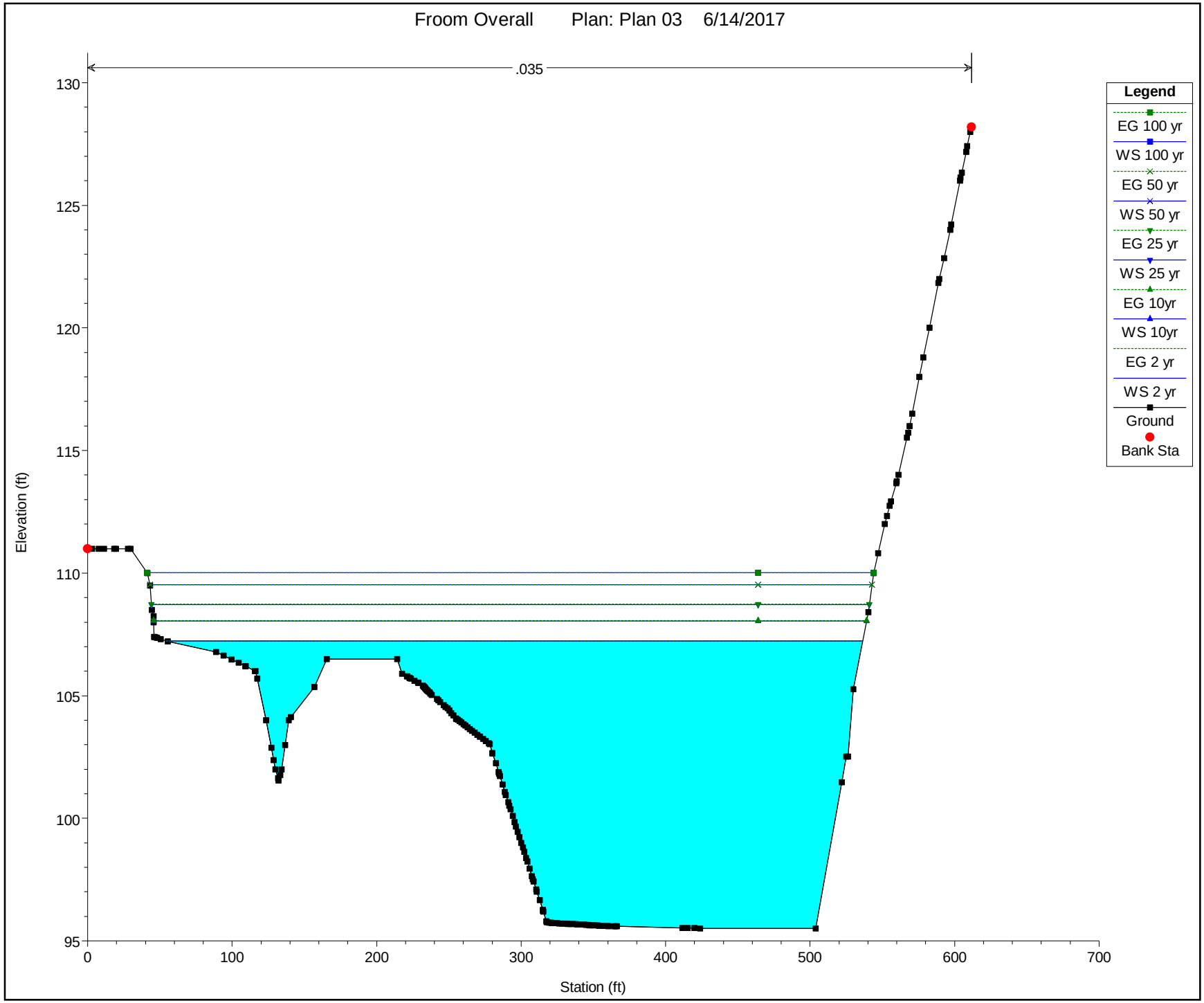
HEC - RAS Summary Table and Cross Sections


Froom Tributary
Area leg
Froom Creek Leg
Portion of Mid SLO
Creek
3453.96
4164.67
3969.73
3714.24
Main 2
3210.45
2422.36
River 2
2031.65
1757.69
1429.43
912.75
603.53
463.85
218.37
Highway 101

HEC-RAS Plan: Plan 03 River: Main 2 Reach: River 2

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
River 2	4164.67	2 yr	289.20	122.85	126.65	126.62	127.50	0.015272	7.41	39.03	21.95	0.98
River 2	4164.67	10yr	394.30	122.85	127.12	127.09	128.08	0.014664	7.88	50.04	24.91	0.98
River 2	4164.67	25 yr	489.10	122.85	127.48	127.44	128.53	0.014264	8.23	59.45	27.19	0.98
River 2	4164.67	50 yr	612.20	122.85	127.89	127.85	129.04	0.013847	8.60	71.16	29.78	0.98
River 2	4164.67	100 yr	691.80	122.85	128.13	128.09	129.34	0.013661	8.82	78.39	31.28	0.98
River 2	3969.73	2 yr	289.20	120.21	124.22	123.99	124.90	0.011357	6.58	43.96	23.70	0.85
River 2	3969.73	10yr	394.30	120.21	124.63	124.45	125.46	0.012068	7.28	54.18	26.30	0.89
River 2	3969.73	25 yr	489.10	120.21	124.94	124.81	125.89	0.012634	7.82	62.56	28.25	0.93
River 2	3969.73	50 yr	612.20	120.21	125.28	125.21	126.39	0.013273	8.43	72.65	30.43	0.96
River 2	3969.73	100 yr	691.80	120.21	125.49	125.44	126.68	0.013548	8.76	79.00	31.73	0.98
River 2	3714.24	2 yr	289.20	117.12	120.76	120.76	121.56	0.016383	7.20	40.19	25.24	1.01
River 2	3714.24	10yr	394.30	117.12	121.18	121.18	122.09	0.015641	7.64	51.62	28.67	1.00
River 2	3714.24	25 yr	489.10	117.12	121.51	121.51	122.49	0.015175	7.97	61.34	31.25	1.00
River 2	3714.24	50 yr	612.20	117.12	121.88	121.88	122.95	0.014706	8.33	73.51	34.31	1.00
River 2	3714.24	100 yr	691.80	117.12	122.09	122.09	123.22	0.014458	8.53	81.13	36.10	1.00
River 2	3453.96	2 yr	435.90	115.14	118.61	118.32	119.04	0.009472	5.27	82.66	55.87	0.76
River 2	3453.96	10yr	594.40	115.14	118.98	118.66	119.48	0.009242	5.71	104.13	61.25	0.77
River 2	3453.96	25 yr	737.30	115.14	119.26	118.92	119.83	0.009190	6.05	121.88	65.36	0.78
River 2	3453.96	50 yr	922.90	115.14	119.59	119.22	120.22	0.009055	6.40	144.14	70.12	0.79
River 2	3453.96	100 yr	1042.80	115.14	119.77	119.40	120.46	0.009048	6.62	157.50	72.77	0.79
River 2	3210.45	2 yr	435.90	111.66	114.50	114.50	115.29	0.015793	7.11	61.30	39.14	1.00
River 2	3210.45	10yr	594.40	111.66	114.89	114.89	115.81	0.015309	7.72	76.99	42.40	1.01
River 2	3210.45	25 yr	737.30	111.66	115.20	115.20	116.23	0.014793	8.11	90.90	45.27	1.01
River 2	3210.45	50 yr	922.90	111.66	115.56	115.56	116.71	0.014306	8.58	107.54	47.92	1.01
River 2	3210.45	100 yr	1042.80	111.66	115.79	115.79	116.99	0.013780	8.78	118.77	49.69	1.00
River 2	2422.36	2 yr	435.90	108.51	110.50	109.46	110.53	0.000818	1.50	290.01	210.43	0.23
River 2	2422.36	10yr	594.40	108.51	110.96	109.61	111.00	0.000631	1.51	392.60	231.85	0.21
River 2	2422.36	25 yr	737.30	108.51	112.36	109.73	112.37	0.000158	0.96	770.53	320.00	0.11
River 2	2422.36	50 yr	922.90	108.51	113.00	109.87	113.02	0.000114	0.94	977.81	324.27	0.10
River 2	2422.36	100 yr	1042.80	108.51	113.43	109.96	113.45	0.000095	0.93	1117.68	327.11	0.09
River 2	2031.65	2 yr	435.90	108.00	110.26		110.29	0.000679	1.29	337.03	266.26	0.20
River 2	2031.65	10yr	594.40	108.00	110.81		110.83	0.000400	1.22	487.83	283.41	0.16
River 2	2031.65	25 yr	737.30	108.00	112.32		112.32	0.000129	0.68	1086.30	649.69	0.09
River 2	2031.65	50 yr	922.90	108.00	112.98		112.99	0.000067	0.61	1517.87	652.65	0.07
River 2	2031.65	100 yr	1042.80	108.00	113.42		113.42	0.000048	0.58	1802.99	654.59	0.06
River 2	1757.69	2 yr	435.90	106.36	110.19		110.20	0.000161	0.89	487.49	227.12	0.11
River 2	1757.69	10yr	594.40	106.36	110.75		110.77	0.000142	0.96	617.59	234.25	0.10
River 2	1757.69	25 yr	737.30	106.36	112.29		112.30	0.000076	0.72	1029.70	382.16	0.08
River 2	1757.69	50 yr	922.90	106.36	112.96		112.97	0.000058	0.72	1287.34	385.79	0.07
River 2	1757.69	100 yr	1042.80	106.36	113.40		113.41	0.000049	0.72	1457.33	388.16	0.07
River 2	1429.43	2 yr	518.70	107.48	109.68		109.96	0.007914	4.18	124.07	105.45	0.68
River 2	1429.43	10yr	707.30	107.48	110.38		110.58	0.003168	3.58	197.84	106.18	0.46
River 2	1429.43	25 yr	877.20	107.48	112.15		112.21	0.001005	1.99	440.04	239.90	0.26
River 2	1429.43	50 yr	1098.10	107.48	112.86		112.91	0.000535	1.80	609.99	240.16	0.20
River 2	1429.43	100 yr	1240.80	107.48	113.31		113.36	0.000397	1.73	719.08	240.33	0.18
River 2	912.75	2 yr	518.70	103.64	108.28		108.36	0.000864	2.34	221.26	84.93	0.26
River 2	912.75	10yr	707.30	103.64	109.76		109.82	0.000425	1.93	367.01	111.16	0.19
River 2	912.75	25 yr	877.20	103.64	111.89		111.91	0.000192	1.16	757.84	272.67	0.12
River 2	912.75	50 yr	1098.10	103.64	112.69		112.71	0.000136	1.12	983.31	287.05	0.11
River 2	912.75	100 yr	1240.80	103.64	113.18		113.20	0.000113	1.10	1124.52	289.32	0.10
River 2	603.53	2 yr	518.70	97.00	108.33		108.33	0.000006	0.38	1361.62	183.55	0.02
River 2	603.53	10yr	707.30	97.00	109.80		109.80	0.000007	0.43	1636.19	191.66	0.03
River 2	603.53	25 yr	877.20	97.00	111.89		111.90	0.000008	0.41	2152.88	313.43	0.03
River 2	603.53	50 yr	1098.10	97.00	112.70		112.70	0.000008	0.46	2405.54	315.68	0.03
River 2	603.53	100 yr	1240.80	97.00	113.19		113.19	0.000009	0.48	2560.37	317.05	0.03
River 2	463.85	2 yr	518.70	95.51	108.33		108.33	0.000001	0.14	3598.84	494.73	0.01
River 2	463.85	10yr	707.30	95.51	109.80		109.80	0.000001	0.16	4329.52	501.42	0.01
River 2	463.85	25 yr	877.20	95.51	111.89		111.89	0.000001	0.16	5433.35	551.16	0.01
River 2	463.85	50 yr	1098.10	95.51	112.70		112.70	0.000001	0.19	5877.62	554.86	0.01
River 2	463.85	100 yr	1240.80	95.51	113.19		113.19	0.000001	0.20	6149.88	557.24	0.01
River 2	218.37	2 yr	518.70	100.00	108.30	102.41	108.33	0.000100	1.36	382.20	61.83	0.10
River 2	218.37	10yr	707.30	100.00	109.76	102.86	109.79	0.000100	1.49	475.99	66.56	0.10
River 2	218.37	25 yr	877.20	100.00	111.87	103.21	111.89	0.000100	1.24	706.78	132.01	0.09
River 2	218.37	50 yr	1098.10	100.00	112.67	103.62	112.69	0.000100	1.35	812.20	132.01	0.10
River 2	218.37	100 yr	1240.80	100.00	113.15	103.88	113.18	0.000100	1.42	876.44	132.01	0.10

Section 463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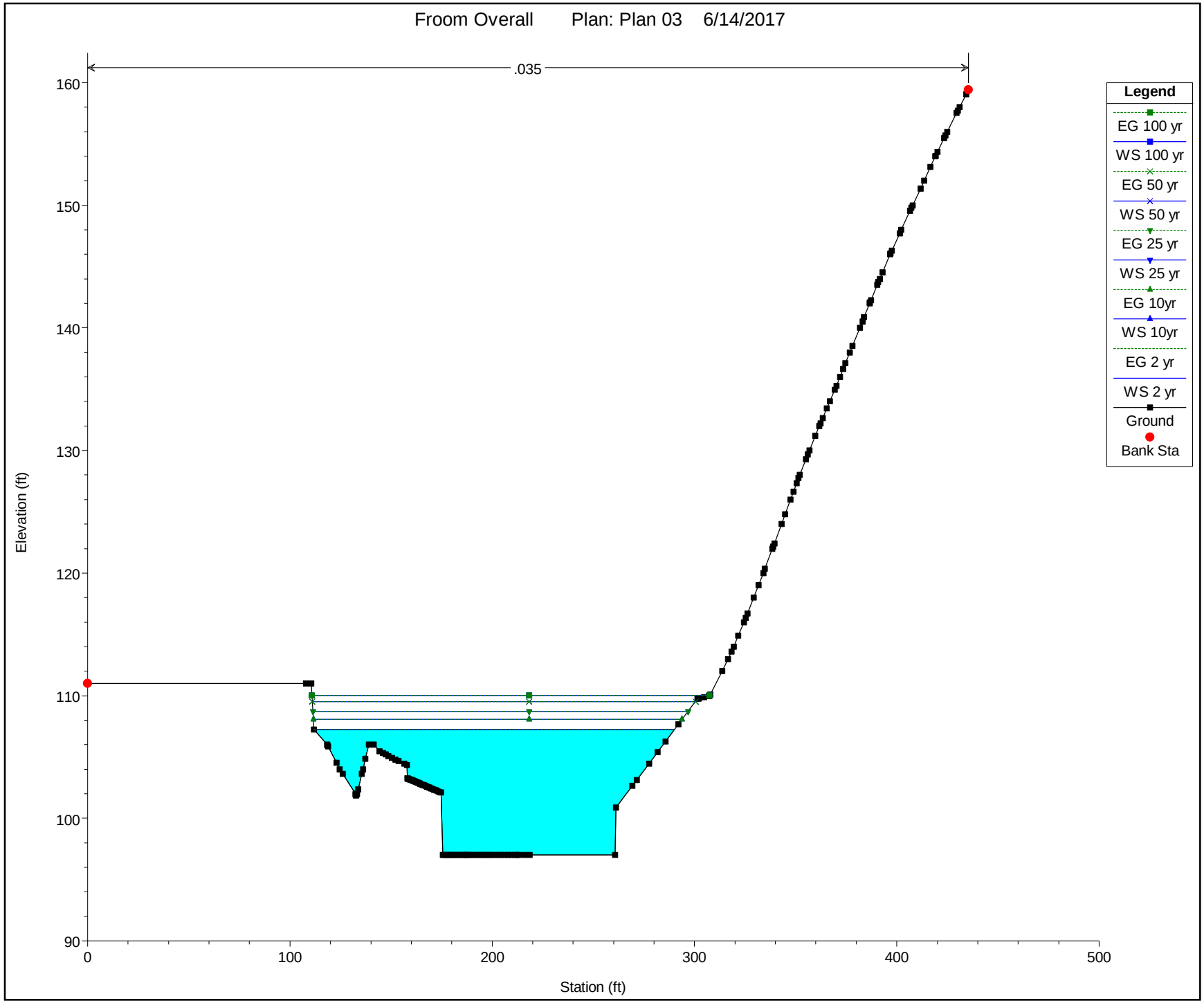
Legend
EG 100 yr
WS 100 yr
EG 50 yr
WS 50 yr
EG 25 yr
WS 25 yr
EG 10yr
WS 10yr
EG 2 yr
WS 2 yr
Ground
Bank Sta
Elevation (ft)
130
125
120
115
110
105
100
95
0
100
200
300
400
500
600
700
Station (ft)

Section 603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.035
Legend
EG 100 yr
WS 100 yr
EG 50 yr
WS 50 yr
EG 25 yr
WS 25 yr
EG 10yr
WS 10yr
EG 2 yr
WS 2 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
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150
140
130
120
110
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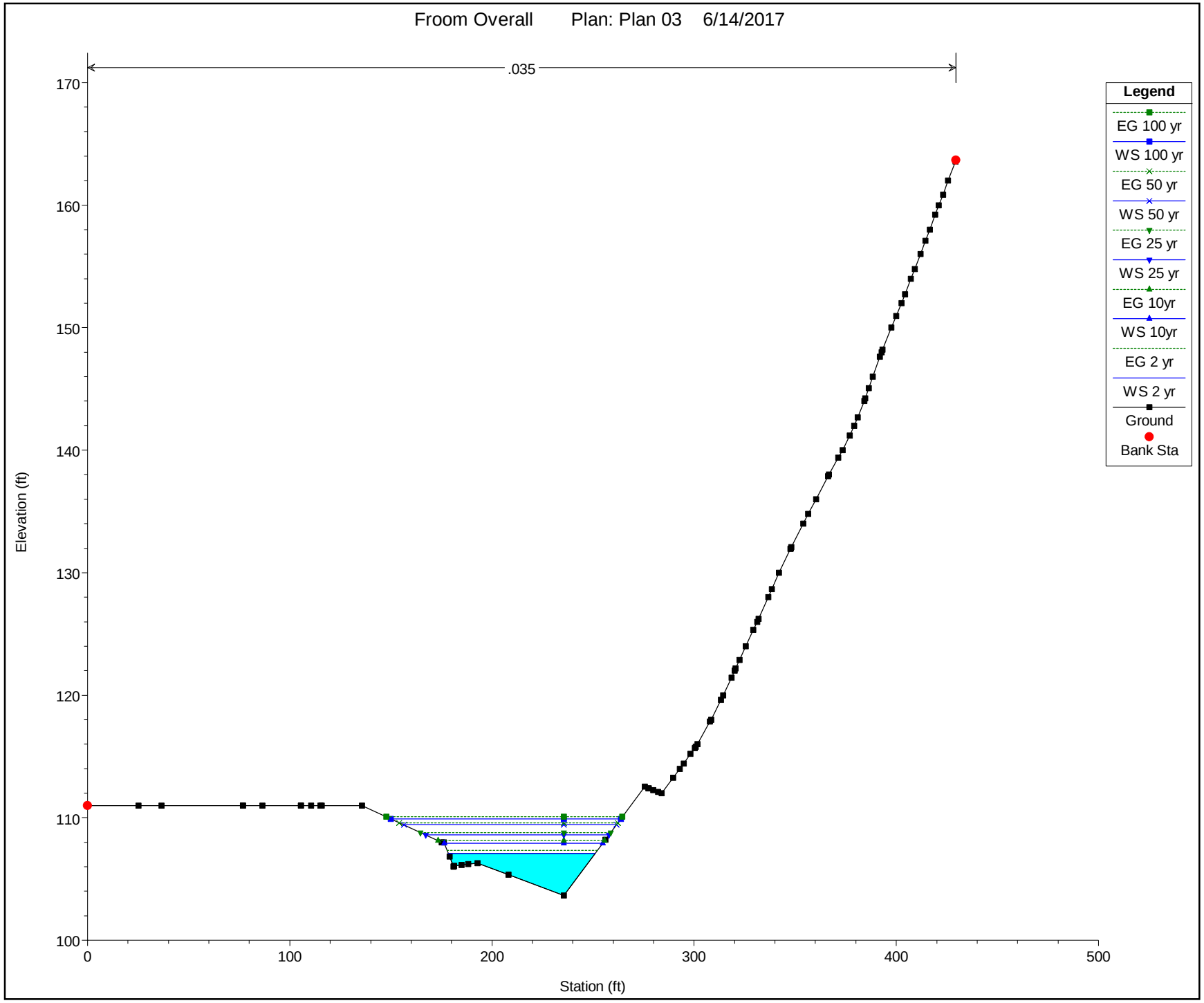
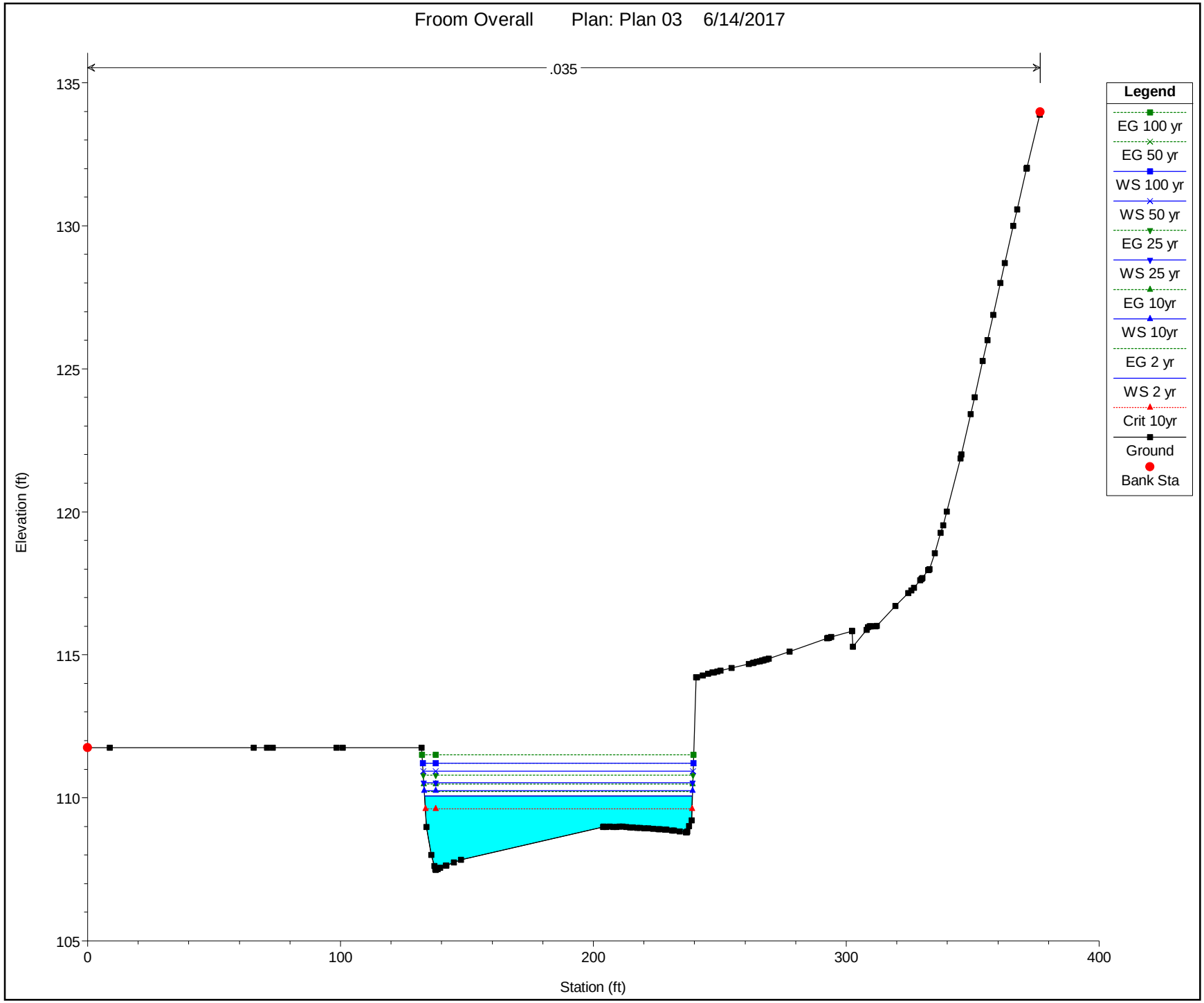
90
0
100
200
300
400
500

Section 912


Froom Overall Plan: Plan 03 6/14/2017
.035
Legend
EG 100 yr
WS 100 yr
EG 50 yr
WS 50 yr
EG 25 yr
WS 25 yr
EG 10yr
WS 10yr
EG 2 yr
WS 2 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
170
160
150
140
130
120
110
100
0
100
200
300
400
500

Section 1429



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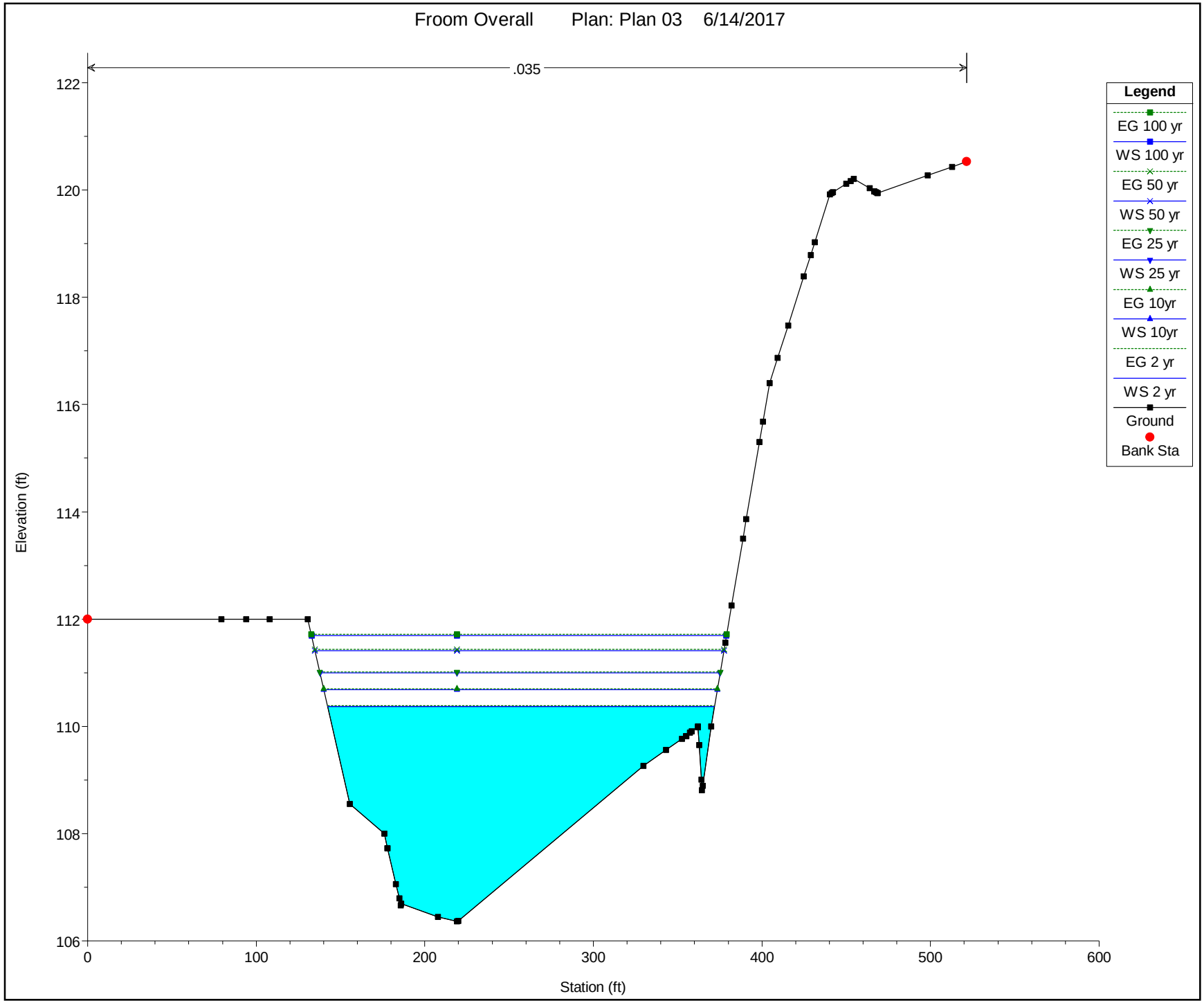

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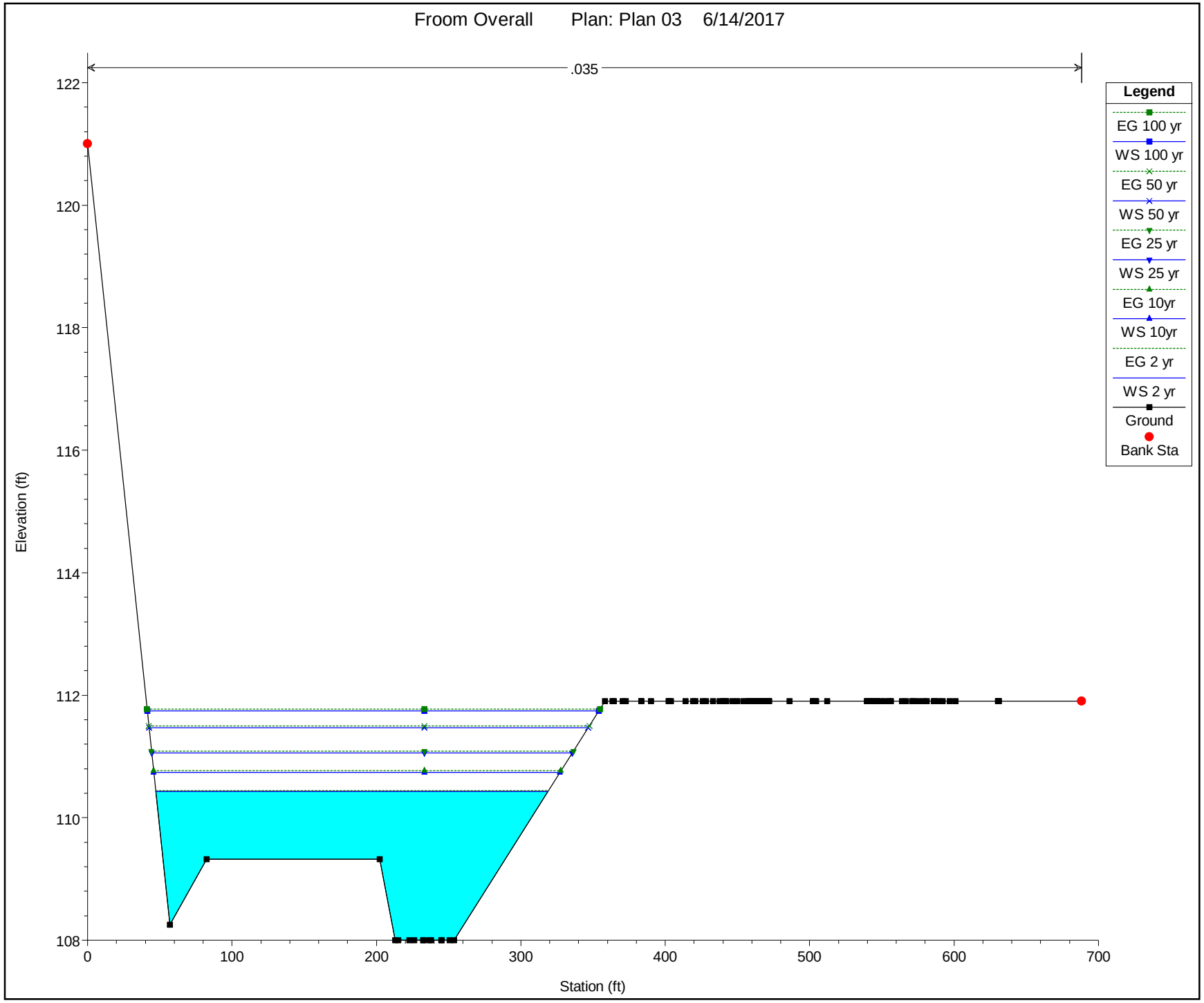

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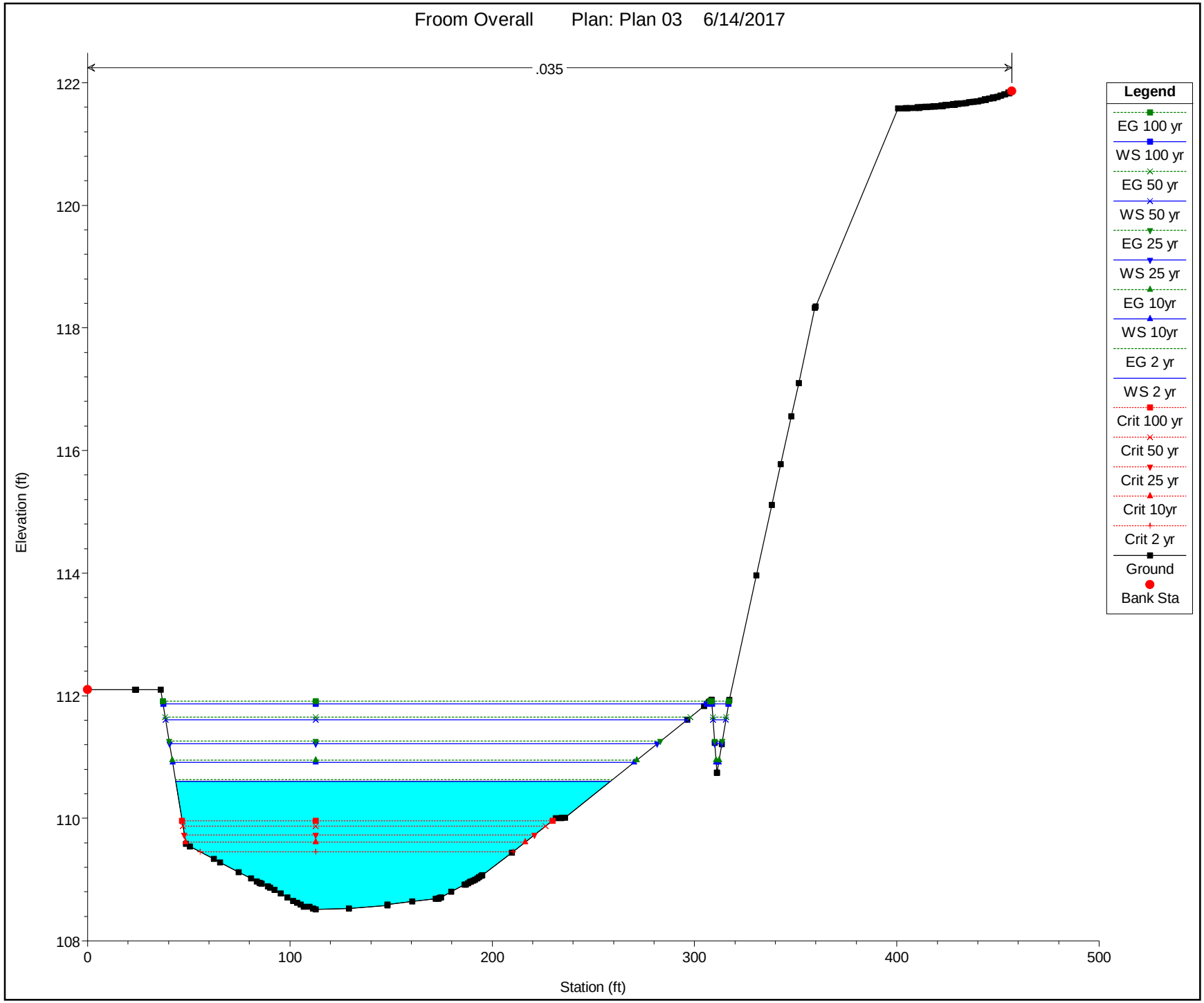

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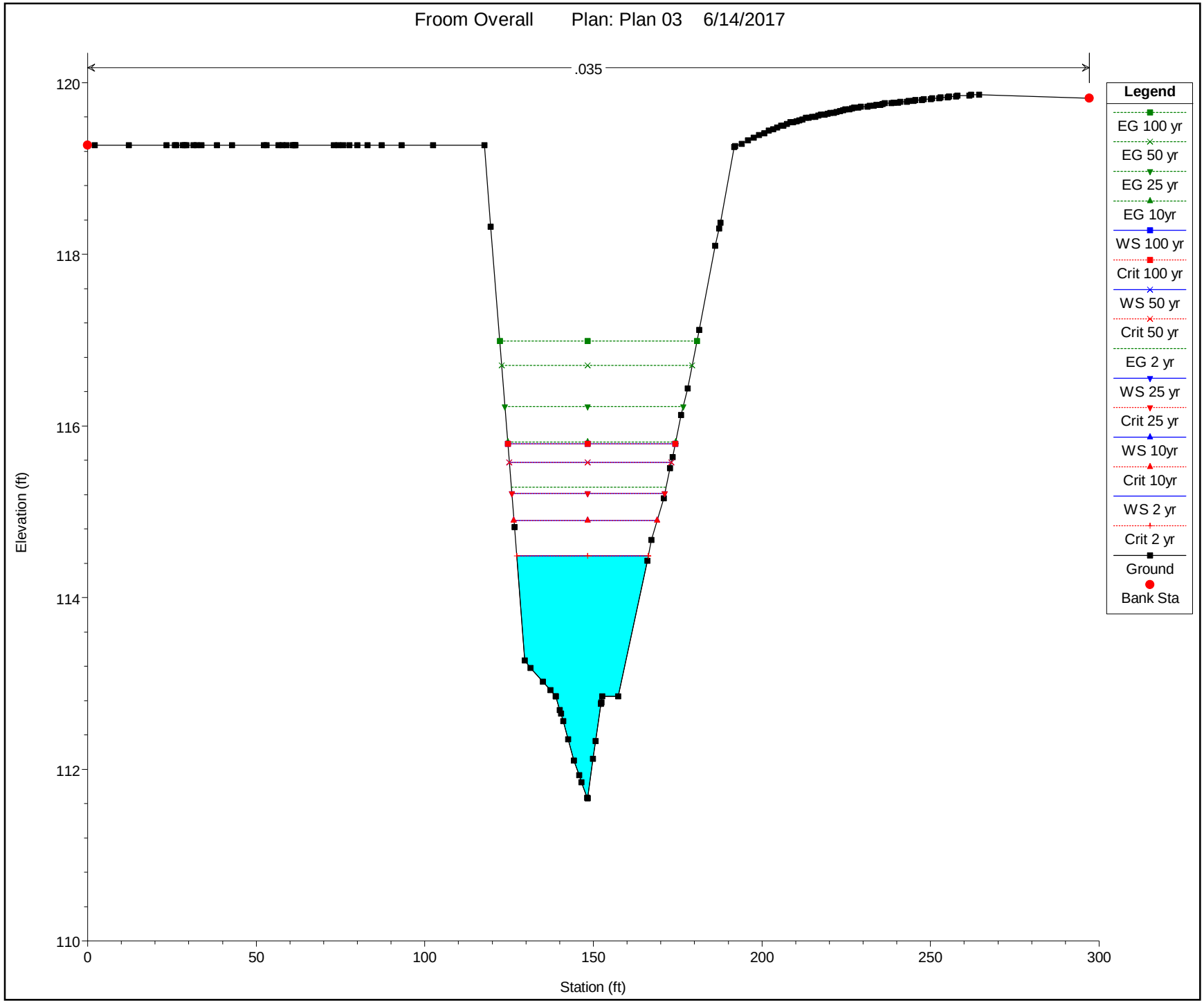

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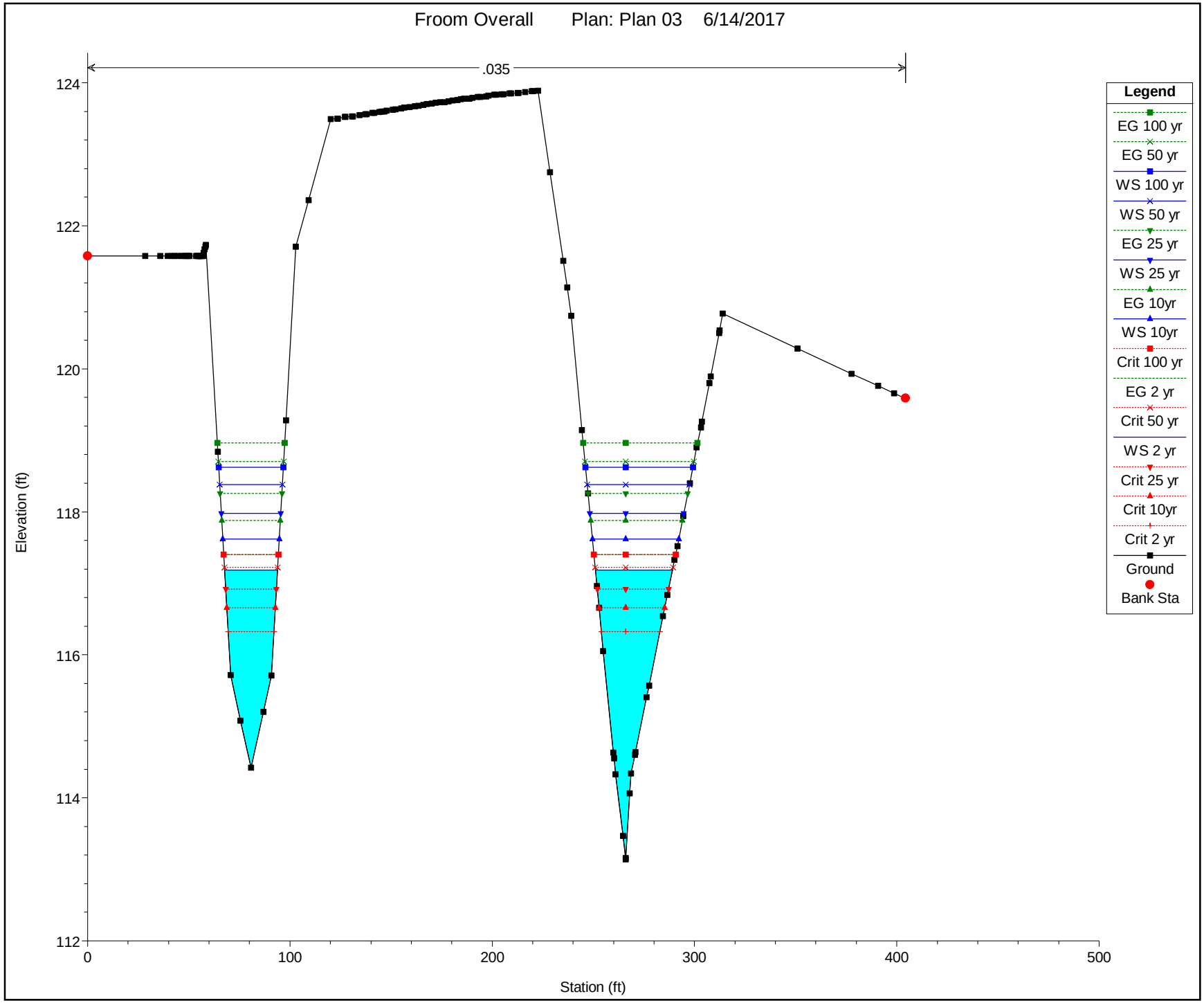

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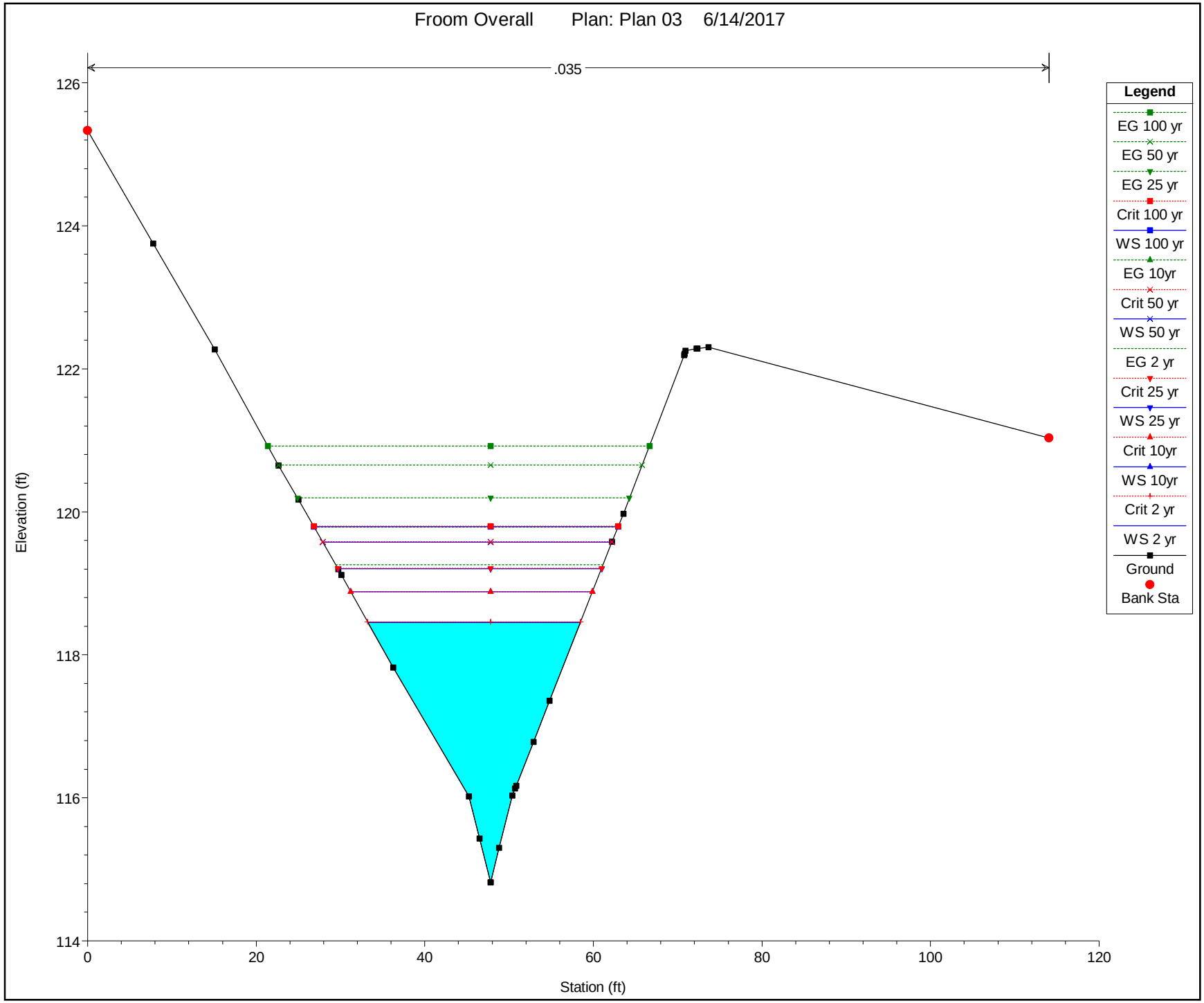

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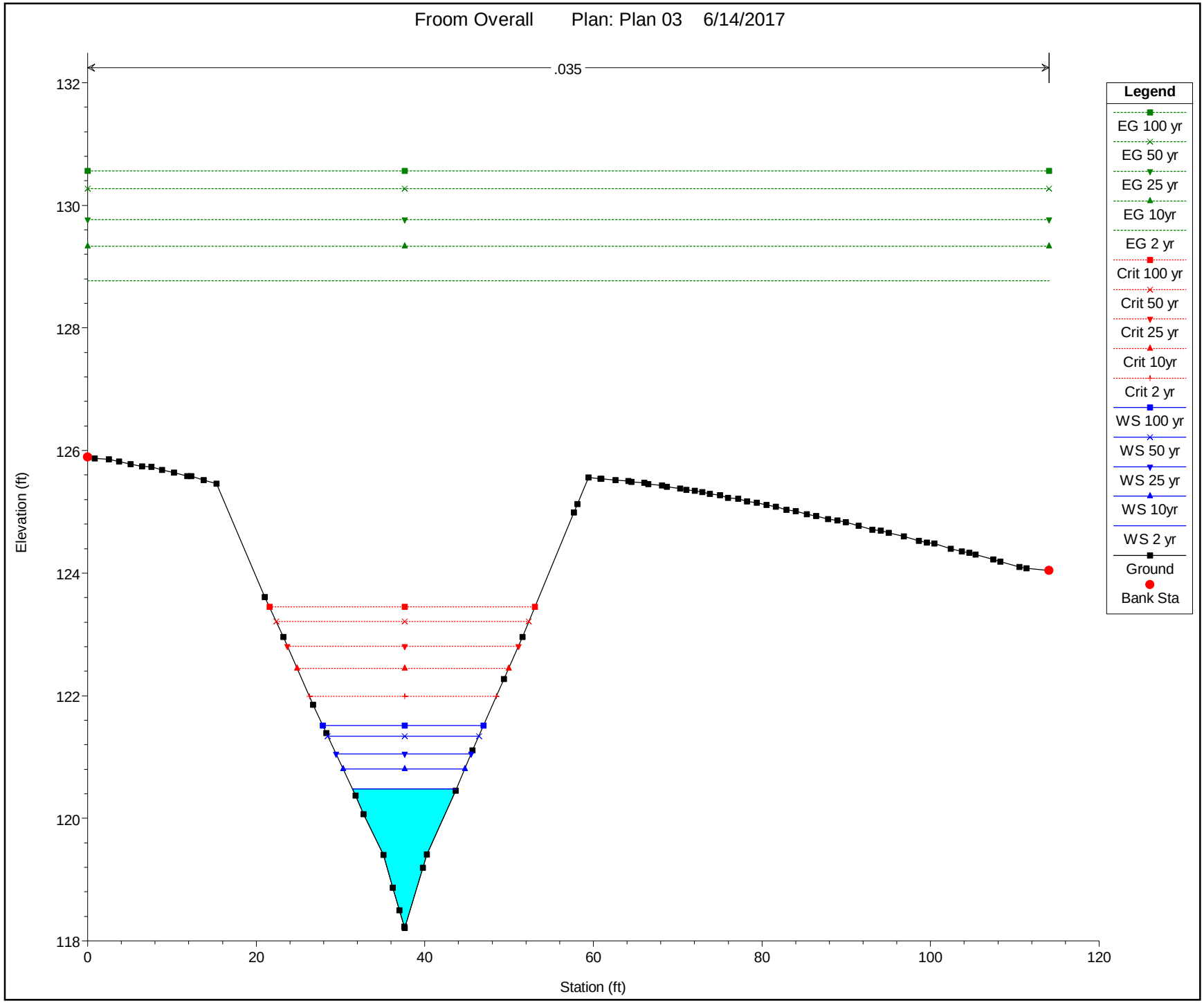

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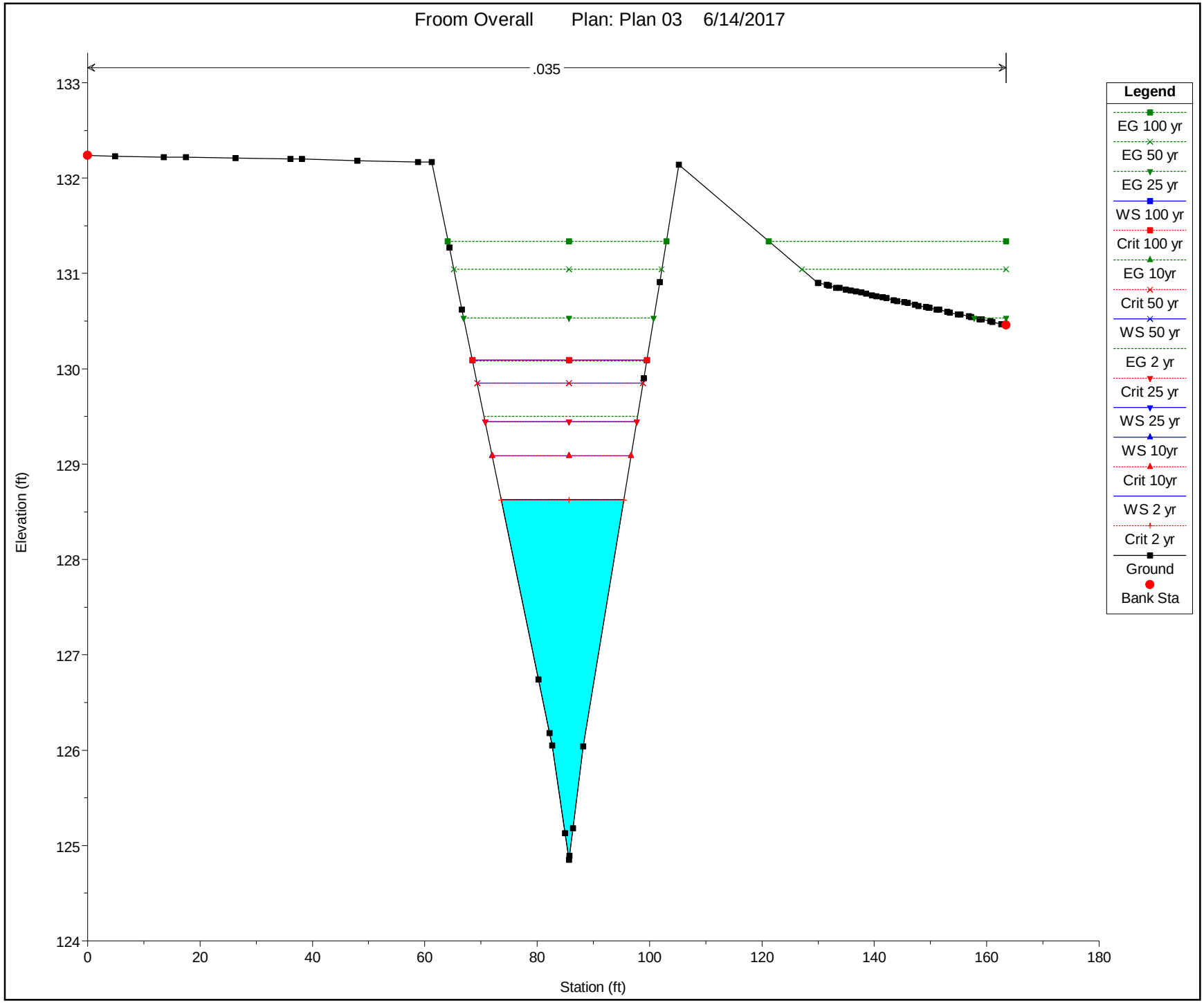


Appendix 2

Existing Tributary Area

WATERSHED INDEX #5
[FROOM CREEK UPPER]
(574.0 ac)

WATERSHED INDEX #1
[COSTCO HILL]
(108.0 ac)

WATERSHED INDEX #8
[HOME DEPOT + COSTCO]
(30.3 ac)

WATERSHED INDEX #9
[IRISH HILLS]
(15.2 ac)

WATERSHED INDEX #7 [PRE-DEV] — SHEET FLOW
[FROOM CREEK REALIGNMENT]
(TOTAL DRAINAGE AREA = 761.2 ac)

WATERSHED INDEX #4
[FROOM CREEK TOP]
(204.2 ac)

WATERSHED INDEX #6
[FROOM DEVELOPMENT]
(33.5 ac)

WATERSHED INDEX #7 [POST-DEV] — CHANNEL FLOW
[FROOM CREEK REALIGNMENT]
(TOTAL DRAINAGE AREA = 761.2 ac)

WATERSHED INDEX #3
[FROOM CREEK LOWER]
(150.0 ac)

WATERSHED INDEX #2
[DOUBLE BOX CULVERT]
(TOTAL DRAINAGE AREA = 971.5 ac)

WATERSHED INDEX #13
[SLO CREEK + FROOM CONFLUENCE]
(TOTAL DRAINAGE AREA = 27,152 ac)

EXISTING SAN LUIS OBISPO
CREEK DRAINAGE

WATERSHED INDEX #11
[MOUNTAINBROOK]
(60.0 ac)

WATERSHED INDEX #10
[Mid SLO Creek]
(670.0 ac)

WATERSHED INDEX #12
[SLO CREEK + EAST BRANCH CONFLUENCE]
(TOTAL DRAINAGE AREA = 35,629 ac)

N:\2014\10140\24-Froom Ranch-SP&EIR\Engineering\Hydro\CAD Exhibits\Watershed Analysis_100418.dwg, 10/19/16 (2), Jan 14, 2019 3:51pm, rgrundfest

Froom Ranch

WATERSHED ANALYSIS

0 250' 500' 1000'
SCALE: 1" = 500'

Exhibit
January 18, 2019

rrm design group

Appendix 3

Proposed Peak Flow Tabulation

Summary of pre-development and post development Curve Numbers

Index	Element Name	[Pre] CN	[Post] CN	Comments
1	Costco Hill	69.3	69.3	The CN is derived from the existing SLO HEC-HMS Hydrology Model
2	Double Box @ Hwy101	-	-	The junction elements in the HEC-HMS model do not have associated CN
3	Froom Creek (Lower)	69.3	82.67	Post development curve number calculated by weighted area development versus landscape
4	Froom Creek (Top)	69.3	69.3	The CN is derived from the existing SLO HEC-HMS Hydrology Model
5	Froom Creek (Upper)	69.3	69.3	The CN is derived from the existing SLO HEC-HMS Hydrology Model
6	Froom Development	69.3	90	Post development curve number calculated by weighted area development versus landscape
7	Froom Realignment	-	-	The junction elements in the HEC-HMS model do not have associated CN
8	Home Depot + Costco	93	93	This curve number is a similar development to the Irish Hills development and thus equal CN
9	Irish Hills	93	93	The CN is derived from the Irish Hills HEC-HMS model and report
10	Mid SLO Creek	69.3	69.3	The CN is derived from the existing SLO HEC-HMS Hydrology Model
11	Mountainbrook	69.3	69.3	The CN is derived from the existing SLO HEC-HMS Hydrology Model
12	SLO @ E Br ST 10177	-	-	The junction elements in the HEC-HMS model do not have associated CN
13	SLO @ Froom ST 11897	-	-	The junction elements in the HEC-HMS model do not have associated CN
14	SLO-Prefumo to E Fk	-	-	The junction elements in the HEC-HMS model do not have associated CN

Froom development hydrologic summary of modeled elements [2-yr event]

Index	Element Name	[Pre] Drainage Area (ac)	[Post] Drainage Area (ac)	[Pre] Peak Discharge (cfs)	[Post] Peak Discharge (cfs)	[Pre] Time of Peak	[Post] Time of Peak	[Pre] Volume (ac-ft)	[Post] Volume (ac-ft)	CFS % Change
1	Costco Hill	108.00	108.00	29.73	29.73	12:35	12:35	14.09	14.09	0.00%
2	Double Box @ Hwy101	1175.67	1175.67	276.27	283.15	13:10	12:45	190.09	197.64	2.49%
3	Froom Creek (Lower)	150.02	150.02	51.35	76.78	12:20	12:20	30.13	36.25	49.53%
4	Froom Creek (Top)	204.20	204.20	38.28	38.28	13:55	13:55	33.69	33.69	0.00%
5	Froom Creek (Upper)	574.00	574.00	163.66	163.66	12:20	12:20	65.29	65.29	0.00%
6	Froom Development	33.56	33.56	18.47	29.04	12:20	12:20	20.45	22.91	57.20%
7	Froom Realignment	965.34	965.34	237.15	272.43	13:15	12:25	150.73	155.36	14.88%
8	Home Depot + Costco	30.36	30.36	20.01	20.01	12:35	12:35	10.48	10.48	0.00%
9	Irish Hills	15.23	15.23	15.86	15.86	12:15	12:15	9.05	9.05	0.00%
10	Mid SLO Creek	670.02	670.02	221.23	221.23	12:20	12:20	78.30	78.30	0.00%
11	Mountainbrook	60.31	60.31	21.19	21.19	12:20	12:20	9.56	9.56	0.00%
12	SLO @ E Br ST 10177	35833.33	35833.33	6875.06	6876.80	14:25	14:25	4139.20	4144.87	0.03%
13	SLO @ Froom ST 11897	27356.59	27356.59	5803.82	5807.94	14:05	14:05	3216.10	3223.65	0.07%
14	SLO-Prefumo to E Fk	27356.59	27356.59	5649.87	5651.61	14:25	14:25	3162.20	3167.87	0.03%

Froom development hydrologic summary of modeled elements [10-yr event]

Index	Element Name	[Pre] Drainage Area (ac)	[Post] Drainage Area (ac)	[Pre] Peak Discharge (cfs)	[Post] Peak Discharge (cfs)	[Pre] Time of Peak	[Post] Time of Peak	[Pre] Volume (ac-ft)	[Post] Volume (ac-ft)	CFS % Change
1	Costco Hill	108.00	108.00	59.06	59.06	12:35	12:35	22.13	22.13	0.00%
2	Double Box @ Hwy101	1175.67	1175.67	507.92	507.33	13:25	12:50	275.28	286.96	-0.12%
3	Froom Creek (Lower)	150.02	150.02	101.56	143.38	12:20	12:20	40.95	49.94	41.18%
4	Froom Creek (Top)	204.20	204.20	72.18	72.18	13:50	13:50	48.03	48.03	0.00%
5	Froom Creek (Upper)	574.00	574.00	347.76	347.76	12:20	12:20	106.66	106.66	0.00%
6	Froom Development	33.56	33.56	29.70	45.49	12:20	12:20	22.87	26.29	53.14%
7	Froom Realignment	965.34	965.34	462.10	531.01	13:15	12:25	220.88	227.32	14.91%
8	Home Depot + Costco	30.36	30.36	31.98	31.98	12:30	12:30	13.72	13.72	0.00%
9	Irish Hills	15.23	15.23	23.68	23.68	12:15	12:15	10.69	10.69	0.00%
10	Mid SLO Creek	670.02	670.02	448.35	448.35	12:20	12:20	127.83	127.83	0.00%
11	Mountainbrook	60.31	60.31	41.64	41.64	12:20	12:20	14.02	14.02	0.00%
12	SLO @ E Br ST 10177	35833.33	35833.33	14669.32	14604.66	13:50	13:50	7007.97	7018.09	-0.44%
13	SLO @ Froom ST 11897	27356.59	27356.59	12208.55	12154.05	13:40	13:40	5448.90	5460.57	-0.45%
14	SLO-Prefumo to E Fk	27356.59	27356.59	11998.17	11957.38	13:55	13:55	5387.57	5397.69	-0.34%

Froom development hydrologic summary of modeled elements [25-yr event]

Index	Element Name	[Pre] Drainage Area (ac)	[Post] Drainage Area (ac)	[Pre] Peak Discharge (cfs)	[Post] Peak Discharge (cfs)	[Pre] Time of Peak	[Post] Time of Peak	[Pre] Volume (ac-ft)	[Post] Volume (ac-ft)	CFS % Change
1	Costco Hill	108.00	108.00	79.46	79.46	12:35	12:35	29.60	29.60	0.00%
2	Double Box @ Hwy101	1175.67	1175.67	618.59	721.56	13:35	12:45	354.89	369.24	16.65%
3	Froom Creek (Lower)	150.02	150.02	137.10	184.24	12:20	12:20	51.18	62.14	34.38%
4	Froom Creek (Top)	204.20	204.20	97.90	97.90	13:45	13:45	61.42	61.42	0.00%
5	Froom Creek (Upper)	574.00	574.00	479.27	479.27	12:20	12:20	145.73	145.73	0.00%
6	Froom Development	33.56	33.56	37.65	54.64	12:20	12:15	25.16	29.21	45.13%
7	Froom Realignment	965.34	965.34	623.27	712.16	13:15	12:25	285.96	294.21	14.26%
8	Home Depot + Costco	30.36	30.36	38.07	38.07	12:30	12:30	16.44	16.44	0.00%
9	Irish Hills	15.23	15.23	27.49	27.49	12:15	12:15	12.07	12.07	0.00%
10	Mid SLO Creek	670.02	670.02	604.34	604.34	12:20	12:20	174.13	174.13	0.00%
11	Mountainbrook	60.31	60.31	55.68	55.68	12:20	12:20	18.19	18.19	0.00%
12	SLO @ E Br ST 10177	35833.33	35833.33	19834.18	19790.58	13:45	13:45	9381.03	9394.05	-0.22%
13	SLO @ Froom ST 11897	27356.59	27356.59	16351.58	16313.91	13:35	13:35	7238.20	7252.55	-0.23%
14	SLO-Prefumo to E Fk	27356.59	27356.59	16132.18	16095.44	13:50	13:50	7167.09	7180.12	-0.23%

Froom development hydrologic summary of modeled elements [50-yr event]

Index	Element Name	[Pre] Drainage Area (ac)	[Post] Drainage Area (ac)	[Pre] Peak Discharge (cfs)	[Post] Peak Discharge (cfs)	[Pre] Time of Peak	[Post] Time of Peak	[Pre] Volume (ac-ft)	[Post] Volume (ac-ft)	CFS % Change
1	Costco Hill	108.00	108.00	95.60	95.60	12:35	12:35	35.26	35.26	0.00%
2	Double Box @ Hwy101	1175.67	1175.67	771.27	1029.27	13:30	12:35	414.62	430.78	33.45%
3	Froom Creek (Lower)	150.02	150.02	166.21	216.86	12:20	12:20	58.99	71.17	30.47%
4	Froom Creek (Top)	204.20	204.20	115.11	115.11	13:45	13:45	71.45	71.45	0.00%
5	Froom Creek (Upper)	574.00	574.00	586.26	586.26	12:20	12:20	175.56	175.56	0.00%
6	Froom Development	33.56	33.56	44.17	61.93	12:20	12:15	26.91	31.33	40.22%
7	Froom Realignment	965.34	965.34	747.75	855.40	13:15	12:25	334.75	344.75	14.40%
8	Home Depot + Costco	30.36	30.36	42.76	42.76	12:30	12:30	18.39	18.40	0.00%
9	Irish Hills	15.23	15.23	30.78	30.78	12:15	12:15	13.07	13.07	0.00%
10	Mid SLO Creek	670.02	670.02	732.85	732.85	12:20	12:20	209.35	209.35	0.00%
11	Mountainbrook	60.31	60.31	67.24	67.24	12:20	12:20	21.36	21.36	0.00%
12	SLO @ E Br ST 10177	35833.33	35833.33	24064.02	23926.35	13:40	13:40	11409.09	11424.05	-0.57%
13	SLO @ Froom ST 11897	27356.59	27356.59	20095.68	19938.77	13:30	13:30	8833.34	8849.50	-0.78%
14	SLO-Prefumo to E Fk	27356.59	27356.59	19786.36	19643.42	13:45	13:45	8750.22	8765.18	-0.72%

Froom development hydrologic summary of modeled elements [100-yr event]

Index	Element Name	[Pre] Drainage Area (ac)	[Post] Drainage Area (ac)	[Pre] Peak Discharge (cfs)	[Post] Peak Discharge (cfs)	[Pre] Time of Peak	[Post] Time of Peak	[Pre] Volume (ac-ft)	[Post] Volume (ac-ft)	CFS % Change
1	Costco Hill	108.00	108.00	107.91	107.91	12:35	12:35	36.82	36.82	0.00%
2	Double Box @ Hwy101	1175.67	1175.67	896.79	1230.72	13:25	12:30	431.98	448.37	37.24%
3	Froom Creek (Lower)	150.02	150.02	187.49	243.09	12:20	12:20	61.09	73.57	29.65%
4	Froom Creek (Top)	204.20	204.20	128.84	128.84	13:45	13:45	74.48	74.48	0.00%
5	Froom Creek (Upper)	574.00	574.00	664.08	664.08	12:20	12:20	183.63	183.63	0.00%
6	Froom Development	33.56	33.56	48.92	68.30	12:20	12:15	27.38	31.90	39.60%
7	Froom Realignment	965.34	965.34	840.78	962.40	13:15	12:25	349.07	358.78	14.47%
8	Home Depot + Costco	30.36	30.36	47.53	47.53	12:30	12:30	18.92	18.93	0.00%
9	Irish Hills	15.23	15.23	34.04	34.04	12:15	12:15	13.33	13.33	0.00%
10	Mid SLO Creek	670.02	670.02	829.32	829.32	12:20	12:20	218.84	218.84	0.00%
11	Mountainbrook	60.31	60.31	75.93	75.93	12:20	12:20	22.21	22.21	0.00%
12	SLO @ E Br ST 10177	35833.33	35833.33	27724.58	27523.21	13:35	13:35	12346.63	12361.76	-0.73%
13	SLO @ Froom ST 11897	27356.59	27356.59	23113.25	22872.23	13:25	13:25	9645.16	9661.56	-1.04%
14	SLO-Prefumo to E Fk	27356.59	27356.59	22761.01	22513.37	13:40	13:40	9561.66	9576.79	-1.09%

Appendix 4

Soils Information

GeoSolutions - Soils & Geology, June, 2016

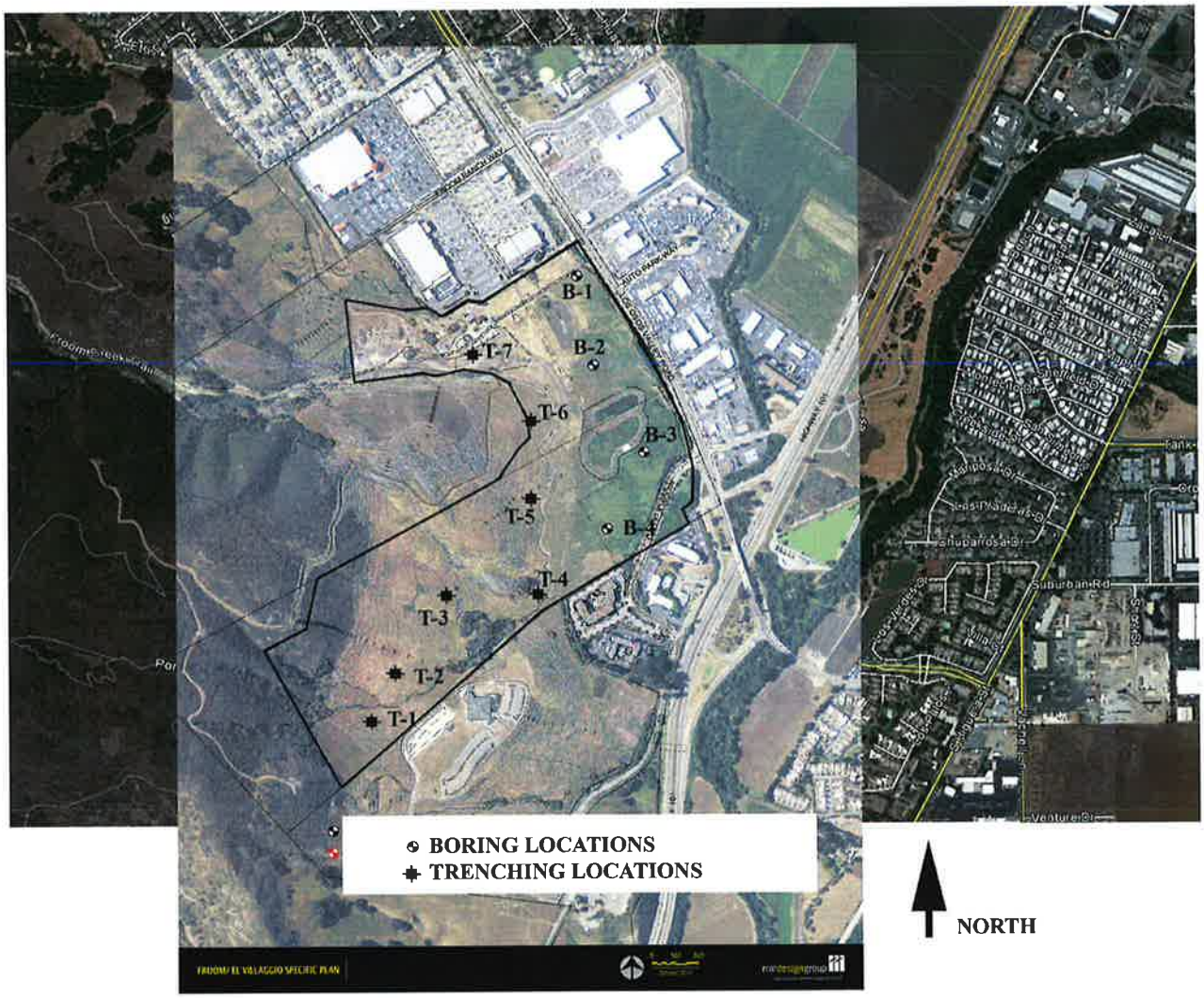


Figure 2: Site Plan

Data gathered during the field investigation suggest that the soil materials at the Site consist of alluvial soil overlying competent formational material. The depth to competent formational material varies across the site, increasing in depth towards Los Osos Valley Road to a maximum depth of approximately 50 feet bgs. The surface material at the Site generally consisted of dark gray to dark grayish brown sandy FAT CLAY (CH) encountered in a soft to stiff and moist to wet condition to termination depth of borings B1-B4, and dark reddish brown sandy CLAY (CL) encountered in a dry to moist condition to an approximate depth of 2.0 to 8.0 feet bgs, underlain by competent formational material in trenches T1-T7.

Regional site geology was obtained by using the *Geologic Map of the Pismo Beach Quadrangle* (Dibblee, 2006) and the MapView internet application (USGS, 2013); the later application is available from the United States Geological Survey website (USGS, 2013) and compiles existing geologic maps. The majority of all underlying material at the Site was interpreted as Surficial Alluvial Sediments alongside/overlying Franciscan Formation and Serpentinite, which will hereafter be referred to as competent formational material. **Shallow ground water was encountered between the depths of 1.5 to 4.0 feet**, although it should be expected that groundwater elevations may vary seasonally and with irrigation practices. See Figure 3: Regional Geologic Map.

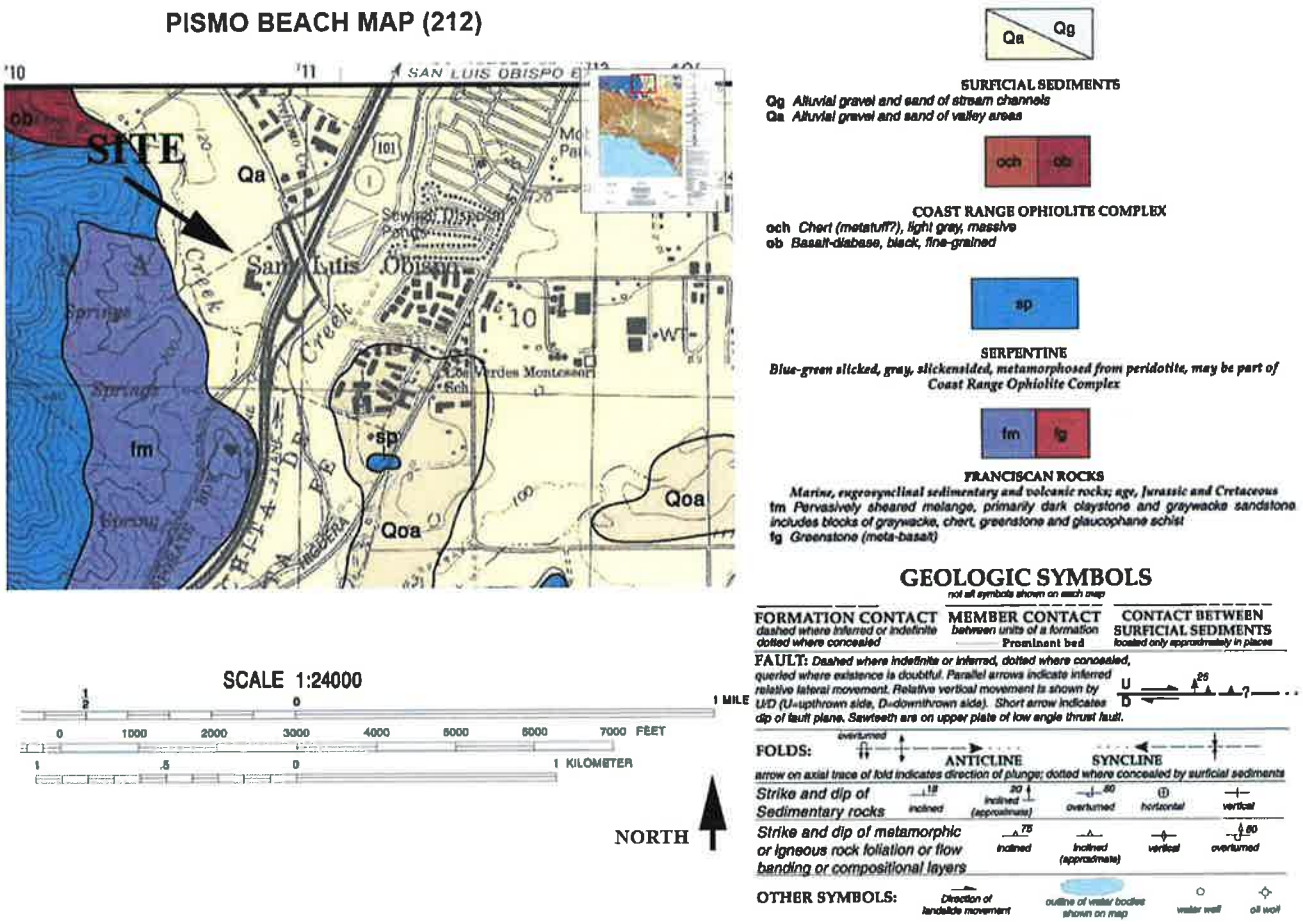


Figure 3: Regional Geologic Map

During the boring operations the soils encountered were continuously examined, visually classified, and sampled for general laboratory testing. A project engineer has reviewed a continuous log of the soils encountered at the time of field investigation. See **Appendix A** for the Boring Logs from the field investigation.

Laboratory tests were performed on soil samples that were obtained from the Site during the field investigation. The results of these tests are listed below in Table 1: Engineering Properties. Laboratory data reports and detailed explanations of the laboratory tests performed during this investigation are provided in **Appendix B**.

Table 1: Engineering Properties

Sample Name	Sample Description	USCS Specification	Expansion Index	Expansion Potential	Angle of Internal Friction, ϕ (deg.)	Cohesion, c (psf)	Plasticity Index	Fines Content (%)	Compression Index, C_C	Recompression Index, C_r
A B-1 @ 1.0'	Very Dark Grayish Brown Sandy FAT CLAY	CH	107	High	-	-	31	79.6	-	-
B B-3 @ 1.0'	Dark Gray FAT CLAY	CH	186	Very High	-	-	48	94.7	-	-
C T-2 @ 2.0'	Dark Reddish Brown Sandy CLAY	CL	79	Medium	-	-	-	-	-	-
B-1 @ 5.0'	Very Dark Grayish Brown Sandy CLAY	CL	-	-	28.7	110	-	-	0.165	0.017

4.0 HYDROLOGIC SOIL GROUP

Based on the Web Soil Survey provided by the Natural Resources Conservation Service, the Site was initially designated as containing Hydrologic Soil Groups C and D. Groups C and D are similar in that they are both comprised of fine-grained and/or nearly impervious material with slow to very slow infiltration rates. The main distinction between the two groups is that Group D soil conditions are less favorable for infiltration of storm water and runoff due to; very slow infiltration rate (high runoff potential), clays with high shrink-swell potential, soils with high water table, and soils that are shallow over nearly impervious material. Based on the sub-surface data obtained during the field investigation and the results of the laboratory testing, it is our opinion that the entire Site is best defined as **Hydrologic Soil Group D**. See Figure 4: Hydrologic Soil Group.

Due to shallow groundwater encountered at an approximate depth of 1.5 to 4.0 bgs during the field investigation, field infiltration testing was not performed. Observed shallow ground water and soil characteristics, including competent formational material encountered at shallow depths, are indicative of slow to very slow infiltration rate and are in support of the prescribed hydrologic soil group.

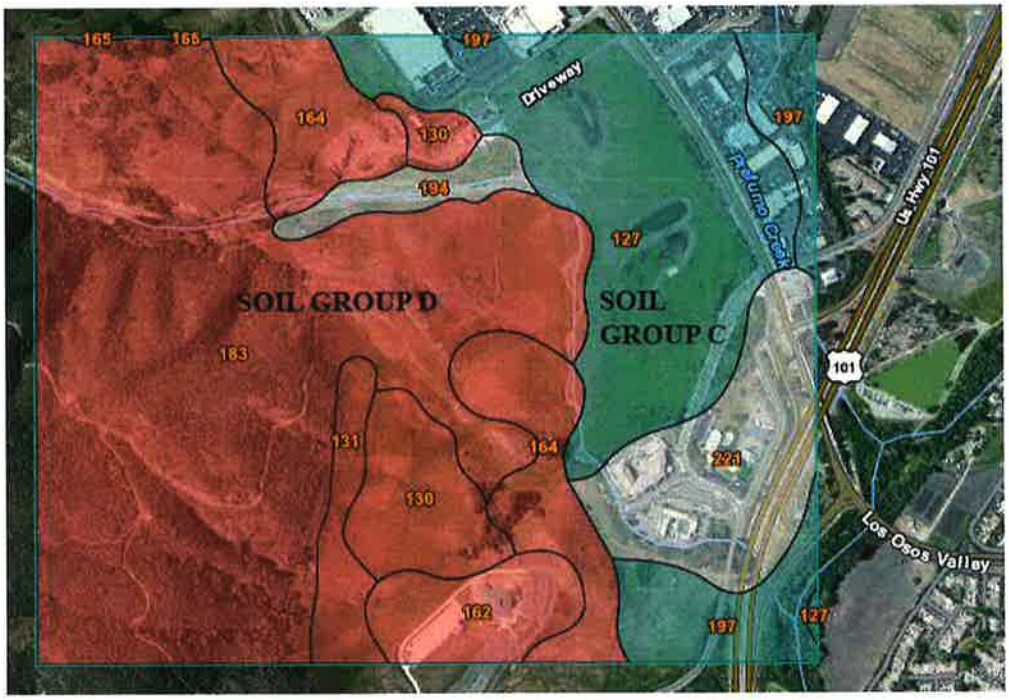


Figure 4: Hydrologic Soil Group

5.0 SEISMIC DESIGN CONSIDERATIONS

4.1 Seismic Hazard Analysis

1. According to section 1613 of the 2013 CBC (CBSC, 2013), all structures and portions of structures should be designed to resist the effects of seismic loadings caused by earthquake ground motions in accordance with the *Minimum Design Loads for Buildings and Other Structures* (ASCE7) (ASCE, 2010). ASCE7 considers the most severe earthquake ground motion to be the ground motion caused by the Maximum Considered Earthquake (MCE) (ASCE, 2010), which is defined in Section 1613 of the 2013 CBC to be short period S_{MS} and 1-second period S_{M1}, spectral response accelerations.

2. The a_{max} of the Site depends on several factors, which include the distance of the Site from known active faults, the expected magnitude of the MCE, and the Site soil profile characteristics.

3. As per section 1613.3.2 of the 2013 CBC (CBSC, 2013), the Site soil profile classification is determined by the average soil properties in the upper 100 feet of the Site profile

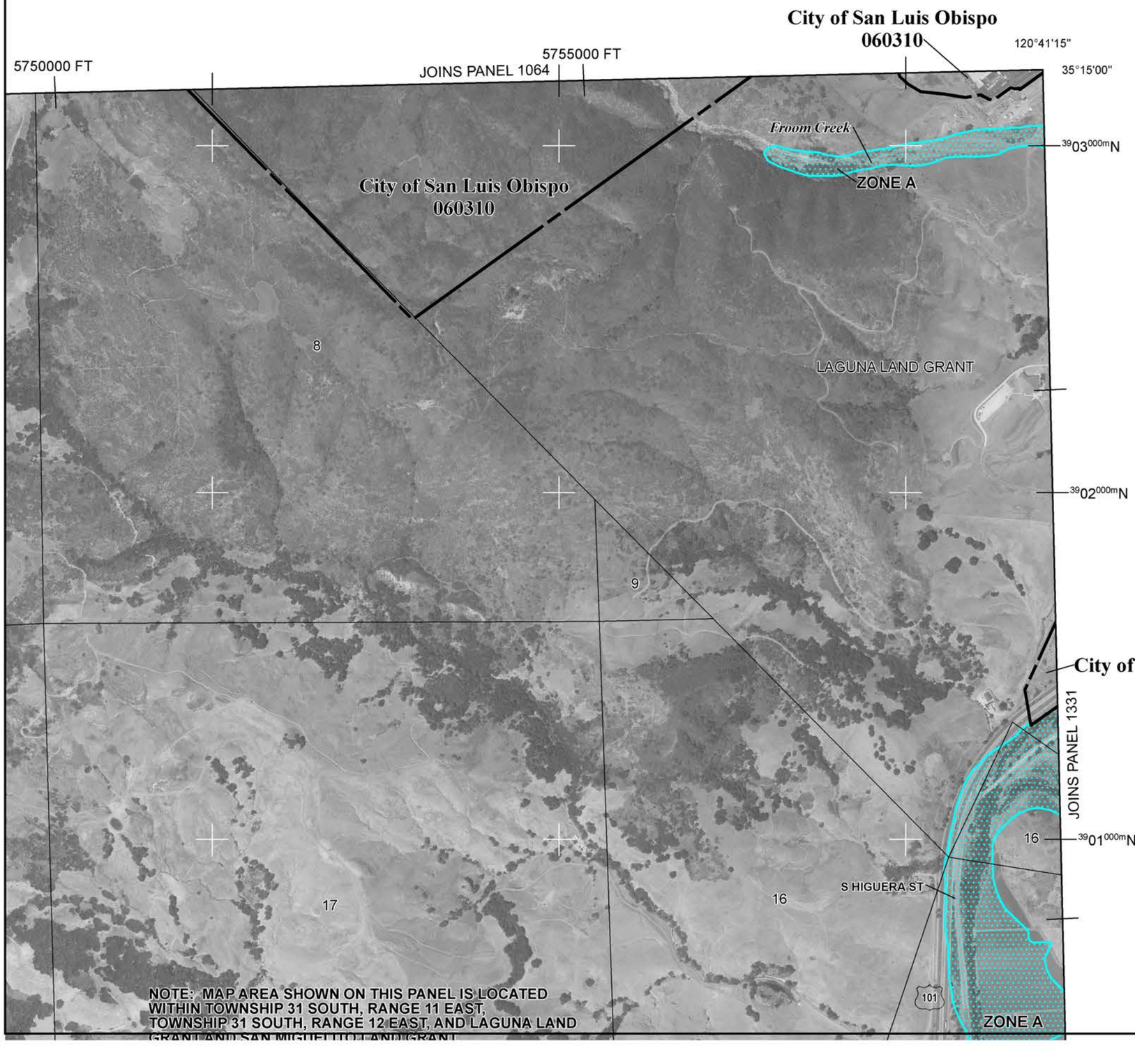
Appendix 5

FIRM Maps

ance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'

0 500 1,000 1,500 2,000 FEET



NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 1330G

FIRM

FLOOD INSURANCE RATE MAP

SAN LUIS OBISPO COUNTY, CALIFORNIA AND INCORPORATED AREAS

PANEL 1330 OF 2050

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
SAN LUIS OBISPO COUNTY	060304	1330	G
SAN LUIS OBISPO, CITY OF	060310	1330	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
06079C1330G

MAP REVISED
NOVEMBER 16, 2012

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

ance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

0 250 500 750 1,000 FEET

120°41'15" 5760000 FT PROFILE BASE LINE JOINS PANEL 1

35°15'00"

City of San Luis Obispo
060310

ZONE A

ZONE AE

Prefumo Creek

LOS OSOS VALLEY RD

CALLE JOAQUIN

Bridge

San Luis Obispo Creek

LAS PRADERAS DR

CHUPARROSA DR

BIRCH MAGNOLIA PINE REDWOOD MAPLE ELM CT MUIRFIELD DR CANTERBURY DR SHEFIELD CREEKSIDE DR SAN SIMEON LONG ST HIND

CARISSA CT MARIPOSA DR CROSS ST

S HIGUERA ST SHORT ST SUBURBA

LINDA LN DEL SOL CT VILLA CT LOS VERDES DR

City of San Luis Obispo
060310

ENCANTO LN LOS PALOS CONTENTA CT PERLA LN VISTA LN LOS PALOS DR VACHELL LN FV0744

2285000 FT

LAGUNA LAND GRANT

San Luis Obispo County
Unincorporated Areas
060304

ZONE A

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 1331G

FIRM

FLOOD INSURANCE RATE MAP

SAN LUIS OBISPO COUNTY, CALIFORNIA AND INCORPORATED AREAS

PANEL 1331 OF 2050

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
SAN LUIS OBISPO COUNTY	060304	1331	G
SAN LUIS OBISPO, CITY OF	060310	1331	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
06079C1331G

MAP REVISED
NOVEMBER 16, 2012

Federal Emergency Management Agency

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Appendix 6

City of San Luis Obispo – Storm Water Control Plan Application

Stormwater Control Plan for Post Construction Requirements

Application Submittal

- *Where directions state "**Done**" that means no additional information or forms below that point needs to be filled out or furnished.*
- *See **Exhibits** for Watershed Management Zones, Basins, & Urban Sustainability Areas*
- *Use "n/a" where information requested is not applicable. If you are unsure regarding how to fill out any of the information, please come in and request assistance from a staff person.*

Project Information

Step 1

Applicant Name:	Tim Walters			
Application No:				
Project Name:	Froom Ranch Specific Plan			
Location Address:	Area northwest of the intersection of Calle Joaquin and Los Osos Valley Road			
Location APN:	067-241-30 & 067-241-31			
Site Zoning:	Residential R-3-SP, & R-4-SP, Commercial CR-SP, Parks P-F-SP and Open Space C/OS-SP			
Project Type: ✓	✓	Commercial		Detached Single Family Residential
		Industrial	✓	Multi-unit Residential
		Mixed Use	✓	Public
Project Phase:	Specific Plan			
Project Description:	Construction of Medium to High Density Residential, a Life Plan Community and Commercial Retail including roads utilities and drainage facilities to serve the project.			
Total Project Site Area =	109.7 acres			

Your project is NOT subject to Post Construction Requirements if…

Step 2

☐ Area (c) of project is < 2,500 square feet – ***Done***

OR

☐ Area (c) of project is ≥ 2,500 square feet, ***and*** is a project type listed below (✓ type) – ***Done***

- ☐ Road & parking surface repair – slurry & fog & crack seal, pothole & spot patching, overlay & resurfacing & other damage repair with no expansion
- ☐ Road & parking shoulder grading
- ☐ Road & parking cleaning, repairing, maintaining, reshaping, regarding drainage systems
- ☐ Sidewalk & bike path / lane project – no other impervious service created and runoff is directed to vegetated area
- ☐ Curb & gutter improvement or replacement – no other impervious created
- ☐ Underground utility project – surface replaced in kind
- ☐ Utility vaults – Ex: lift stations, backflows
- ☐ Fuel storage – above ground with spill containment
- ☐ Photovoltaic systems – on existing impervious surface, over pervious surface with vegetated cover, buffer strip at the most down gradient row of panels
- ☐ Second story – no increase in building footprint
- ☐ Decks & stairs & walkways – raised with space below for drainage
- ☐ Temporary structures – in place less than 6 months

Otherwise, your project is subject to the Post Construction Requirements

Project Site Details

Step 3

Watershed Management Zone:	Zone 1 & Zone 9		
Urban Sustainability Area Name:	N/A		✓ Meet USA Conditions

Areas		
(a)	Total **New** Impervious Surface Area =	38.7 ac
(b)	Total **Replaced** Impervious Surface Area =	0 ac
(c)	Total **Existing** Impervious Area =	0 ac
(d)	Total Impervious Area of **Completed** Project =	38.7 ac
(e)	Net Impervious Area: (a+b) – (c-d) = **OR** where (c-d) is a negative number: (a+b) =	38.7 ac

- *See Area calculations in Step 3 to compare to thresholds in each Step below*
- *Where directions state "**Go To**", fill out and attach the referenced Form and any supporting documents*

Step 4

Project is ≥ 2,500 square feet
☑ Yes - ***Go To*** Requirement 1 – Site Design & Runoff Reduction - Form 1 ***AND THEN*** ***Go To*** Step 5

Step 5

Detached single family residential project where Area (e) is ≥ 15,000 square feet ***OR*** Project where Area (e) ≥ 5,000 square feet
☑ Yes - ***Go To*** Requirement 2 – Water Quality Treatment - Form 2 ***AND THEN*** ***Go To*** Step 6
☐ No - ***Done***

Step 6

Detached single family residential project where Area (e) ≥ 15,000 square feet ***OR*** Project where Area (a+b) ≥ 15,000 square feet ***AND*** is in Watershed Management Zone 4,7,10 over a ground water basin OR in Zone 1,2,5,6,8,9
☑ Yes - ***Go To*** Requirement 3 – Runoff Retention - Form 3 ***AND THEN*** ***Go To*** Step 7
☐ No - ***Done***

Step 7

Project where Area (a+b) ≥ 22,000 square feet ***AND*** is in Watershed Management Zone 1,2,3,6,9
☑ Yes - ***Go To*** Requirement 4 – Peak Management - Form 4
☐ No - ***Done***

Exhibits

1. Watershed Management Zones
2. Groundwater Basin Location
3. Watershed Management Zone Revision Request
4. Urban Sustainability Conditions and Maps of Approved Areas

Requirement 1 – Site Design and Runoff Reduction:

Identify the strategies used to reduce runoff through site design. Strategies 1-5 required.

Describe or attach simple plan details for 1. – 5.

1. Limit disturbance of creeks and natural drainage features and setback development from these features.
   A portion of Froom Creek will be re-routed and the channel size will be increased to reduce velocity and to accommodate 100-year storm flow rates.

2. Minimize compaction of highly permeable soils.
   The site has highly impermeable soils; however a large portion of the property is to remain undeveloped and these portions will not be compacted.

3. Minimize clearing of native vegetation and grading, conserving natural areas and maximizing undisturbed areas, and developing along natural landforms.
   Only a portion of the 109.7 acre site is to be developed. Undeveloped areas will be left undisturbed.

4. Minimize impervious surfaces including roadways and parking lots
   Sidewalk and street widths will be minimized to reduced overall site imperviousness.

5. Do ***one*** of the following: ✓
   - ☐ Direct roof run off into cistern, rain barrel, or vegetated area
   - ☑ Direct driveway and/or parking area into vegetated area
   - ☐ Construct surfaces (bike lanes, walks, driveways, parking areas) with permeable surfaces

Requirement 2 – Water Quality Treatment:

(Reference Post Construction Stormwater Management Requirements for Development Projects in the Central Coast Region – Adopted July 12, 2013 California Regional Water Quality Control Board Central Coast Region – for details regarding requirements – Section B.3 and Section C. Alternative Compliance.)

Treatment

Location ✓ ☑ On Site ☐ Off Site - Alternative Compliance

Measure Used ✓
- ☐ 1. Harvesting, infiltration, evapotranspiration
- ☑ 2. Bio-filtration Treatment *(Document inability to use 1.)*
- ☐ 3. Non-Retention Based Treatment *(Document inability to use 1. or 2.)*

Description of structural controls:

Since soils are poorly suited for infiltration, stormwater will be conveyed to bio-retention areas. Retention areas have been sized to hold the required water quality volume.

Alternative compliance measures:

N/A

Attachments

- *Attach treatment/sizing calculations, including any volume treated with off-site compliance.*
- *Attach construction and planting details and specifications for bio-filtration options*
- *Attach documentation regarding Treatment Measure selection*
- *Attach infeasibility analysis where alternative compliance is proposed.*

Certification

I Tim Walters certify that the systems selected and sized, as demonstrated in the attached calculations, meet the Water Quality Treatment required for this project per the Post Construction Requirements adopted by the Central Coast Regional Water Quality Control Board. Where identified in the attached documentation, Water Quality Treatment will be met through alternative compliance.

Signature Date

Requirement 3 – Runoff Retention:

(Reference Post Construction Stormwater Management Requirements for Development Projects in the Central Coast Region – Adopted July 12, 2013 California Regional Water Quality Control Board Central Coast Region – for details regarding requirements – Section B.4 and Section C. Alternative Compliance.)

- *If a revision to the site's Watershed Management Zone is being requested, attach Watershed Management Revision Request Form (Exhibit) and supporting documentation.*
- *Rainfall maps are available from the Regional Water Quality Control Board*

Site Assessment Measures Summary

☑ Attach documentation of the following information:

- Site topography
- Development envelope
- Hydrologic features including natural areas, wetlands, watercourses, seeps, springs, and required setbacks
- Vegetative cover including trees
- Open space requirements
- Location of groundwater wells used for drinking water
- Depth to seasonal high groundwater
- Soil types and hydrologic soil groups
- Depth to impervious layer such as bedrock
- Presence of unique geology (e.g. karst)
- Geotechnical hazards
- Existing structures, utilities, and drainage infrastructure including municipal storm drain system components
- Existing easements and covenants
- Documented soil or groundwater contamination
- Source and estimated stormwater run-on from offsite, coming to project area
- Drainage Management Areas (B.4.d.iii)
- Drainage management strategies by Drainage Management Area
- Runoff reduction measures and any structural control measures by Drainage Management Area (or full site as appropriate)

☐ Technical infeasibility limits on-site compliance

☐ 10% of equivalent impervious surface area is dedicated to retention based stormwater control measures – No alternative compliance for retention
Runoff volume - compliance not achieved on-site:

☐ Alternative compliance for retention proposed
Runoff volume – compliance not achieved onsite:
Runoff volume – alternative compliance used:

Analysis and Sizing

☑ Attach calculated Tributary Areas and Design Volumes per the Post Construction Stormwater Management Requirements – Attachment D

☐ Adjustment made for redevelopment

☐ Adjustment made for being in, and meeting requirements of, an Urban Sustainability Area

Control Mechanism

Site in Zone 1, 4, 7, and/or 10 and over groundwater basin

☑ 95th percentile event retained via infiltration

☐ Finding of technical infeasibility

Site in Zone 2

☐ 95th percentile event retained via storage, harvesting, infiltration, and/or evapotranspiration
☐ Finding of technical infeasibility – Structural Stormwater Measure proposed

Site in Zone 5 and/or 8

☐ 85th percentile event retained via infiltration
☐ Finding of technical infeasibility – Structural Stormwater Measure proposed

Site in Zone 6 and/or 9

☑ 85th percentile event retained via storage, harvesting, infiltration, and/or evapotranspiration
☐ Finding of technical infeasibility – Structural Stormwater Measure proposed

Attachments

- *Attach Attachment D calculations for hydrologic analysis and stormwater control measure sizing*
- *Attach discussion of technical infeasibility for structural stormwater measure, where proposed in lieu of preferred storage, harvesting, infiltration, and/or evapotranspiration, include justification for any non-retention based controls*
- *Attach documentation of technical infeasibility for on-site compliance, including a site specific hydrologic and/or design analysis supporting findings*
- *Attach description of alternative compliance project including a summary description of pollutant and flow reduction comparing the expected aggregate results of the alternate project to the results that would otherwise have been achieved by meeting the numeric performance requirements onsite.*
- *Attach Attachment E calculations for retention requirement adjustment for technical infeasibility*
- *Attach Attachment F calculations for off-site retention requirements*
- *Attach agreement for alternative compliance site use, for purposes of achieving compliance*
- *Attach Operations and Maintenance Plan for all stormwater control measures (include any Peak Management facilities)*

Post-Construction Owner Identification

At the time of completion of the construction work, and the shift to post-construction stormwater controls, the below listed owner is responsible for Operations and Maintenance of stormwater control measures:
Villaggio – Life Plan Community
John Madonna
(If responsibilities are divided, list all responsible owners and associated measures.)

Certification

I Tim Walters certify that the systems selected, sized, and designed as demonstrated in the attached calculations, meet the Runoff Retention Performance Requirement for this project per the Post Construction Requirements adopted by the Central Coast Regional Water Quality Control Board. Where identified in the attached documentation, Runoff Retention will be met through alternative compliance.

Signature Date

Requirement 4 – Peak Management

(Reference Post Construction Stormwater Management Requirements for Development Projects in the Central Coast Region – Adopted July 12, 2013 California Regional Water Quality Control Board Central Coast Region – for details regarding requirements – Section B.5)

Show any stormwater control measures used to meet the requirements of this section, ***in the documentation and attachments required for Retention*** *(Form 3), including in all mapping and Operations and Maintenance materials.*

Peak Management Compliance

☑ Post-development peak flows, discharged from the site, do not exceed pre-project peak flows for the 2 through 10 years storm events.

☐ Technical infeasibility limits on-site compliance

- ☐ Alternative compliance for retention proposed

Runoff volume – compliance not achieved onsite:

Runoff volume – alternative compliance used:

Attachments

- *Attach calculations showing pre-project discharge and post-project discharge for the 2 through 10 year storm events*
- *Attach documentation of technical infeasibility for on-site compliance, including a site specific hydrologic and/or design analysis supporting findings*
- *Attach description of alternative compliance project including a summary description of pollutant and flow reduction comparing the expected aggregate results of the alternate project to the results that would otherwise have been achieved by meeting the numeric performance requirements onsite.*
- *Attach agreement for alternative compliance site use, for purposes of achieving compliance*

Post-Construction Owner Identification

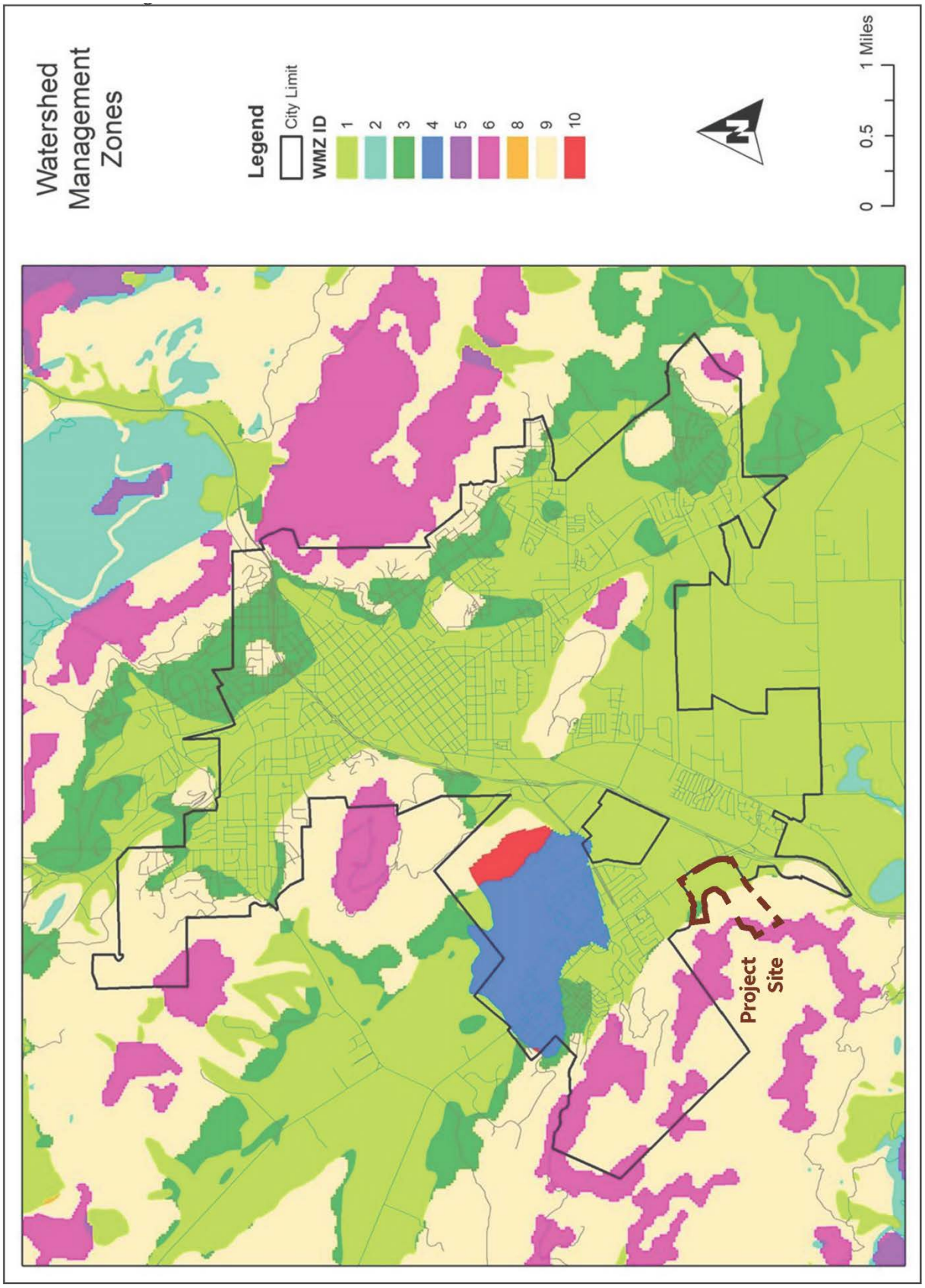
At the time of completion of the construction work, and the shift to post-construction stormwater controls, the below listed owner is responsible for Operations and Maintenance of the peak management control measures:
Villaggio – Life Plan Community
John Madonna
(If responsibilities are divided, list all responsible owners and associated measures.)

Certification

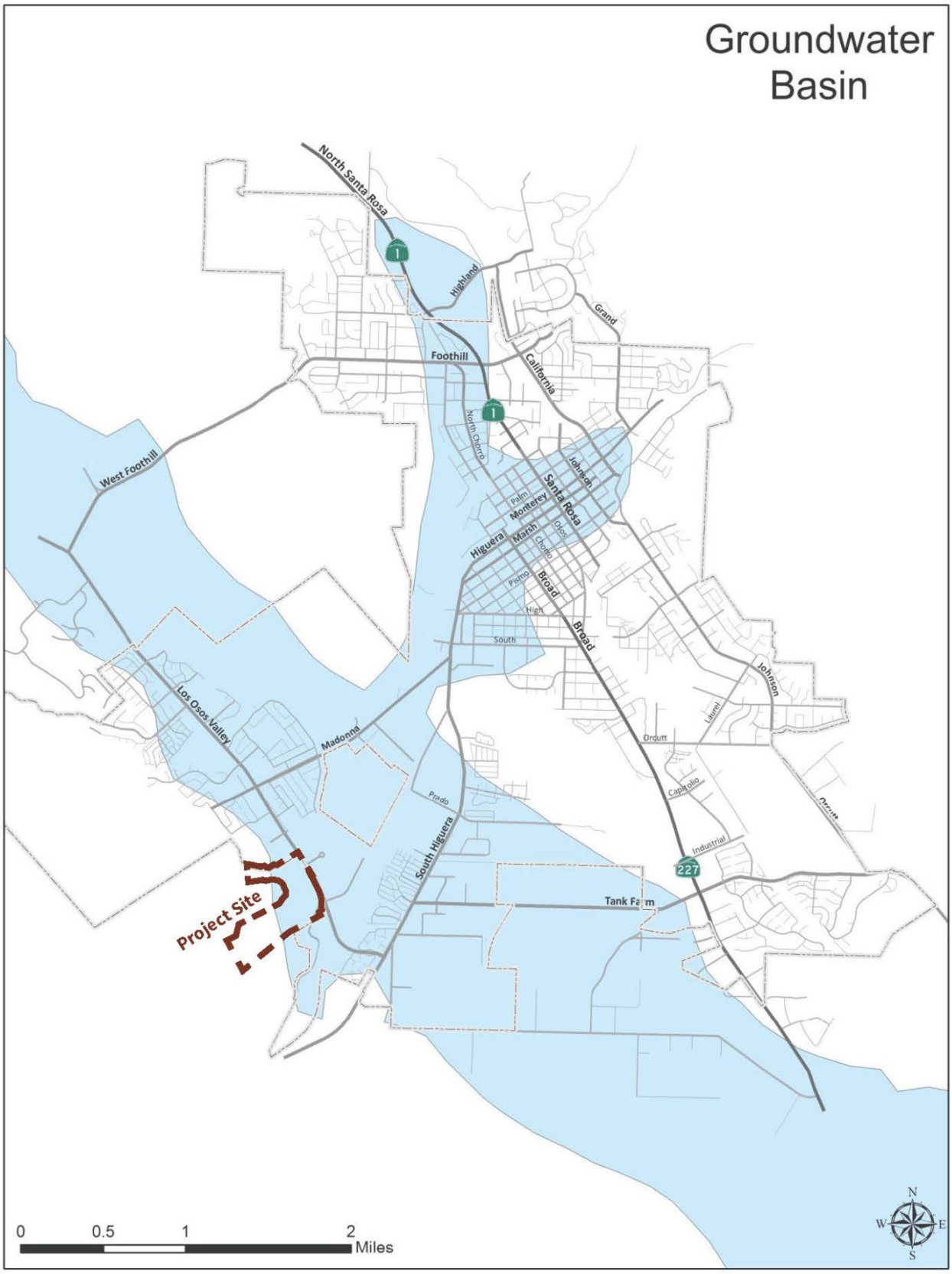
I Tim Walters certify that the systems selected, sized, and designed as demonstrated in the attached calculations, meet the Peak Management requirements for this project per the Post Construction Requirements adopted by the Central Coast Regional Water Quality Control Board. Where identified in the attached documentation, Peak Management will be met through alternative compliance.

Signature Date

Watershed Management Zones



Ground Water Basin



Watershed Management Zone Revision Request

It is understood that Watershed Management Zones were developed through the Central Coast Regional Water Quality Control Board Joint Effort with available data, at varying degrees of detail and accuracy. Zones may vary across properties, or be off from verifiable, on the ground data. Applicants may propose revisions to the designate Watershed Management Zone for the project.

*Applicants should carefully review the **Post-Construction Stormwater Management Requirements For Development Projects in the Central Coast Region, California – Technical Support Document** for a clear understanding of the basis of the Watershed Management Zone designations before proceeding with this application.*

Site Information

Project Address:	Area northwest of the intersection of Calle Joaquin and Los Osos Valley Road
Current Watershed Management Zone(s):	Zone 1 & 9
Proposed Watershed Management Zone(s):	Zone 1 & 9

Watershed Management Zone Summary

Copy table for multiple zones in the Project area

- *Mark the characteristics supported by geotechnical observation in the column marked "(P)"*
- *Identify the page number in any geotechnical report reference in the column marked "Pg"*

Watershed Management Zone	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**(P)**	**Pg**
Drains to:												
Stream					✓	✓						
Wetland								✓	✓			
Stream or Wetland	✓	✓	✓						✓			
Lake										✓		
River							✓					
Lake or River				✓						✓		
Underlain by:												
0-10% All types				✓								
> 40% All types							✓			✓4		
0-40% Quaternary & Late Tertiary	✓											
10-40% Quaternary & Late Tertiary				✓								
0-10% Early to Mid-Tertiary	✓											
10-40% Early to Mid-Tertiary		✓										
10-40% Franciscan melange, Pre-Quaternary crystalline, Early to Mid-Tertiary										✓5		
> 40% Quaternary, Late Tertiary, Early to Mid-Tertiary					✓			✓				
0-10% Franciscan melange, Pre-Quaternary crystalline			✓									
> 10% Franciscan melange, Pre-Quaternary crystalline									✓2			
10-40% Franciscan melange, Pre-Quaternary crystalline									✓3			
> 40% Franciscan melange, Pre-Quaternary crystalline						✓						

Watershed Management Zone	1	2	3	4	5	6	7	8	9	10	(P)	Pg
Slope:												
Steep					✓	✓	✓	✓				
Moderate	✓	✓							✓	✓		
Low			✓	✓								
Watershed Process:												
Infiltration dominant	✓			✓[1]	✓			✓				
Infiltration less dominant		✓				✓			✓	✓		
Chemical & biological remediation			✓	✓								
Overland flow minimal	✓	✓	✓			✓			✓			

Notes:
1 – Over groundwater basin
2 – Zone 9 Wetland Draining
3 – Zone 9 Stream or Wetland Draining
4 – Zone 10 Lake Draining
5 – Zone 10 Lake or River Draining

Watershed Management Zone Revision Supporting Summary

Provide written summary of geotechnical/geological information supporting revised Watershed Management Zone designation.

N/A

Attachment

- *Attach geotechnical or geological information which supports revision (include page references in table above)*

Pages 6 thru 10: GeoSolutions Soils and Geotechnical Report, June 28, 2016.

Urban Sustainability Areas

Urban Sustainability Areas (USA) encompass high density urban centers where the documented objective is to preserve or enhance and existing pedestrian-oriented and/or public transit-oriented type of urban design through the promotion of high density redevelopment and infill.

Requirements for USAs

The City has received approval for certain sub-areas within three land use zoning areas for USAs designation, superimposed with minimum requirements. The Zones are Retail Commercial, Downtown Commercial, and High Density Residential. Maps are provided at the end of this document.

Site specific requirements relating to floor areas or dwelling units, surface parking allowance, and alternative transportation meet or exceed the current Zoning Regulation requirements. To be eligible for reductions of Post-Construction Requirements, development and redevelopment projects must meet all the USA requirements listed below for the Zone.

A. Retail Commercial (C-R) USA Requirements

- Ratio of gross building floor area to site area minimum = 3:1
- Site area building coverage minimum = 90%
- Project uses < 10% of area for surface parking
- Within 8 blocks of local transit route with at least hourly daytime service Monday through Friday, with connections to regional transit routes and train station
- Provision of bike parking spaces = minimum 15% of auto parking requirement
- Sidewalks provided on both sides of the street

B. Downtown Commercial (C-D) USA Requirements

- Ratio of gross building floor area to site area minimum = 3:1
- Site area building coverage maximum = 100%
- Project provides no surface parking, beyond incidental uses for emergency and ADA. Exception is municipal multi-story structures provided as park-in-lieu facilities for intense site developments
- Within 8 blocks of local transit route with at least hourly daytime service Monday through Friday, with connections to regional transit routes and train station
- Provision of bike parking spaces = minimum 15% of auto parking requirement
- Sidewalks provided on both sides of the street

C. High-Density Residential (R-4) USA Requirements

- Dwelling units per net acre (net acre - excludes right-of-way, creeks, endangered & threatened species habitat) minimum = 24 + a low or moderate income density bonus
- Site area building coverage minimum = 60%
- Within 8 blocks of local transit route with at least hourly daytime service Monday through Friday, with connections to regional transit routes and train station
- Provision of bike parking spaces = minimum 10% of auto parking requirement
- Sidewalks provided on both sides of the street or approved alternative connection pathways

Application of Post Construction Requirements within a USA

Post Construction Requirements will be applied in USAs as follows:

A. Performance Requirement No. 1: Site Design and Runoff Reduction

- The City will apply those aspects of Site Design and Runoff Reduction that are applicable.
  - Site design activities may be limited by the pre-project condition and density goals.
  - Where complete, or nearly complete lot coverage is proposed, shifting of rainwater to vegetated areas, or for reuse may not be applicable.

B. Performance Requirement No. 2: Water Quality Treatment

- The City will apply Water Quality Treatment
- Where Water Quality Treatment is demonstrated as infeasible, it will be handled per C.3.b
  - Site specific analysis completed and endorsed to show infeasibility per sections C.1.a & c
  - Off-site Project description, location within the same watershed, and scheduled completion date identified

C. Performance Requirement No. 3: Runoff Retention

- The City will apply Runoff Retention
  - Per B.4.b.ii, the total runoff volume to be retained from replaced impervious surfaces shall be less than, or equivalent to, the pre-project runoff volume retained
  - New impervious surfaces will comply with requirements of section B.4, calculated per Attachment D, where the tributary area is a function of new impervious only

D. Performance Requirement No. 4 – Peak Management

- The City will apply Peak Management Requirements
  - Post-development peak flows will generally not exceed pre-project peak flows for the 2 through 10 year storm events for redevelopment sites
  - Technical infeasibility will apply where density goals result in space constraints as provided for in C.1.c.v. Per C.1.a, and no site specific hydrologic or geotechnical analysis will be required.

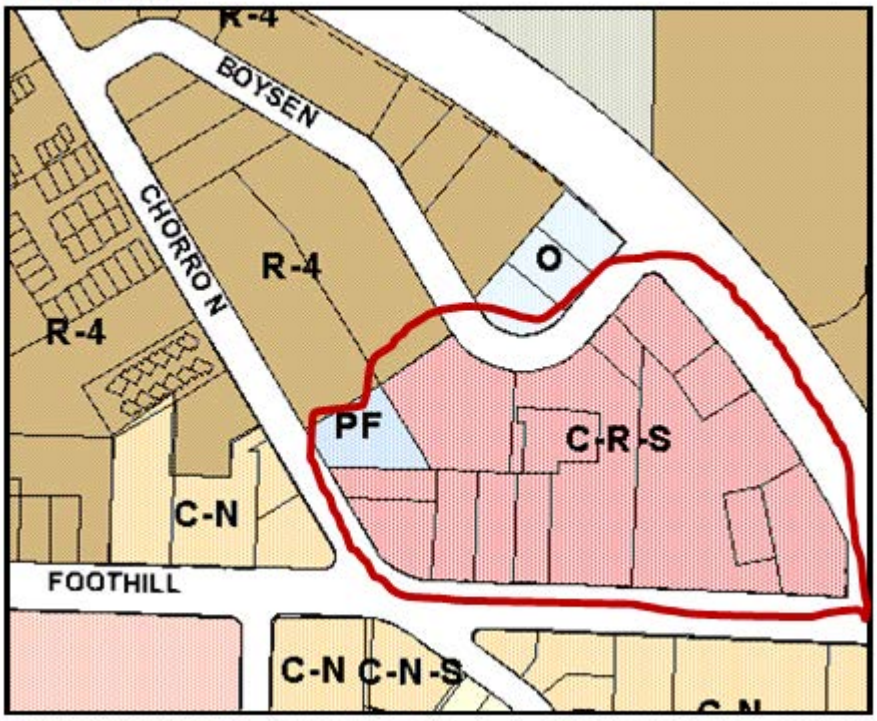
E. Off-Site Compliance

- Where an off-site compliance proposal is included in the project submittal
  - Location, analysis for performance requirement compliance, and project mitigation completion schedule for off-site compliance will be required as part of the submittal.
  - Off-site compliance site will be within the same watershed, unless otherwise approved by the Central Coast Water Board EO.

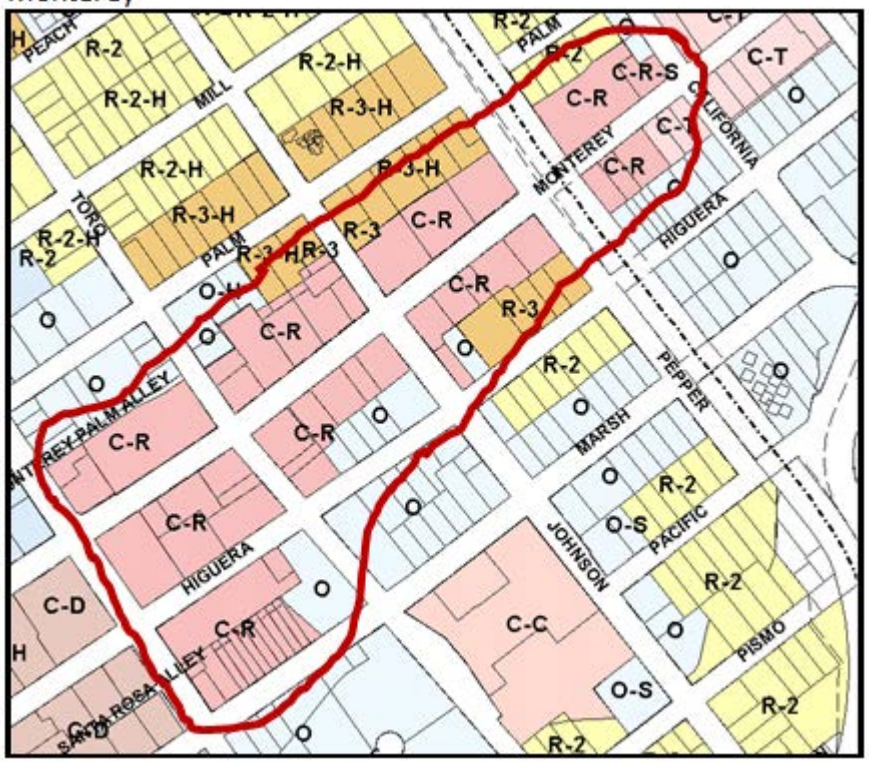
Maps of Approved USAs

A. Retail Commercial (C-R)

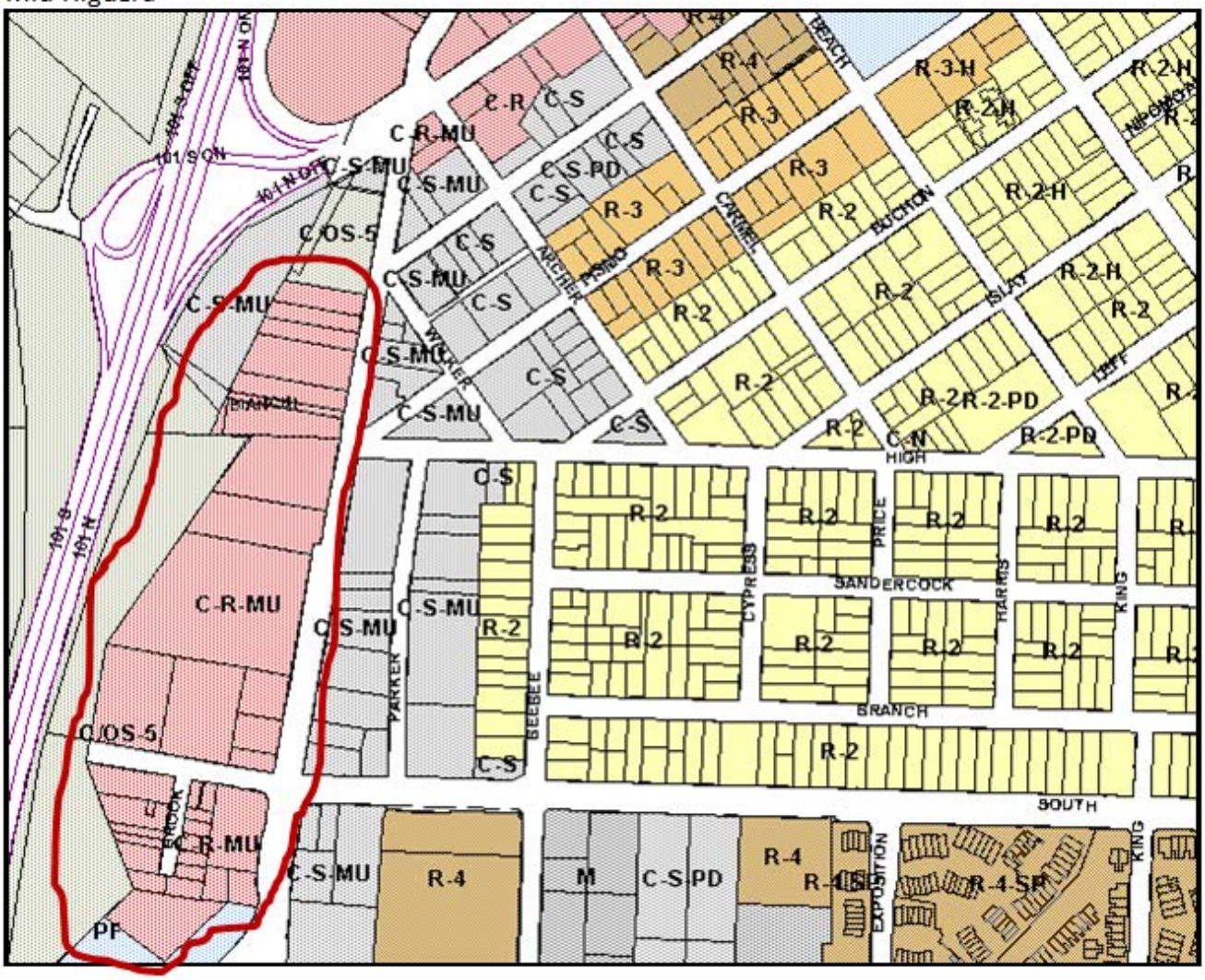
North Foothill



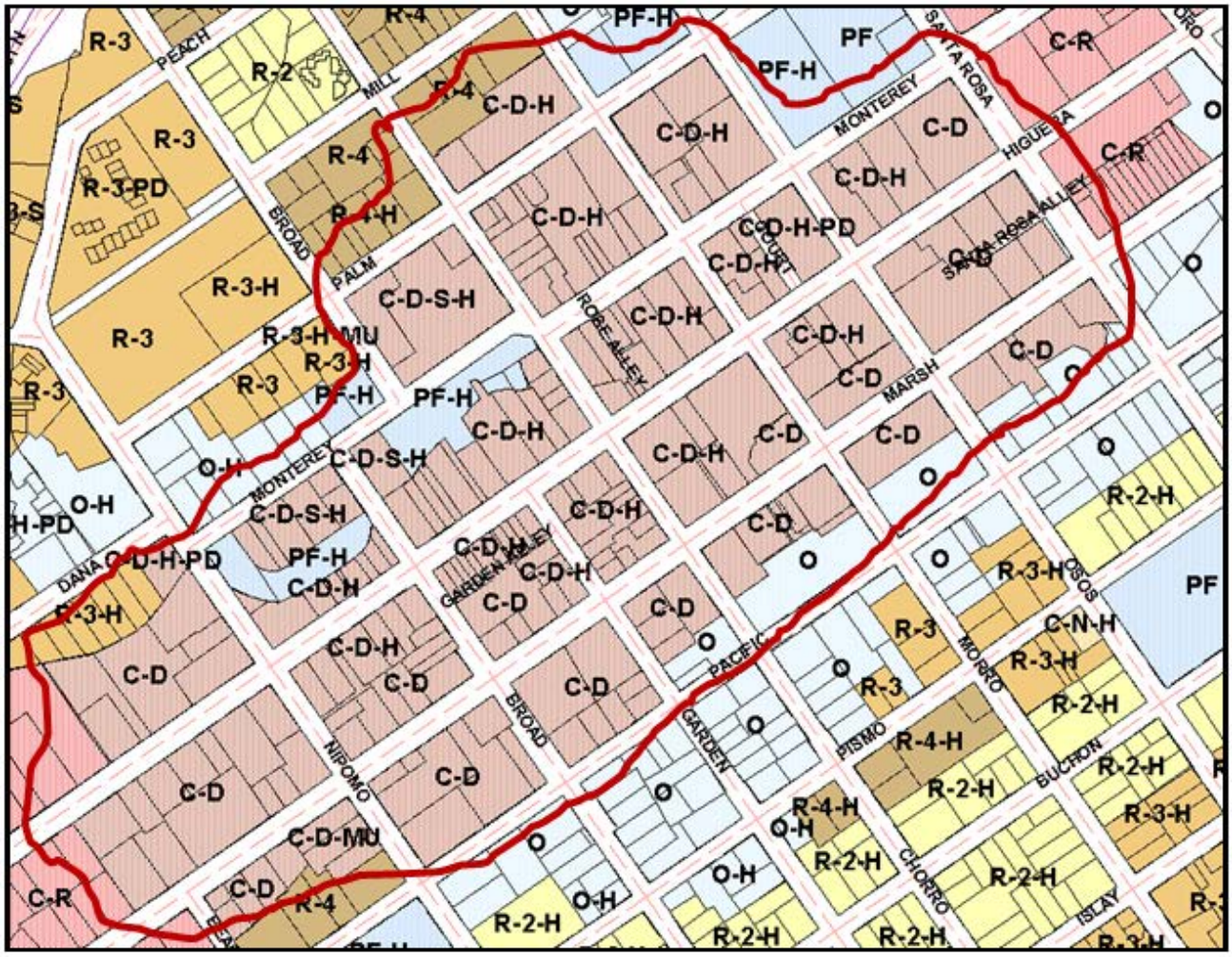
Monterey



Mid-Higuera

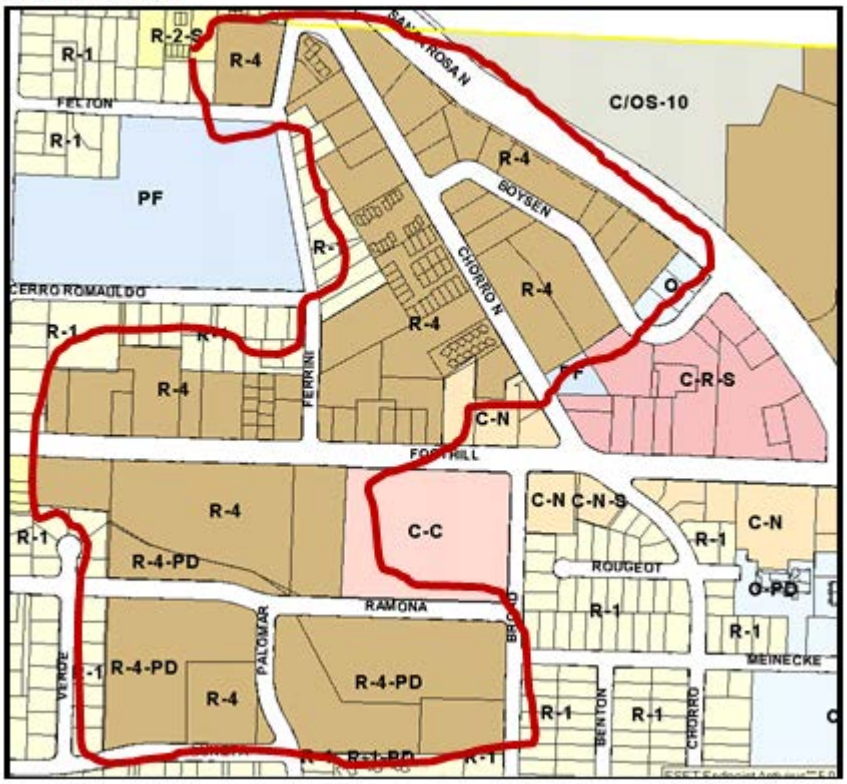

C-R-MU
C-S-MU
C-S
C-S-PD
C-OS-5
R-4
R-3
R-2
R-3-H
R-2-H
R-2-PD
C-N
M
R-4-SP
PF
BEACH
CARMEL
BUCHON
SILAT
HIGH
PRICE
SANDERCOCK
CYPRESS
HARRIS
KING
BRANCH
SOUTH
PARKER
BEEBEE
EXPOSITION
101 S ON
101 S OFF
101 N ON
101 N OFF
101 S
101 N

B. Downtown Commercial (C-D)

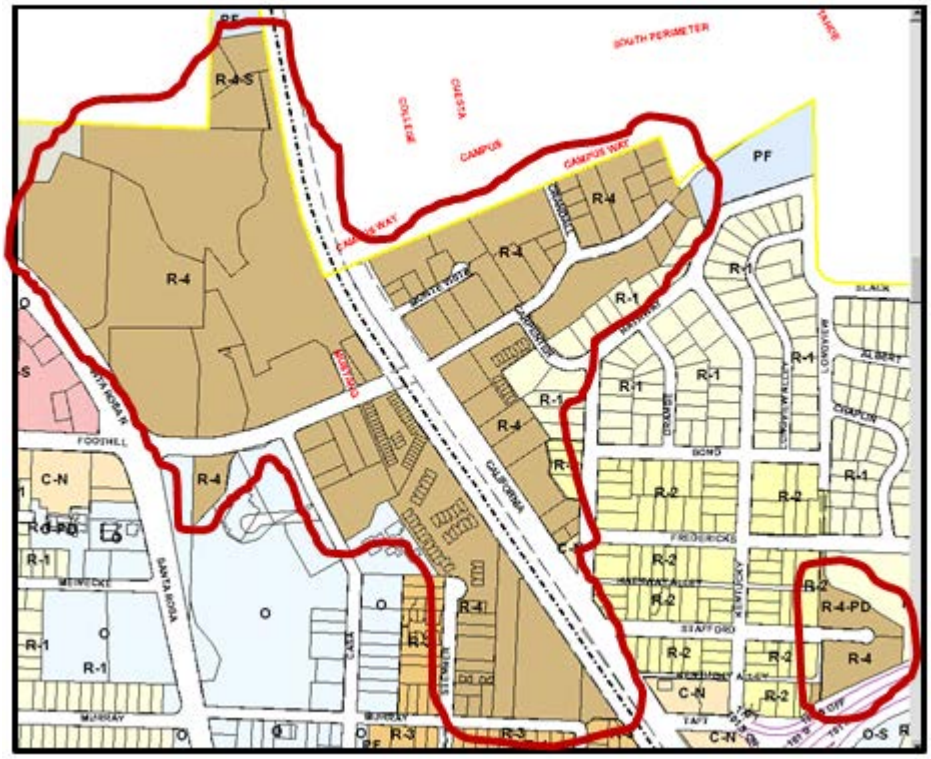


C. High-Density Residential (R-4)

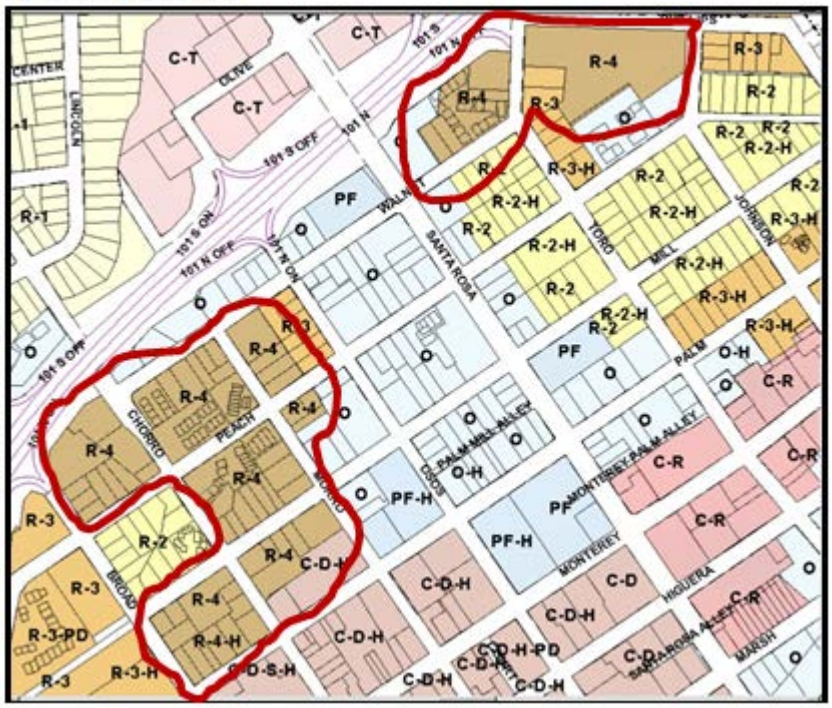
North Foothill



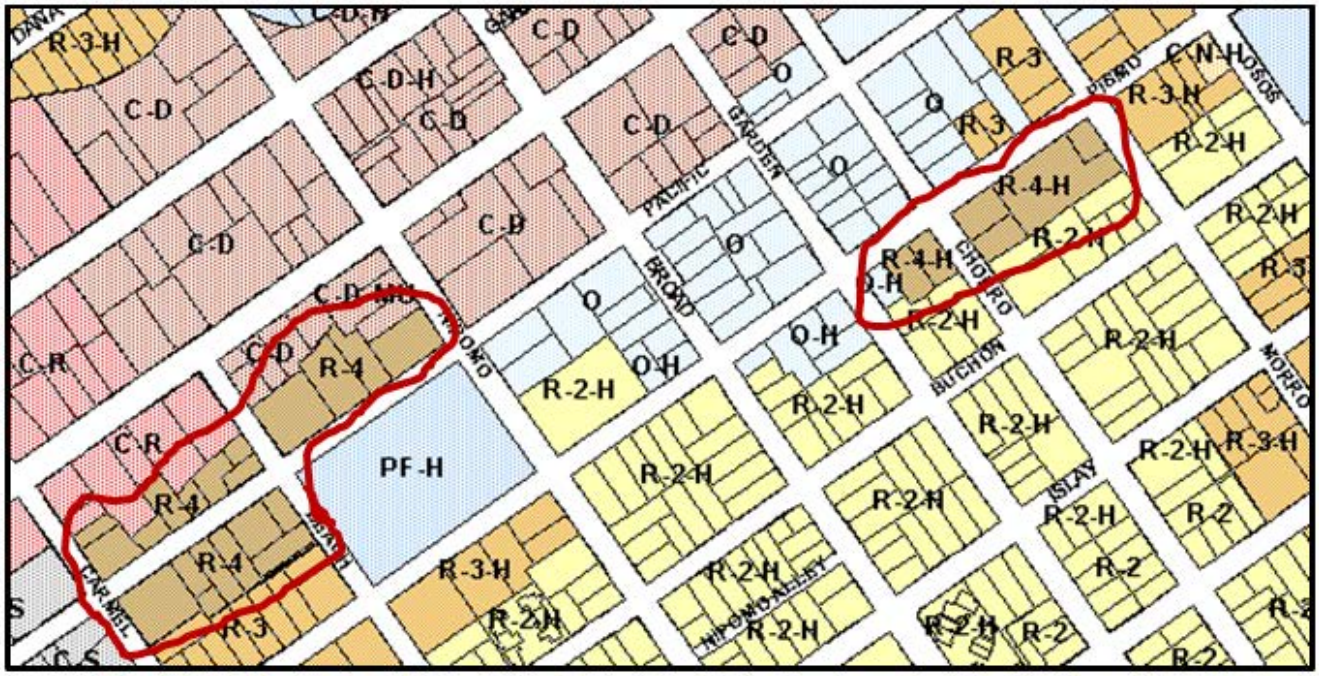
Santa Rosa



North Downtown



Old Town



EXISTING DRAINAGE FEATURES (TYP)

HEADWALL AND PIPE CULVERTS (TYP)

POINT-SOURCE TREATMENT AREA (TYP)

HEADWALL AND ARCH-CULVERT CROSSING

POINT-SOURCE TREATMENT AREA (TYP)

INTERCEPT EX STORM DRAIN OUTLET

HOME DEPOT WATER QUALITY TREATMENT AREA

RESTORED FROOM CREEK CONVEYANCE

EXISTING STORM DRAIN OUTLET

HEADWALL AND (4) 24" STORM DRAIN

PROPOSED BASIN (V = 28.62 ac-ft)

APPROXIMATE OUTLET TO FROOM CREEK

APPROXIMATE LOCATION OF SEDIMENT BASIN

APPROXIMATE ROADSIDE BIOFILTRATION AREA

OUTLET THROUGH EX BOX CULVERTS

Froom Ranch

STORMWATER MANAGEMENT

SCALE: 1" = 100'

Exhibit

July 13, 2017

rrm design group

EXISTING DRAINAGE FEATURES (TYP)

UPPER VILLAGIO
AREA = 12.53 ac
V = 0.56 ac-ft
COVERAGE = 65%

HEADWALL AND PIPE CULVERTS (TYP)

RESIDENTIAL + PARK
AREA = 12.70 ac
V = 0.90 ac-ft
COVERAGE = 65%

MOUNTAINBROOK
AREA = 3.67 ac
V = 0.37 ac-ft
(85th PERCENTILE ONLY)

WATERSHED MANAGEMENT ZONE 9
WATERSHED MANAGEMENT ZONE 1

HEADWALL AND ARCH-CULVERT CROSSING

HOME DEPOT
AREA = 10.14 ac
C = 0.75
V = 1.27 ac-ft
(Q_2 - Q_{50})

HEADWALL AND (3) 24" STORM DRAIN

IRISH HILLS
AREA = 18.62 ac
C = 0.75
V = 2.33 ac-ft
(Q_2 - Q_{50})

RESTORED FROOM CREEK CONVEYANCE

POINT-SOURCE TREATMENT AREA (TYP)

EXISTING STORM DRAIN OUTLET

LOT 6
5.62 ACRES

PROPOSED BASIN
(V = 25.5± ac-ft)

CALLE JOAQUIN

LOWER VILLAGIO
AREA = 26.94 ac
V = 2.32 ac-ft
COVERAGE = 75%

LOS OSOS VALLEY ROAD

AUTO PARKWAY

COMMERCIAL
AREA = 10.07 ac
V = 1.05 ac-ft
COVERAGE = 85%

NOTES

VOLUME IS CALCULATED USING THE CITY OF SAN LUIS OBISPO POST CONSTRUCTION STORMWATER REQUIREMENTS FOR RETENTION VOLUME ATTACHMENT D WHERE THE 85th PERCENTILE DEPTH IS 1.2 INCHES AND THE 95th PERCENTILE DEPTH IS 1.9 INCHES.

Froom Ranch

DRAINAGE MANAGEMENT AREAS

SCALE: 1" = 100'

Exhibit
January 18, 2018

rrm design group

Appendix 7

Cleath-Harris Groundwater Report

Cleath-Harris Geologists, Inc.
71 Zaca Lane, Suite 140
San Luis Obispo, CA 93401
(805) 543-1413

September 21, 2018

John Madonna
John Madonna Construction Company
P.O. Box 5310
San Luis Obispo, California 93403

Subject: Groundwater Impacts Assessment
Froom Ranch Development
San Luis Obispo, California

Dear Mr. Madonna:

Cleath-Harris Geologists (CHG) has performed an assessment of groundwater impacts resulting from the Froom Ranch Development project, San Luis Obispo, California. The proposed project location is presented on Figure 1. The focus of this assessment is the improvements that are proposed on the valley floor portion of the ranch. The impacts include impacts to the wetland area along Calle Joaquin, groundwater levels, groundwater recharge from percolation of flows in the Froom Creek stream channel, and subsidence from lowered groundwater levels.

The existing and proposed drainage and wells on the ranch have been reviewed along with the proposed ground surface grade and the subsurface and surface hydrology as a basis for this analysis. Previous reports that form the partial basis for this assessment include the RRM Preliminary Hydraulic and Hydrologic Calculations (2017) and the GeoSolutions 2017 Subsurface Fault Investigation and Development Setback Map.

For this assessment, the project applicant provided project preliminary plans, hydrologic investigations, fault studies, soils reports, and various data files and information. Data provided by the project applicant included: existing improvement and project plans and drawings, soils reports, well information, and drainage/stream flow calculations and environmental studies. Several test pits were dug to measure the depth to water around the forebay/detention basins. Access was provided to the property and to the wells for water level measurements. Well head elevations were surveyed to convert depth to water to groundwater level elevations.

CONDUCT OF STUDY

The impact assessment involved a characterization of groundwater basin sediments and groundwater level within the valley floor area between the Irish Hills and Los Osos Valley Road, a review of the proposed project drainage and finished grade topography,



Explanation

- Wells and Borings
- Cross Section Lines
- Specific Plan Area
- Detention Basin Drains
- Wetlands
- Pit with Water Level (9/20/18)

Figure 1
Location Map
Froom Ranch
Cleath-Harris Geologists

and an evaluation of potential impacts to the wetlands and groundwater resources resulting from the project.

Some of the tasks included in this characterization included:

1. A review of existing drainage works on the property and along Los Osos Valley Road and the proposed changes to the subsurface/surface drains;
2. A site reconnaissance to identify hydrologic features and facilities on the property
3. A definition of existing groundwater level elevations using water levels measured in existing wells, and exploratory holes;
4. Plotting of the groundwater level elevations using well head survey information.
5. Estimating the range of groundwater level fluctuations during wet and dry periods based on available groundwater level records and published literature;
6. Identifying where, and at what depth, sand and gravel aquifers are present underlying the property based on available subsurface data;
7. Identifying areas of confined groundwater resulting in artesian flow from wells and areas of rising water/wetland areas;

SURFACE WATER/GROUNDWATER FACILITIES

The existing water facilities on the valley floor portion of the ranch include the Froom Creek bermed drainage channel (flowing from the canyon, along the base of the hills, to where the creek flows between Calle Joaquin and the Vineyard Church property, and thence toward a culvert at Highway 101); A forebay basin and detention basin with subsurface drains receives water from the commercial property to the west of the ranch; two water supply wells (the domestic well and the irrigation well).

Froom Creek, as it exists, has been moved to the current alignment from it's original stream channel orientation as was documented in the RRM Hydrology Study, Figure 1-2. The original stream channel alignment was generally parallel to the Froom Ranch driveway. The NRCS soil survey map has "Riverwash"/xerofluvents soils in Froom Creek Canyon and in the vicinity of the ranch buildings, and Cropley clay soils on the remainder of the valley portion of the property. Downstream of where the creek flows out of the canyon (watershed area of 2 square miles), the geologic maps published by the California Geologic Survey (Wiegers, 2011) and by Lettis and Hall (1994) show an alluvial fan along the original stream channel alignment (GeoSolutions, 2017, Plates 3A and 7A). Typically, alluvial fan deposits are coarse grained sands and gravels at the mouth of a canyon. The current alignment parallels the hillside for a length of about 1,500 feet. The current channel bed is comprised of sand and gravel. Adjacent trenches excavated for seismic studies found that below the creek channel elevation, the soils were colluvial: a mixture of clays, sands, and gravels. The on-line NRCS soils survey map shows that much of the current channel alignment is on Obispo weathered bedrock soils.

The subsurface drains at the forebay/detention basin include perimeter drains and sub-basin drains. The western perimeter drain and the forebay/detention basin subsurface drains flow to a surface water discharge point that feeds to the drainageway along Los Osos Valley Road. The southern perimeter drain discharges to a leach field that allows the water to rise into the wetland area east of the detention basin.

The domestic well (estimated pumping rate of about 10 gallons per minute) provides water to the ranch house and also to a construction water tank. The irrigation well (estimated pumping rate of about 300 gallons per minute) also provides water to the construction water tank. This water is primarily used for dust control at constructions sites. The water production from the wells is about 10 acre-feet.

PROPOSED SURFACE WATER/GROUNDWATER FACILITIES

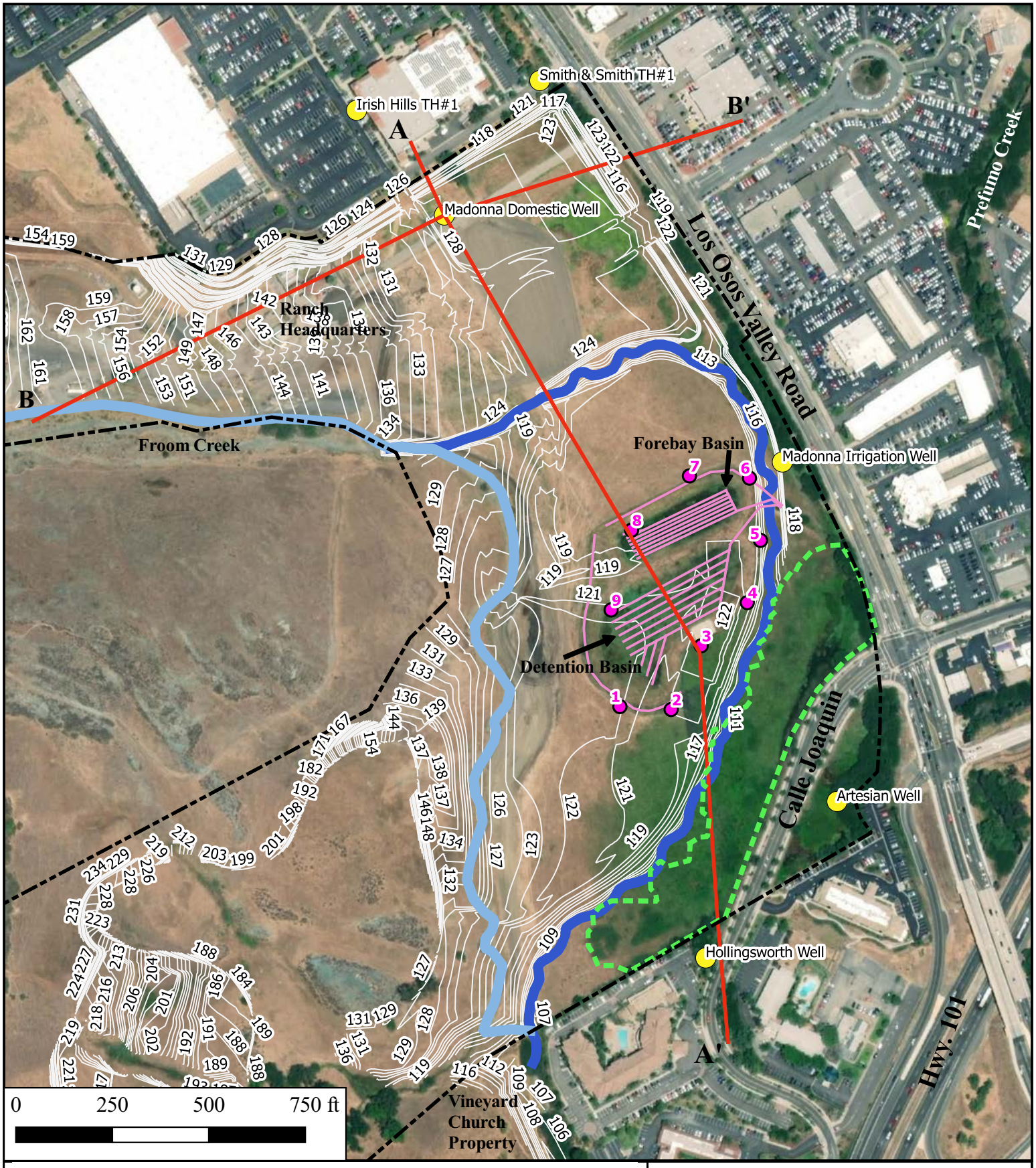
The proposed project includes topographic modification of the site for roads, building pads and drainage (Figure 2). As part of this modification, the stream channel for Froom Creek along the base of the Irish Hills would be re-aligned in part to be near to the original channel position toward Los Osos Valley Road and then turning to an alignment parallel to Los Osos Valley Road and thence toward the base of the hills, along the western edge of the wetland (as shown on Figure 1-4 of the RRM Hydrology Study, returning to the existing creek channel- a distance of about 2,500 feet. The underlying soils along this proposed alignment are predominantly clayey.

The existing stream channel and adjacent berm would be removed as a part of the grading for the development. The existing drainage detention basins would be removed as a part of the grading and the flow from the Home Depot/Costco property would be drained to the modified stream channel. Excess flow from the modified stream channel (not contained in the wetland area) would drain to an off-site detention basin proposed on the Vineyard Church property.

Water supply to the proposed project would be from the City of San Luis Obispo and potentially from on-site wells and wastewater would be disposed of to the City sewer.

SITE HYDROGEOLOGY

The valley floor portion of the proposed development is underlain by alluvial deposits. The alluvium includes fan deposits at the mouth of Froom Creek Canyon and flood plain fine-grained sediments interbedded with stream channel sands and gravels. The depth of the alluvium reaches 200 feet near the driveway entrance to the Froom Ranch residence. The subsurface alluvial deposits, as defined at wells and borings (located on Figure 1), include clayey beds to a depth ranging from 25 to 50 feet below ground surface before



Explanation

- Wells and Borings
- Cross Section Lines
- Specific Plan Area
- Wetlands
- 127 Contour Elevation in Feet
- Detention Basin Drains
- Proposed Stream Channel
- Current Stream Channel
- Pit with Water Level (9/20/18)

Figure 2
Proposed Project Grade
From Ranch
Cleath-Harris Geologists

reaching the first sand and gravel bed. The cross sections on Figures 3 and 4 include the borehole logs for some of these test holes/wells.

Groundwater saturates much of the alluvial deposits. The shallow clay bed is an aquitard that inhibits percolation of surface water and confines the groundwater stored within the underlying sand and gravels.

The groundwater level within the sand and gravel beds is typically at or above the level within the shallow saturated clays and, when this occurs, some upward leakage of groundwater occurs. Balance Hydrologics in their Calle Joaquin Wetlands groundwater study determined, based on salt concentration ratios, that a significant "key" source of the water feeding the wetlands was from upward leakage of groundwater from the deep sand and gravel deposits. Other recharge to the wetland occurs from percolation of Froom Creek surface water within the area of the alluvial fan and in the colluvial deposits along the western edge of the valley. Overflow from Froom Creek during high stream flow (400 cubic foot per second) conditions occurs infrequently and "may not be sufficient to sustain both seasonal and perennial wetlands" (Balance Hydrologics, 2004).

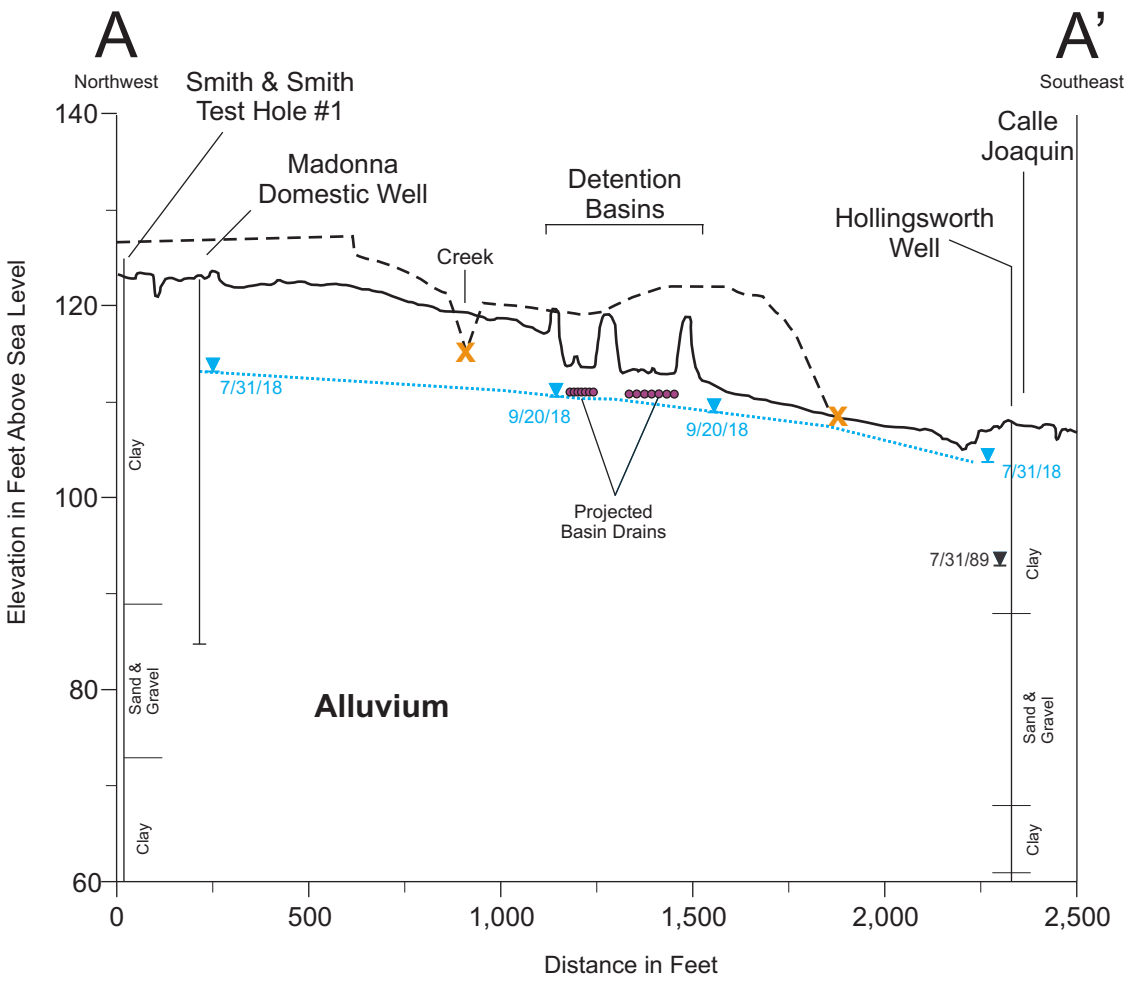
Historically, groundwater levels on the property have fluctuated from near surface to about 30 feet below ground surface (CHG, 2018). The lowest level occurred when the City was extracting groundwater during the 1987-1991 drought years and has not occurred since then.

The groundwater level measurements at the Madonna domestic well and the Artesian well, during this investigation found that the groundwater level depth below ground surface was about 10 feet at the Madonna domestic well on the west and at ground surface at the Artesian Well by Calle Joaquin on July 31, 2018. The depth to water in the proximity of the forebay/detention basins were measured in several backhoe pits on September 20, 2018. The depths to water in the backhoe pits around the basins were between 3 and 6 feet and inside the basins the depths to water were 2.3 feet (forebay) and 2.6 feet (detention) below the lowest point in the basins. The levels at pits 8 and 3 are included on Cross Section A-A' (Figure 3).

Based on historic groundwater monitoring at the Calle Joaquin wetlands, the groundwater level at the wetlands fluctuates seasonally 2 to 4 feet with a range of about 5 feet (from 3 feet below ground to 1+ feet above ground). Surface flow out of the wetland via drainages and culverts occurs once the water level is above grade.

PROPOSED PROJECT GRADE

The ground surface grade for the proposed development of the valley portion of the Froom Ranch is shown on Figure 2. Over the improved portion of the valley floor on the

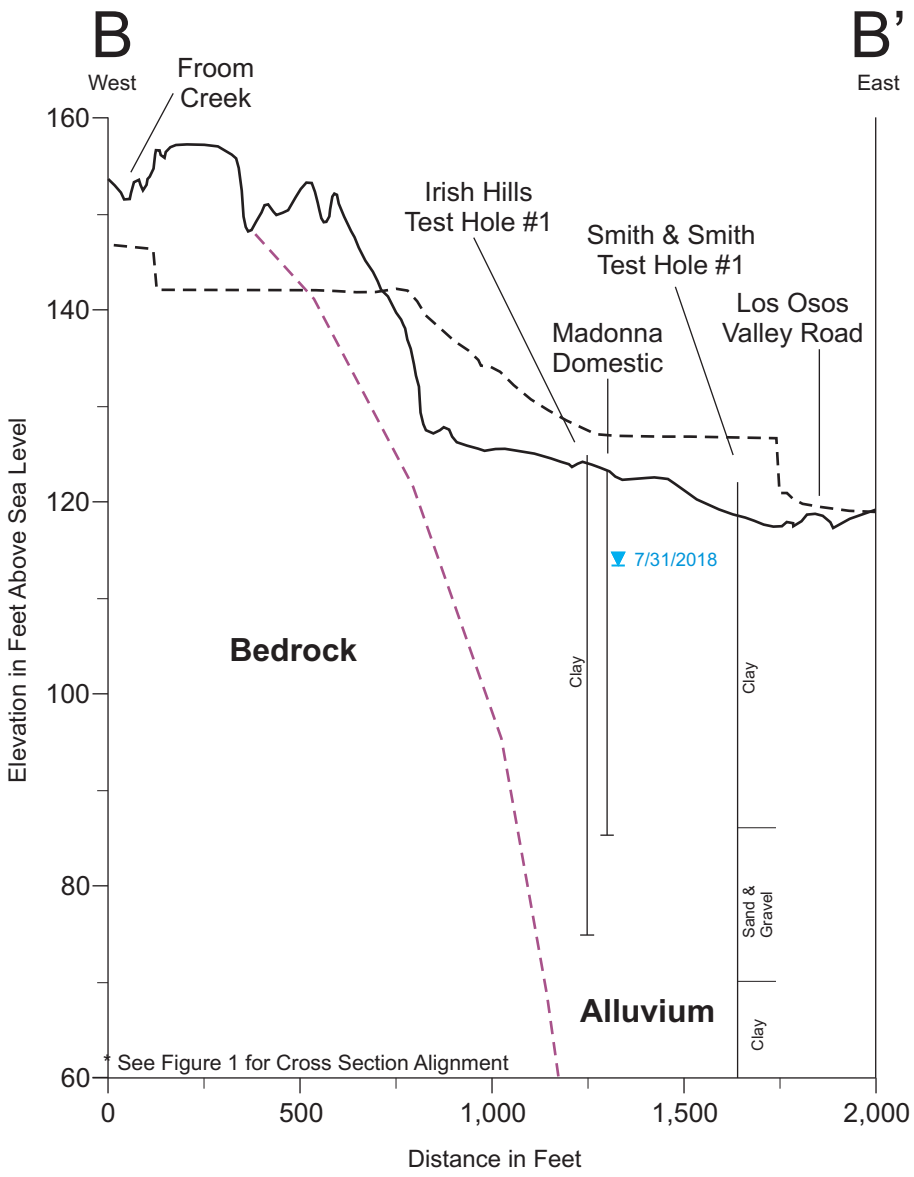


* See Figure 1 for Cross Section Alignment

Explanation	
▼ ·····	Recent Water Level (Sounded)
~~	Current Grade
- - -	Proposed Grade
X	Proposed Stream Channel

Figure 3
Hydrogeologic Cross Section A-A'
Froom Ranch

Cleath-Harris Geologists



Explanation

- 7/31/18 — Current Water Level (Sounded)
- Bedrock Surface
- Current Grade
- Proposed Grade
- Completed Well

Figure 4
Hydrogeologic Cross Section B-B'
Froom Ranch

Cleath-Harris Geologists

property, the ground surface will generally be raised to a higher elevation for the project (Cross Sections A-A' and B-B' (Figures 3 and 4).

The proposed creek alignment would be incised into the fill from the mouth of the canyon toward Los Osos Valley Road. The proposed creek would join with the drainage ditch along Los Osos Valley Road and follow the eastern/southeastern edge of the graded fill slope adjacent to the wetland, where the low flow creek channel will be shallow (and above the wetland elevation). During high flow conditions with a two year frequency event, overbank flow would go into the wetlands. RRM hydraulic sections/calculations drawn across the low flow/overbank flow section between the fill graded slope and the Calle Joaquin/Marriott property bank indicate that the creek/overbank wetland area can handle flows up to 100-year frequency flows.

IMPACT ASSESSMENT

The project impacts addressed include groundwater level impacts, changes in flow to the wetlands, subsidence, and recharge to the groundwater.

The proposed project impacts to the groundwater level are not expected to be significant as no significant increase in groundwater extractions are proposed. Groundwater levels in the project area may rise if the detention basin drains are removed along with the basins. Rising water would cause more water to flow into the wetland area.

Wetland Impact

The proposed project's impact to the wetlands would be to increase flow into the wetlands as the Froom Creek channel would utilize the wetlands as a part of the drainageway for winter flows and would be expected to allow more percolation into the alluvial fan deposits at the mouth of Froom Creek Canyon and along the longer project creek channel length resulting in a more extended period of high water levels after the end of the rainy season.

Subsidence Impact

Subsidence has been addressed recently by Yeh and Associates for the San Luis Obispo Groundwater Basin Characterization Study. Historically, subsidence has been observed when groundwater levels declined 30 feet along Los Osos Valley Road in the late 1980's. Some of the old well concrete pad bottoms (such as at the Madonna Artesian well) are now above grade. Yeh and Associates mapped this area as having a moderate potential for subsidence (Yeh and Associates, Plate 2). The clayey soils identified on the soils map

and in the test hole logs indicate that there is a higher potential for compaction/subsidence. The proposed project (with no major groundwater extractions proposed) would not result in significantly lowered groundwater levels. If groundwater levels decline to a depth as occurred in the 1980's due to regional or on-site pumping, subsidence can be expected to occur. The actual depth to water where subsidence would start to be noticed in this area has not been determined. One example of an area where subsidence was related to groundwater level change was in Cambria, where no significant ground deformation occurred when groundwater levels were maintained at 20 feet or shallower.

Groundwater Recharge Impact

Groundwater recharge to the alluvial aquifers in the wetland area is anticipated to increase as a result of the re-alignment of the Froom Creek stream channel. The longer reach and flatter grade of the re-aligned stream channel allows for a greater surface area and longer duration of wetted stream channel, increasing groundwater recharge when stream flow occurs. The re-aligned stream channel will traverse alluvial fan deposits along the old stream channel alignment and will not be flowing over Obispo weathered bedrock soils as occurs in the current channel alignment. The detention basin downstream of the project area, when saturated, is anticipated to result in a higher groundwater level than currently exists and reduce the groundwater flow gradient in the proximity to the wetlands.

CONCLUSION

The Froom Ranch Specific Plan valley area is underlain by up to 200-feet thick alluvial deposits comprised of shallow alluvial fan deposits near the ranch headquarters and shallow clayey deposits elsewhere underlain by permeable sand and gravel beds. The clayey deposits confine groundwater in these deeper sand and gravel beds but do allow for gradual upward leakage contributing water to the wetlands. Groundwater recharge also occurs from percolation of runoff where shallow alluvial fan deposits and stream channel deposits are present.

During wet year winters, groundwater levels are near ground surface in the higher topographic areas of the valley and in the lower elevation wetland area above ground surface. Historically, the groundwater level declined more than 30 feet as a result of regional groundwater extractions during the 1987-1991 drought and subsidence was experienced. During the most recent drought period, groundwater levels remained within 10 feet of ground surface over most of the Froom Ranch valley area and no documented subsidence has occurred.

The proposed project will raise the ground surface on the valley floor in the buildable area and re-align the stream channel. The higher ground surface will increase the depth to water below grade, assuming the groundwater level elevation will be similar to the recent groundwater level elevations. The re-aligned stream channel is anticipated to result in some increase in recharge to the groundwater basin and increase the period of time during the winter when standing water is present in the wetland area. Groundwater levels are anticipated to be higher for a longer period after the rainy season due to the flatter groundwater gradient resulting from the downstream detention basin.

Very truly yours,
CLEATH-HARRIS GEOLOGISTS



Timothy S. Cleath, Certified Hydrogeologist #81
President

REFERENCES

Balance Hydrologics, Inc., 2004, Hydrologic Sufficiency for Sustaining a Separated Wetland near Calle Joaquin, San Luis Obispo, California.

Cleath-Harris Geologists, 2018, Groundwater Flow Analysis, Recycled Water Project, San Luis Valley Sub-Area, San Luis Obispo Valley Groundwater Basin, prepared for the City of San Luis Obispo under contract with Water Systems Consulting.

Cleveland, George, 1980, Drought and Ground Deformation, Cambria, San Luis Obispo County, California

GeoSolutions, Inc., 2017, Subsurface Fault Investigation and Development Setback Map, Proposed Madonna Froom Ranch Specific Plan Area, APNs 067-241-030 and -031, San Luis Obispo Area, San Luis Obispo County, California.

RRM Design Group, 2018, Preliminary Grading Plans, Froom Ranch Development.

RRM Design Group, 2017, Preliminary Hydrologic and Hydraulic Calculations, prepared for the Froom Ranch Specific Plan.

RRM Design Group, 2018, Well Head Survey Information.

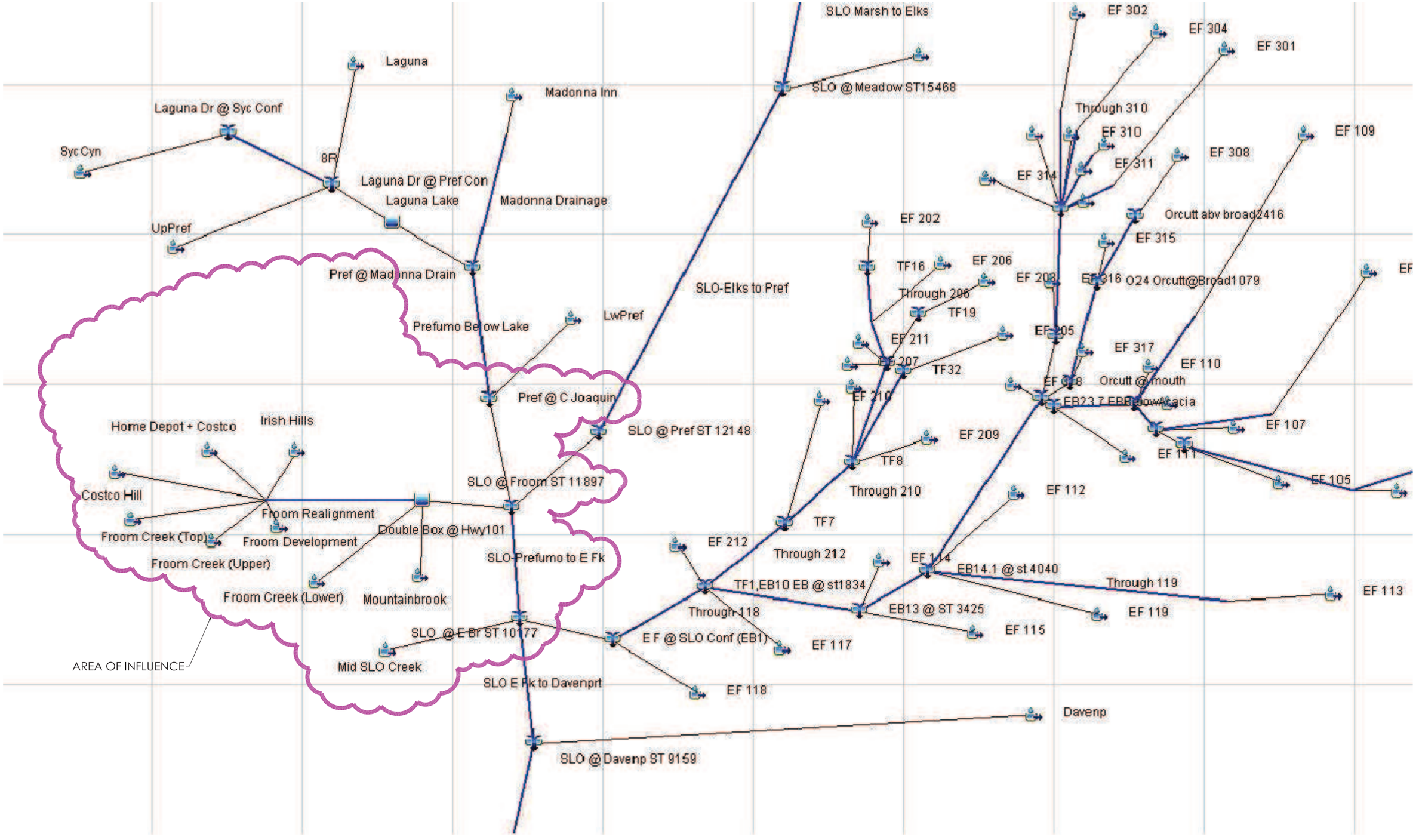
University of California, Davis and United States Department of Agriculture Natural Resources Conservation District, Soil Web.

Wallace Group, 2006, Storm Water Basin Grading Plan Irish Hills Plaza 1, Drawing No. B-1.2, 48 of 66 Sheets.

Yeh and Associates, 2017, Subsidence Evaluation, San Luis Obispo Valley Groundwater Basin Characterization Project, San Luis Obispo County, California

Appendix 8

HEC-HMS Hydraulic Modeling Results



Froom Ranch

HEC-HMS NODE MAP

Exhibit
January 18, 2019

rrm design group

Project: Modified_Froom(Pre-Post) Simulation Run: Proposed-2A

Start of Run: 01Jan2000, 00:00 Basin Model: Froom Development
End of Run: 01Jan2000, 23:45 Meteorologic Model: 2-yr Size A-12 km2
Compute Time: 12Oct2018, 11:04:47 Control Specifications: 24-hr Design, 5 min

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Costco Hill	0.16875	29.733	01Jan2000, 12:35	14.089
Double Box @ Hwy101	1.51794	267.045	01Jan2000, 12:45	168.115
Froom Creek (Lower)	0.2344	76.775	01Jan2000, 12:20	36.251
Froom Creek (Upper)	0.8969	163.660	01Jan2000, 12:20	65.289
Froom Development	0.05243	35.438	01Jan2000, 12:15	26.198
Froom Realignment	1.18931	257.319	01Jan2000, 12:25	124.982
Home Depot + Costco	0.04743	20.008	01Jan2000, 12:35	10.482
Irish Hills	0.0238	15.857	01Jan2000, 12:15	9.048
Mid SLO Creek	1.0469	221.230	01Jan2000, 12:20	78.303
Mountainbrook	0.09423	21.193	01Jan2000, 12:20	9.560
Pref @ C Joaquin	14.7016	2207.510	01Jan2000, 12:55	998.034
SLO @ E Br ST 10177	55.67054	6850.794	01Jan2000, 14:25	4116.095
SLO @ Froom ST 11897	42.42564	5774.610	01Jan2000, 14:05	3194.125

Project: Modified_Froom(Pre-Post) Simulation Run: Proposed-10A

Start of Run: 01Jan2000, 00:00 Basin Model: Froom Development
End of Run: 01Jan2000, 23:45 Meteorologic Model: 10-yr Size A-12 km2
Compute Time: 12Oct2018, 11:04:59 Control Specifications: 24-hr Design, 5 min

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Costco Hill	0.16875	59.058	01Jan2000, 12:35	22.125
Double Box @ Hwy101	1.51794	477.759	01Jan2000, 12:50	243.406
Froom Creek (Lower)	0.2344	143.383	01Jan2000, 12:20	49.941
Froom Creek (Upper)	0.8969	347.765	01Jan2000, 12:20	106.663
Froom Development	0.05243	51.630	01Jan2000, 12:15	29.777
Froom Realignment	1.18931	499.685	01Jan2000, 12:25	182.814
Home Depot + Costco	0.04743	31.980	01Jan2000, 12:30	13.719
Irish Hills	0.0238	23.681	01Jan2000, 12:15	10.690
Mid SLO Creek	1.0469	448.352	01Jan2000, 12:20	127.825
Mountainbrook	0.09423	41.635	01Jan2000, 12:20	14.018
Pref @ C Joaquin	14.7016	4196.327	01Jan2000, 13:00	1676.039
SLO @ E Br ST 10177	55.67054	14567.886	01Jan2000, 13:50	6975.220
SLO @ Froom ST 11897	42.42564	12112.301	01Jan2000, 13:40	5417.020

Project: Modified_Froom(Pre-Post) Simulation Run: Proposed-25A

Start of Run: 01Jan2000, 00:00 Basin Model: Froom Development
End of Run: 01Jan2000, 23:45 Meteorologic Model: 25-yr Size A-12 km2
Compute Time: 12Oct2018, 11:05:20 Control Specifications: 24-hr Design, 5 min

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Costco Hill	0.16875	79.460	01Jan2000, 12:35	29.602
Double Box @ Hwy101	1.51794	613.298	01Jan2000, 12:50	312.503
Froom Creek (Lower)	0.2344	184.236	01Jan2000, 12:20	62.137
Froom Creek (Upper)	0.8969	479.282	01Jan2000, 12:20	145.731
Froom Development	0.05243	59.725	01Jan2000, 12:15	32.796
Froom Realignment	1.18931	664.459	01Jan2000, 12:25	236.430
Home Depot + Costco	0.04743	38.069	01Jan2000, 12:30	16.441
Irish Hills	0.0238	27.486	01Jan2000, 12:15	12.070
Mid SLO Creek	1.0469	604.343	01Jan2000, 12:20	174.126
Mountainbrook	0.09423	55.676	01Jan2000, 12:20	18.185
Pref @ C Joaquin	14.7016	5398.284	01Jan2000, 13:05	2309.797
SLO @ E Br ST 10177	55.67054	19729.606	01Jan2000, 13:45	9338.087
SLO @ Froom ST 11897	42.42564	16251.354	01Jan2000, 13:35	7195.816

Project: Modified_Froom(Pre-Post) Simulation Run: Proposed-50A

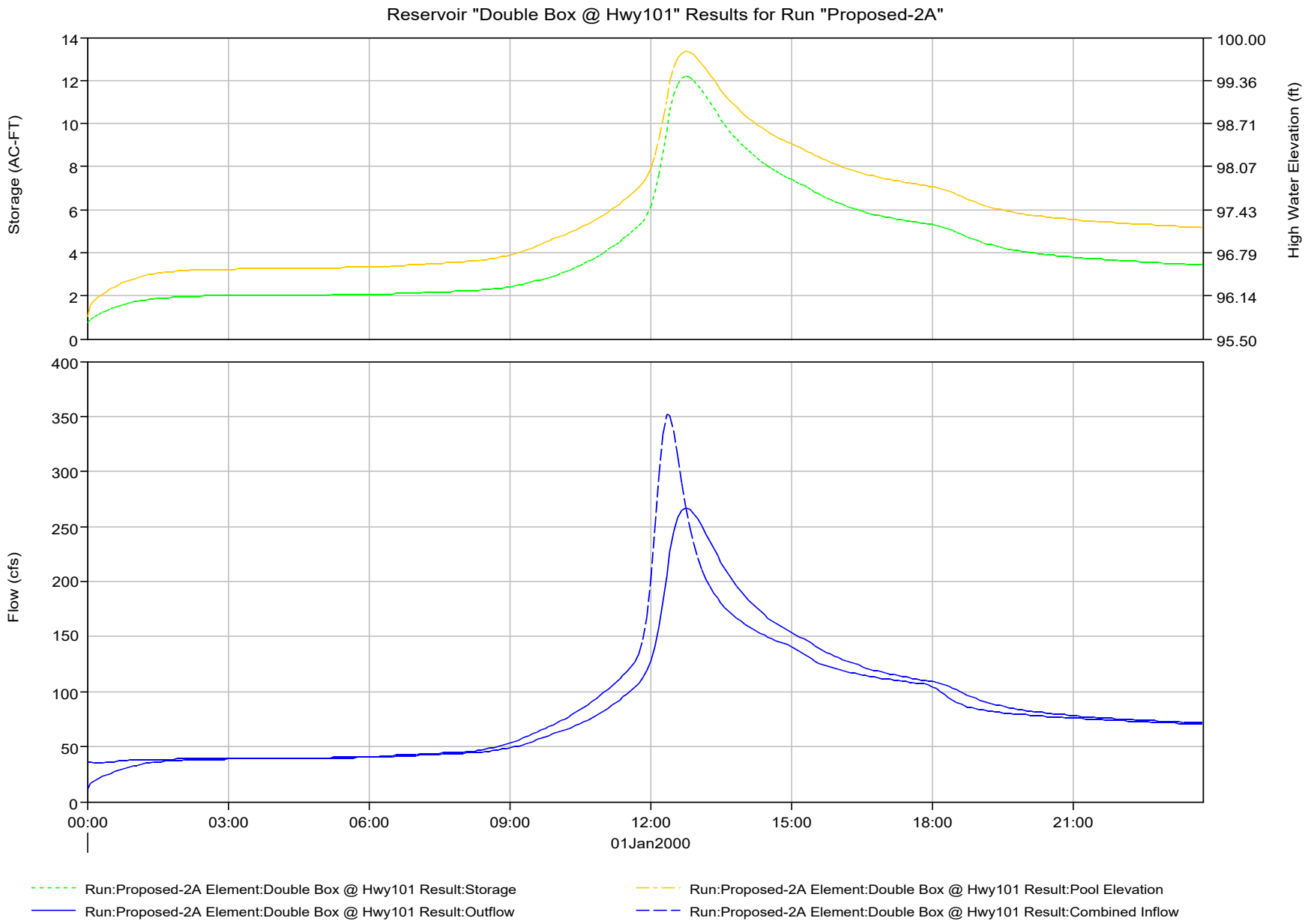
Start of Run: 01Jan2000, 00:00 Basin Model: Froom Development
End of Run: 01Jan2000, 23:45 Meteorologic Model: 50-yr Size A-12 km2
Compute Time: 12Oct2018, 11:06:02 Control Specifications: 24-hr Design, 5 min

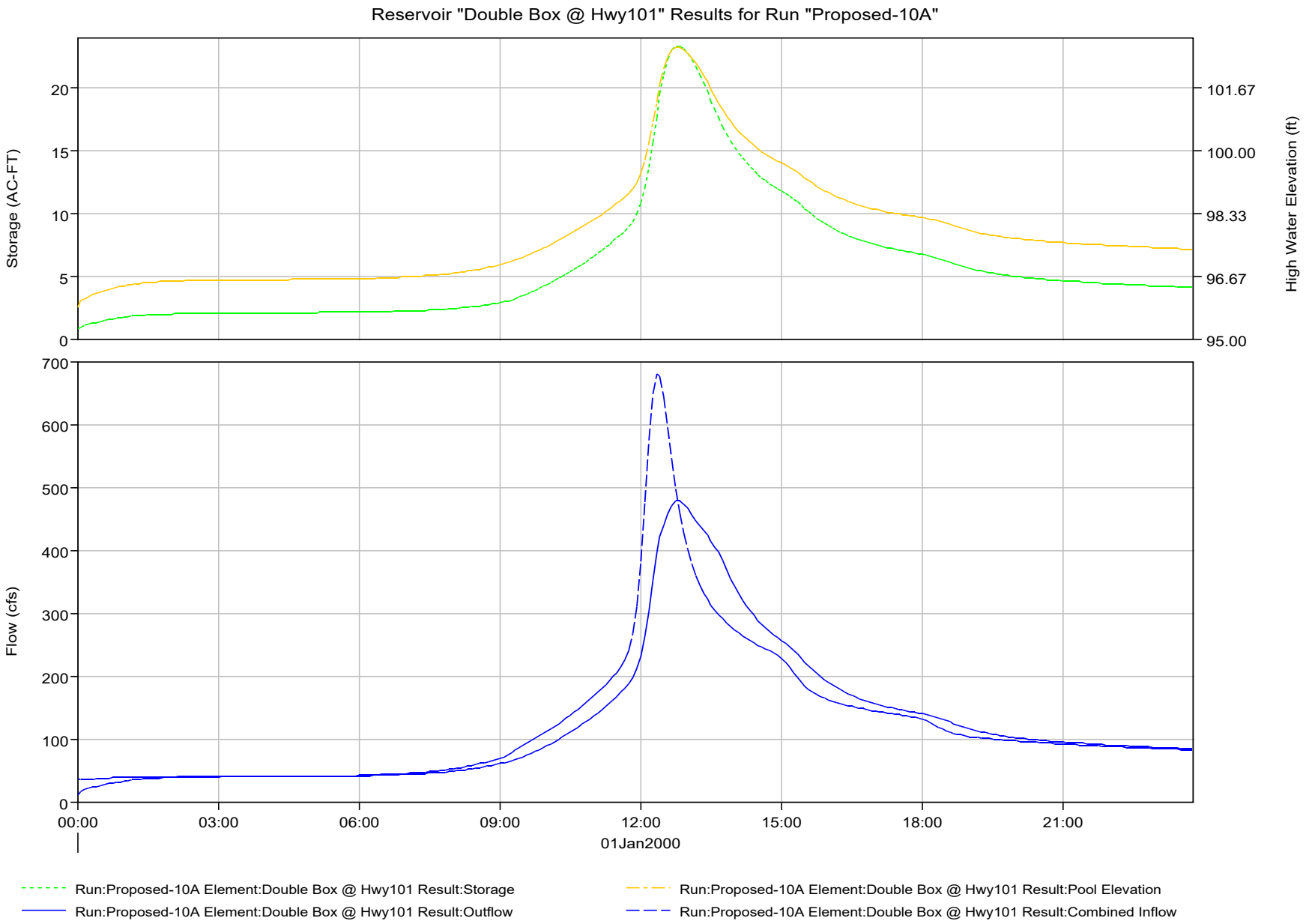
Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Costco Hill	0.16875	95.596	01Jan2000, 12:35	35.261
Double Box @ Hwy101	1.51794	928.170	01Jan2000, 12:35	364.434
Froom Creek (Lower)	0.2344	216.860	01Jan2000, 12:20	71.165
Froom Creek (Upper)	0.8969	586.277	01Jan2000, 12:20	175.563
Froom Development	0.05243	66.527	01Jan2000, 12:15	34.976
Froom Realignment	1.18931	797.881	01Jan2000, 12:25	276.997
Home Depot + Costco	0.04743	42.762	01Jan2000, 12:30	18.398
Irish Hills	0.0238	30.783	01Jan2000, 12:15	13.066
Mid SLO Creek	1.0469	732.854	01Jan2000, 12:20	209.350
Mountainbrook	0.09423	67.243	01Jan2000, 12:20	21.356
Pref @ C Joaquin	14.7016	6071.159	01Jan2000, 13:10	2789.396
SLO @ E Br ST 10177	55.67054	23882.626	01Jan2000, 13:40	11358.320
SLO @ Froom ST 11897	42.42564	19895.094	01Jan2000, 13:30	8783.155

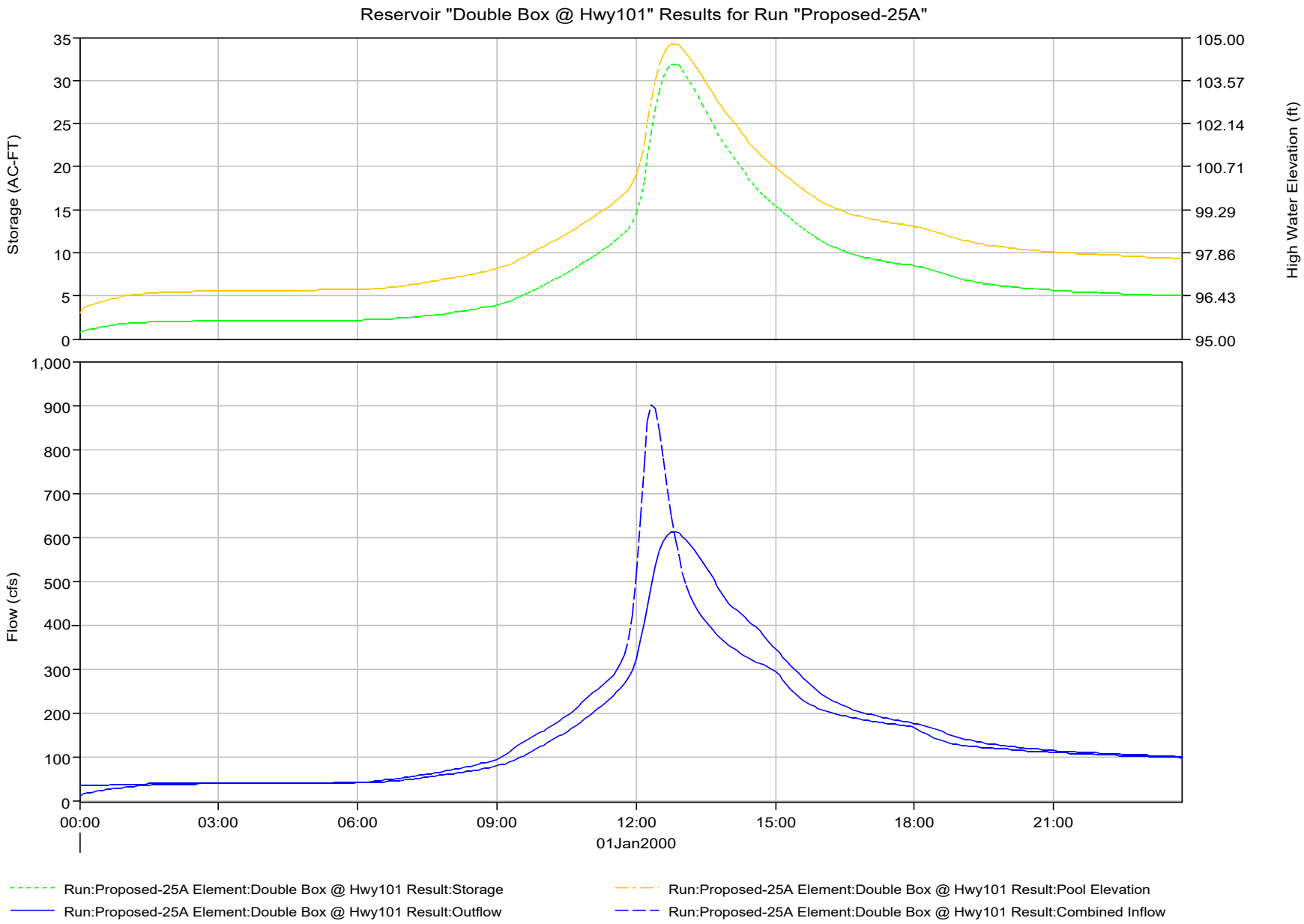
Project: Modified_Froom(Pre-Post) Simulation Run: Proposed-100A

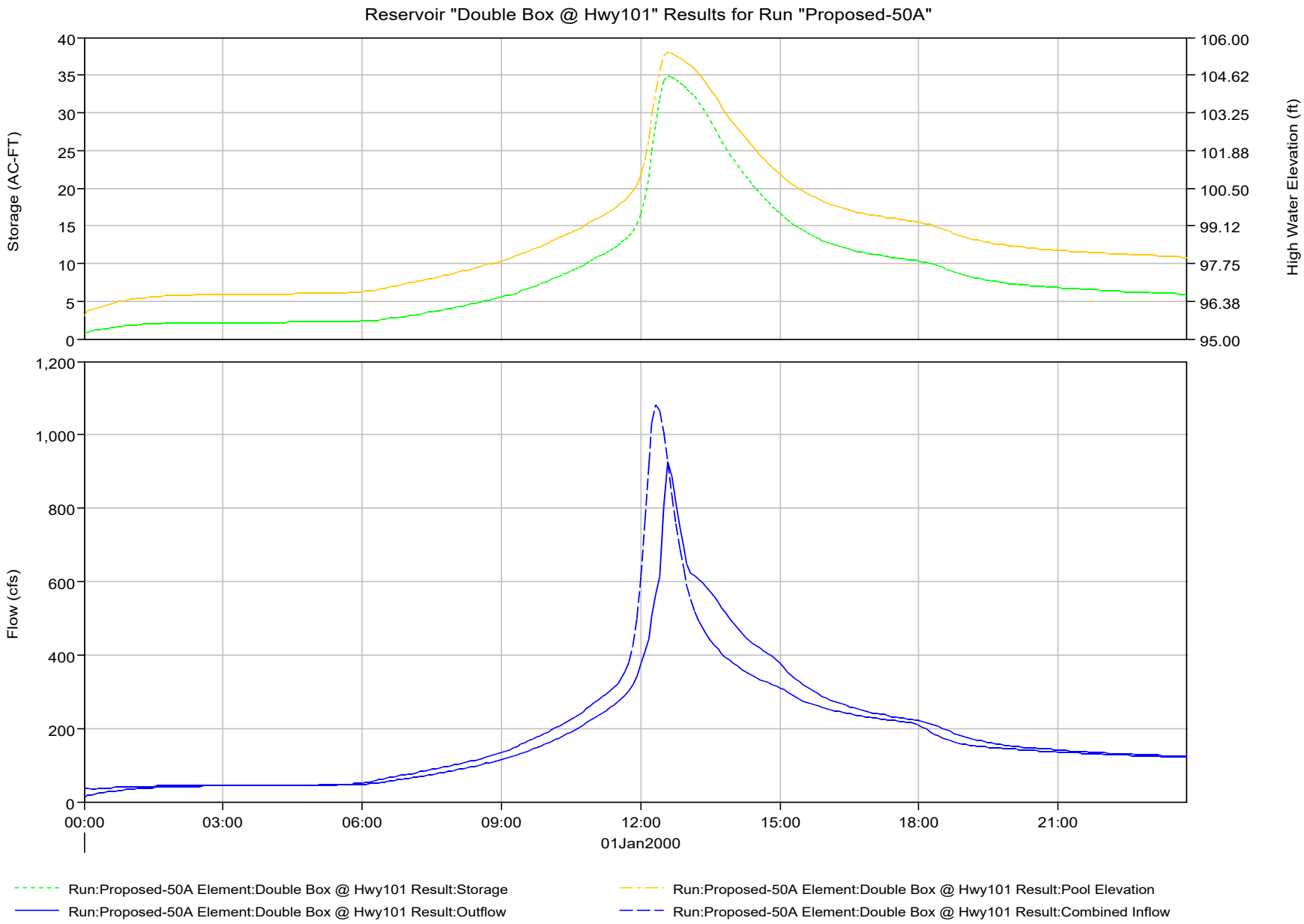
Start of Run: 01Jan2000, 00:00 Basin Model: Froom Development
End of Run: 01Jan2000, 23:45 Meteorologic Model: 100-yr Size A 12 km2
Compute Time: 16Oct2018, 11:16:33 Control Specifications: 24-hr Design, 5 min

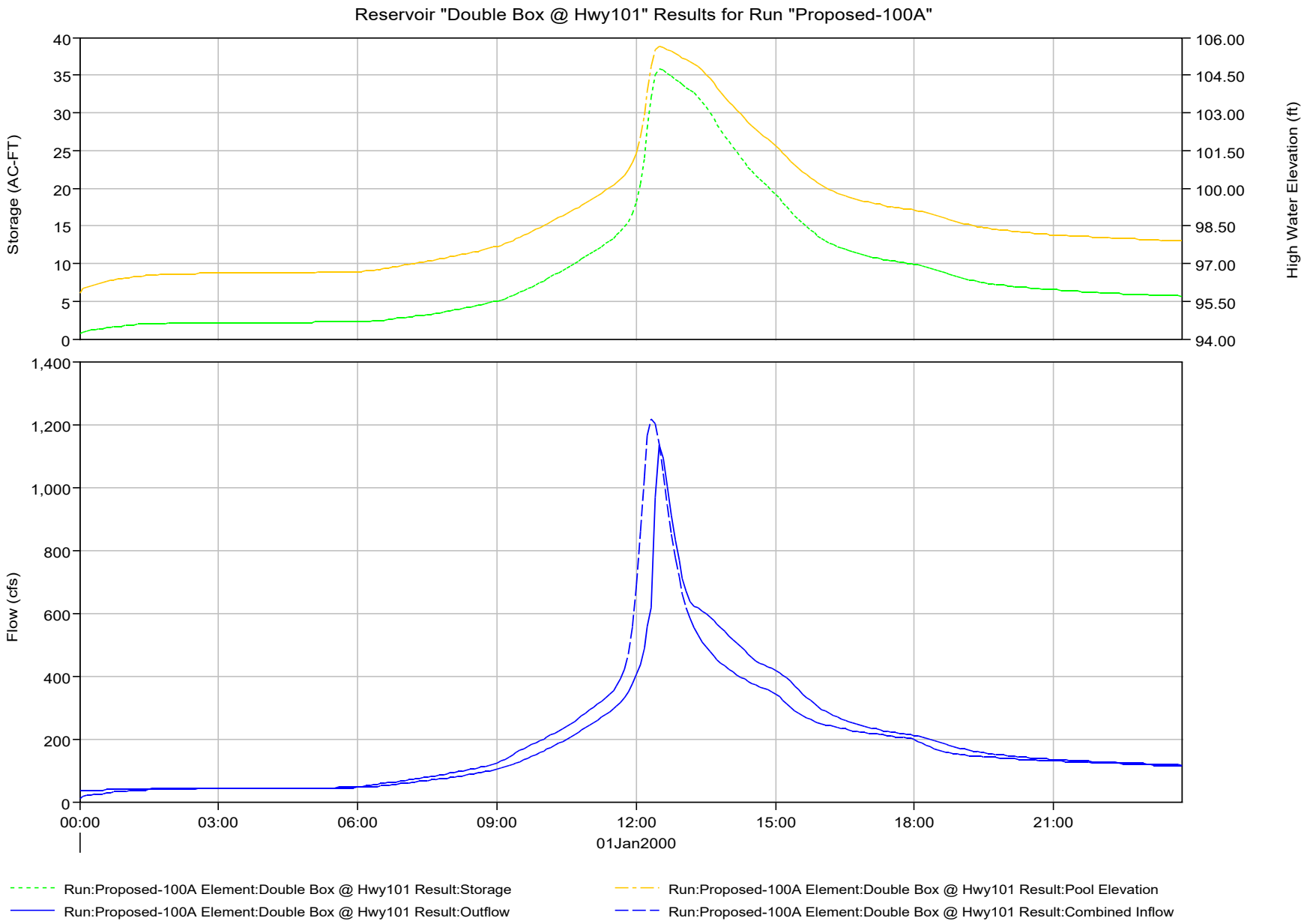
Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Costco Hill	0.16875	107.907	01Jan2000, 12:35	36.819
Double Box @ Hwy101	1.51794	1132.482	01Jan2000, 12:30	378.904
Froom Creek (Lower)	0.2344	243.088	01Jan2000, 12:20	73.567
Froom Creek (Upper)	0.8969	664.096	01Jan2000, 12:20	183.637
Froom Development	0.05243	73.187	01Jan2000, 12:15	35.551
Froom Realignment	1.18931	899.656	01Jan2000, 12:25	288.013
Home Depot + Costco	0.04743	47.525	01Jan2000, 12:30	18.925
Irish Hills	0.0238	34.039	01Jan2000, 12:15	13.327
Mid SLO Creek	1.0469	829.323	01Jan2000, 12:20	218.839
Mountainbrook	0.09423	75.926	01Jan2000, 12:20	22.210
Pref @ C Joaquin	14.7016	6547.904	01Jan2000, 13:10	2924.130
SLO @ E Br ST 10177	55.67054	27469.665	01Jan2000, 13:35	12293.146
SLO @ Froom ST 11897	42.42564	22823.015	01Jan2000, 13:25	9592.088


Reservoir "Double Box @ Hwy101" Results for Run "Proposed-2A"
Storage (AC-FT)
High Water Elevation (ft)
Flow (cfs)
0
2
4
6
8
10
12
14
95.50
96.14
96.79
97.43
98.07
98.71
99.36
100.00
0
50
100
150
200
250
300
350
400
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
01Jan2000
Run:Proposed-2A Element:Double Box @ Hwy101 Result:Storage
Run:Proposed-2A Element:Double Box @ Hwy101 Result:Pool Elevation
Run:Proposed-2A Element:Double Box @ Hwy101 Result:Outflow
Run:Proposed-2A Element:Double Box @ Hwy101 Result:Combined Inflow


Reservoir "Double Box @ Hwy101" Results for Run "Proposed-10A"
Storage (AC-FT)
High Water Elevation (ft)
0
5
10
15
20
95.00
96.67
98.33
100.00
101.67
Flow (cfs)
0
100
200
300
400
500
600
700
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
01Jan2000
Run:Proposed-10A Element:Double Box @ Hwy101 Result:Storage
Run:Proposed-10A Element:Double Box @ Hwy101 Result:Pool Elevation
Run:Proposed-10A Element:Double Box @ Hwy101 Result:Outflow
Run:Proposed-10A Element:Double Box @ Hwy101 Result:Combined Inflow


Reservoir "Double Box @ Hwy101" Results for Run "Proposed-25A"
Storage (AC-FT)
High Water Elevation (ft)
Flow (cfs)
35
30
25
20
15
10
5
0
105.00
103.57
102.14
100.71
99.29
97.86
96.43
95.00
1,000
900
800
700
600
500
400
300
200
100
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
01Jan2000
Run:Proposed-25A Element:Double Box @ Hwy101 Result:Storage
Run:Proposed-25A Element:Double Box @ Hwy101 Result:Pool Elevation
Run:Proposed-25A Element:Double Box @ Hwy101 Result:Outflow
Run:Proposed-25A Element:Double Box @ Hwy101 Result:Combined Inflow


Reservoir "Double Box @ Hwy101" Results for Run "Proposed-50A"
Storage (AC-FT)
High Water Elevation (ft)
40
35
30
25
20
15
10
5
0
106.00
104.62
103.25
101.88
100.50
99.12
97.75
96.38
95.00
Flow (cfs)
1,200
1,000
800
600
400
200
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
01Jan2000
Run:Proposed-50A Element:Double Box @ Hwy101 Result:Storage
Run:Proposed-50A Element:Double Box @ Hwy101 Result:Pool Elevation
Run:Proposed-50A Element:Double Box @ Hwy101 Result:Outflow
Run:Proposed-50A Element:Double Box @ Hwy101 Result:Combined Inflow


Reservoir "Double Box @ Hwy101" Results for Run "Proposed-100A"
Storage (AC-FT)
High Water Elevation (ft)
Flow (cfs)
40
35
30
25
20
15
10
5
0
106.00
104.50
103.00
101.50
100.00
98.50
97.00
95.50
94.00
1,400
1,200
1,000
800
600
400
200
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
01Jan2000
Run:Proposed-100A Element:Double Box @ Hwy101 Result:Storage
Run:Proposed-100A Element:Double Box @ Hwy101 Result:Pool Elevation
Run:Proposed-100A Element:Double Box @ Hwy101 Result:Outflow
Run:Proposed-100A Element:Double Box @ Hwy101 Result:Combined Inflow

Double Box Culvert Outlet and Storage [2-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
0:00	36.000	11.000	95.836	0.768
0:05	35.829	16.791	96.010	0.918
0:10	35.057	18.942	96.069	1.039
0:15	35.190	20.871	96.121	1.144
0:20	35.445	22.642	96.167	1.237
0:25	35.806	24.271	96.208	1.321
0:30	36.217	25.773	96.245	1.397
0:35	36.631	27.159	96.279	1.465
0:40	37.010	28.435	96.309	1.527
0:45	37.332	29.605	96.337	1.583
0:50	37.598	30.695	96.362	1.634
0:55	37.820	31.655	96.384	1.679
1:00	38.007	32.498	96.403	1.719
1:05	38.163	33.279	96.421	1.755
1:10	38.290	33.975	96.437	1.786
1:15	38.393	34.592	96.450	1.814
1:20	38.477	35.139	96.462	1.839
1:25	38.548	35.621	96.473	1.861
1:30	38.608	36.045	96.482	1.879
1:35	38.661	36.418	96.490	1.896
1:40	38.707	36.745	96.498	1.910
1:45	38.748	37.032	96.504	1.923
1:50	38.785	37.283	96.509	1.934
1:55	38.818	37.504	96.514	1.944
2:00	38.849	37.698	96.518	1.952
2:05	38.878	37.868	96.522	1.960
2:10	38.906	38.017	96.525	1.966
2:15	38.932	38.149	96.528	1.972
2:20	38.956	38.265	96.530	1.977
2:25	38.981	38.368	96.533	1.982
2:30	39.005	38.460	96.534	1.986
2:35	39.029	38.542	96.536	1.989
2:40	39.053	38.615	96.538	1.992
2:45	39.076	38.681	96.539	1.995
2:50	39.099	38.741	96.540	1.998
2:55	39.123	38.795	96.542	2.000
3:00	39.147	38.845	96.543	2.002
3:05	39.171	38.891	96.544	2.004
3:10	39.195	38.934	96.545	2.006
3:15	39.219	38.974	96.545	2.008
3:20	39.244	39.012	96.546	2.010
3:25	39.269	39.048	96.547	2.011
3:30	39.294	39.082	96.548	2.013
3:35	39.319	39.116	96.548	2.014

Double Box Culvert Outlet and Storage [2-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
3:40	39.344	39.147	96.549	2.015
3:45	39.370	39.178	96.550	2.017
3:50	39.397	39.209	96.550	2.018
3:55	39.423	39.238	96.551	2.019
4:00	39.451	39.268	96.552	2.021
4:05	39.478	39.297	96.552	2.022
4:10	39.506	39.326	96.553	2.023
4:15	39.535	39.354	96.554	2.024
4:20	39.564	39.383	96.554	2.026
4:25	39.593	39.412	96.555	2.027
4:30	39.623	39.441	96.555	2.028
4:35	39.654	39.470	96.556	2.029
4:40	39.685	39.500	96.557	2.031
4:45	39.716	39.529	96.557	2.032
4:50	39.749	39.559	96.558	2.033
4:55	39.781	39.590	96.559	2.035
5:00	39.815	39.621	96.559	2.036
5:05	39.849	39.652	96.560	2.037
5:10	39.883	39.684	96.561	2.039
5:15	39.918	39.716	96.561	2.040
5:20	39.954	39.748	96.562	2.041
5:25	39.991	39.782	96.563	2.043
5:30	40.028	39.816	96.563	2.044
5:35	40.066	39.850	96.564	2.046
5:40	40.105	39.885	96.565	2.047
5:45	40.145	39.920	96.566	2.049
5:50	40.190	39.957	96.566	2.050
5:55	40.263	39.997	96.567	2.052
6:00	40.387	40.046	96.568	2.054
6:05	40.585	40.111	96.570	2.057
6:10	40.845	40.201	96.571	2.061
6:15	41.134	40.318	96.574	2.066
6:20	41.425	40.461	96.577	2.072
6:25	41.699	40.625	96.580	2.079
6:30	41.944	40.804	96.584	2.087
6:35	42.163	40.991	96.588	2.095
6:40	42.365	41.181	96.592	2.103
6:45	42.554	41.373	96.596	2.111
6:50	42.734	41.564	96.600	2.119
6:55	42.906	41.752	96.604	2.127
7:00	43.071	41.938	96.608	2.135
7:05	43.232	42.121	96.612	2.143
7:10	43.392	42.301	96.615	2.150
7:15	43.551	42.478	96.619	2.158

Double Box Culvert Outlet and Storage [2-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
7:20	43.712	42.653	96.623	2.165
7:25	43.875	42.825	96.626	2.172
7:30	44.039	42.997	96.630	2.179
7:35	44.206	43.168	96.633	2.187
7:40	44.376	43.339	96.637	2.194
7:45	44.549	43.510	96.640	2.201
7:50	44.726	43.682	96.644	2.208
7:55	44.917	43.856	96.647	2.215
8:00	45.134	44.034	96.651	2.223
8:05	45.399	44.223	96.655	2.231
8:10	45.735	44.429	96.659	2.239
8:15	46.153	44.662	96.664	2.249
8:20	46.659	44.930	96.669	2.260
8:25	47.248	45.241	96.676	2.273
8:30	47.910	45.603	96.683	2.288
8:35	48.636	46.016	96.691	2.305
8:40	49.416	46.483	96.701	2.324
8:45	50.240	47.004	96.711	2.345
8:50	51.118	47.579	96.722	2.368
8:55	52.080	48.210	96.735	2.394
9:00	53.162	48.905	96.749	2.422
9:05	54.392	49.677	96.764	2.453
9:10	55.755	50.536	96.781	2.487
9:15	57.211	51.487	96.799	2.524
9:20	58.724	52.531	96.819	2.566
9:25	60.267	53.659	96.841	2.610
9:30	61.819	54.890	96.864	2.656
9:35	63.382	56.156	96.888	2.705
9:40	64.963	57.480	96.913	2.756
9:45	66.567	58.859	96.939	2.808
9:50	68.204	60.289	96.965	2.862
9:55	69.879	61.767	96.992	2.917
10:00	71.593	62.946	97.014	2.975
10:05	73.361	64.058	97.034	3.036
10:10	75.192	65.257	97.055	3.103
10:15	77.087	66.542	97.078	3.173
10:20	79.069	67.913	97.103	3.248
10:25	81.158	69.371	97.128	3.327
10:30	83.369	70.924	97.156	3.410
10:35	85.733	72.576	97.184	3.499
10:40	88.251	74.337	97.215	3.592
10:45	90.906	76.212	97.247	3.690
10:50	93.690	78.207	97.281	3.794
10:55	96.567	80.324	97.316	3.903

Double Box Culvert Outlet and Storage [2-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
11:00	99.482	82.556	97.353	4.018
11:05	102.420	84.896	97.392	4.136
11:10	105.369	87.334	97.432	4.259
11:15	108.321	89.860	97.473	4.384
11:20	111.333	92.468	97.515	4.513
11:25	114.477	95.161	97.558	4.644
11:30	117.833	97.952	97.602	4.779
11:35	121.855	100.889	97.647	4.920
11:40	127.200	104.087	97.697	5.072
11:45	134.613	107.752	97.753	5.244
11:50	146.939	112.318	97.822	5.455
11:55	167.934	118.651	97.916	5.744
12:00	202.071	127.797	98.049	6.168
12:05	248.056	140.760	98.232	6.793
12:10	296.483	158.910	98.479	7.635
12:15	334.101	181.364	98.772	8.633
12:20	351.973	205.317	99.071	9.663
12:25	351.299	227.231	99.335	10.593
12:30	336.619	245.248	99.544	11.334
12:35	314.277	257.823	99.688	11.843
12:40	289.661	264.829	99.768	12.122
12:45	267.781	267.045	99.793	12.210
12:50	249.633	265.714	99.778	12.158
12:55	234.644	261.962	99.735	12.008
13:00	221.858	256.624	99.675	11.794
13:05	211.138	250.314	99.603	11.540
13:10	202.352	243.499	99.524	11.263
13:15	195.274	236.562	99.444	10.979
13:20	189.477	229.758	99.364	10.698
13:25	184.624	223.240	99.287	10.427
13:30	180.436	217.106	99.214	10.168
13:35	176.647	211.343	99.144	9.922
13:40	173.160	205.939	99.078	9.689
13:45	169.936	200.878	99.016	9.470
13:50	166.913	196.028	98.956	9.263
13:55	164.082	191.457	98.899	9.069
14:00	161.464	187.194	98.846	8.886
14:05	159.041	183.217	98.795	8.714
14:10	156.800	179.508	98.748	8.553
14:15	154.743	176.048	98.703	8.401
14:20	152.838	172.822	98.662	8.259
14:25	151.085	169.816	98.623	8.125
14:30	149.480	167.017	98.586	8.001
14:35	147.978	164.408	98.552	7.884

Double Box Culvert Outlet and Storage [2-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
14:40	146.560	161.975	98.520	7.774
14:45	145.229	159.703	98.489	7.671
14:50	143.891	157.572	98.461	7.574
14:55	142.424	155.553	98.434	7.482
15:00	140.695	153.600	98.408	7.392
15:05	138.619	151.661	98.381	7.303
15:10	136.292	149.694	98.355	7.212
15:15	133.893	147.745	98.327	7.118
15:20	131.568	145.632	98.299	7.022
15:25	129.414	143.586	98.271	6.924
15:30	127.510	141.495	98.242	6.827
15:35	125.845	139.490	98.214	6.732
15:40	124.381	137.553	98.187	6.640
15:45	123.076	135.698	98.161	6.551
15:50	121.896	133.933	98.136	6.466
15:55	120.824	132.260	98.112	6.385
16:00	119.849	130.679	98.090	6.309
16:05	118.942	129.189	98.069	6.236
16:10	118.093	127.784	98.049	6.168
16:15	117.296	126.461	98.030	6.103
16:20	116.539	125.212	98.012	6.041
16:25	115.817	123.995	97.994	5.983
16:30	115.133	122.773	97.976	5.929
16:35	114.476	121.634	97.960	5.878
16:40	113.846	120.568	97.944	5.830
16:45	113.247	119.569	97.929	5.785
16:50	112.671	118.632	97.916	5.743
16:55	112.114	117.749	97.903	5.703
17:00	111.578	116.915	97.890	5.665
17:05	111.052	116.126	97.879	5.629
17:10	110.536	115.376	97.867	5.595
17:15	110.036	114.662	97.857	5.562
17:20	109.547	113.980	97.847	5.531
17:25	109.069	113.326	97.837	5.501
17:30	108.604	112.700	97.827	5.473
17:35	108.148	112.097	97.818	5.445
17:40	107.702	111.517	97.810	5.418
17:45	107.271	110.957	97.801	5.392
17:50	106.740	110.409	97.793	5.367
17:55	105.913	109.843	97.785	5.341
18:00	104.565	109.207	97.775	5.311
18:05	102.573	108.429	97.763	5.275
18:10	100.091	107.453	97.748	5.230
18:15	97.413	106.259	97.730	5.174

Double Box Culvert Outlet and Storage [2-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
18:20	94.803	104.871	97.709	5.109
18:25	92.422	103.339	97.685	5.036
18:30	90.395	101.723	97.660	4.960
18:35	88.720	100.084	97.635	4.882
18:40	87.348	98.468	97.610	4.804
18:45	86.192	96.906	97.585	4.729
18:50	85.213	95.419	97.562	4.657
18:55	84.380	94.015	97.539	4.589
19:00	83.675	92.701	97.519	4.524
19:05	83.066	91.478	97.499	4.464
19:10	82.529	90.345	97.481	4.408
19:15	82.048	89.298	97.464	4.357
19:20	81.606	88.330	97.448	4.308
19:25	81.194	87.435	97.434	4.264
19:30	80.810	86.607	97.420	4.222
19:35	80.448	85.840	97.408	4.184
19:40	80.104	85.127	97.396	4.148
19:45	79.778	84.465	97.385	4.115
19:50	79.466	83.848	97.375	4.083
19:55	79.166	83.272	97.365	4.054
20:00	78.879	82.732	97.356	4.027
20:05	78.601	82.227	97.348	4.001
20:10	78.332	81.752	97.340	3.977
20:15	78.073	81.304	97.333	3.954
20:20	77.820	80.881	97.326	3.932
20:25	77.571	80.481	97.319	3.912
20:30	77.330	80.100	97.312	3.892
20:35	77.094	79.738	97.306	3.873
20:40	76.862	79.393	97.301	3.855
20:45	76.633	79.062	97.295	3.838
20:50	76.404	78.744	97.290	3.822
20:55	76.176	78.438	97.285	3.806
21:00	75.950	78.142	97.280	3.791
21:05	75.726	77.856	97.275	3.776
21:10	75.506	77.577	97.270	3.761
21:15	75.292	77.306	97.265	3.747
21:20	75.085	77.044	97.261	3.734
21:25	74.883	76.788	97.257	3.720
21:30	74.687	76.541	97.252	3.707
21:35	74.495	76.299	97.248	3.695
21:40	74.304	76.065	97.244	3.683
21:45	74.114	75.836	97.240	3.671
21:50	73.922	75.612	97.237	3.659
21:55	73.731	75.392	97.233	3.647

Double Box Culvert Outlet and Storage [2-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
22:00	73.542	75.176	97.229	3.636
22:05	73.358	74.964	97.225	3.625
22:10	73.178	74.755	97.222	3.614
22:15	73.001	74.551	97.218	3.603
22:20	72.826	74.350	97.215	3.592
22:25	72.653	74.153	97.212	3.582
22:30	72.483	73.959	97.208	3.572
22:35	72.315	73.768	97.205	3.562
22:40	72.149	73.580	97.202	3.552
22:45	71.988	73.395	97.198	3.542
22:50	71.830	73.214	97.195	3.532
22:55	71.673	73.035	97.192	3.523
23:00	71.518	72.860	97.189	3.514
23:05	71.365	72.687	97.186	3.504
23:10	71.211	72.517	97.183	3.495
23:15	71.059	72.349	97.180	3.486
23:20	70.908	72.183	97.177	3.478
23:25	70.756	72.019	97.175	3.469
23:30	70.605	71.857	97.172	3.460
23:35	70.454	71.696	97.169	3.452
23:40	70.303	71.536	97.166	3.443
23:45	70.157	71.378	97.163	3.435

Double Box Culvert Outlet and Storage [10-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
0:00	36.000	11.000	95.836	0.768
0:05	35.830	16.791	96.010	0.918
0:10	35.067	18.943	96.070	1.039
0:15	35.224	20.875	96.121	1.144
0:20	35.525	22.652	96.167	1.238
0:25	35.951	24.294	96.209	1.322
0:30	36.436	25.817	96.246	1.399
0:35	36.925	27.232	96.281	1.469
0:40	37.372	28.543	96.312	1.533
0:45	37.753	29.752	96.340	1.590
0:50	38.067	30.876	96.366	1.643
0:55	38.330	31.902	96.389	1.690
1:00	38.551	32.774	96.410	1.732
1:05	38.737	33.596	96.428	1.769
1:10	38.889	34.332	96.445	1.803
1:15	39.011	34.987	96.459	1.832
1:20	39.112	35.569	96.472	1.858
1:25	39.197	36.083	96.483	1.881
1:30	39.270	36.537	96.493	1.901
1:35	39.334	36.937	96.502	1.919
1:40	39.391	37.288	96.509	1.934
1:45	39.441	37.598	96.516	1.948
1:50	39.486	37.870	96.522	1.960
1:55	39.528	38.109	96.527	1.970
2:00	39.567	38.320	96.531	1.980
2:05	39.603	38.505	96.535	1.988
2:10	39.637	38.668	96.539	1.995
2:15	39.670	38.813	96.542	2.001
2:20	39.702	38.942	96.545	2.007
2:25	39.734	39.056	96.547	2.012
2:30	39.764	39.158	96.549	2.016
2:35	39.795	39.250	96.551	2.020
2:40	39.826	39.333	96.553	2.023
2:45	39.856	39.407	96.555	2.027
2:50	39.886	39.476	96.556	2.030
2:55	39.917	39.539	96.557	2.032
3:00	39.948	39.597	96.559	2.035
3:05	39.979	39.651	96.560	2.037
3:10	40.010	39.702	96.561	2.039
3:15	40.042	39.750	96.562	2.041
3:20	40.074	39.796	96.563	2.043
3:25	40.106	39.839	96.564	2.045
3:30	40.139	39.881	96.565	2.047
3:35	40.172	39.922	96.566	2.049

Double Box Culvert Outlet and Storage [10-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
3:40	40.205	39.961	96.566	2.051
3:45	40.239	40.000	96.567	2.052
3:50	40.274	40.038	96.568	2.054
3:55	40.309	40.076	96.569	2.055
4:00	40.344	40.113	96.570	2.057
4:05	40.381	40.150	96.570	2.059
4:10	40.418	40.187	96.571	2.060
4:15	40.455	40.224	96.572	2.062
4:20	40.493	40.261	96.573	2.063
4:25	40.532	40.299	96.574	2.065
4:30	40.572	40.336	96.574	2.067
4:35	40.612	40.374	96.575	2.068
4:40	40.653	40.413	96.576	2.070
4:45	40.694	40.452	96.577	2.072
4:50	40.737	40.491	96.578	2.073
4:55	40.780	40.531	96.578	2.075
5:00	40.824	40.571	96.579	2.077
5:05	40.869	40.612	96.580	2.078
5:10	40.915	40.654	96.581	2.080
5:15	40.961	40.697	96.582	2.082
5:20	41.009	40.739	96.583	2.084
5:25	41.058	40.783	96.584	2.086
5:30	41.108	40.828	96.585	2.088
5:35	41.159	40.874	96.586	2.090
5:40	41.214	40.921	96.587	2.092
5:45	41.271	40.969	96.588	2.094
5:50	41.340	41.019	96.589	2.096
5:55	41.444	41.075	96.590	2.098
6:00	41.609	41.142	96.591	2.101
6:05	41.860	41.231	96.593	2.105
6:10	42.185	41.350	96.596	2.110
6:15	42.548	41.502	96.599	2.116
6:20	42.922	41.688	96.603	2.124
6:25	43.284	41.900	96.607	2.133
6:30	43.619	42.135	96.612	2.143
6:35	43.929	42.382	96.617	2.154
6:40	44.221	42.638	96.622	2.164
6:45	44.499	42.899	96.628	2.175
6:50	44.764	43.162	96.633	2.186
6:55	45.018	43.425	96.638	2.197
7:00	45.263	43.687	96.644	2.208
7:05	45.505	43.946	96.649	2.219
7:10	45.760	44.204	96.654	2.230
7:15	46.047	44.464	96.660	2.241

Double Box Culvert Outlet and Storage [10-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
7:20	46.394	44.734	96.665	2.252
7:25	46.827	45.023	96.671	2.264
7:30	47.359	45.341	96.678	2.277
7:35	47.991	45.702	96.685	2.292
7:40	48.720	46.113	96.693	2.308
7:45	49.532	46.582	96.703	2.328
7:50	50.416	47.110	96.713	2.349
7:55	51.360	47.701	96.725	2.373
8:00	52.353	48.354	96.738	2.400
8:05	53.392	49.067	96.752	2.428
8:10	54.473	49.838	96.767	2.459
8:15	55.590	50.665	96.783	2.492
8:20	56.746	51.546	96.800	2.527
8:25	57.939	52.479	96.818	2.564
8:30	59.169	53.463	96.837	2.602
8:35	60.438	54.523	96.857	2.642
8:40	61.749	55.598	96.877	2.684
8:45	63.100	56.723	96.899	2.727
8:50	64.575	57.901	96.921	2.772
8:55	66.345	59.162	96.944	2.819
9:00	68.613	60.558	96.970	2.872
9:05	71.518	62.167	96.999	2.932
9:10	74.978	63.466	97.023	3.004
9:15	78.774	65.037	97.051	3.091
9:20	82.725	66.891	97.084	3.192
9:25	86.673	69.011	97.122	3.308
9:30	90.511	71.367	97.163	3.434
9:35	94.243	73.922	97.208	3.570
9:40	97.898	76.646	97.254	3.713
9:45	101.517	79.513	97.303	3.862
9:50	105.135	82.509	97.353	4.015
9:55	108.769	85.619	97.404	4.173
10:00	112.432	88.834	97.456	4.334
10:05	116.173	92.149	97.510	4.497
10:10	120.012	95.565	97.564	4.664
10:15	123.959	99.083	97.619	4.834
10:20	128.066	102.708	97.676	5.006
10:25	132.369	106.452	97.733	5.183
10:30	136.890	110.330	97.792	5.363
10:35	141.692	114.361	97.852	5.549
10:40	146.774	118.564	97.915	5.740
10:45	152.108	122.957	97.979	5.937
10:50	157.686	127.255	98.041	6.142
10:55	163.434	131.644	98.104	6.356

Double Box Culvert Outlet and Storage [10-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
11:00	169.247	136.266	98.169	6.578
11:05	175.093	141.099	98.237	6.809
11:10	180.944	146.149	98.306	7.045
11:15	186.775	151.319	98.377	7.287
11:20	192.719	156.669	98.449	7.533
11:25	198.936	162.180	98.522	7.783
11:30	205.607	167.884	98.597	8.039
11:35	213.800	173.898	98.676	8.306
11:40	224.889	180.506	98.761	8.596
11:45	240.465	188.186	98.858	8.928
11:50	266.695	197.950	98.980	9.345
11:55	310.994	211.383	99.145	9.923
12:00	382.081	231.792	99.388	10.783
12:05	476.302	262.610	99.743	12.034
12:10	573.696	303.136	100.207	13.698
12:15	647.658	351.639	100.740	15.646
12:20	680.566	396.900	101.272	17.625
12:25	676.065	420.782	101.762	19.480
12:30	643.610	439.604	102.171	21.059
12:35	595.859	457.167	102.472	22.247
12:40	543.949	471.441	102.656	22.973
12:45	497.964	477.591	102.737	23.293
12:50	459.933	477.759	102.739	23.301
12:55	428.190	473.582	102.684	23.084
13:00	401.051	466.191	102.588	22.703
13:05	378.249	456.429	102.463	22.210
13:10	359.530	446.041	102.319	21.642
13:15	344.369	439.142	102.161	21.018
13:20	331.927	431.489	101.991	20.349
13:25	321.533	422.997	101.809	19.657
13:30	312.605	414.186	101.624	18.958
13:35	304.611	405.208	101.440	18.262
13:40	297.343	396.238	101.259	17.575
13:45	290.681	383.917	101.083	16.908
13:50	284.473	368.395	100.919	16.299
13:55	278.683	354.318	100.769	15.751
14:00	273.328	341.825	100.633	15.256
14:05	268.363	330.510	100.510	14.806
14:10	263.756	320.328	100.398	14.397
14:15	259.525	311.133	100.296	14.024
14:20	255.605	302.804	100.203	13.684
14:25	252.001	295.240	100.118	13.373
14:30	248.699	288.361	100.040	13.087
14:35	245.602	282.001	99.967	12.825

Double Box Culvert Outlet and Storage [10-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
14:40	242.678	276.094	99.899	12.585
14:45	239.934	270.697	99.836	12.364
14:50	236.982	265.747	99.778	12.159
14:55	233.299	260.879	99.723	11.965
15:00	228.287	256.120	99.669	11.774
15:05	221.630	251.217	99.613	11.576
15:10	213.805	245.971	99.553	11.364
15:15	205.594	240.319	99.487	11.133
15:20	197.658	234.331	99.418	10.888
15:25	190.412	228.141	99.345	10.631
15:30	184.193	221.927	99.272	10.371
15:35	178.969	215.859	99.199	10.115
15:40	174.576	210.028	99.128	9.865
15:45	170.801	204.501	99.061	9.627
15:50	167.524	199.305	98.997	9.402
15:55	164.666	194.310	98.935	9.190
16:00	162.167	189.698	98.877	8.993
16:05	159.934	185.453	98.824	8.811
16:10	157.917	181.548	98.774	8.641
16:15	156.091	177.958	98.728	8.485
16:20	154.407	174.657	98.685	8.340
16:25	152.828	171.615	98.646	8.205
16:30	151.330	168.806	98.609	8.080
16:35	149.882	166.201	98.575	7.964
16:40	148.488	163.778	98.543	7.855
16:45	147.176	161.517	98.514	7.753
16:50	145.949	159.405	98.485	7.657
16:55	144.800	157.432	98.459	7.568
17:00	143.722	155.587	98.434	7.483
17:05	142.689	153.858	98.411	7.404
17:10	141.696	152.234	98.389	7.329
17:15	140.746	150.707	98.368	7.259
17:20	139.828	149.266	98.349	7.192
17:25	138.932	147.903	98.330	7.128
17:30	138.052	146.647	98.313	7.068
17:35	137.167	145.377	98.296	7.010
17:40	136.280	144.208	98.279	6.954
17:45	135.407	143.095	98.264	6.901
17:50	134.412	141.936	98.248	6.848
17:55	133.072	140.825	98.233	6.796
18:00	131.128	139.645	98.216	6.740
18:05	128.443	138.315	98.198	6.676
18:10	125.210	136.770	98.176	6.603
18:15	121.787	134.993	98.151	6.517

Double Box Culvert Outlet and Storage [10-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
18:20	118.478	133.011	98.123	6.422
18:25	115.452	130.881	98.093	6.319
18:30	112.830	128.671	98.061	6.211
18:35	110.599	126.444	98.029	6.102
18:40	108.718	124.235	97.997	5.994
18:45	107.124	121.896	97.963	5.889
18:50	105.790	119.696	97.931	5.791
18:55	104.675	117.647	97.901	5.698
19:00	103.732	115.752	97.873	5.612
19:05	102.898	114.007	97.847	5.532
19:10	102.137	112.402	97.823	5.459
19:15	101.434	110.926	97.801	5.391
19:20	100.774	109.565	97.780	5.328
19:25	100.144	108.309	97.761	5.269
19:30	99.536	107.144	97.744	5.215
19:35	98.931	106.060	97.727	5.164
19:40	98.330	105.044	97.712	5.117
19:45	97.743	104.089	97.697	5.072
19:50	97.185	103.189	97.683	5.029
19:55	96.674	102.341	97.670	4.989
20:00	96.232	101.544	97.658	4.951
20:05	95.854	100.802	97.646	4.916
20:10	95.512	100.113	97.635	4.883
20:15	95.173	99.472	97.625	4.852
20:20	94.805	98.871	97.616	4.824
20:25	94.402	98.300	97.607	4.796
20:30	93.977	97.751	97.598	4.770
20:35	93.538	97.219	97.590	4.744
20:40	93.098	96.699	97.582	4.719
20:45	92.671	96.192	97.574	4.694
20:50	92.264	95.698	97.566	4.671
20:55	91.885	95.218	97.559	4.647
21:00	91.548	94.755	97.551	4.625
21:05	91.249	94.311	97.544	4.603
21:10	90.967	93.889	97.537	4.583
21:15	90.673	93.485	97.531	4.563
21:20	90.346	93.093	97.525	4.544
21:25	89.993	92.709	97.519	4.525
21:30	89.641	92.330	97.513	4.506
21:35	89.310	91.956	97.507	4.488
21:40	89.004	91.589	97.501	4.470
21:45	88.722	91.233	97.495	4.452
21:50	88.448	90.887	97.489	4.435
21:55	88.169	90.551	97.484	4.419

Double Box Culvert Outlet and Storage [10-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
22:00	87.876	90.222	97.479	4.402
22:05	87.567	89.896	97.474	4.386
22:10	87.241	89.572	97.468	4.370
22:15	86.909	89.248	97.463	4.354
22:20	86.574	88.923	97.458	4.338
22:25	86.249	88.597	97.453	4.322
22:30	85.952	88.275	97.447	4.306
22:35	85.690	87.958	97.442	4.290
22:40	85.454	87.649	97.437	4.275
22:45	85.232	87.352	97.432	4.260
22:50	85.003	87.064	97.428	4.245
22:55	84.758	86.783	97.423	4.231
23:00	84.492	86.505	97.418	4.217
23:05	84.208	86.229	97.414	4.203
23:10	83.922	85.951	97.409	4.189
23:15	83.656	85.674	97.405	4.176
23:20	83.416	85.400	97.400	4.162
23:25	83.198	85.132	97.396	4.148
23:30	82.988	84.872	97.392	4.135
23:35	82.775	84.618	97.388	4.122
23:40	82.560	84.369	97.383	4.110
23:45	82.355	84.126	97.379	4.097

Double Box Culvert Outlet and Storage [25-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
0:00	36.000	11.000	95.836	0.768
0:05	35.832	16.792	96.010	0.918
0:10	35.085	18.944	96.070	1.039
0:15	35.287	20.881	96.121	1.145
0:20	35.674	22.671	96.168	1.239
0:25	36.221	24.337	96.210	1.325
0:30	36.844	25.899	96.248	1.403
0:35	37.471	27.368	96.284	1.475
0:40	38.044	28.744	96.317	1.542
0:45	38.532	30.026	96.347	1.603
0:50	38.934	31.209	96.374	1.659
0:55	39.270	32.296	96.399	1.710
1:00	39.554	33.289	96.421	1.755
1:05	39.791	34.187	96.441	1.796
1:10	39.985	34.996	96.459	1.833
1:15	40.141	35.720	96.475	1.865
1:20	40.270	36.365	96.489	1.894
1:25	40.379	36.937	96.502	1.919
1:30	40.472	37.443	96.513	1.941
1:35	40.553	37.890	96.522	1.961
1:40	40.625	38.285	96.531	1.978
1:45	40.689	38.633	96.538	1.993
1:50	40.746	38.939	96.545	2.006
1:55	40.800	39.210	96.550	2.018
2:00	40.849	39.448	96.556	2.028
2:05	40.894	39.659	96.560	2.038
2:10	40.938	39.845	96.564	2.046
2:15	40.980	40.010	96.567	2.053
2:20	41.020	40.157	96.571	2.059
2:25	41.060	40.288	96.573	2.065
2:30	41.098	40.406	96.576	2.070
2:35	41.137	40.512	96.578	2.074
2:40	41.176	40.608	96.580	2.078
2:45	41.214	40.696	96.582	2.082
2:50	41.252	40.776	96.584	2.085
2:55	41.291	40.850	96.585	2.089
3:00	41.330	40.919	96.587	2.092
3:05	41.369	40.983	96.588	2.094
3:10	41.408	41.044	96.589	2.097
3:15	41.448	41.101	96.590	2.099
3:20	41.488	41.156	96.591	2.102
3:25	41.529	41.209	96.593	2.104
3:30	41.570	41.260	96.594	2.106
3:35	41.611	41.310	96.595	2.108

Double Box Culvert Outlet and Storage [25-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
3:40	41.653	41.358	96.596	2.110
3:45	41.696	41.406	96.597	2.112
3:50	41.740	41.453	96.598	2.114
3:55	41.784	41.499	96.599	2.116
4:00	41.829	41.545	96.600	2.118
4:05	41.874	41.591	96.601	2.120
4:10	41.921	41.637	96.602	2.122
4:15	41.968	41.683	96.602	2.124
4:20	42.016	41.730	96.603	2.126
4:25	42.066	41.777	96.604	2.128
4:30	42.116	41.824	96.605	2.130
4:35	42.167	41.872	96.606	2.132
4:40	42.222	41.920	96.607	2.134
4:45	42.281	41.970	96.608	2.136
4:50	42.345	42.022	96.610	2.138
4:55	42.418	42.076	96.611	2.141
5:00	42.498	42.134	96.612	2.143
5:05	42.586	42.195	96.613	2.146
5:10	42.683	42.262	96.614	2.148
5:15	42.786	42.333	96.616	2.151
5:20	42.898	42.410	96.618	2.155
5:25	43.017	42.493	96.619	2.158
5:30	43.142	42.582	96.621	2.162
5:35	43.273	42.676	96.623	2.166
5:40	43.409	42.777	96.625	2.170
5:45	43.549	42.883	96.627	2.175
5:50	43.704	42.996	96.630	2.179
5:55	43.907	43.119	96.632	2.185
6:00	44.195	43.261	96.635	2.190
6:05	44.600	43.434	96.639	2.198
6:10	45.112	43.650	96.643	2.207
6:15	45.700	43.918	96.649	2.218
6:20	46.357	44.241	96.655	2.231
6:25	47.086	44.622	96.663	2.247
6:30	47.893	45.063	96.672	2.265
6:35	48.791	45.569	96.682	2.286
6:40	49.786	46.145	96.694	2.310
6:45	50.869	46.795	96.707	2.336
6:50	52.026	47.522	96.721	2.366
6:55	53.239	48.324	96.737	2.398
7:00	54.493	49.199	96.755	2.433
7:05	55.785	50.142	96.773	2.471
7:10	57.112	51.149	96.793	2.511
7:15	58.468	52.216	96.813	2.553

Double Box Culvert Outlet and Storage [25-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
7:20	59.854	53.339	96.835	2.597
7:25	61.270	54.542	96.857	2.643
7:30	62.712	55.761	96.881	2.690
7:35	64.185	57.029	96.904	2.738
7:40	65.688	58.342	96.929	2.788
7:45	67.219	59.698	96.954	2.840
7:50	68.782	61.096	96.980	2.892
7:55	70.378	62.428	97.004	2.946
8:00	72.003	63.448	97.023	3.003
8:05	73.664	64.546	97.043	3.063
8:10	75.363	65.719	97.064	3.128
8:15	77.099	66.962	97.086	3.196
8:20	78.879	68.275	97.109	3.268
8:25	80.704	69.654	97.133	3.342
8:30	82.571	71.098	97.159	3.420
8:35	84.489	72.606	97.185	3.500
8:40	86.459	74.177	97.212	3.583
8:45	88.479	75.811	97.240	3.669
8:50	90.707	77.517	97.269	3.758
8:55	93.420	79.330	97.300	3.852
9:00	96.949	81.321	97.333	3.955
9:05	101.497	83.588	97.371	4.070
9:10	106.894	86.217	97.414	4.203
9:15	112.769	89.262	97.463	4.355
9:20	118.790	92.720	97.519	4.525
9:25	124.735	96.554	97.580	4.712
9:30	130.418	100.701	97.645	4.911
9:35	135.858	105.094	97.712	5.119
9:40	141.112	109.677	97.782	5.333
9:45	146.260	114.406	97.853	5.551
9:50	151.366	119.252	97.925	5.771
9:55	156.461	124.196	97.997	5.992
10:00	161.567	128.772	98.063	6.216
10:05	166.760	133.455	98.129	6.443
10:10	172.067	138.265	98.197	6.674
10:15	177.499	143.248	98.266	6.908
10:20	183.151	148.279	98.335	7.146
10:25	189.084	153.514	98.406	7.388
10:30	195.354	158.927	98.479	7.636
10:35	202.064	164.551	98.554	7.890
10:40	209.188	170.421	98.631	8.152
10:45	216.654	176.561	98.710	8.423
10:50	224.422	182.985	98.792	8.704
10:55	232.357	189.690	98.877	8.993

Double Box Culvert Outlet and Storage [25-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
11:00	240.285	196.654	98.964	9.290
11:05	248.165	203.698	99.051	9.592
11:10	255.970	210.848	99.138	9.901
11:15	263.688	218.160	99.227	10.212
11:20	271.504	225.623	99.316	10.527
11:25	279.624	233.267	99.405	10.844
11:30	288.270	241.108	99.497	11.166
11:35	298.867	249.301	99.591	11.499
11:40	313.161	258.210	99.693	11.858
11:45	333.179	268.397	99.809	12.269
11:50	367.352	281.098	99.956	12.789
11:55	425.415	298.812	100.158	13.520
12:00	518.759	325.845	100.459	14.619
12:05	642.081	366.591	100.900	16.229
12:10	768.429	407.018	101.477	18.400
12:15	862.687	440.012	102.181	21.096
12:20	902.095	490.475	102.910	23.976
12:25	892.225	535.542	103.552	26.617
12:30	845.862	569.530	104.073	28.793
12:35	779.856	592.167	104.438	30.390
12:40	709.369	605.939	104.667	31.392
12:45	647.672	612.396	104.776	31.869
12:50	597.516	613.298	104.792	31.936
12:55	556.174	610.068	104.737	31.696
13:00	521.278	603.698	104.629	31.227
13:05	492.196	594.936	104.484	30.589
13:10	468.453	584.419	104.311	29.836
13:15	449.201	572.682	104.123	29.012
13:20	433.306	559.895	103.922	28.151
13:25	419.905	546.208	103.712	27.280
13:30	408.242	532.311	103.504	26.419
13:35	397.631	518.364	103.301	25.576
13:40	387.852	504.473	103.103	24.759
13:45	378.810	490.425	102.909	23.973
13:50	370.357	476.295	102.720	23.225
13:55	362.483	462.519	102.540	22.516
14:00	355.229	449.250	102.371	21.848
14:05	348.536	441.230	102.208	21.205
14:10	342.334	434.053	102.048	20.570
14:15	336.625	426.554	101.884	19.945
14:20	331.319	418.941	101.723	19.333
14:25	326.432	411.385	101.566	18.739
14:30	321.959	403.963	101.414	18.165
14:35	317.774	396.704	101.268	17.611

Double Box Culvert Outlet and Storage [25-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
14:40	313.833	388.304	101.129	17.082
14:45	310.128	376.136	101.001	16.599
14:50	306.143	365.031	100.883	16.169
14:55	301.212	355.073	100.777	15.780
15:00	294.581	345.937	100.678	15.418
15:05	285.868	337.018	100.581	15.065
15:10	275.712	328.081	100.483	14.709
15:15	265.123	318.985	100.383	14.343
15:20	254.925	309.759	100.281	13.968
15:25	245.621	300.524	100.177	13.591
15:30	237.607	291.446	100.075	13.216
15:35	230.830	282.665	99.974	12.852
15:40	225.072	274.133	99.876	12.505
15:45	220.086	266.202	99.783	12.177
15:50	215.740	258.530	99.696	11.871
15:55	211.956	251.490	99.616	11.587
16:00	208.673	245.043	99.542	11.326
16:05	205.768	239.157	99.474	11.086
16:10	203.155	233.793	99.412	10.865
16:15	200.766	228.902	99.354	10.663
16:20	198.525	224.382	99.302	10.477
16:25	196.403	220.363	99.253	10.305
16:30	194.398	216.611	99.208	10.146
16:35	192.488	213.146	99.166	9.999
16:40	190.678	209.934	99.127	9.861
16:45	188.987	206.955	99.091	9.733
16:50	187.393	204.184	99.057	9.614
16:55	185.876	201.604	99.025	9.502
17:00	184.419	199.182	98.995	9.397
17:05	182.988	196.849	98.966	9.298
17:10	181.581	194.662	98.939	9.205
17:15	180.213	192.602	98.914	9.118
17:20	178.882	190.655	98.889	9.034
17:25	177.605	188.809	98.866	8.955
17:30	176.409	187.059	98.844	8.880
17:35	175.276	185.400	98.823	8.808
17:40	174.178	183.826	98.803	8.740
17:45	173.084	182.327	98.784	8.675
17:50	171.760	180.873	98.765	8.612
17:55	169.897	179.403	98.747	8.548
18:00	167.151	177.815	98.726	8.478
18:05	163.356	175.987	98.703	8.398
18:10	158.802	173.825	98.675	8.303
18:15	153.991	171.308	98.642	8.192

Double Box Culvert Outlet and Storage [25-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
18:20	149.336	168.485	98.605	8.066
18:25	145.080	165.443	98.565	7.930
18:30	141.406	162.288	98.524	7.788
18:35	138.306	159.119	98.482	7.644
18:40	135.705	156.014	98.440	7.503
18:45	133.493	153.025	98.400	7.366
18:50	131.615	150.185	98.361	7.234
18:55	130.020	147.575	98.325	7.110
19:00	128.658	145.014	98.291	6.993
19:05	127.460	142.755	98.259	6.884
19:10	126.393	140.554	98.229	6.783
19:15	125.438	138.577	98.201	6.689
19:20	124.574	136.752	98.176	6.602
19:25	123.777	135.067	98.152	6.521
19:30	123.031	133.511	98.130	6.446
19:35	122.301	132.069	98.110	6.376
19:40	121.573	130.726	98.091	6.311
19:45	120.839	129.468	98.073	6.250
19:50	120.099	128.282	98.056	6.192
19:55	119.365	127.159	98.040	6.137
20:00	118.665	126.091	98.024	6.084
20:05	118.005	125.078	98.010	6.035
20:10	117.391	124.084	97.995	5.987
20:15	116.826	123.084	97.981	5.943
20:20	116.299	122.150	97.967	5.901
20:25	115.804	121.279	97.954	5.862
20:30	115.335	120.465	97.942	5.825
20:35	114.877	119.703	97.931	5.791
20:40	114.413	118.986	97.921	5.759
20:45	113.928	118.303	97.911	5.728
20:50	113.408	117.648	97.901	5.698
20:55	112.862	117.010	97.892	5.669
21:00	112.309	116.386	97.882	5.641
21:05	111.763	115.774	97.873	5.613
21:10	111.233	115.173	97.864	5.586
21:15	110.730	114.585	97.856	5.559
21:20	110.258	114.012	97.847	5.533
21:25	109.826	113.457	97.839	5.507
21:30	109.444	112.923	97.831	5.483
21:35	109.108	112.415	97.823	5.459
21:40	108.793	111.932	97.816	5.437
21:45	108.467	111.473	97.809	5.416
21:50	108.099	111.030	97.802	5.396
21:55	107.687	110.594	97.796	5.375

Double Box Culvert Outlet and Storage [25-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
22:00	107.243	110.161	97.789	5.355
22:05	106.781	109.725	97.783	5.335
22:10	106.314	109.286	97.776	5.315
22:15	105.859	108.844	97.769	5.294
22:20	105.423	108.402	97.763	5.274
22:25	105.017	107.964	97.756	5.253
22:30	104.654	107.534	97.750	5.233
22:35	104.331	107.116	97.743	5.214
22:40	104.025	106.713	97.737	5.195
22:45	103.705	106.322	97.731	5.177
22:50	103.347	105.940	97.725	5.159
22:55	102.964	105.559	97.719	5.141
23:00	102.581	105.178	97.714	5.123
23:05	102.221	104.799	97.708	5.105
23:10	101.888	104.425	97.702	5.088
23:15	101.581	104.059	97.696	5.070
23:20	101.281	103.702	97.691	5.053
23:25	100.976	103.352	97.686	5.037
23:30	100.658	103.008	97.680	5.021
23:35	100.327	102.667	97.675	5.005
23:40	100.000	102.328	97.670	4.988
23:45	99.700	101.993	97.665	4.973

Double Box Culvert Outlet and Storage [50-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
0:00	36.000	11.000	95.836	0.768
0:05	35.835	16.792	96.010	0.918
0:10	35.109	18.946	96.070	1.040
0:15	35.367	20.889	96.121	1.145
0:20	35.861	22.695	96.168	1.240
0:25	36.560	24.392	96.211	1.327
0:30	37.357	26.003	96.251	1.408
0:35	38.157	27.538	96.288	1.484
0:40	38.888	28.997	96.323	1.554
0:45	39.509	30.372	96.355	1.620
0:50	40.021	31.681	96.384	1.680
0:55	40.448	32.843	96.411	1.735
1:00	40.808	33.936	96.436	1.785
1:05	41.109	34.931	96.458	1.830
1:10	41.354	35.831	96.478	1.870
1:15	41.551	36.640	96.495	1.906
1:20	41.713	37.363	96.511	1.938
1:25	41.850	38.007	96.525	1.966
1:30	41.966	38.578	96.537	1.991
1:35	42.067	39.084	96.548	2.013
1:40	42.157	39.531	96.557	2.032
1:45	42.236	39.926	96.566	2.049
1:50	42.307	40.274	96.573	2.064
1:55	42.372	40.582	96.579	2.077
2:00	42.432	40.854	96.585	2.089
2:05	42.488	41.094	96.590	2.099
2:10	42.541	41.307	96.595	2.108
2:15	42.592	41.496	96.599	2.116
2:20	42.641	41.664	96.602	2.123
2:25	42.688	41.814	96.605	2.130
2:30	42.735	41.950	96.608	2.135
2:35	42.782	42.072	96.611	2.140
2:40	42.828	42.182	96.613	2.145
2:45	42.874	42.283	96.615	2.149
2:50	42.920	42.376	96.617	2.153
2:55	42.966	42.462	96.619	2.157
3:00	43.013	42.541	96.620	2.160
3:05	43.059	42.616	96.622	2.163
3:10	43.107	42.687	96.623	2.166
3:15	43.154	42.754	96.625	2.169
3:20	43.202	42.818	96.626	2.172
3:25	43.251	42.880	96.627	2.174
3:30	43.299	42.940	96.629	2.177
3:35	43.349	42.999	96.630	2.179

Double Box Culvert Outlet and Storage [50-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
3:40	43.399	43.056	96.631	2.182
3:45	43.451	43.112	96.632	2.184
3:50	43.507	43.168	96.633	2.187
3:55	43.568	43.224	96.634	2.189
4:00	43.636	43.281	96.636	2.191
4:05	43.713	43.341	96.637	2.194
4:10	43.800	43.404	96.638	2.196
4:15	43.898	43.472	96.639	2.199
4:20	44.006	43.545	96.641	2.202
4:25	44.124	43.625	96.643	2.206
4:30	44.251	43.711	96.644	2.209
4:35	44.388	43.803	96.646	2.213
4:40	44.532	43.904	96.648	2.217
4:45	44.683	44.011	96.651	2.222
4:50	44.840	44.126	96.653	2.227
4:55	45.004	44.248	96.655	2.232
5:00	45.171	44.376	96.658	2.237
5:05	45.343	44.511	96.661	2.243
5:10	45.521	44.653	96.664	2.248
5:15	45.712	44.801	96.667	2.254
5:20	45.931	44.958	96.670	2.261
5:25	46.202	45.129	96.673	2.268
5:30	46.549	45.321	96.677	2.276
5:35	46.989	45.545	96.682	2.285
5:40	47.526	45.809	96.687	2.296
5:45	48.153	46.124	96.693	2.309
5:50	48.894	46.497	96.701	2.324
5:55	49.819	46.942	96.710	2.342
6:00	51.018	47.486	96.721	2.364
6:05	52.563	48.161	96.734	2.392
6:10	54.418	49.001	96.751	2.426
6:15	56.486	50.024	96.771	2.466
6:20	58.665	51.230	96.794	2.514
6:25	60.878	52.604	96.821	2.568
6:30	63.062	54.123	96.850	2.628
6:35	65.207	55.789	96.881	2.691
6:40	67.318	57.518	96.914	2.757
6:45	69.405	59.325	96.947	2.826
6:50	71.474	61.195	96.982	2.896
6:55	73.524	62.824	97.011	2.968
7:00	75.560	64.192	97.036	3.044
7:05	77.594	65.647	97.062	3.124
7:10	79.636	67.182	97.090	3.208
7:15	81.683	68.789	97.118	3.295

Double Box Culvert Outlet and Storage [50-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
7:20	83.744	70.461	97.147	3.386
7:25	85.821	72.195	97.178	3.478
7:30	87.913	73.983	97.209	3.573
7:35	90.029	75.825	97.240	3.670
7:40	92.169	77.716	97.272	3.769
7:45	94.333	79.655	97.305	3.869
7:50	96.527	81.638	97.338	3.971
7:55	98.755	83.666	97.372	4.074
8:00	101.015	85.736	97.406	4.179
8:05	103.316	87.850	97.440	4.285
8:10	105.661	90.006	97.475	4.392
8:15	108.046	92.206	97.511	4.500
8:20	110.483	94.450	97.546	4.610
8:25	112.972	96.740	97.583	4.721
8:30	115.510	99.077	97.619	4.833
8:35	118.110	101.463	97.656	4.947
8:40	120.773	103.899	97.694	5.063
8:45	123.496	106.389	97.732	5.180
8:50	126.370	108.939	97.771	5.299
8:55	129.529	111.572	97.811	5.421
9:00	133.125	114.329	97.852	5.547
9:05	137.259	117.263	97.895	5.681
9:10	141.834	120.422	97.942	5.823
9:15	146.658	123.828	97.991	5.976
9:20	151.587	127.189	98.040	6.138
9:25	156.514	130.729	98.091	6.311
9:30	161.347	134.477	98.144	6.492
9:35	166.117	138.400	98.199	6.680
9:40	170.858	142.530	98.256	6.873
9:45	175.606	146.704	98.313	7.070
9:50	180.421	150.983	98.372	7.271
9:55	185.320	155.422	98.432	7.476
10:00	190.310	159.970	98.493	7.683
10:05	195.459	164.635	98.555	7.894
10:10	200.786	169.422	98.618	8.108
10:15	206.292	174.343	98.681	8.326
10:20	212.052	179.412	98.747	8.548
10:25	218.082	184.647	98.813	8.776
10:30	224.375	190.067	98.882	9.009
10:35	231.018	195.692	98.952	9.249
10:40	238.020	201.484	99.024	9.496
10:45	245.362	207.411	99.096	9.753
10:50	253.070	213.627	99.172	10.019
10:55	261.034	220.140	99.250	10.296

Double Box Culvert Outlet and Storage [50-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
11:00	269.089	226.954	99.331	10.582
11:05	277.190	234.043	99.414	10.876
11:10	285.281	241.349	99.499	11.175
11:15	293.302	248.835	99.586	11.480
11:20	301.619	256.476	99.673	11.788
11:25	310.699	264.353	99.762	12.103
11:30	321.078	272.330	99.855	12.431
11:35	334.739	280.982	99.955	12.784
11:40	353.749	290.744	100.066	13.185
11:45	380.423	302.456	100.199	13.670
11:50	424.894	318.057	100.373	14.305
11:55	498.518	340.797	100.622	15.215
12:00	614.535	375.613	100.995	16.578
12:05	765.898	409.759	101.533	18.613
12:10	919.755	444.181	102.276	21.472
12:15	1033.733	507.211	103.142	24.919
12:20	1080.486	565.261	104.006	28.499
12:25	1067.042	611.951	104.769	31.836
12:30	1008.735	804.741	105.316	34.299
12:35	925.650	928.170	105.453	34.929
12:40	836.445	888.918	105.412	34.740
12:45	757.323	815.495	105.329	34.359
12:50	691.917	748.178	105.243	33.964
12:55	637.159	692.405	105.159	33.580
13:00	590.607	648.293	105.075	33.192
13:05	551.678	624.047	104.976	32.744
13:10	519.830	616.325	104.843	32.162
13:15	493.942	606.624	104.679	31.442
13:20	472.645	595.510	104.493	30.631
13:25	454.908	583.417	104.295	29.765
13:30	439.840	570.678	104.091	28.873
13:35	426.618	557.122	103.879	27.973
13:40	414.849	543.046	103.664	27.082
13:45	404.238	528.925	103.454	26.212
13:50	394.455	514.868	103.250	25.368
13:55	385.387	500.962	103.054	24.556
14:00	377.007	486.823	102.861	23.780
14:05	369.233	472.857	102.675	23.046
14:10	362.001	459.322	102.500	22.355
14:15	355.336	446.752	102.335	21.705
14:20	349.130	439.810	102.176	21.078
14:25	343.386	432.762	102.019	20.458
14:30	338.073	425.380	101.859	19.849
14:35	333.055	417.970	101.703	19.256

Double Box Culvert Outlet and Storage [50-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
14:40	328.317	410.629	101.551	18.680
14:45	323.901	403.422	101.403	18.123
14:50	319.579	396.363	101.261	17.585
14:55	315.066	387.981	101.125	17.069
15:00	310.049	375.951	100.999	16.591
15:05	304.310	364.718	100.880	16.156
15:10	298.071	354.412	100.770	15.754
15:15	291.712	344.903	100.667	15.377
15:20	285.538	335.902	100.569	15.021
15:25	279.781	327.446	100.476	14.683
15:30	274.650	319.523	100.389	14.364
15:35	270.128	312.138	100.307	14.065
15:40	266.125	305.284	100.231	13.786
15:45	262.556	298.945	100.160	13.526
15:50	259.331	293.096	100.093	13.284
15:55	256.385	287.705	100.032	13.060
16:00	253.662	282.664	99.974	12.852
16:05	251.076	277.931	99.920	12.660
16:10	248.601	273.562	99.869	12.481
16:15	246.236	269.513	99.822	12.315
16:20	243.957	265.773	99.778	12.160
16:25	241.771	262.128	99.737	12.015
16:30	239.705	258.736	99.699	11.879
16:35	237.738	255.574	99.663	11.752
16:40	235.862	252.620	99.629	11.633
16:45	234.077	249.851	99.597	11.521
16:50	232.354	247.245	99.567	11.415
16:55	230.681	244.787	99.539	11.316
17:00	229.059	242.461	99.512	11.221
17:05	227.467	240.253	99.487	11.131
17:10	225.916	238.149	99.462	11.045
17:15	224.428	236.142	99.439	10.962
17:20	222.986	234.222	99.417	10.883
17:25	221.578	232.383	99.395	10.807
17:30	220.196	230.617	99.374	10.734
17:35	218.821	228.913	99.354	10.663
17:40	217.470	227.266	99.335	10.595
17:45	216.176	225.671	99.316	10.528
17:50	214.640	224.092	99.298	10.463
17:55	212.384	222.506	99.279	10.396
18:00	208.851	220.711	99.257	10.320
18:05	203.742	218.541	99.231	10.228
18:10	197.468	215.849	99.199	10.114
18:15	190.737	212.600	99.160	9.976

Double Box Culvert Outlet and Storage [50-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
18:20	184.174	208.859	99.114	9.815
18:25	178.179	204.765	99.064	9.639
18:30	173.076	200.482	99.011	9.453
18:35	168.870	196.064	98.957	9.265
18:40	165.403	191.733	98.903	9.080
18:45	162.460	187.599	98.851	8.903
18:50	159.928	183.698	98.801	8.735
18:55	157.753	180.050	98.755	8.576
19:00	155.901	176.661	98.711	8.428
19:05	154.313	173.534	98.671	8.290
19:10	152.937	170.661	98.634	8.163
19:15	151.732	168.030	98.599	8.046
19:20	150.640	165.623	98.568	7.938
19:25	149.627	163.419	98.539	7.839
19:30	148.670	161.396	98.512	7.748
19:35	147.742	159.533	98.487	7.663
19:40	146.837	157.810	98.464	7.585
19:45	145.958	156.210	98.443	7.512
19:50	145.099	154.717	98.423	7.443
19:55	144.272	153.318	98.404	7.379
20:00	143.495	152.006	98.386	7.319
20:05	142.767	150.776	98.369	7.262
20:10	142.077	149.620	98.354	7.208
20:15	141.411	148.533	98.339	7.158
20:20	140.747	147.567	98.325	7.110
20:25	140.087	146.560	98.311	7.064
20:30	139.445	145.605	98.299	7.020
20:35	138.819	144.716	98.286	6.979
20:40	138.204	143.888	98.275	6.939
20:45	137.593	143.091	98.263	6.901
20:50	136.971	142.319	98.253	6.863
20:55	136.342	141.486	98.242	6.827
21:00	135.722	140.747	98.232	6.792
21:05	135.114	140.026	98.222	6.758
21:10	134.512	139.322	98.212	6.724
21:15	133.910	138.633	98.202	6.691
21:20	133.302	137.956	98.193	6.659
21:25	132.707	137.290	98.183	6.627
21:30	132.154	136.637	98.174	6.596
21:35	131.655	136.003	98.165	6.566
21:40	131.193	135.390	98.157	6.536
21:45	130.745	134.799	98.148	6.508
21:50	130.278	134.227	98.140	6.480
21:55	129.787	133.667	98.132	6.453

Double Box Culvert Outlet and Storage [50-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
22:00	129.279	133.117	98.125	6.427
22:05	128.763	132.572	98.117	6.401
22:10	128.253	132.032	98.109	6.374
22:15	127.763	131.498	98.102	6.349
22:20	127.291	130.972	98.094	6.323
22:25	126.834	130.455	98.087	6.298
22:30	126.390	129.947	98.080	6.273
22:35	125.954	129.449	98.072	6.249
22:40	125.523	128.959	98.065	6.225
22:45	125.100	128.479	98.059	6.201
22:50	124.681	128.007	98.052	6.178
22:55	124.263	127.542	98.045	6.156
23:00	123.850	127.085	98.039	6.133
23:05	123.437	126.634	98.032	6.111
23:10	123.023	126.188	98.026	6.089
23:15	122.614	125.747	98.019	6.067
23:20	122.203	125.310	98.013	6.046
23:25	121.792	124.878	98.007	6.025
23:30	121.383	124.449	98.000	6.003
23:35	120.973	123.982	97.994	5.983
23:40	120.561	123.521	97.987	5.962
23:45	120.152	123.067	97.980	5.942

Double Box Culvert Outlet and Storage [100-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
0:00	36.000	11.000	95.836	0.768
0:05	35.834	16.792	96.010	0.918
0:10	35.100	18.945	96.070	1.040
0:15	35.338	20.886	96.121	1.145
0:20	35.792	22.686	96.168	1.240
0:25	36.434	24.372	96.210	1.326
0:30	37.167	25.965	96.250	1.406
0:35	37.903	27.475	96.286	1.481
0:40	38.576	28.903	96.320	1.550
0:45	39.149	30.244	96.352	1.614
0:50	39.620	31.507	96.380	1.672
0:55	40.015	32.642	96.407	1.726
1:00	40.347	33.697	96.430	1.774
1:05	40.626	34.657	96.452	1.817
1:10	40.853	35.524	96.471	1.856
1:15	41.036	36.302	96.488	1.891
1:20	41.187	36.997	96.503	1.922
1:25	41.314	37.615	96.516	1.949
1:30	41.423	38.163	96.528	1.973
1:35	41.519	38.648	96.538	1.994
1:40	41.603	39.076	96.548	2.012
1:45	41.678	39.455	96.556	2.029
1:50	41.745	39.789	96.563	2.043
1:55	41.808	40.083	96.569	2.056
2:00	41.865	40.344	96.574	2.067
2:05	41.919	40.575	96.579	2.077
2:10	41.971	40.779	96.584	2.086
2:15	42.020	40.961	96.587	2.093
2:20	42.067	41.123	96.591	2.100
2:25	42.113	41.268	96.594	2.106
2:30	42.159	41.398	96.597	2.112
2:35	42.204	41.516	96.599	2.117
2:40	42.250	41.622	96.601	2.121
2:45	42.295	41.720	96.603	2.126
2:50	42.340	41.810	96.605	2.129
2:55	42.385	41.893	96.607	2.133
3:00	42.431	41.970	96.608	2.136
3:05	42.476	42.043	96.610	2.139
3:10	42.523	42.112	96.611	2.142
3:15	42.569	42.178	96.613	2.145
3:20	42.617	42.240	96.614	2.148
3:25	42.665	42.301	96.615	2.150
3:30	42.713	42.359	96.617	2.153
3:35	42.761	42.416	96.618	2.155

Double Box Culvert Outlet and Storage [100-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
3:40	42.811	42.473	96.619	2.157
3:45	42.861	42.528	96.620	2.160
3:50	42.913	42.582	96.621	2.162
3:55	42.965	42.636	96.622	2.164
4:00	43.018	42.690	96.623	2.166
4:05	43.075	42.744	96.624	2.169
4:10	43.136	42.799	96.626	2.171
4:15	43.204	42.855	96.627	2.173
4:20	43.282	42.914	96.628	2.176
4:25	43.370	42.977	96.629	2.179
4:30	43.467	43.043	96.631	2.181
4:35	43.574	43.116	96.632	2.184
4:40	43.690	43.194	96.634	2.188
4:45	43.815	43.279	96.635	2.191
4:50	43.947	43.370	96.637	2.195
4:55	44.086	43.469	96.639	2.199
5:00	44.232	43.574	96.642	2.204
5:05	44.385	43.686	96.644	2.208
5:10	44.544	43.805	96.646	2.213
5:15	44.708	43.930	96.649	2.218
5:20	44.876	44.062	96.652	2.224
5:25	45.049	44.200	96.654	2.230
5:30	45.228	44.344	96.657	2.236
5:35	45.422	44.495	96.660	2.242
5:40	45.650	44.654	96.664	2.248
5:45	45.933	44.829	96.667	2.256
5:50	46.314	45.028	96.671	2.264
5:55	46.866	45.269	96.676	2.274
6:00	47.662	45.577	96.682	2.286
6:05	48.757	45.984	96.691	2.303
6:10	50.127	46.521	96.701	2.325
6:15	51.697	47.206	96.715	2.353
6:20	53.393	48.043	96.732	2.387
6:25	55.152	49.024	96.751	2.426
6:30	56.924	50.137	96.773	2.471
6:35	58.699	51.363	96.797	2.520
6:40	60.476	52.687	96.822	2.572
6:45	62.255	54.096	96.849	2.627
6:50	64.038	55.603	96.878	2.684
6:55	65.824	57.141	96.906	2.743
7:00	67.611	58.733	96.936	2.803
7:05	69.410	60.372	96.967	2.865
7:10	71.226	62.053	96.997	2.928
7:15	73.057	63.272	97.020	2.993

Double Box Culvert Outlet and Storage [100-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
7:20	74.912	64.525	97.042	3.062
7:25	76.793	65.858	97.066	3.136
7:30	78.697	67.266	97.091	3.213
7:35	80.632	68.744	97.117	3.293
7:40	82.599	70.289	97.144	3.376
7:45	84.596	71.898	97.173	3.462
7:50	86.629	73.568	97.201	3.551
7:55	88.701	75.297	97.231	3.642
8:00	90.810	77.083	97.262	3.736
8:05	92.964	78.925	97.293	3.831
8:10	95.167	80.823	97.325	3.929
8:15	97.414	82.776	97.357	4.029
8:20	99.715	84.785	97.390	4.131
8:25	102.074	86.850	97.424	4.235
8:30	104.484	88.972	97.459	4.340
8:35	106.960	91.151	97.494	4.448
8:40	109.506	93.390	97.530	4.558
8:45	112.118	95.692	97.566	4.670
8:50	114.988	98.069	97.603	4.785
8:55	118.423	100.569	97.643	4.905
9:00	122.788	103.278	97.684	5.033
9:05	128.304	106.314	97.731	5.176
9:10	134.751	109.781	97.784	5.338
9:15	141.723	113.734	97.843	5.520
9:20	148.836	118.167	97.909	5.722
9:25	155.848	123.028	97.980	5.940
9:30	162.551	127.875	98.050	6.172
9:35	168.973	132.879	98.121	6.415
9:40	175.188	138.119	98.195	6.667
9:45	181.289	143.582	98.270	6.924
9:50	187.361	149.128	98.347	7.185
9:55	193.441	154.852	98.424	7.450
10:00	199.555	160.694	98.503	7.716
10:05	205.796	166.651	98.581	7.984
10:10	212.197	172.727	98.661	8.255
10:15	218.767	178.929	98.740	8.527
10:20	225.594	185.272	98.821	8.803
10:25	232.698	191.775	98.903	9.082
10:30	240.074	198.457	98.986	9.366
10:35	247.827	205.160	99.069	9.656
10:40	255.966	212.081	99.153	9.953
10:45	264.482	219.279	99.240	10.260
10:50	273.405	226.795	99.329	10.575
10:55	282.615	234.646	99.422	10.901

Double Box Culvert Outlet and Storage [100-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
11:00	291.931	242.791	99.516	11.234
11:05	301.306	251.196	99.613	11.576
11:10	310.675	259.821	99.711	11.923
11:15	319.971	268.529	99.811	12.275
11:20	329.620	277.256	99.912	12.632
11:25	340.167	286.231	100.015	12.998
11:30	352.242	295.411	100.120	13.380
11:35	368.108	305.405	100.232	13.791
11:40	390.074	316.887	100.360	14.258
11:45	420.730	330.830	100.514	14.819
11:50	471.614	349.163	100.713	15.548
11:55	555.565	375.845	100.998	16.587
12:00	687.599	404.017	101.416	18.169
12:05	859.621	434.470	102.057	20.606
12:10	1034.337	490.185	102.906	23.961
12:15	1163.761	556.259	103.866	27.917
12:20	1216.915	615.148	104.823	32.074
12:25	1201.904	968.024	105.493	35.113
12:30	1136.026	1132.482	105.645	35.811
12:35	1041.924	1092.485	105.609	35.649
12:40	940.832	1001.905	105.526	35.265
12:45	851.133	911.116	105.435	34.848
12:50	777.011	832.451	105.349	34.450
12:55	714.891	766.942	105.268	34.080
13:00	662.104	712.473	105.191	33.727
13:05	618.028	668.052	105.116	33.382
13:10	581.999	634.703	105.039	33.028
13:15	552.762	622.241	104.945	32.607
13:20	528.790	615.100	104.822	32.071
13:25	508.863	606.557	104.677	31.437
13:30	491.919	597.002	104.518	30.739
13:35	477.000	586.710	104.349	29.999
13:40	463.681	575.884	104.174	29.235
13:45	451.661	564.672	103.997	28.459
13:50	440.583	552.609	103.810	27.685
13:55	430.311	540.435	103.625	26.920
14:00	420.795	528.241	103.444	26.170
14:05	411.928	516.103	103.268	25.442
14:10	403.662	504.090	103.098	24.737
14:15	396.060	492.047	102.932	24.061
14:20	389.035	479.963	102.769	23.417
14:25	382.593	468.259	102.615	22.809
14:30	376.689	456.986	102.470	22.237
14:35	371.136	446.675	102.334	21.701

Double Box Culvert Outlet and Storage [100-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
14:40	365.881	440.975	102.203	21.182
14:45	360.936	435.174	102.072	20.668
14:50	355.782	429.187	101.941	20.159
14:55	349.769	422.966	101.808	19.655
15:00	342.156	416.579	101.674	19.146
15:05	332.542	409.899	101.536	18.624
15:10	321.549	402.825	101.391	18.077
15:15	310.162	395.300	101.240	17.505
15:20	299.182	384.057	101.084	16.914
15:25	289.130	369.589	100.932	16.345
15:30	280.430	355.825	100.785	15.810
15:35	273.038	343.192	100.648	15.310
15:40	266.720	331.515	100.521	14.846
15:45	261.224	320.838	100.404	14.417
15:50	256.385	311.117	100.296	14.024
15:55	252.099	302.275	100.197	13.662
16:00	248.280	294.241	100.106	13.331
16:05	244.796	286.942	100.023	13.028
16:10	241.588	280.150	99.945	12.750
16:15	238.629	273.914	99.873	12.496
16:20	235.859	268.236	99.807	12.263
16:25	233.251	262.984	99.747	12.049
16:30	230.797	258.075	99.691	11.853
16:35	228.461	253.588	99.640	11.672
16:40	226.251	249.472	99.593	11.506
16:45	224.190	245.675	99.549	11.352
16:50	222.258	242.174	99.509	11.209
16:55	220.425	238.938	99.471	11.077
17:00	218.661	235.935	99.437	10.954
17:05	216.917	233.137	99.404	10.838
17:10	215.199	230.511	99.373	10.730
17:15	213.531	228.037	99.344	10.627
17:20	211.908	225.697	99.316	10.530
17:25	210.330	223.534	99.290	10.437
17:30	208.799	221.367	99.265	10.348
17:35	207.288	219.359	99.241	10.263
17:40	205.796	217.433	99.218	10.181
17:45	204.339	215.579	99.196	10.103
17:50	202.655	213.773	99.174	10.026
17:55	200.351	211.942	99.152	9.947
18:00	196.973	209.967	99.128	9.863
18:05	192.285	207.691	99.100	9.765
18:10	186.649	204.998	99.067	9.649
18:15	180.686	201.858	99.028	9.513

Double Box Culvert Outlet and Storage [100-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
18:20	174.923	198.297	98.984	9.359
18:25	169.673	194.389	98.936	9.194
18:30	165.179	190.363	98.885	9.022
18:35	161.430	186.347	98.835	8.849
18:40	158.318	182.445	98.785	8.680
18:45	155.697	178.719	98.738	8.518
18:50	153.485	175.208	98.693	8.364
18:55	151.601	171.928	98.650	8.219
19:00	149.969	168.887	98.611	8.084
19:05	148.498	166.074	98.574	7.958
19:10	147.156	163.476	98.539	7.842
19:15	145.937	161.078	98.508	7.733
19:20	144.822	158.863	98.478	7.633
19:25	143.785	156.818	98.451	7.540
19:30	142.797	154.925	98.425	7.453
19:35	141.821	153.166	98.402	7.372
19:40	140.860	151.523	98.380	7.296
19:45	139.934	149.982	98.359	7.225
19:50	139.057	148.534	98.339	7.158
19:55	138.226	147.224	98.320	7.094
20:00	137.442	145.903	98.303	7.034
20:05	136.684	144.683	98.286	6.977
20:10	135.951	143.568	98.270	6.924
20:15	135.250	142.509	98.255	6.872
20:20	134.577	141.418	98.241	6.824
20:25	133.923	140.447	98.228	6.778
20:30	133.279	139.521	98.215	6.734
20:35	132.629	138.635	98.202	6.692
20:40	131.976	137.783	98.190	6.651
20:45	131.335	136.960	98.179	6.612
20:50	130.714	136.163	98.168	6.573
20:55	130.123	135.394	98.157	6.537
21:00	129.569	134.652	98.146	6.501
21:05	129.038	133.939	98.136	6.467
21:10	128.514	133.251	98.126	6.433
21:15	127.975	132.585	98.117	6.401
21:20	127.406	131.935	98.108	6.370
21:25	126.815	131.295	98.099	6.339
21:30	126.222	130.662	98.090	6.308
21:35	125.638	130.037	98.081	6.277
21:40	125.074	129.419	98.072	6.247
21:45	124.540	128.811	98.063	6.218
21:50	124.032	128.215	98.055	6.189
21:55	123.545	127.633	98.046	6.160

Double Box Culvert Outlet and Storage [100-year]

Time	Inflow (cfs)	Outflow (cfs)	Elevation	Storage (AC-FT)
22:00	123.076	127.066	98.038	6.132
22:05	122.619	126.513	98.030	6.105
22:10	122.171	125.974	98.023	6.079
22:15	121.734	125.448	98.015	6.053
22:20	121.294	124.934	98.007	6.027
22:25	120.836	124.430	98.000	6.003
22:30	120.348	123.880	97.992	5.978
22:35	119.825	123.335	97.984	5.954
22:40	119.289	122.794	97.976	5.930
22:45	118.779	122.256	97.969	5.906
22:50	118.316	121.726	97.961	5.882
22:55	117.903	121.210	97.953	5.859
23:00	117.530	120.712	97.946	5.836
23:05	117.177	120.234	97.939	5.815
23:10	116.828	119.774	97.932	5.794
23:15	116.471	119.331	97.926	5.774
23:20	116.101	118.898	97.919	5.755
23:25	115.719	118.475	97.913	5.736
23:30	115.332	118.057	97.907	5.717
23:35	114.937	117.644	97.901	5.698
23:40	114.536	117.234	97.895	5.679
23:45	114.133	116.824	97.889	5.661

APPENDIX H.2

Existing Froom Creek Hydrologic Analysis

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EXISTING FROOM CREEK
HYDROLOGIC ANALYSIS

Prepared as a Supplement for the Froom Ranch Hydrology Report for the Proposed Condition



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No. 76597
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DATE:

rrm design group

CREATING
ENVIRONMENTS
PEOPLE
ENJOY®

Date: 07-16-2019
Prepared by RRM Design Group
Prepared for John and Susan Madonna Trust and Villaggio Communities

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1. Purpose:

The purpose of this report is to describe and analyze the Historic and Existing Froom Creek conditions, and to compare those with the Proposed condition, with respect to periodic overbanking of the creek banks, which flows to the existing LOVR Ditch and Calle Joaquin Wetlands.

2. Background:

a. Historic Condition (Prior to 2013)

For the purpose of this report, the condition of Froom Creek prior to 2013 is referred to as the 'Historic Condition.' Appendix I of this report analyzes the Historical Condition of the Froom Creek before 2013, and the creek bank overbanking that occurred. This analysis confirms the overbanking conditions anticipated by Balanced Hydrologics in their report from 2005, appendix A (pg. 5). This report also details the specific water surface elevation at which each cross-section overbanks. See Appendix 1, section D (pgs. 7-17), of this report for the specific water surface elevations when overbanking occurs. Aerial imagery from 2005 and 2011 (pg. 4-5) is provided to show the creek condition before the addition of the artificial berm placed after 2013 (see pg. 21).

b. Existing Condition (2013 to Present)

In or around 2013, an artificial berm was placed along the eastern bank of Froom Creek. The analysis of the Existing Froom Creek is included in this report, Appendix 2. Overbanking is significantly reduced and occurs at a much higher flowrate when compared to the Historic Condition; See Appendix 2, Section C (pgs. 23-45). Aerial imagery from 2013 (pg. 21) has been provided to show the visible change to the creek due to the added embankment.

The Froom Creek Channel receives water from watershed indexes #4 (Froom Creek Top) and #5 (Froom Creek Upper) (see report titled "Preliminary Hydrologic and Hydraulic Calculations," Appendix 3, prepared by RRM Design Group, dated February 22, 2019). The parallel channel, comprised of the LOVR Ditch and the Calle Joaquin Wetland, receives water from watershed indexes #8 (Home Depot + Costco), #9 (Irish Hills), and occasionally from the Existing Froom Creek when overbanking occurs.

3. Scope, Objectives, and Analysis:

a. Scope:

The Historic Condition was analyzed conveying the flow from watershed indexes #4 (Froom Creek Top) and #5 (Froom Creek Upper). The cross-sections used in this analysis only consider the extents of the Historic Froom Creek channel to accurately depict where overbanking occurs.

The Existing Condition was also analyzed conveying the flow from watershed indexes #4 (Froom Creek Top) and #5 (Froom Creek Upper) in the Existing Froom Creek. The LOVR Ditch and Calle Joaquin Wetland convey flow from watershed indexes #8 (Home Depot + Costco), #9 (Irish Hills), and occasionally from the Existing Froom Creek when overbanking occurs.

b. Objectives:

The objectives of this report are to describe and analyze the Historic and Existing Froom Creek conditions, and to compare those with the Proposed condition, with respect to periodic overbanking of the creek banks, which flows to the existing LOVR Ditch and Calle Joaquin Wetlands.

c. Analysis:

The proposed restored Froom Creek condition will mimic the historic condition, in that the creek will overbank only after the 2-yr peak flow is achieved. Flows greater than a 2-yr design storm will overbank to the Calle Joaquin Wetland or be contained within the channel when not adjacent to the wetland. This is much like the Historical Condition, which had no artificial berm placed adjacent to the creek. See table below for a summary comparison of the three conditions and when Froom Creek overbanking occurs.

Total Creek Flow (Overbank Flowrate) (cfs)			
	Historic	**Existing**	**Proposed**
2-yr	253.3 (100)	253.3 (0)	518.7 (0)
10-yr	521.5 (318)	521.5 (89.4)	707.3 (188.6)
25-yr	714.3 (475.2)	714.3 (282.2)	877.2 (358.5)
50-yr	867.6 (599.3)	867.6 (435.5)	1098.1 (579.4)
100-yr	980.4 (691)	980.4 (548.3)	1240.8 (722.1)

4. Conclusion:

With the exception of a two-year design storm, the Proposed Condition overflows at similar flowrates compared to the Historic Condition. The two-year design storm is contained within a low flow swale, as required by the City of San Luis Obispo, per the Drainage Design Manual. The Existing Condition overbanking flowrates are reduced due to the artificial berm placed adjacent to Froom Creek. In summary, the proposed development achieves the objective of returning the watershed to the historic condition.

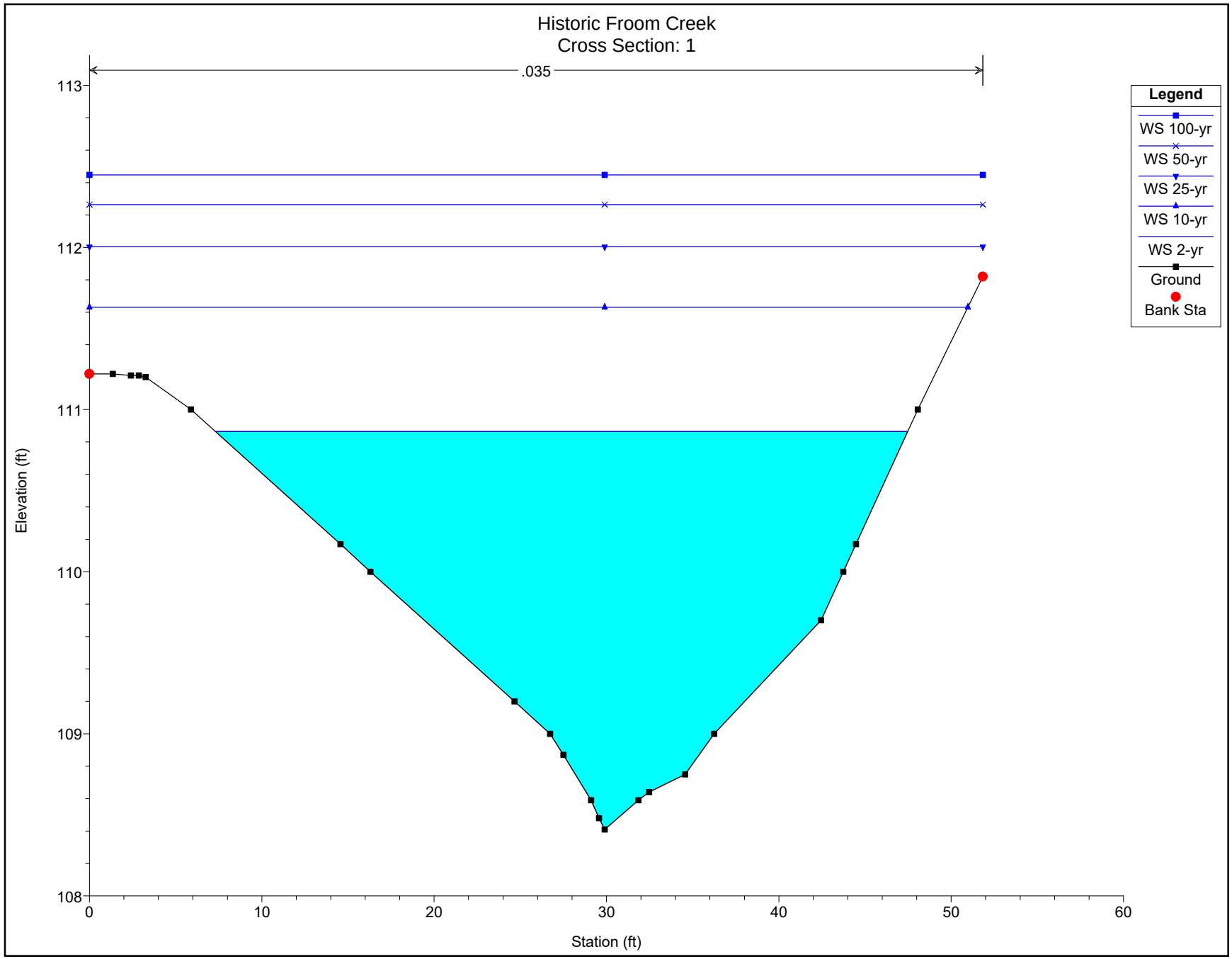
Appendix 1: Historic Condition Analysis

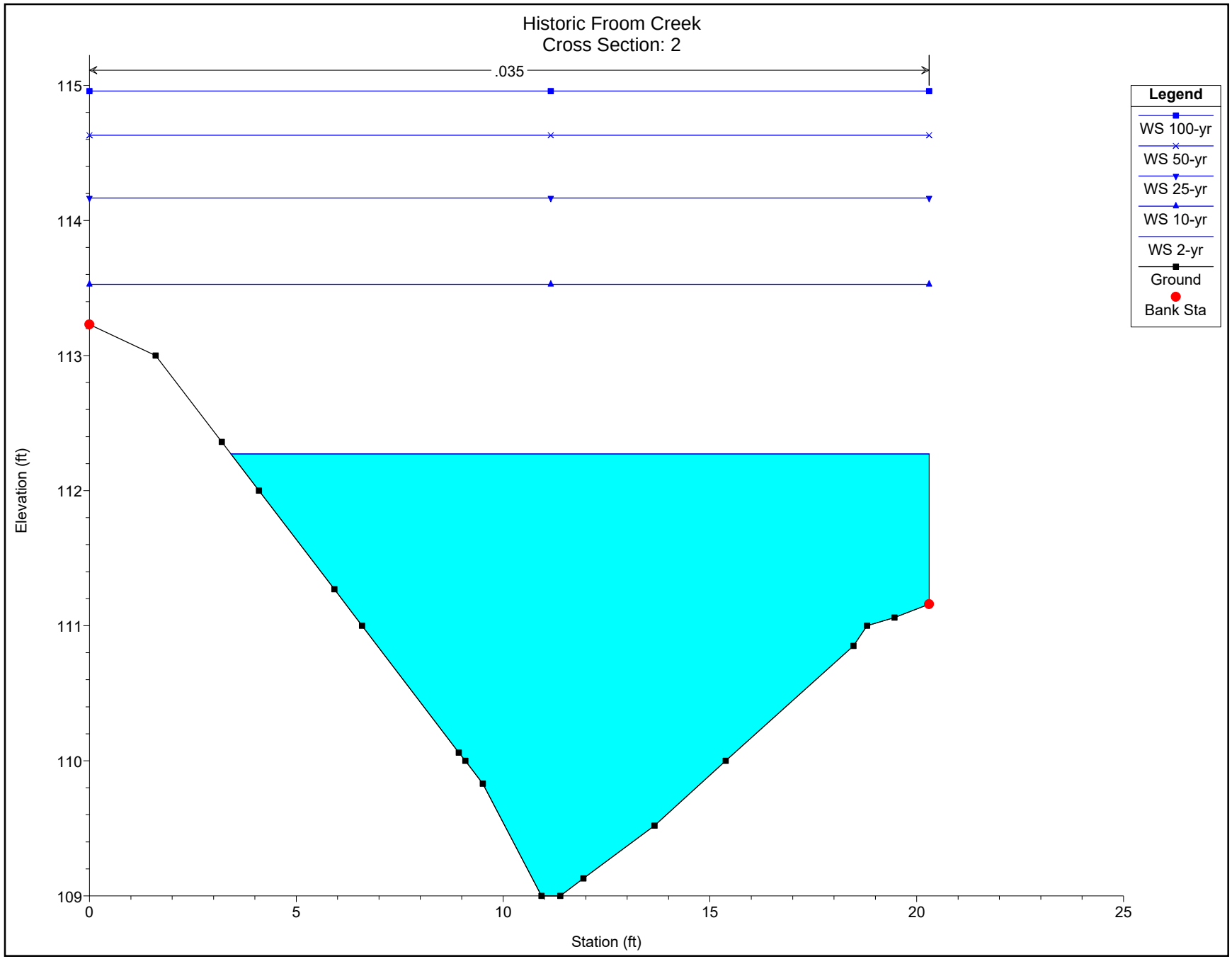


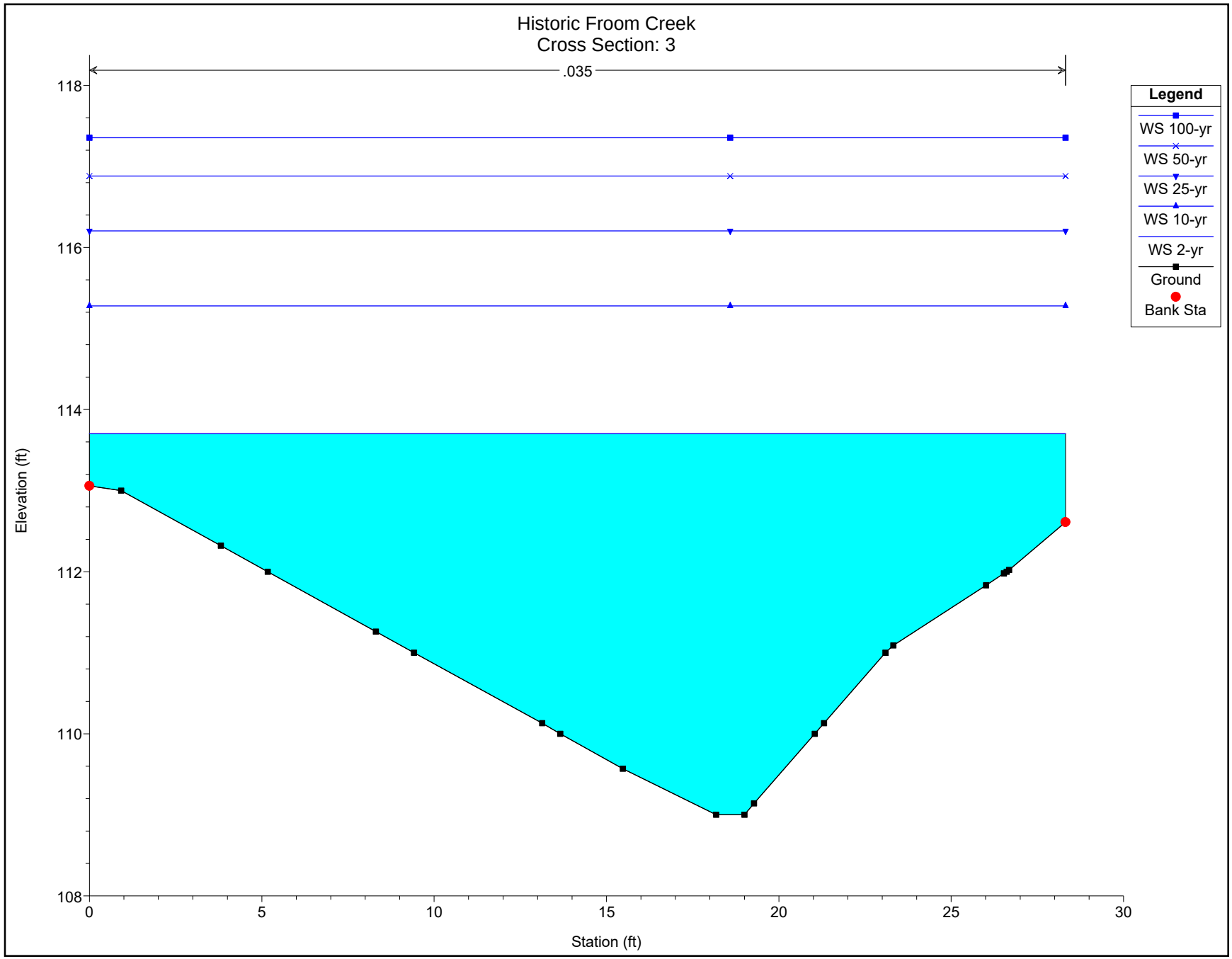
2005 Froom Creek Aerial

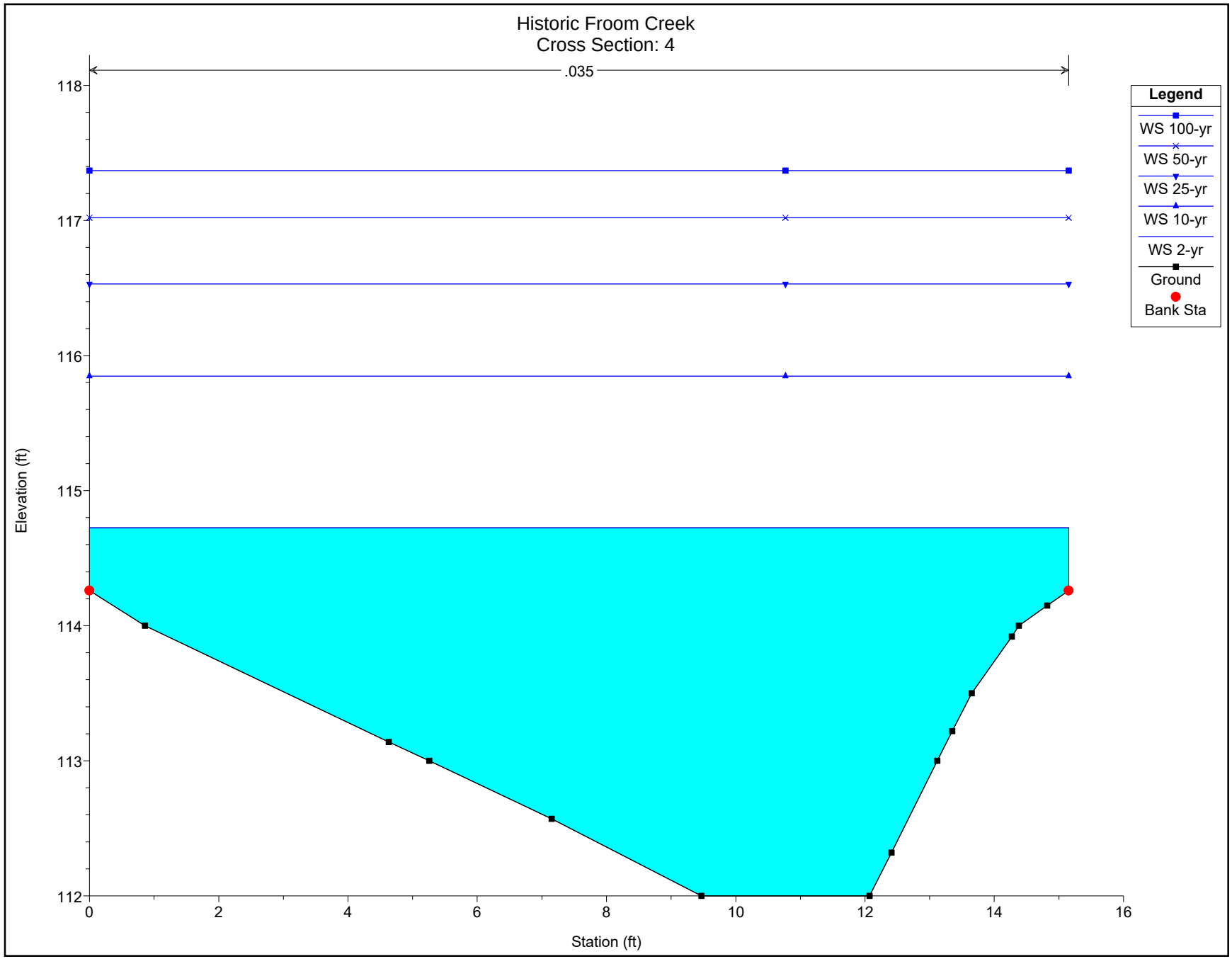

No Artificial Berm Placed Adjacent to Creek
Froom Creek - Historic Condition
Detention Basins Added
Page 5
2011 Froom Creek Aerial
N
1000 ft
Google Earth

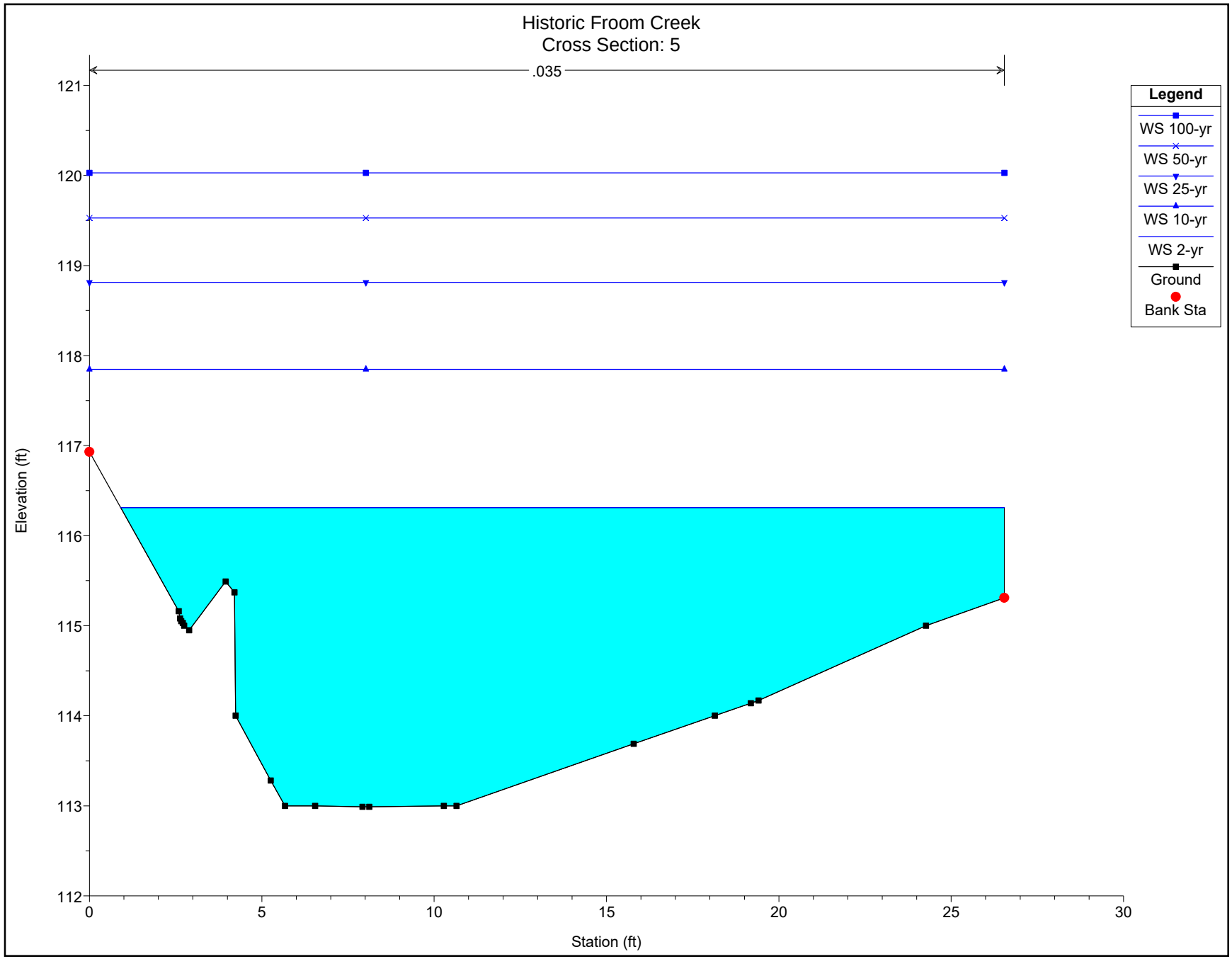


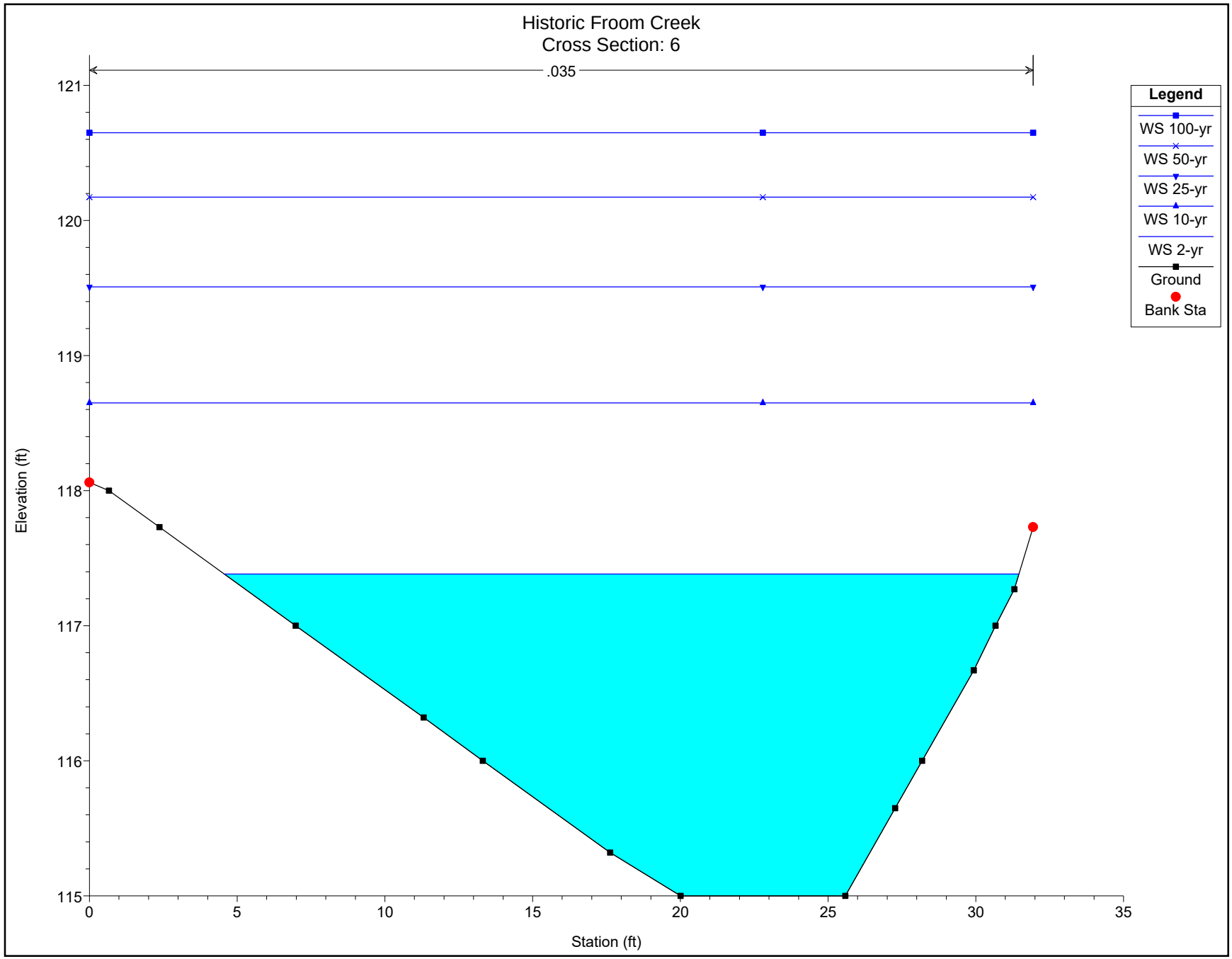

Historic Froom Creek
Cross Section: 1
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
113
112
111
110
109
108
0
10
20
30
40
50
60

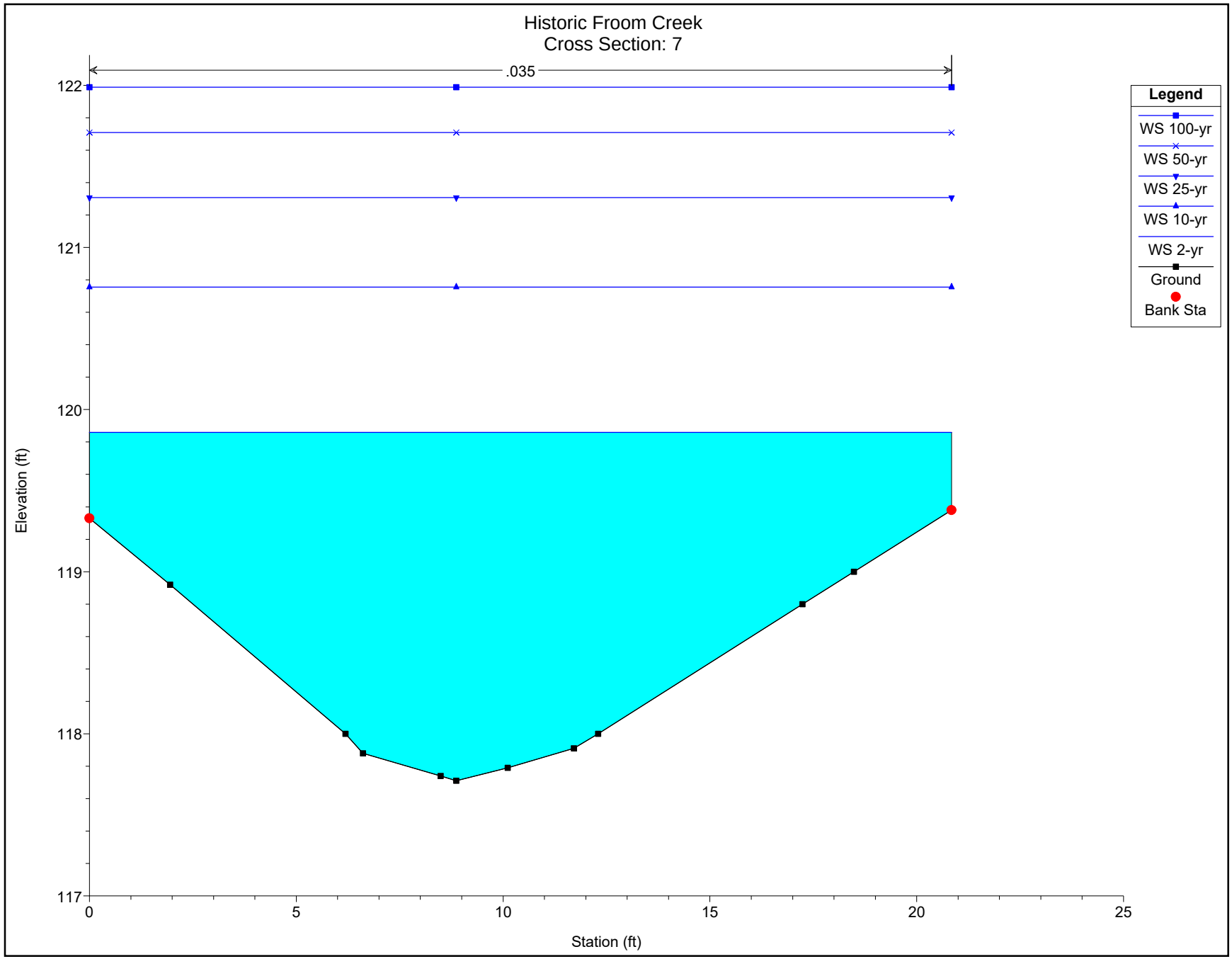

Historic Froom Creek
Cross Section: 2
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
115
114
113
112
111
110
109
0
5
10
15
20
25

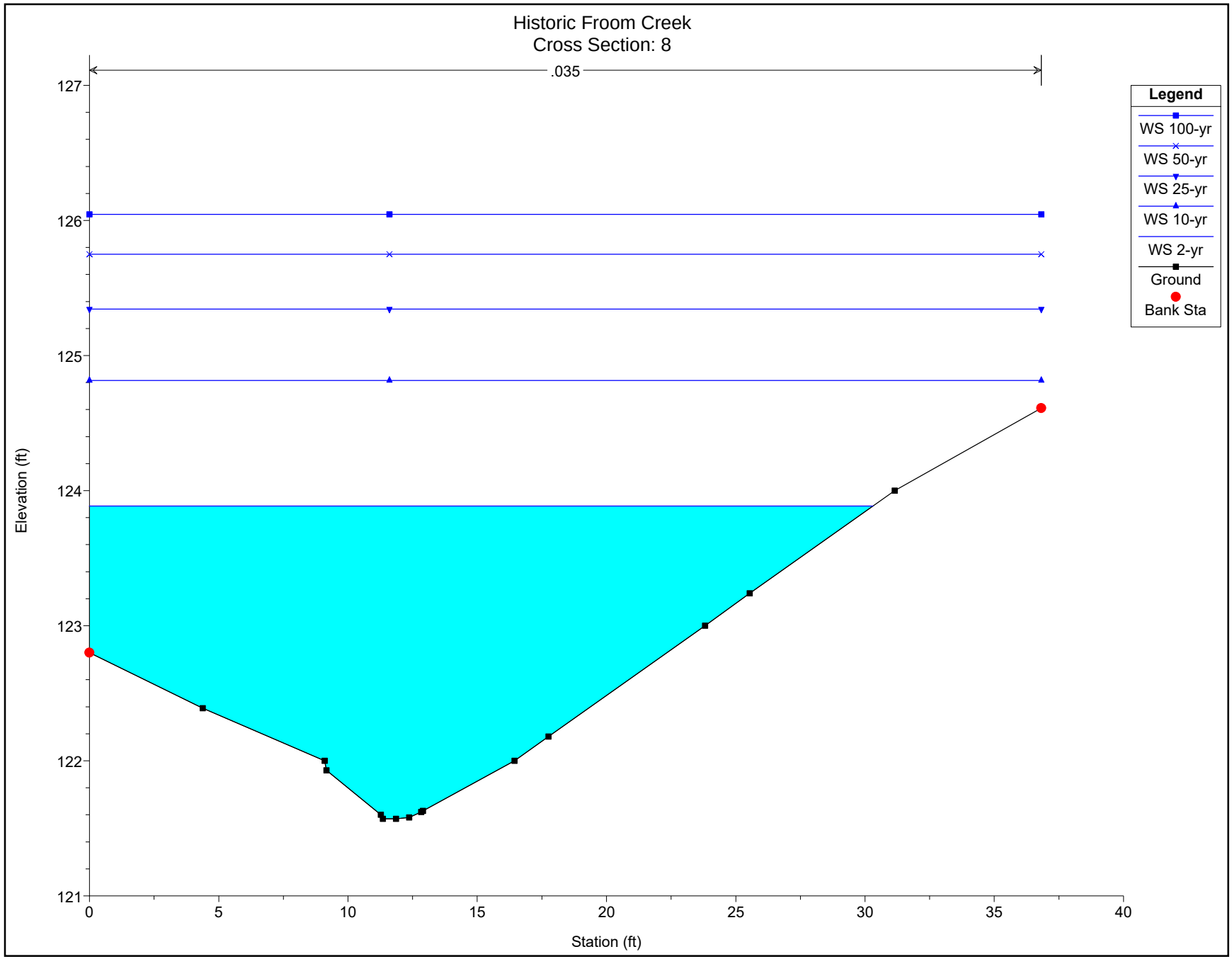

Historic Froom Creek
Cross Section: 3
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
118
116
114
112
110
108
0
5
10
15
20
25
30

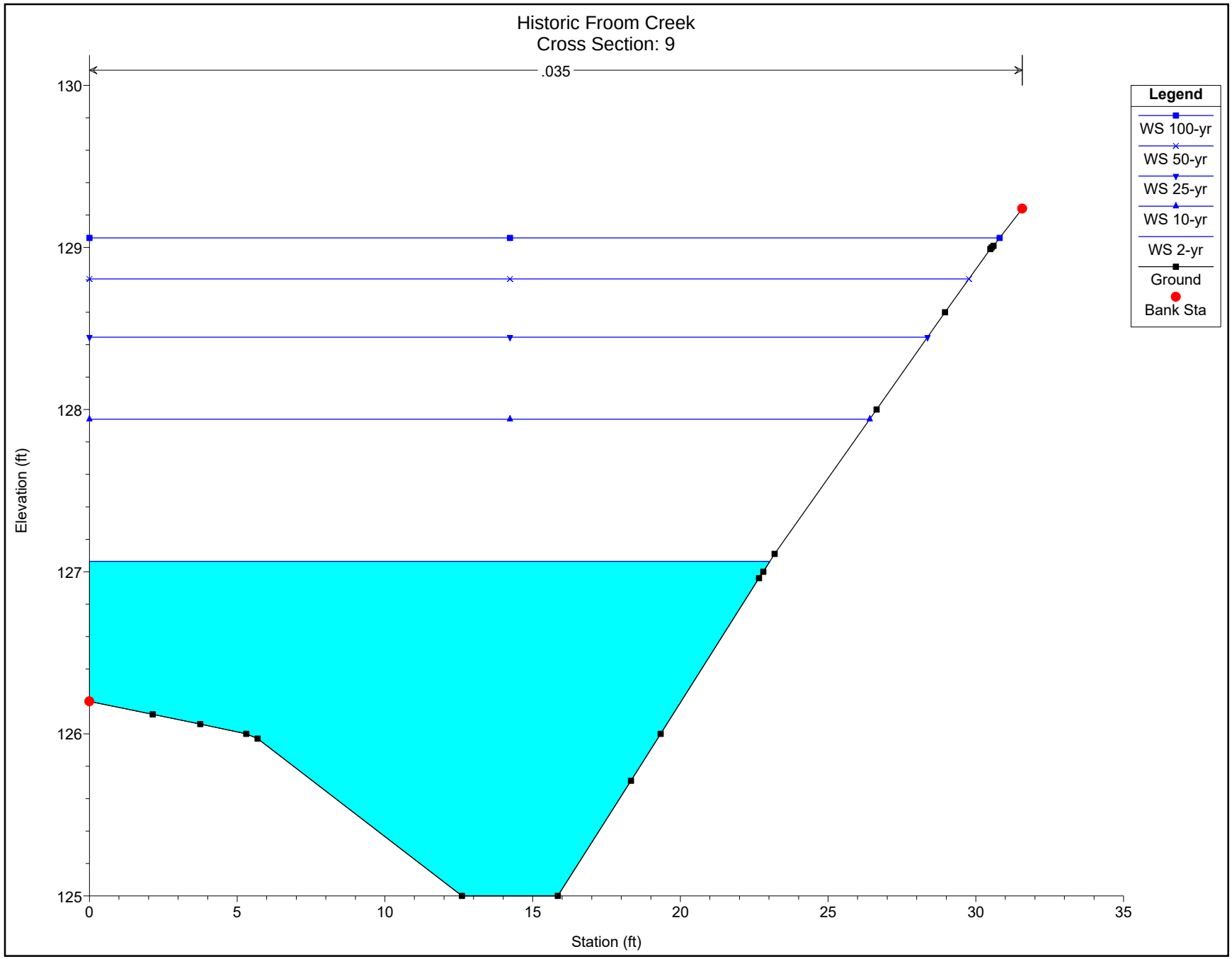

Historic Froom Creek
Cross Section: 4
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
118
117
116
115
114
113
112
0
2
4
6
8
10
12
14
16

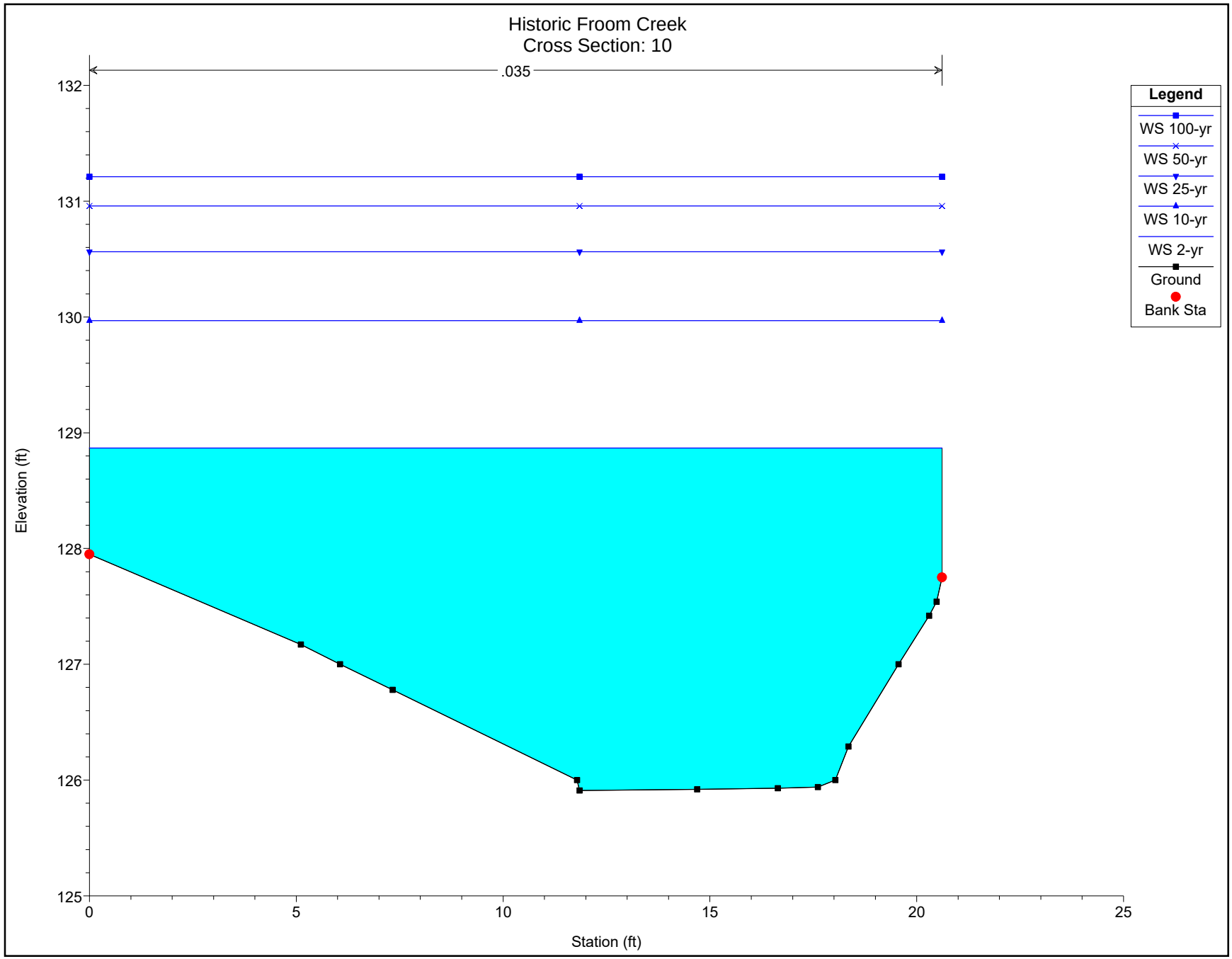

Historic Froom Creek
Cross Section: 5
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
121
120
119
118
117
116
115
114
113
112
0
5
10
15
20
25
30

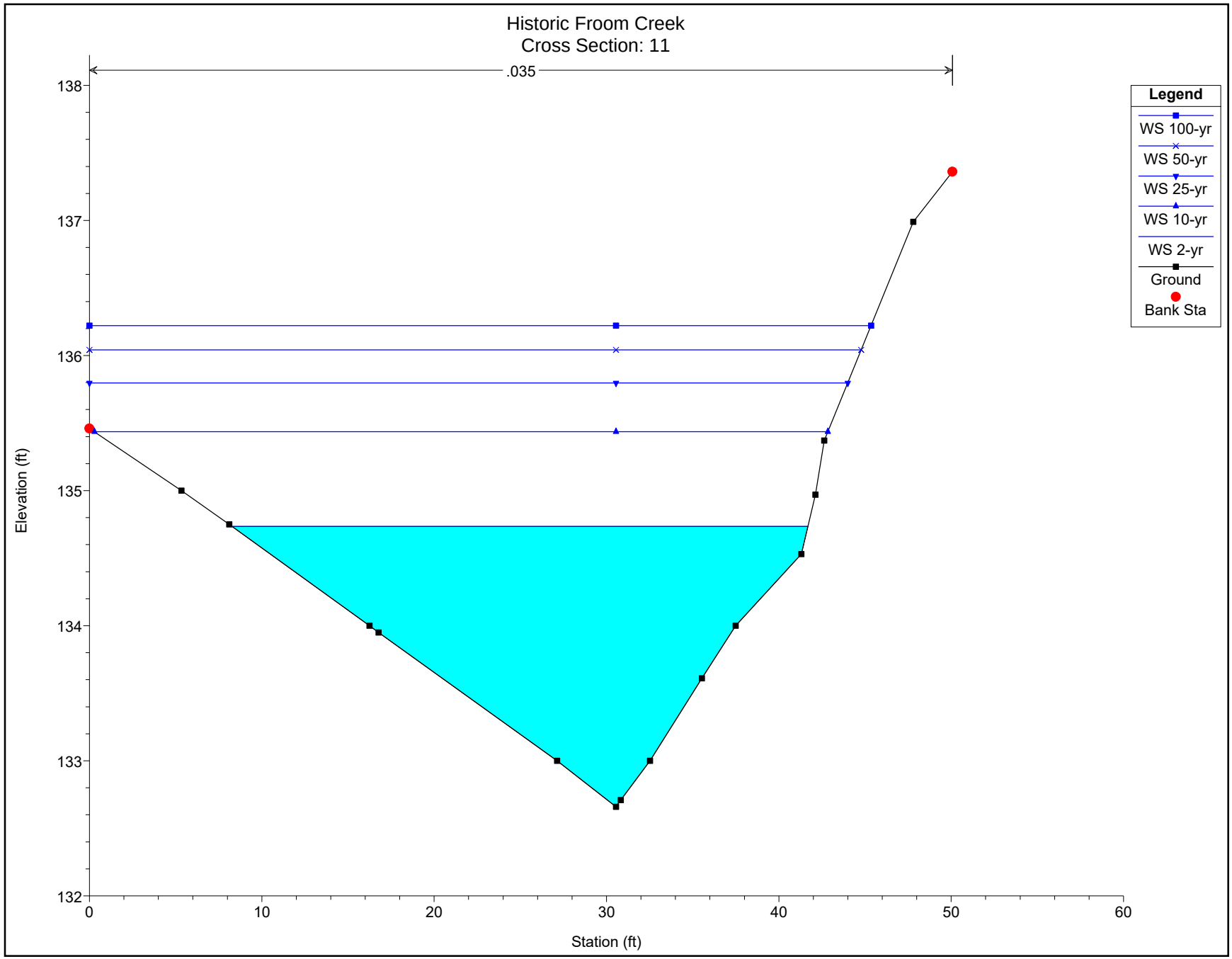

Historic Froom Creek
Cross Section: 6
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
121
120
119
118
117
116
115
0
5
10
15
20
25
30
35

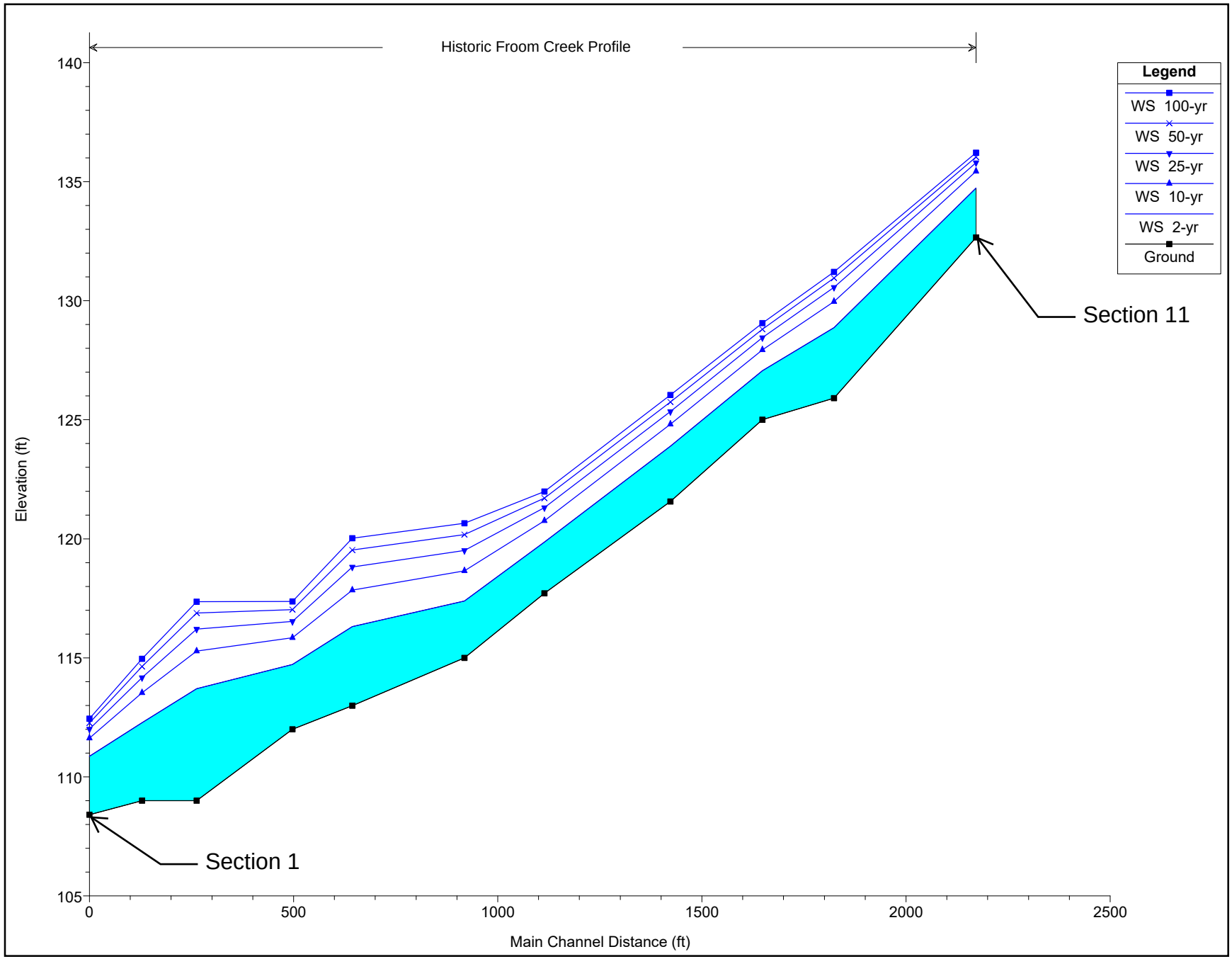

Historic Froom Creek
Cross Section: 7
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
122
121
120
119
118
117
0
5
10
15
20
25


Historic Froom Creek
Cross Section: 8
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
127
126
125
124
123
122
121
0
5
10
15
20
25
30
35
40


Historic Froom Creek
Cross Section: 9
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
130
129
128
127
126
125
0
5
10
15
20
25
30
35


Historic Froom Creek
Cross Section: 10
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
132
131
130
129
128
127
126
125
0
5
10
15
20
25


Historic Froom Creek
Cross Section: 11
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
138
137
136
135
134
133
132
0
10
20
30
40
50
60


Historic Froom Creek Profile
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Section 11
Section 1
Elevation (ft)
Main Channel Distance (ft)
140
135
130
125
120
115
110
105
0
500
1000
1500
2000
2500

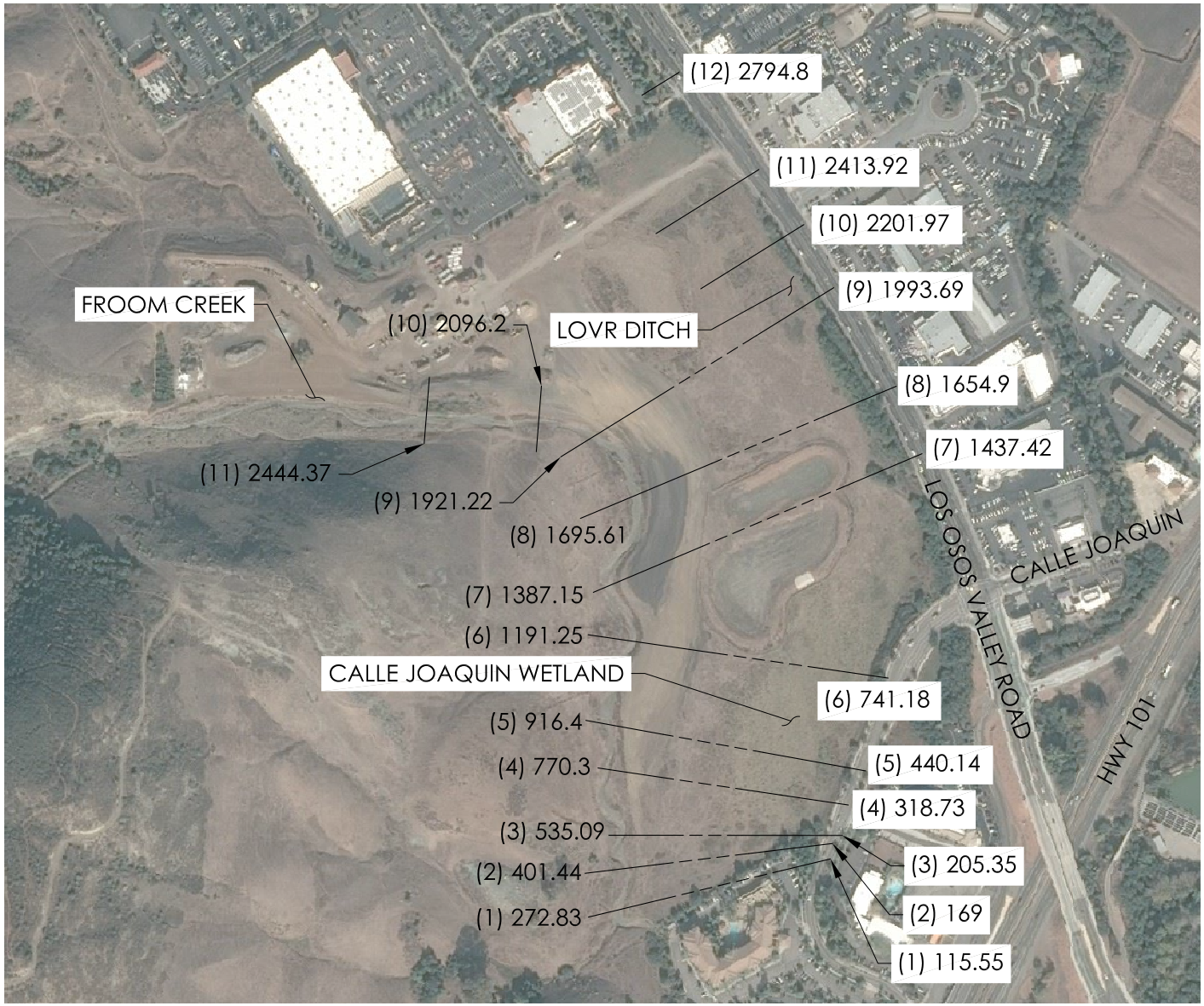
Historic Froom Creek Tabular Results

HEC-RAS Plan: Plan 01 River: Existing Froom C Reach: Froom Creek Exis

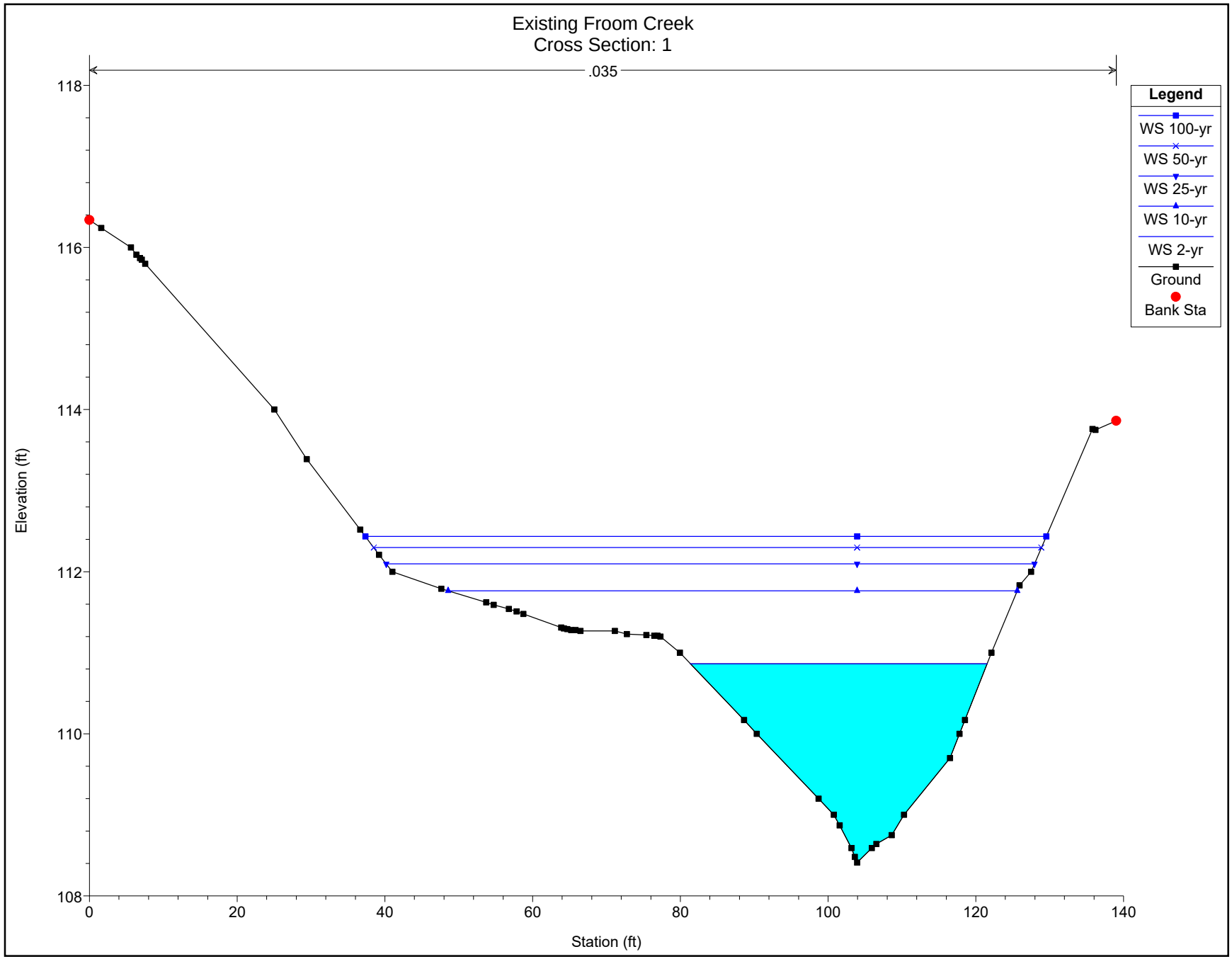
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Froom Creek Exis	2444.37	2-yr	201.93	132.66	134.74	134.74	135.26	0.018234	5.83	34.62	33.42	1.01
Froom Creek Exis	2444.37	10-yr	419.94	132.66	135.44	135.44	136.17	0.016390	6.86	61.18	42.57	1.01
Froom Creek Exis	2444.37	25-yr	577.16	132.66	135.80	135.80	136.67	0.015272	7.51	76.90	44.00	1.00
Froom Creek Exis	2444.37	50-yr	701.37	132.66	136.04	136.04	137.03	0.014997	7.99	87.73	44.78	1.01
Froom Creek Exis	2444.37	100-yr	792.91	132.66	136.22	136.22	137.29	0.014584	8.27	95.87	45.35	1.00
Froom Creek Exis	2096.2	2-yr	201.93	125.91	128.87		129.17	0.004504	4.44	45.52	20.61	0.53
Froom Creek Exis	2096.2	10-yr	419.94	125.91	129.97		130.56	0.005713	6.16	68.17	20.61	0.60
Froom Creek Exis	2096.2	25-yr	577.16	125.91	130.56		131.36	0.006599	7.17	80.46	20.61	0.64
Froom Creek Exis	2096.2	50-yr	701.37	125.91	130.96		131.93	0.007348	7.92	88.59	20.61	0.67
Froom Creek Exis	2096.2	100-yr	792.91	125.91	131.21		132.32	0.007954	8.45	93.79	20.61	0.70
Froom Creek Exis	1921.22	2-yr	201.93	125.00	127.06	127.06	127.74	0.017815	6.61	30.55	23.03	1.01
Froom Creek Exis	1921.22	10-yr	419.94	125.00	127.94	127.94	128.95	0.016096	8.04	52.22	26.41	1.01
Froom Creek Exis	1921.22	25-yr	577.16	125.00	128.45	128.45	129.63	0.015527	8.73	66.09	28.37	1.01
Froom Creek Exis	1921.22	50-yr	701.37	125.00	128.81	128.81	130.11	0.015168	9.17	76.51	29.77	1.01
Froom Creek Exis	1921.22	100-yr	792.91	125.00	129.06	129.06	130.44	0.014857	9.42	84.18	30.81	1.00
Froom Creek Exis	1695.61	2-yr	201.93	121.57	123.89		124.24	0.008535	4.77	42.37	30.30	0.71
Froom Creek Exis	1695.61	10-yr	419.94	121.57	124.81		125.31	0.007637	5.66	74.16	36.82	0.70
Froom Creek Exis	1695.61	25-yr	577.16	121.57	125.34		125.93	0.006873	6.17	93.62	36.82	0.68
Froom Creek Exis	1695.61	50-yr	701.37	121.57	125.75		126.40	0.006359	6.46	108.57	36.82	0.66
Froom Creek Exis	1695.61	100-yr	792.91	121.57	126.05		126.73	0.006021	6.64	119.48	36.82	0.65
Froom Creek Exis	1387.15	2-yr	201.93	117.71	119.86	119.86	120.57	0.017177	6.78	29.78	20.84	1.00
Froom Creek Exis	1387.15	10-yr	419.94	117.71	120.76	120.76	121.92	0.016273	8.67	48.45	20.84	1.00
Froom Creek Exis	1387.15	25-yr	577.16	117.71	121.31	121.31	122.75	0.016052	9.63	59.95	20.84	1.00
Froom Creek Exis	1387.15	50-yr	701.37	117.71	121.71	121.71	123.35	0.015996	10.27	68.31	20.84	1.00
Froom Creek Exis	1387.15	100-yr	792.91	117.71	121.99	121.99	123.77	0.016012	10.69	74.14	20.84	1.00
Froom Creek Exis	1191.25	2-yr	201.93	115.00	117.38		117.79	0.009089	5.13	39.34	26.89	0.75
Froom Creek Exis	1191.25	10-yr	419.94	115.00	118.65		119.10	0.005348	5.38	78.10	31.94	0.61
Froom Creek Exis	1191.25	25-yr	577.16	115.00	119.51		119.97	0.003953	5.47	105.54	31.94	0.53
Froom Creek Exis	1191.25	50-yr	701.37	115.00	120.17		120.65	0.003328	5.53	126.74	31.94	0.49
Froom Creek Exis	1191.25	100-yr	792.91	115.00	120.65		121.13	0.003014	5.59	141.97	31.94	0.47
Froom Creek Exis	916.4	2-yr	201.93	112.99	116.31		116.50	0.002647	3.47	58.19	25.63	0.41
Froom Creek Exis	916.4	10-yr	419.94	112.99	117.85		118.13	0.002297	4.26	98.66	26.54	0.39
Froom Creek Exis	916.4	25-yr	577.16	112.99	118.81		119.15	0.002167	4.64	124.33	26.54	0.38
Froom Creek Exis	916.4	50-yr	701.37	112.99	119.53		119.90	0.002105	4.90	143.28	26.54	0.37
Froom Creek Exis	916.4	100-yr	792.91	112.99	120.03		120.43	0.002076	5.06	156.58	26.54	0.37
Froom Creek Exis	770.3	2-yr	201.93	112.00	114.72	114.72	115.62	0.017780	7.59	26.61	15.15	1.01
Froom Creek Exis	770.3	10-yr	419.94	112.00	115.85	115.85	117.29	0.017453	9.63	43.61	15.15	1.00
Froom Creek Exis	770.3	25-yr	577.16	112.00	116.53	116.53	118.31	0.017744	10.69	53.97	15.15	1.00
Froom Creek Exis	770.3	50-yr	701.37	112.00	117.02	117.02	119.05	0.018138	11.42	61.39	15.15	1.00
Froom Creek Exis	770.3	100-yr	792.91	112.00	117.37	117.37	119.57	0.018358	11.89	66.68	15.15	1.00
Froom Creek Exis	535.09	2-yr	253.28	109.00	113.70		113.87	0.001814	3.30	76.84	28.32	0.35
Froom Creek Exis	535.09	10-yr	521.50	109.00	115.28		115.57	0.001899	4.29	121.50	28.32	0.37
Froom Creek Exis	535.09	25-yr	714.26	109.00	116.21		116.57	0.001992	4.84	147.70	28.32	0.37
Froom Creek Exis	535.09	50-yr	867.58	109.00	116.88		117.30	0.002055	5.20	166.87	28.32	0.38
Froom Creek Exis	535.09	100-yr	980.40	109.00	117.35		117.81	0.002098	5.44	180.24	28.32	0.38
Froom Creek Exis	401.44	2-yr	253.28	109.00	112.27	112.27	113.24	0.017113	7.89	32.11	16.88	1.01
Froom Creek Exis	401.44	10-yr	521.50	109.00	113.53	113.53	114.90	0.016043	9.39	55.56	20.30	1.00
Froom Creek Exis	401.44	25-yr	714.26	109.00	114.17	114.17	115.85	0.016020	10.42	68.54	20.30	1.00
Froom Creek Exis	401.44	50-yr	867.58	109.00	114.63	114.63	116.55	0.016125	11.13	77.98	20.30	1.00
Froom Creek Exis	401.44	100-yr	980.40	109.00	114.96	114.96	117.04	0.016210	11.59	84.61	20.30	1.00
Froom Creek Exis	272.83	2-yr	253.28	108.41	110.86	110.61	111.25	0.010002	4.96	51.10	40.17	0.77
Froom Creek Exis	272.83	10-yr	521.50	108.41	111.63	111.39	112.19	0.010003	6.00	86.97	50.96	0.81
Froom Creek Exis	272.83	25-yr	714.26	108.41	112.00	111.75	112.71	0.010002	6.73	106.20	51.83	0.83
Froom Creek Exis	272.83	50-yr	867.58	108.41	112.27	112.01	113.08	0.010019	7.25	119.74	51.83	0.84
Froom Creek Exis	272.83	100-yr	980.40	108.41	112.45	112.19	113.34	0.010017	7.59	129.21	51.83	0.85

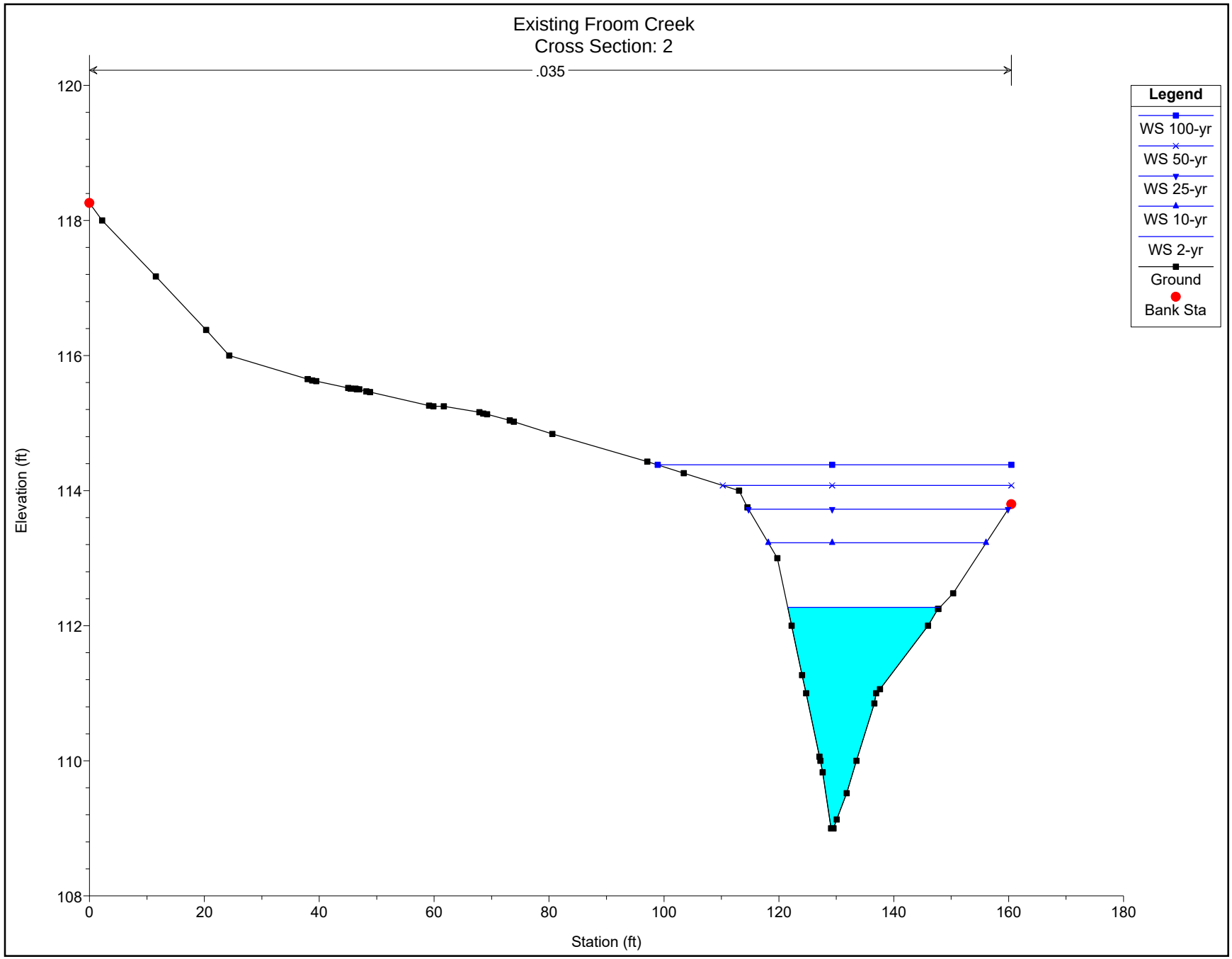
Appendix 2: Existing Condition Analysis

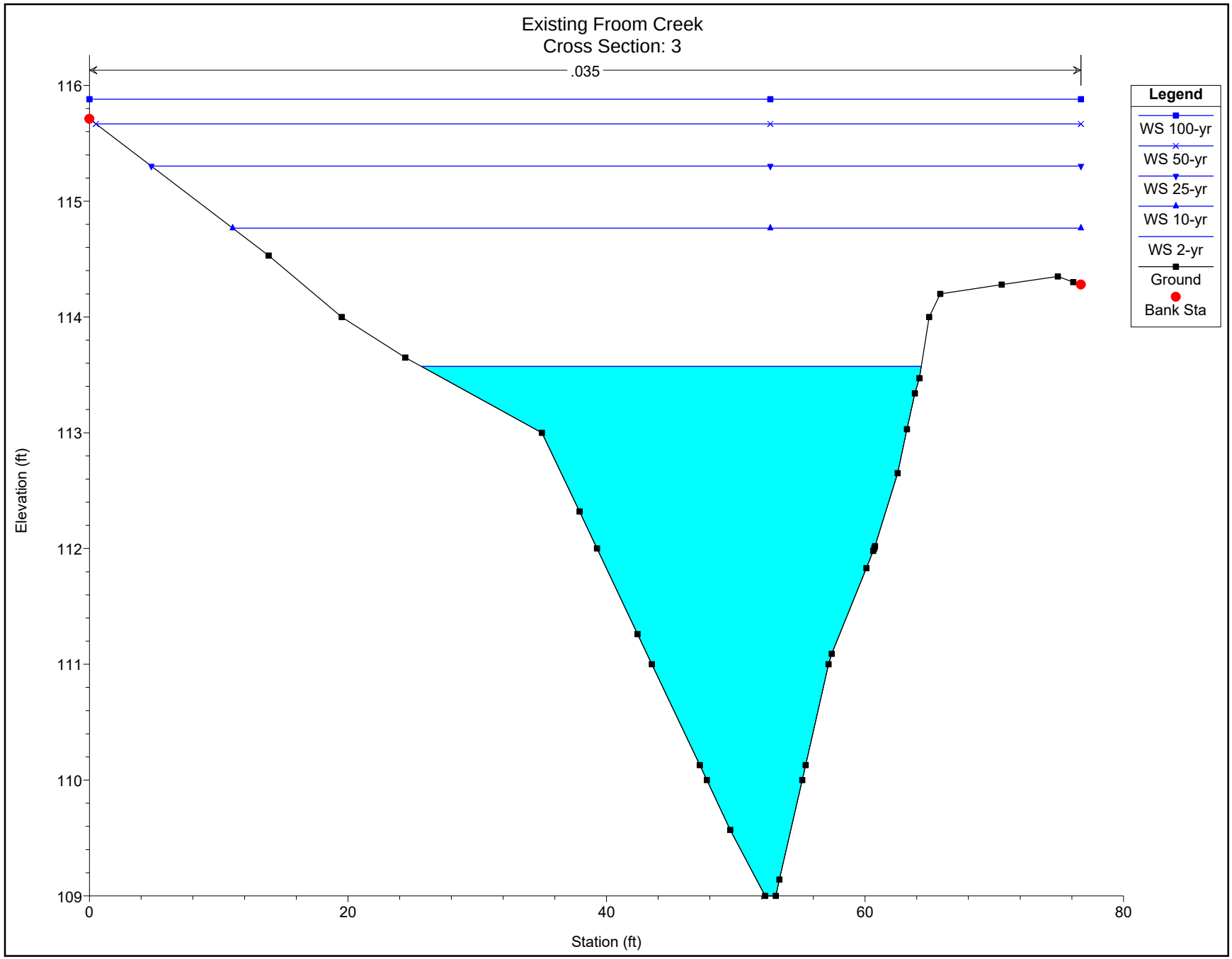

New Artificial Berm Placed Adjacent to Creek
Froom Creek - Existing Condition
Google Earth
Page 21
2013 Froom Creek Aerial
N
1000 ft

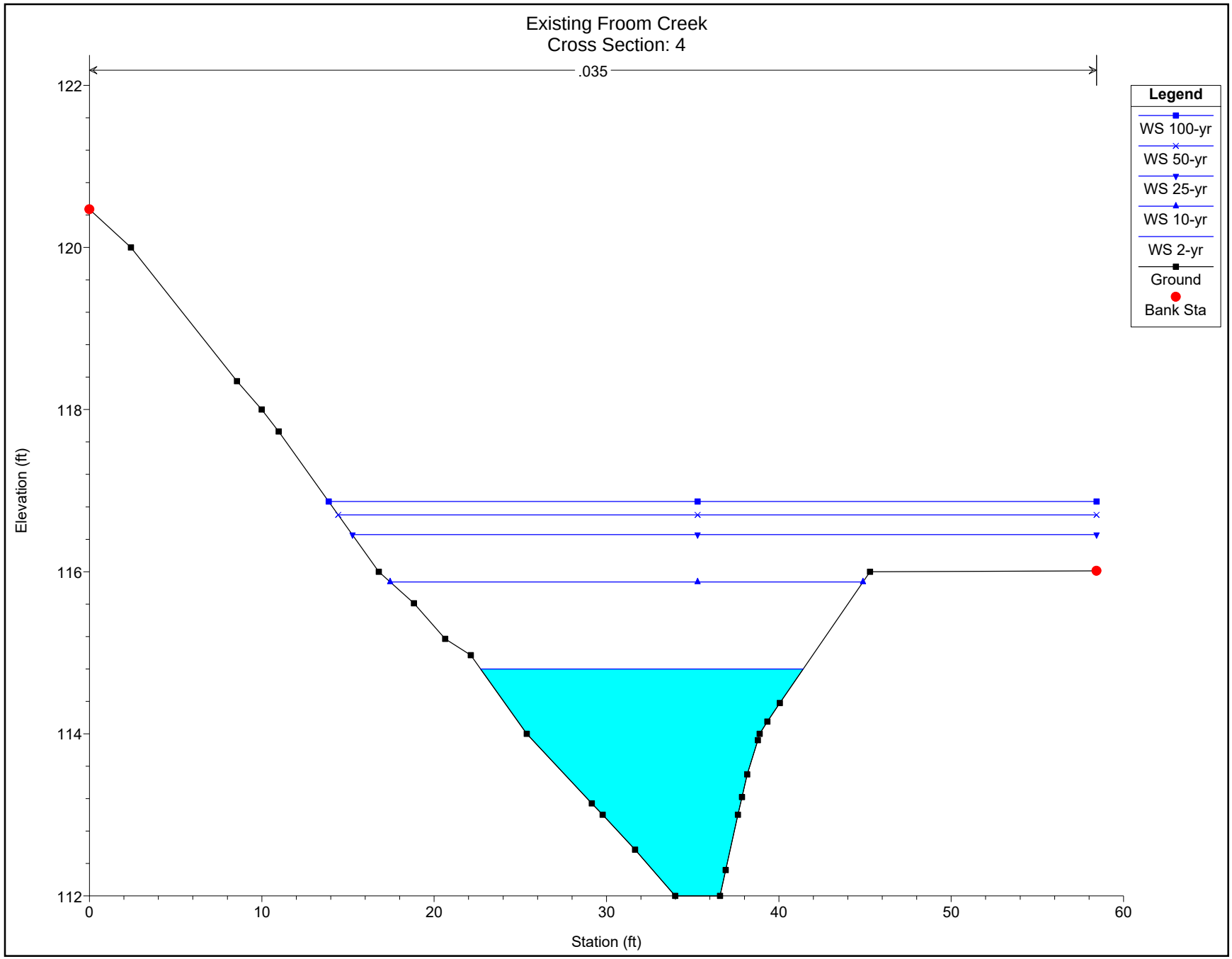


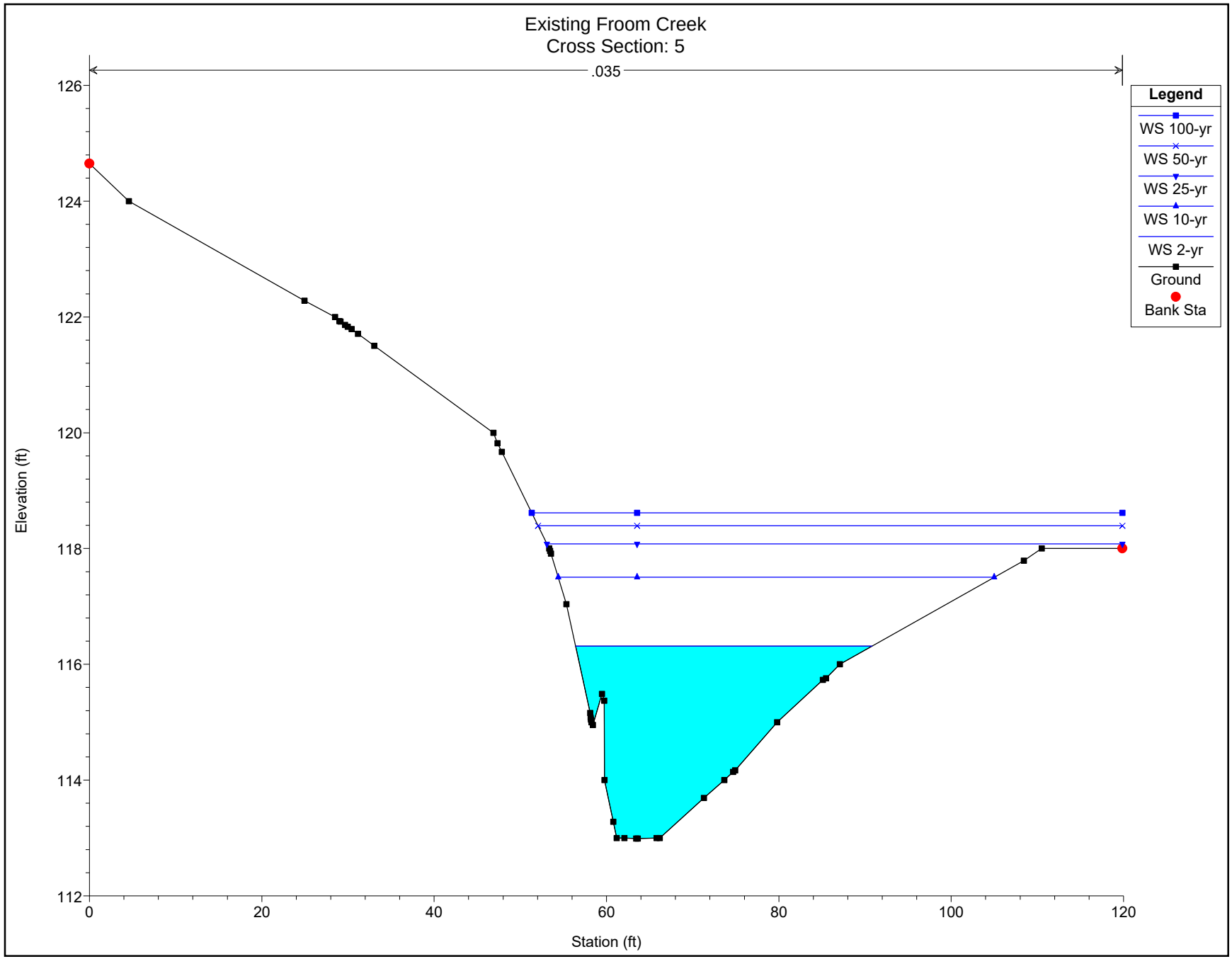
FROOM CREEK HEC-RAS ANALYSIS - EXISTING CONDITION
CROSS-SECTION LOCATIONS

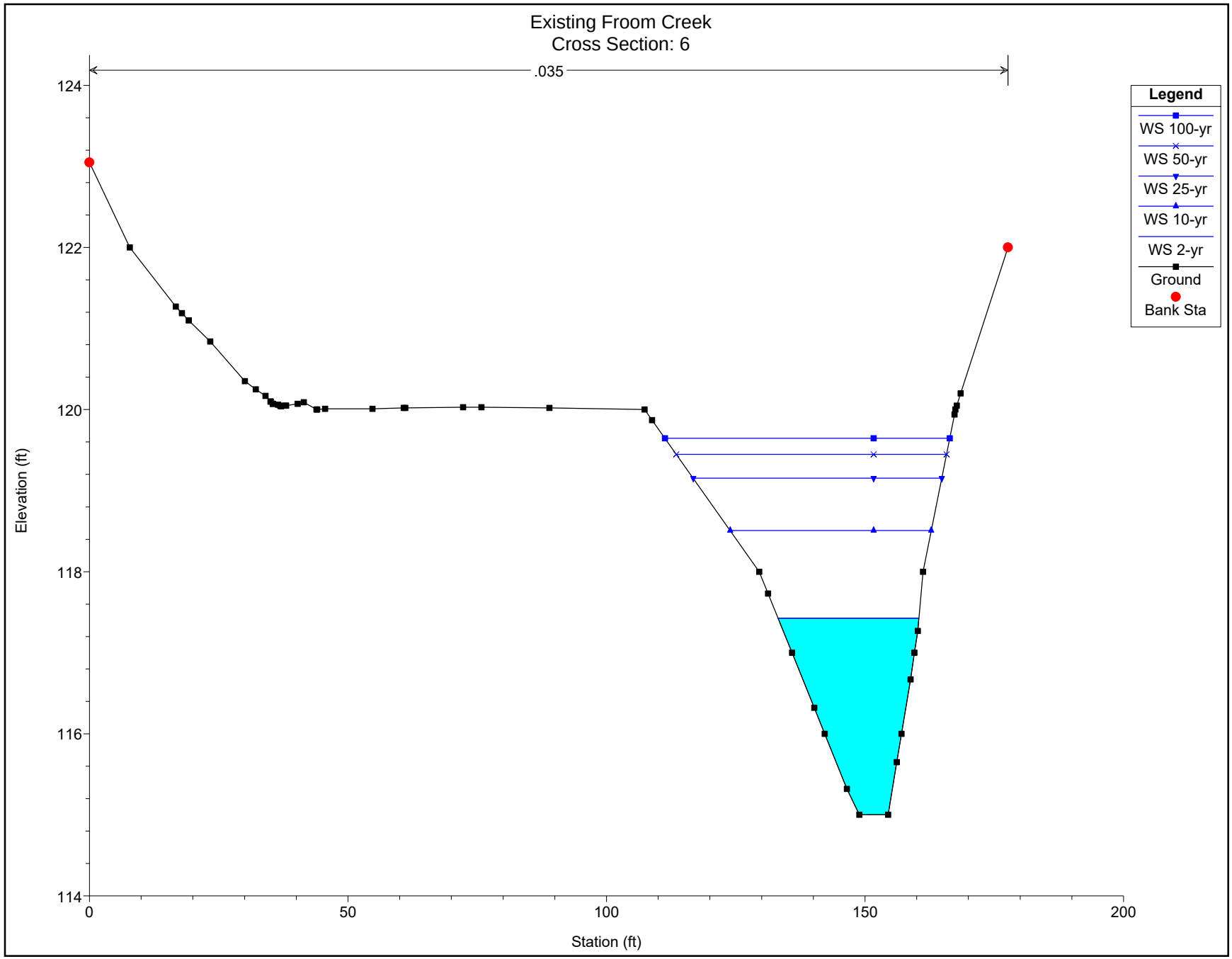

Existing Froom Creek
Cross Section: 1
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
118
116
114
112
110
108
0
20
40
60
80
100
120
140

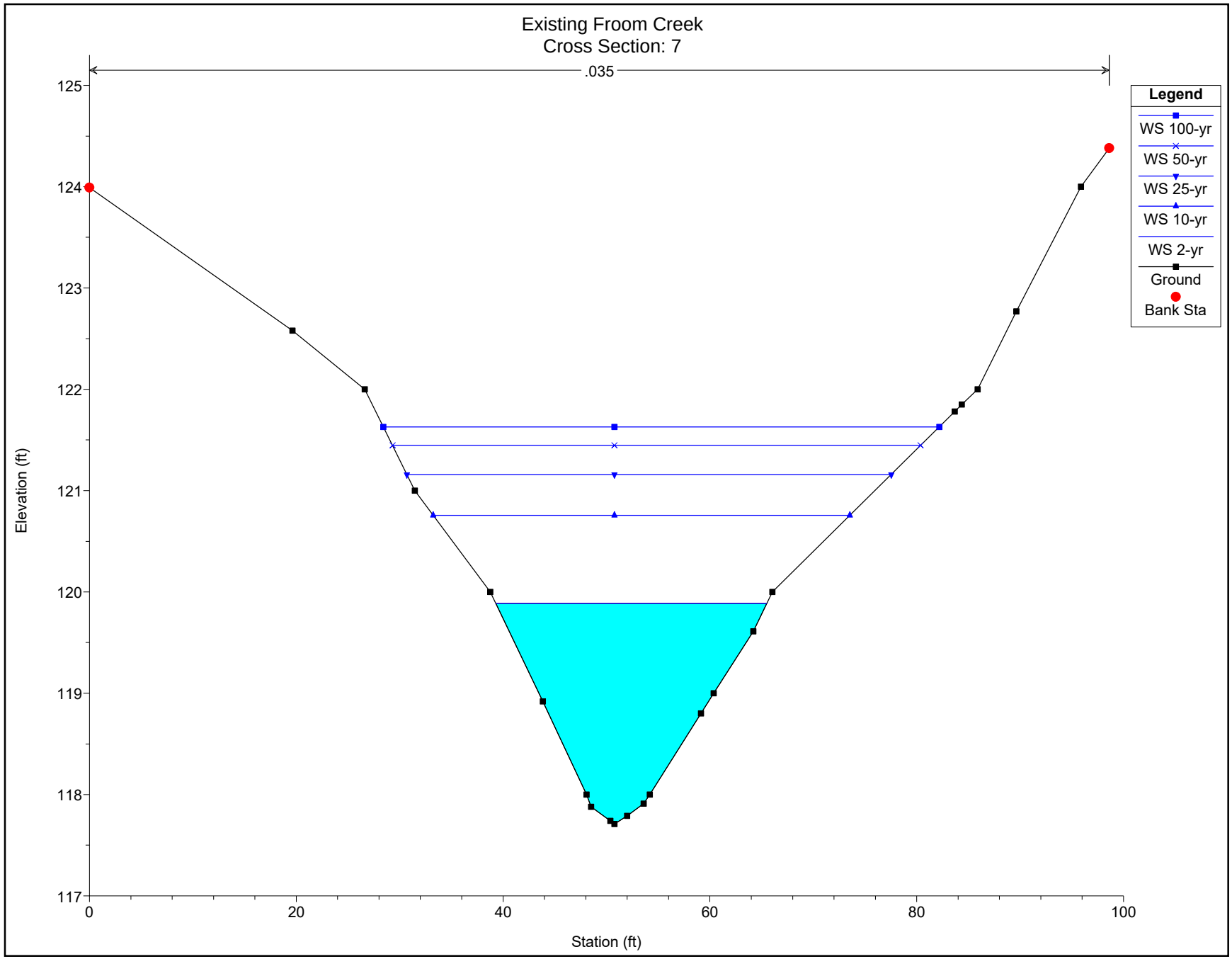

Existing Froom Creek
Cross Section: 2
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
120
118
116
114
112
110
108
0
20
40
60
80
100
120
140
160
180

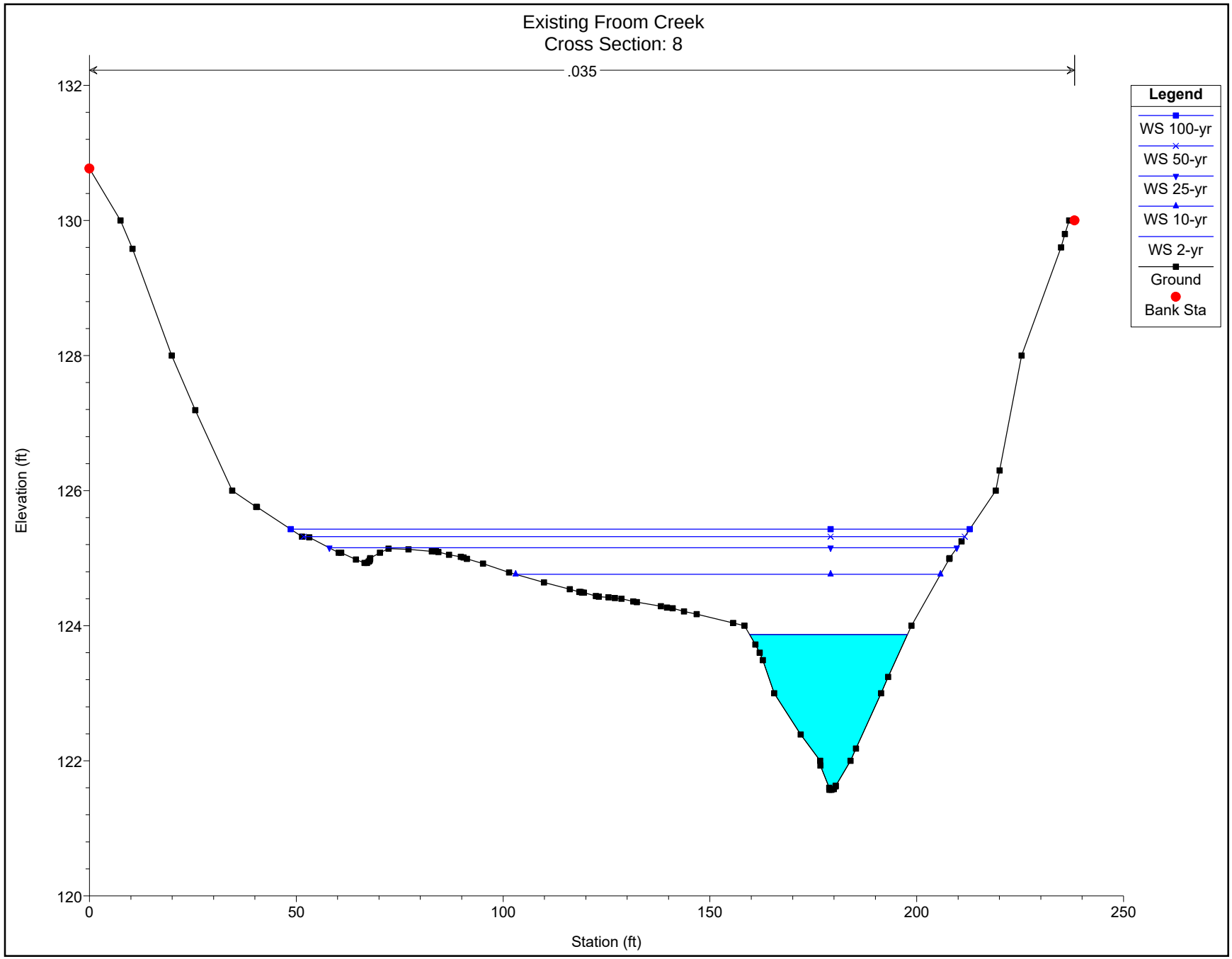

Existing Froom Creek
Cross Section: 3
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
116
115
114
113
112
111
110
109
0
20
40
60
80

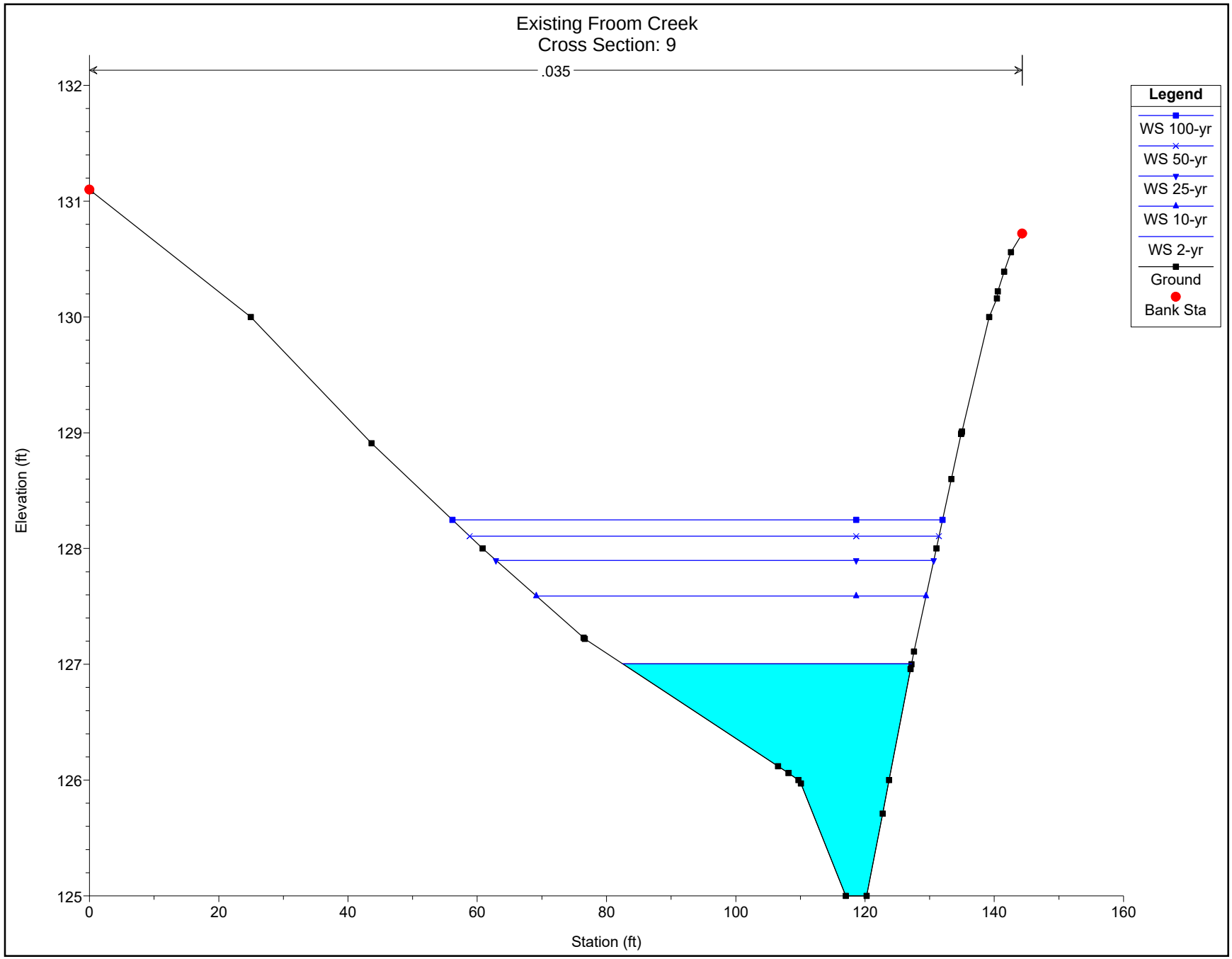

Existing Froom Creek
Cross Section: 4
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
122
120
118
116
114
112
0
10
20
30
40
50
60

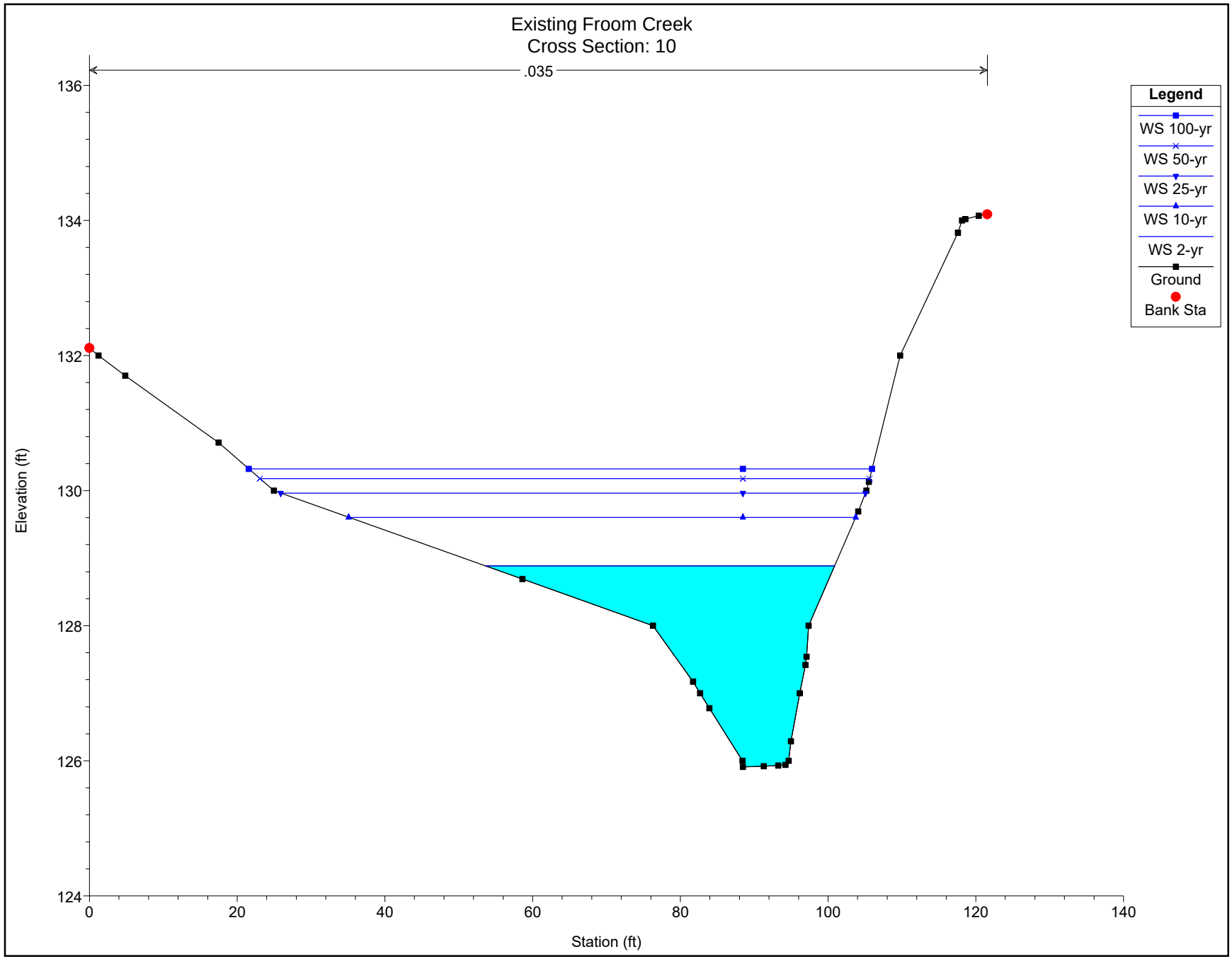

Existing Froom Creek
Cross Section: 5
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
126
124
122
120
118
116
114
112
0
20
40
60
80
100
120

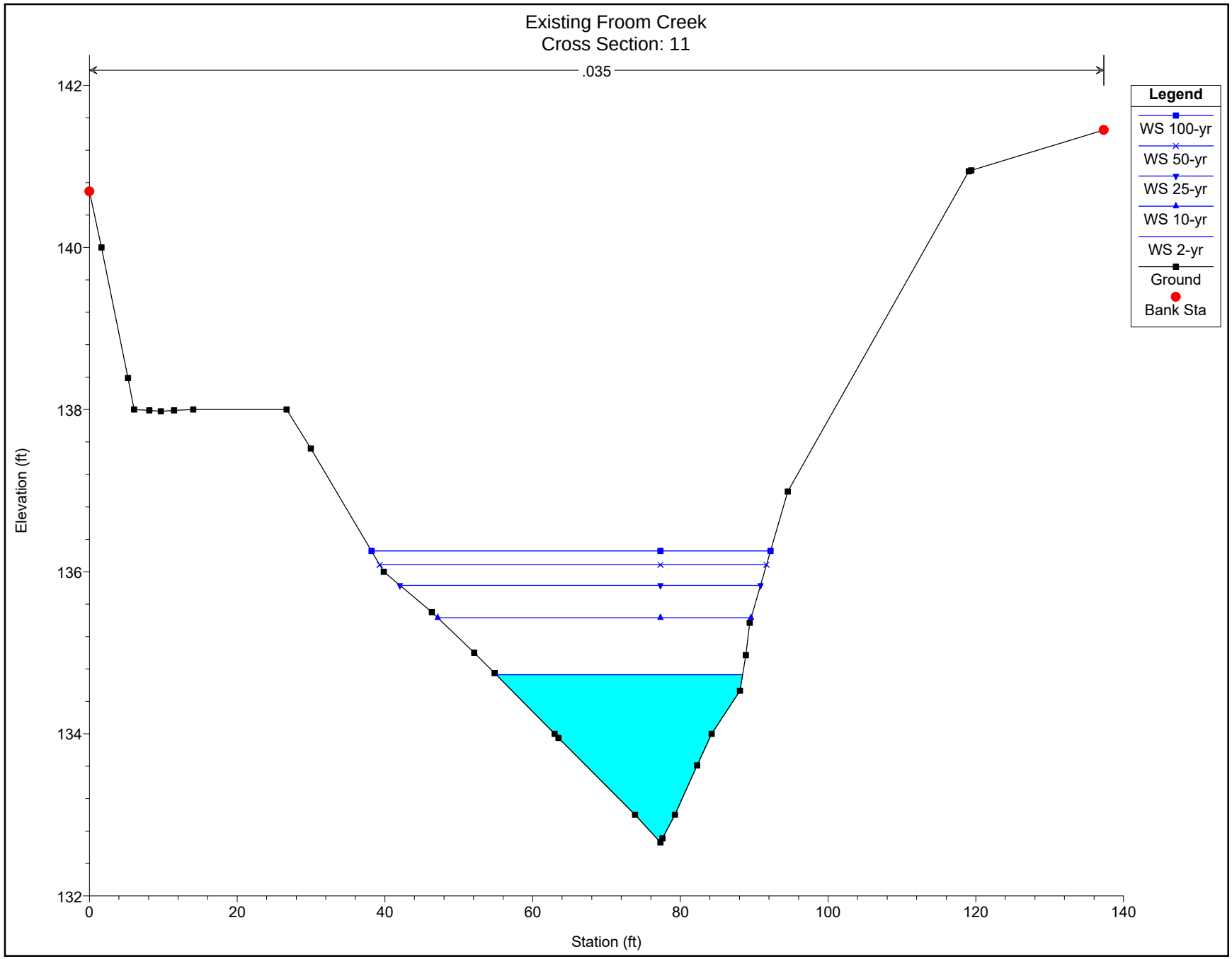

Existing Froom Creek
Cross Section: 6
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
124
122
120
118
116
114
0
50
100
150
200

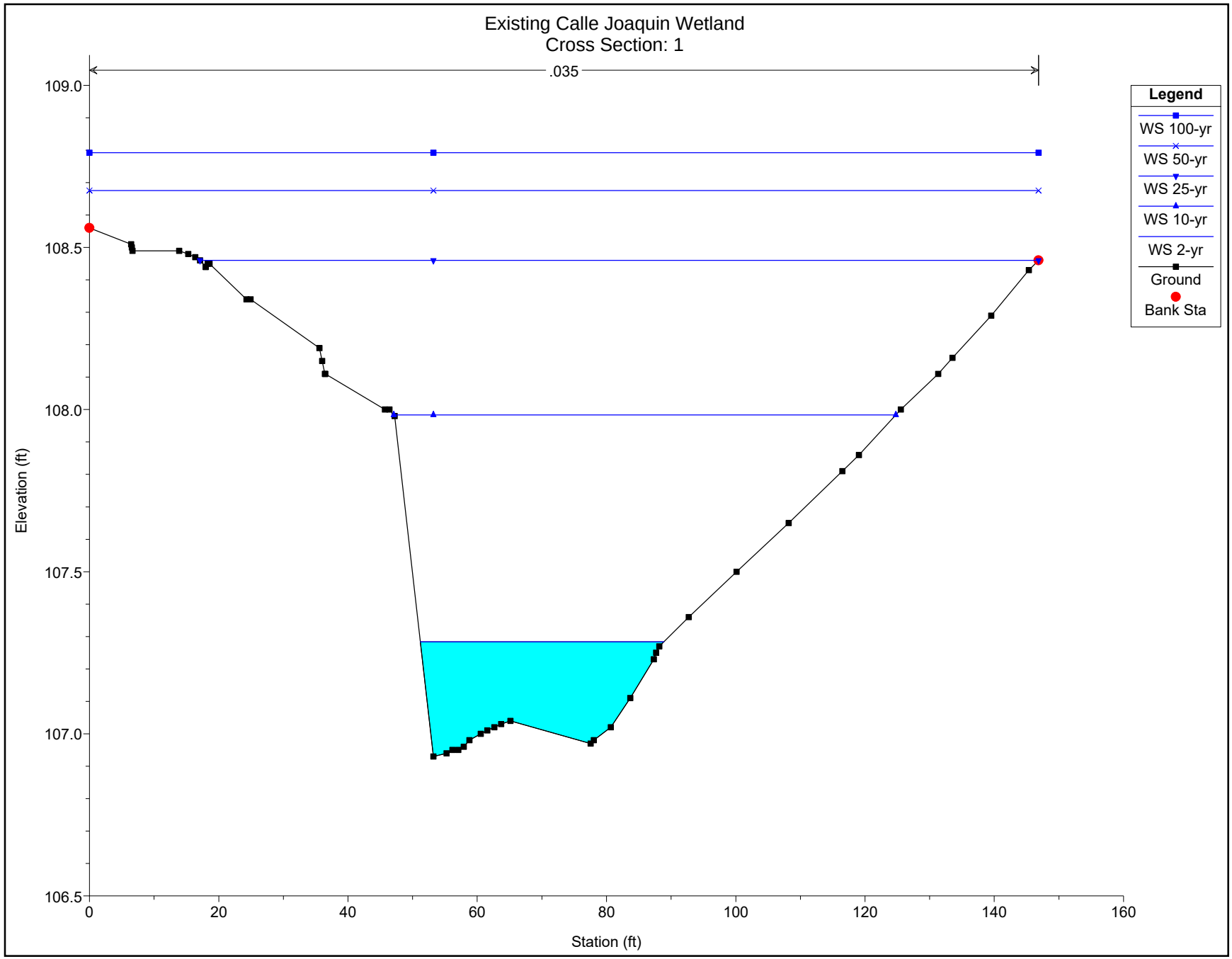

Existing Froom Creek
Cross Section: 7
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
125
124
123
122
121
120
119
118
117
0
20
40
60
80
100

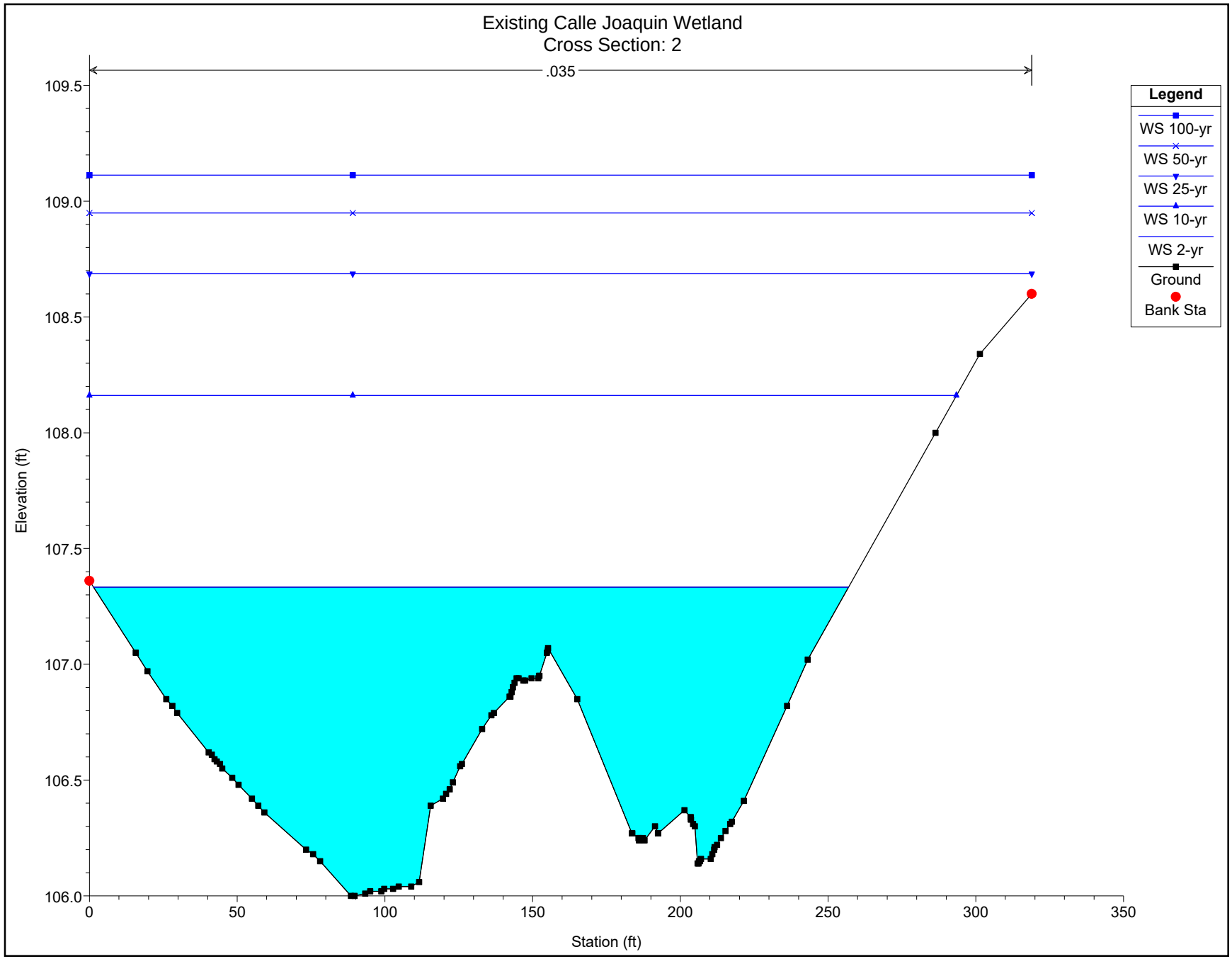

Existing Froom Creek
Cross Section: 8
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
120
122
124
126
128
130
132
0
50
100
150
200
250

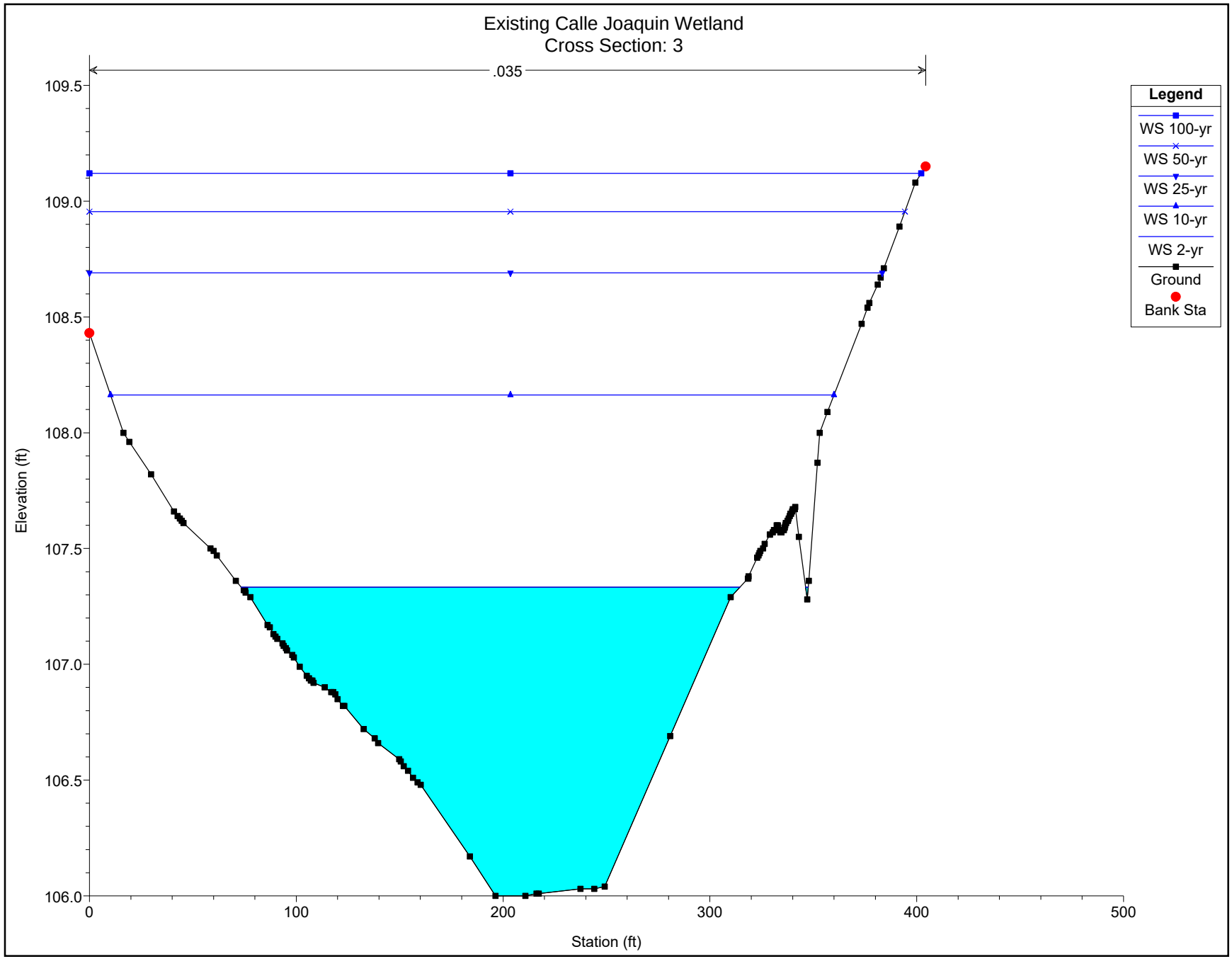

Existing Froom Creek
Cross Section: 9
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
132
131
130
129
128
127
126
125
0
20
40
60
80
100
120
140
160

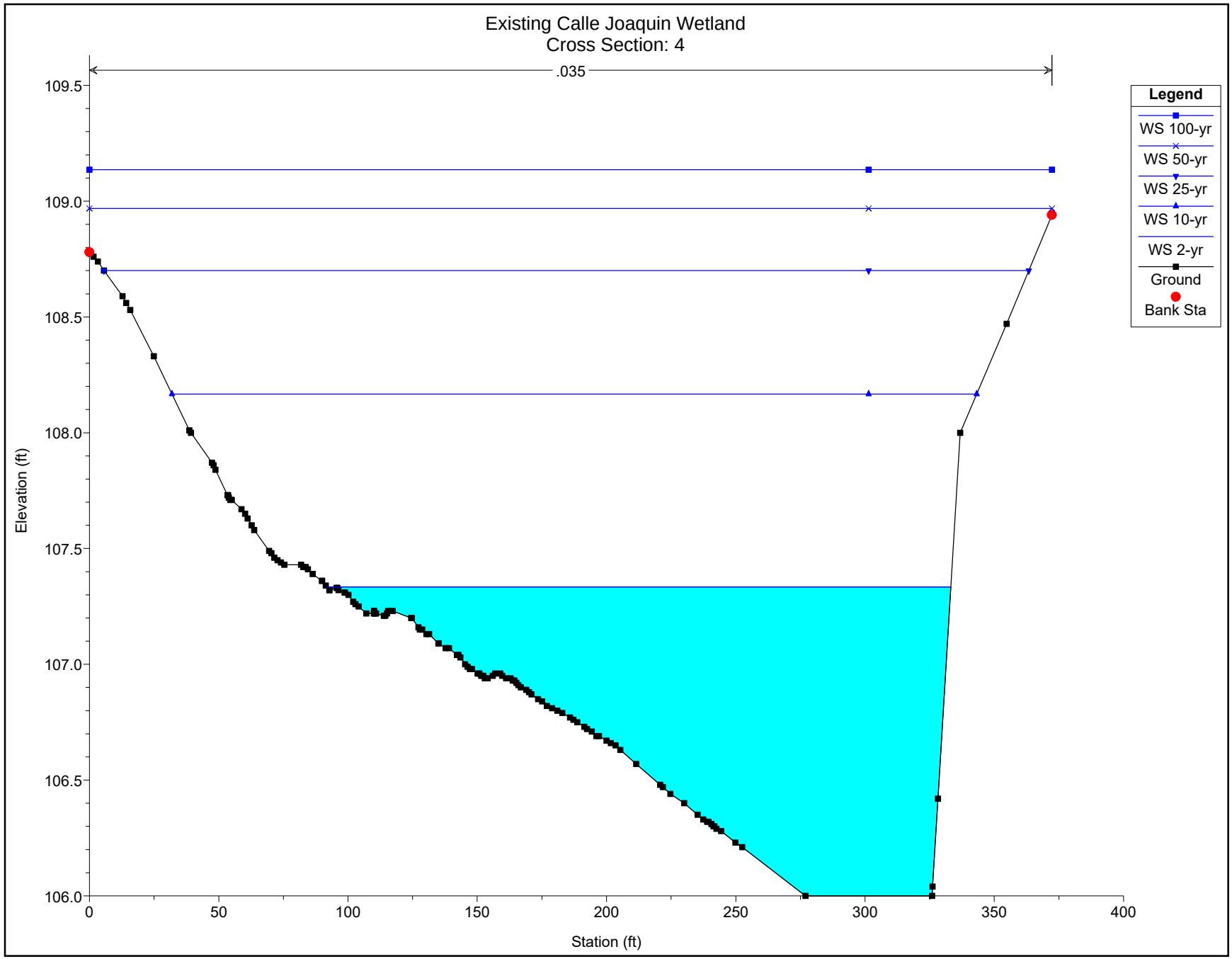

Existing Froom Creek
Cross Section: 10
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
136
134
132
130
128
126
124
0
20
40
60
80
100
120
140

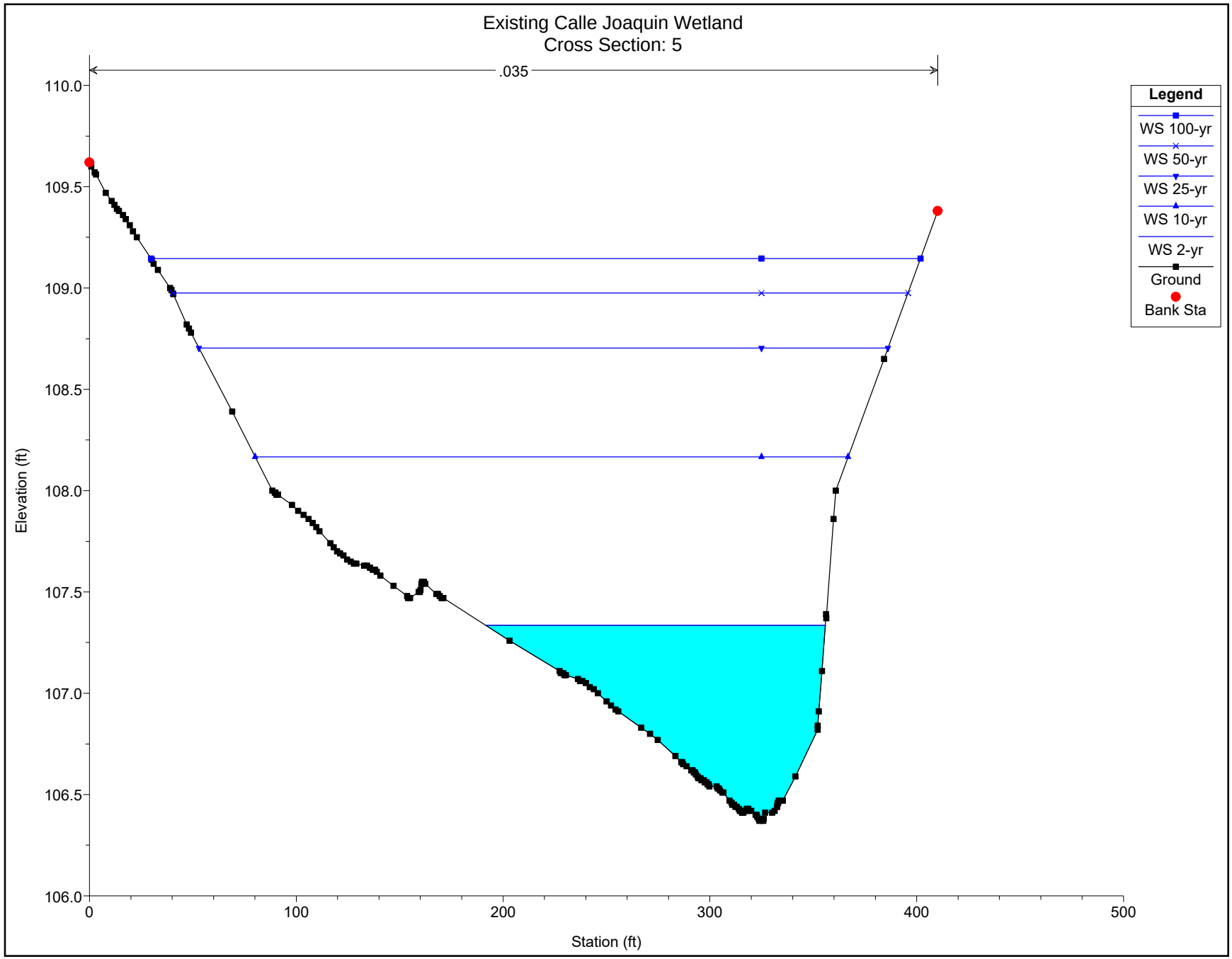

Existing Froom Creek
Cross Section: 11
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
142
140
138
136
134
132
0
20
40
60
80
100
120
140

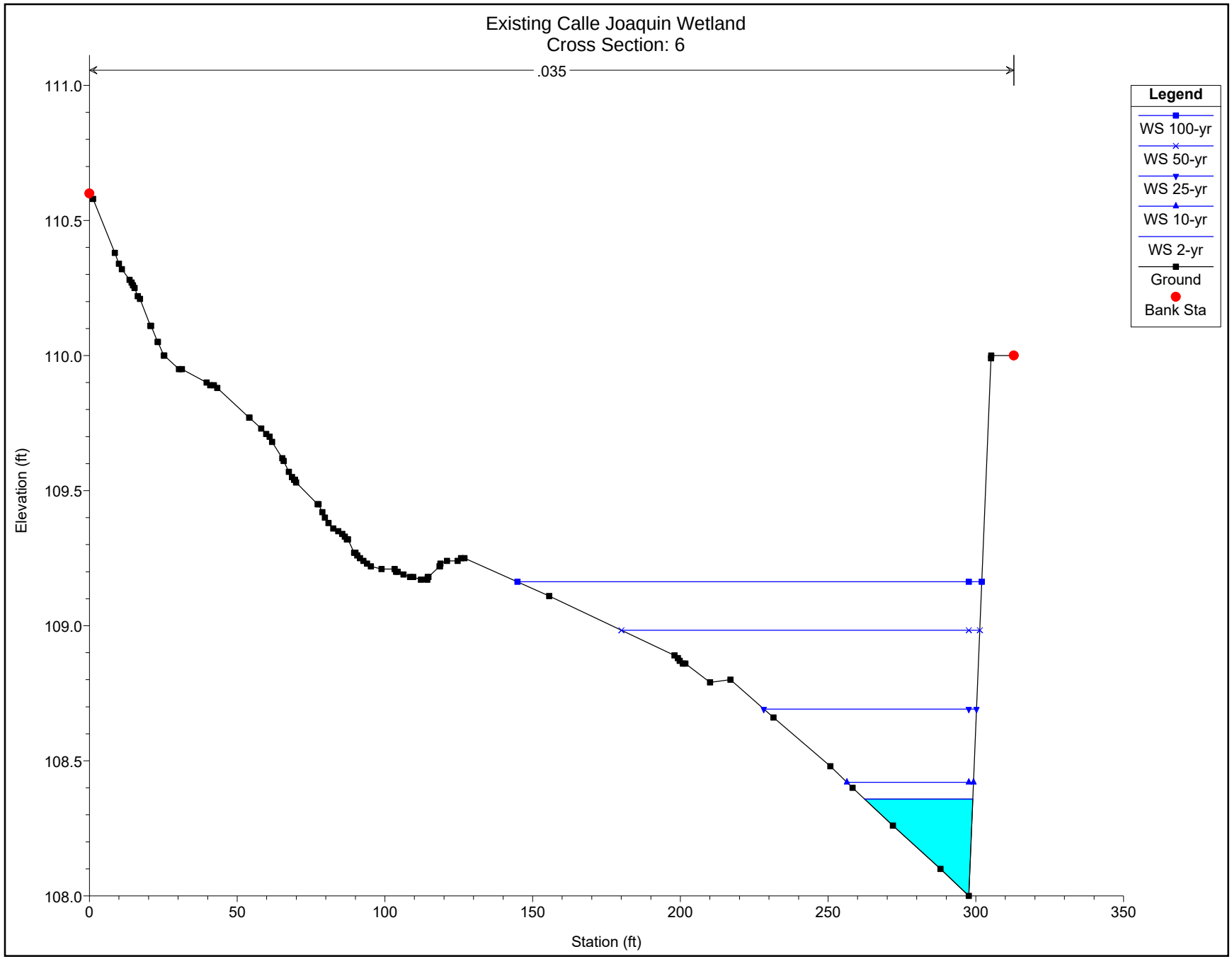

Existing Calle Joaquin Wetland
Cross Section: 1
.035
109.0
108.5
108.0
107.5
107.0
106.5
Elevation (ft)
0
20
40
60
80
100
120
140
160
Station (ft)
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta

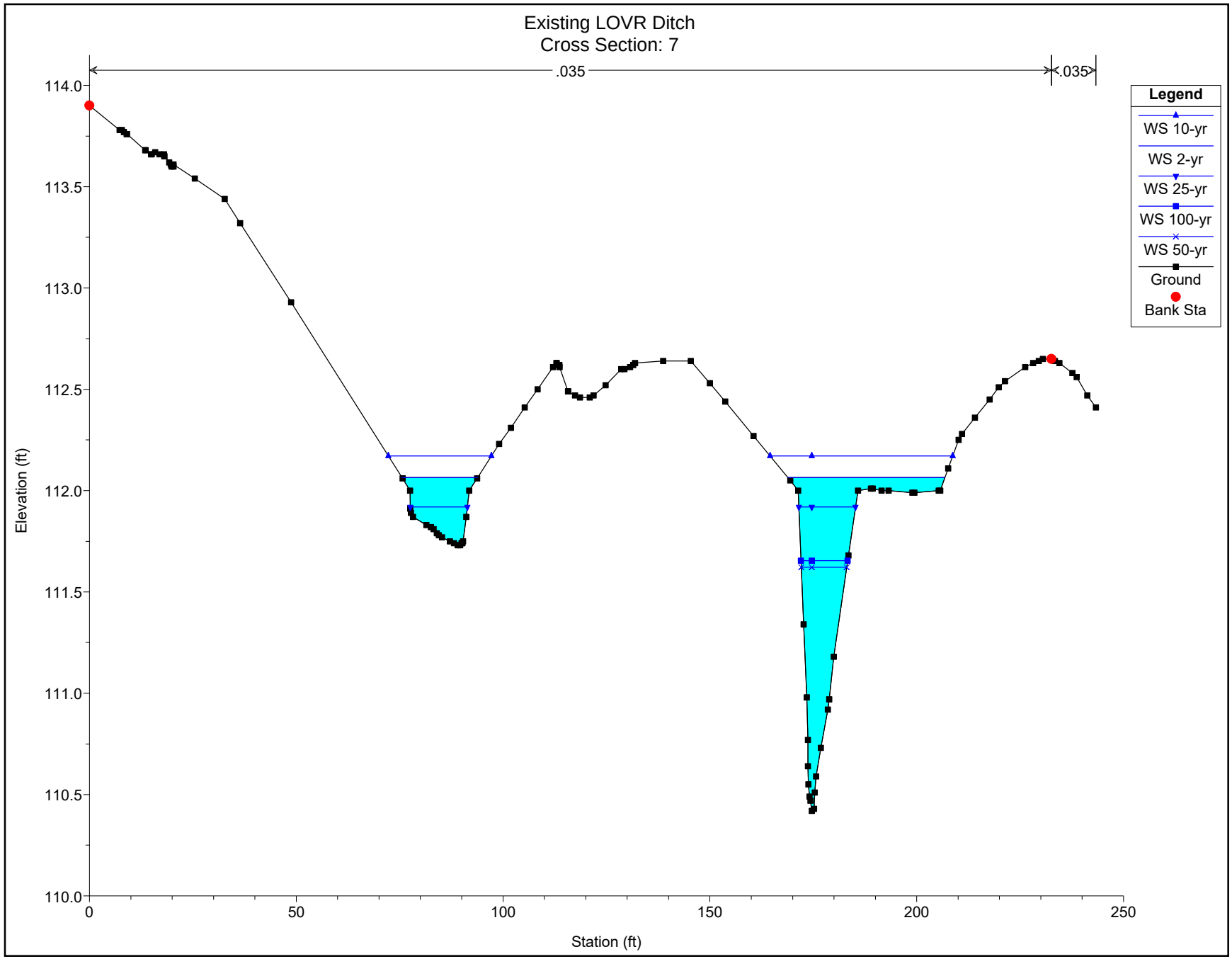

Existing Calle Joaquin Wetland
Cross Section: 2
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
109.5
109.0
108.5
108.0
107.5
107.0
106.5
106.0
0
50
100
150
200
250
300
350

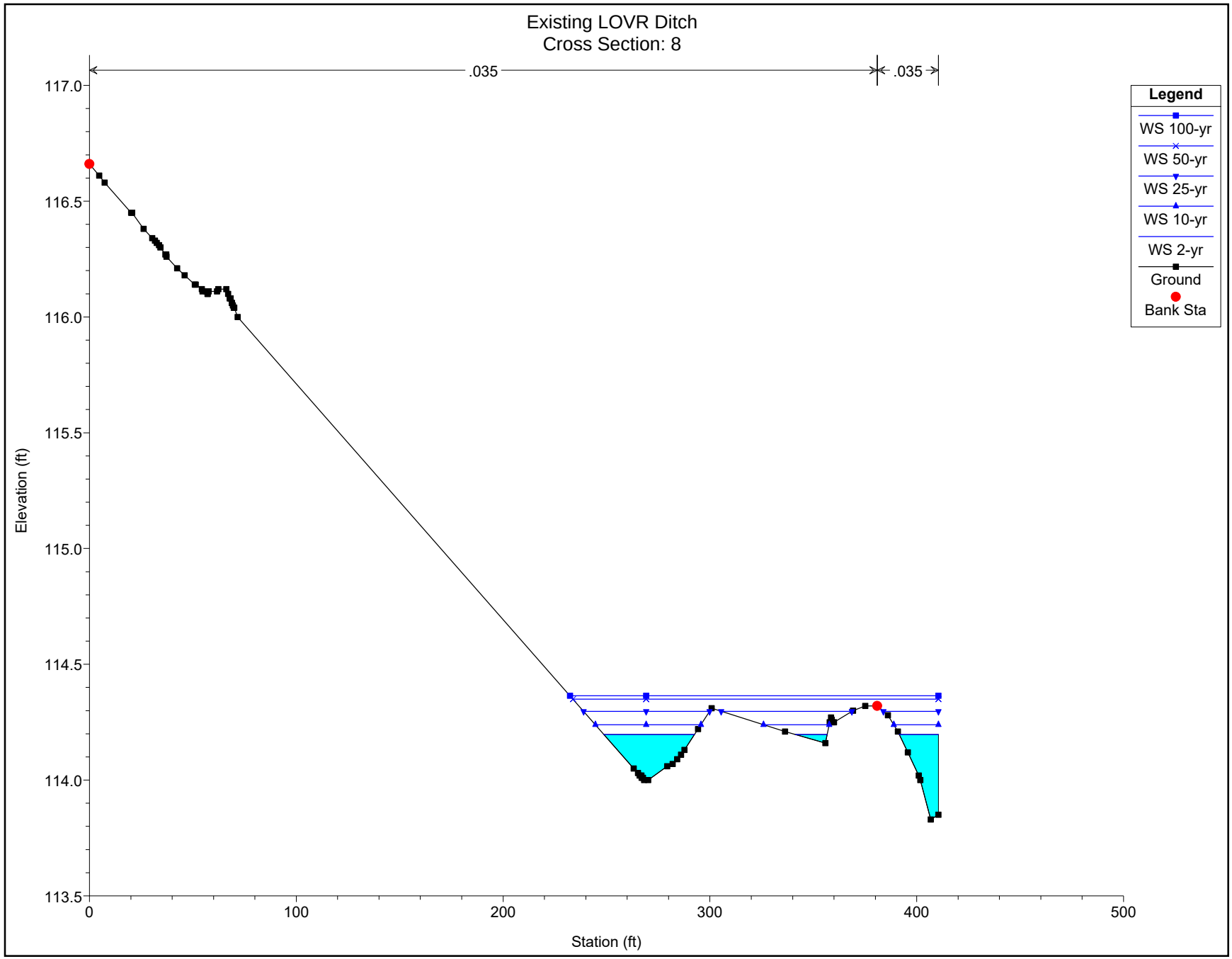

Existing Calle Joaquin Wetland
Cross Section: 3
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
109.5
109.0
108.5
108.0
107.5
107.0
106.5
106.0
0
100
200
300
400
500

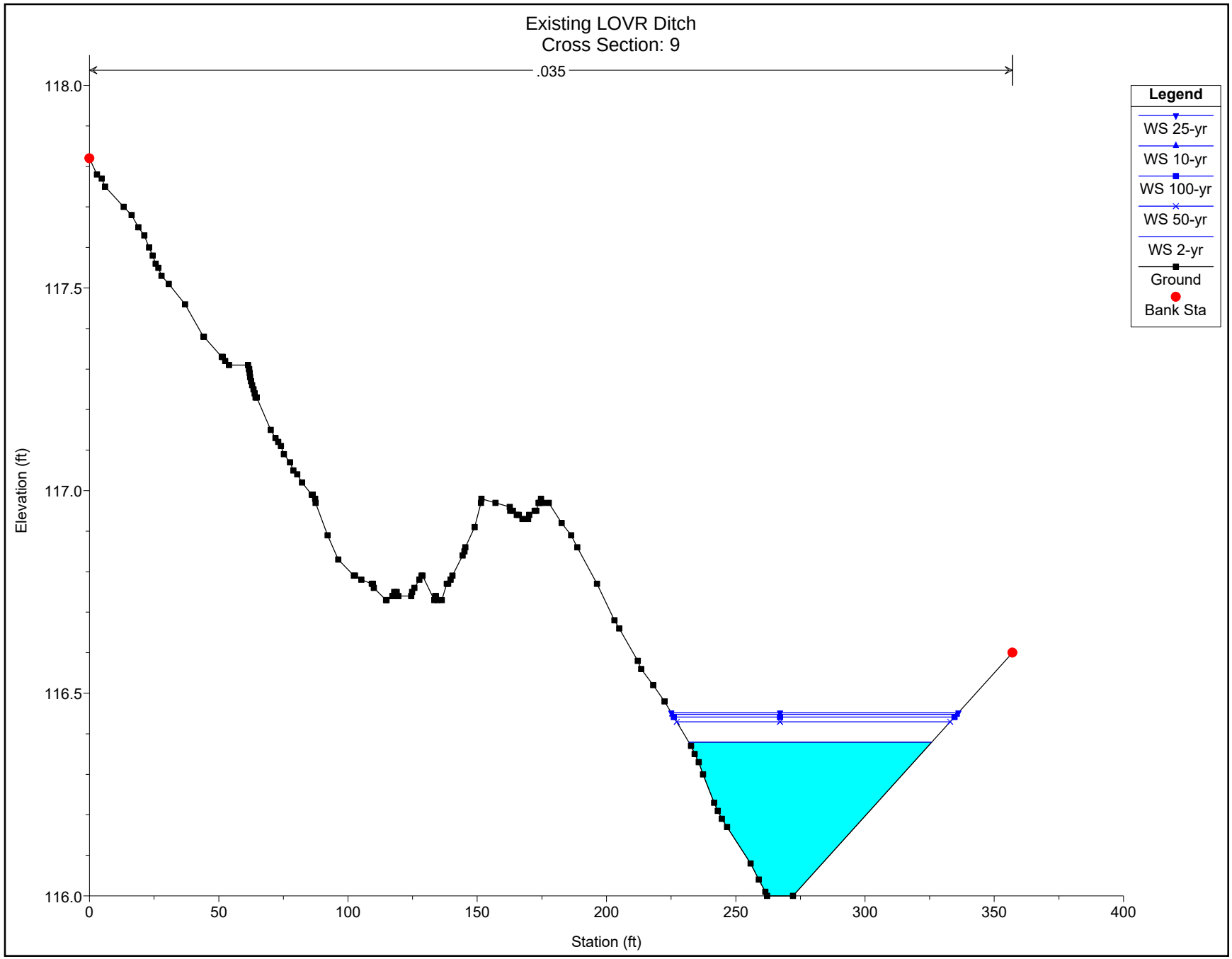

Existing Calle Joaquin Wetland
Cross Section: 4
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
109.5
109.0
108.5
108.0
107.5
107.0
106.5
106.0
0
50
100
150
200
250
300
350
400

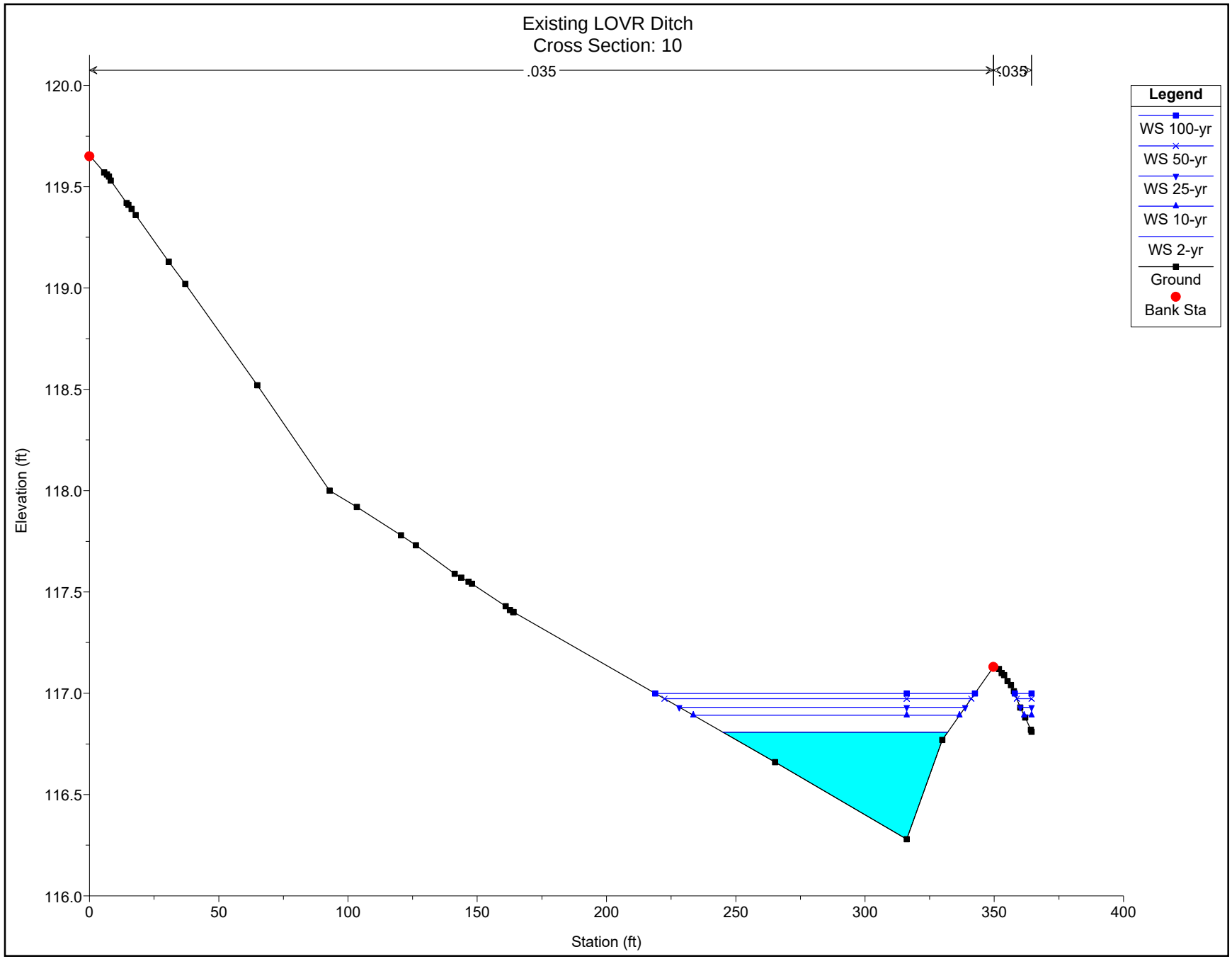

Existing Calle Joaquin Wetland
Cross Section: 5
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
110.0
109.5
109.0
108.5
108.0
107.5
107.0
106.5
106.0
0
100
200
300
400
500

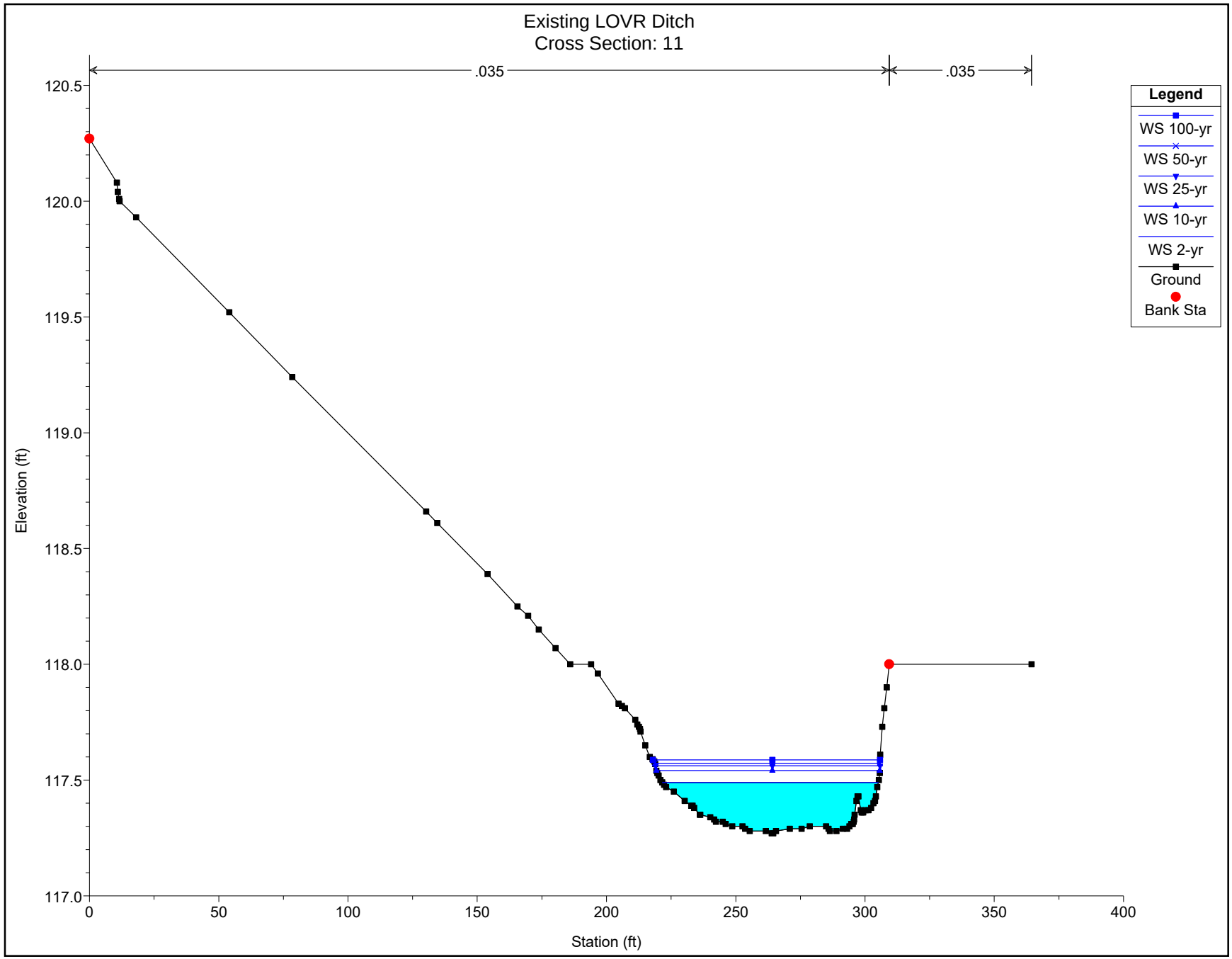

Existing Calle Joaquin Wetland
Cross Section: 6
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
111.0
110.5
110.0
109.5
109.0
108.5
108.0
0
50
100
150
200
250
300
350
Station (ft)

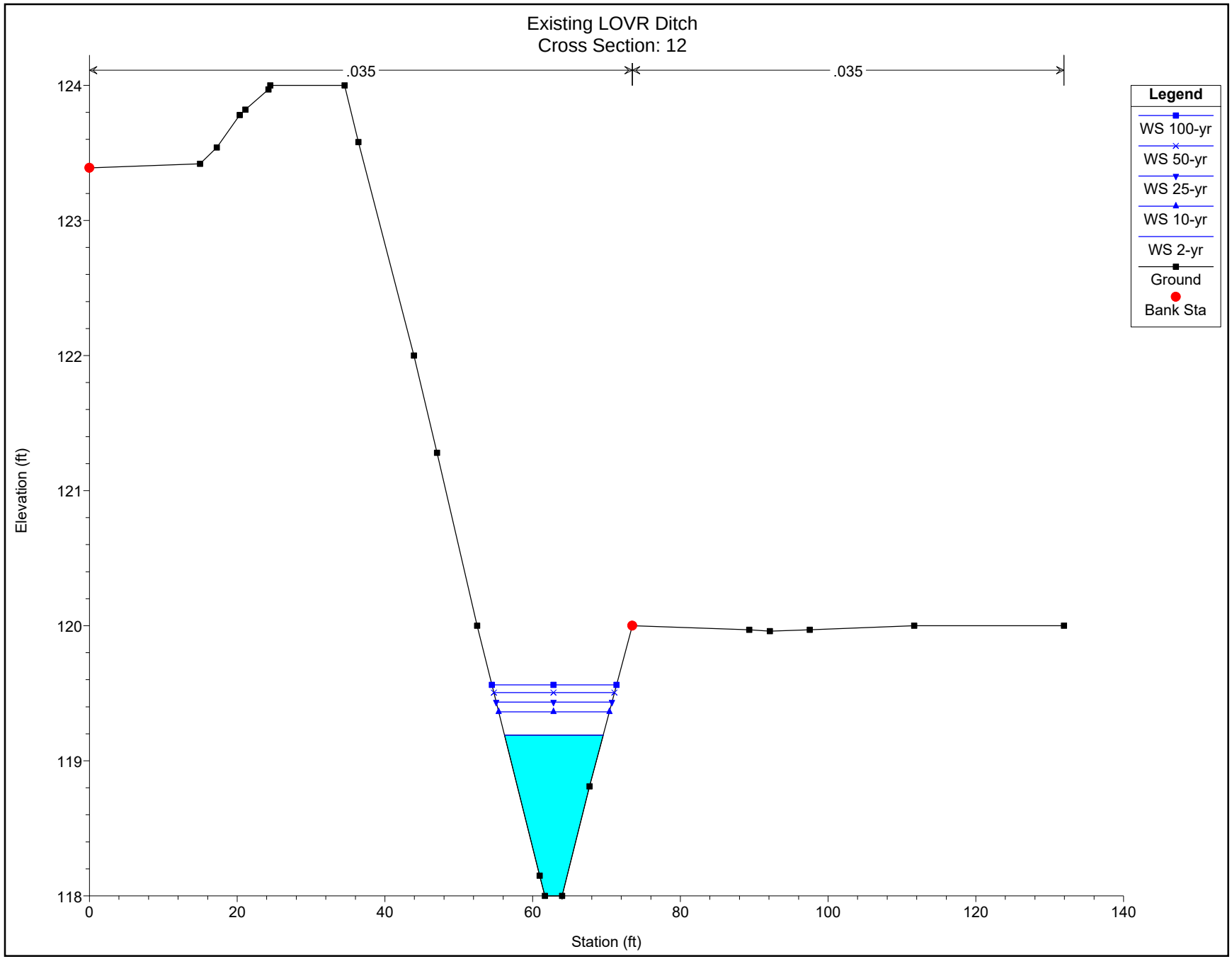

Existing LOVR Ditch
Cross Section: 7
.035
.035
Legend
WS 10-yr
WS 2-yr
WS 25-yr
WS 100-yr
WS 50-yr
Ground
Bank Sta
Elevation (ft)
114.0
113.5
113.0
112.5
112.0
111.5
111.0
110.5
110.0
0
50
100
150
200
250
Station (ft)

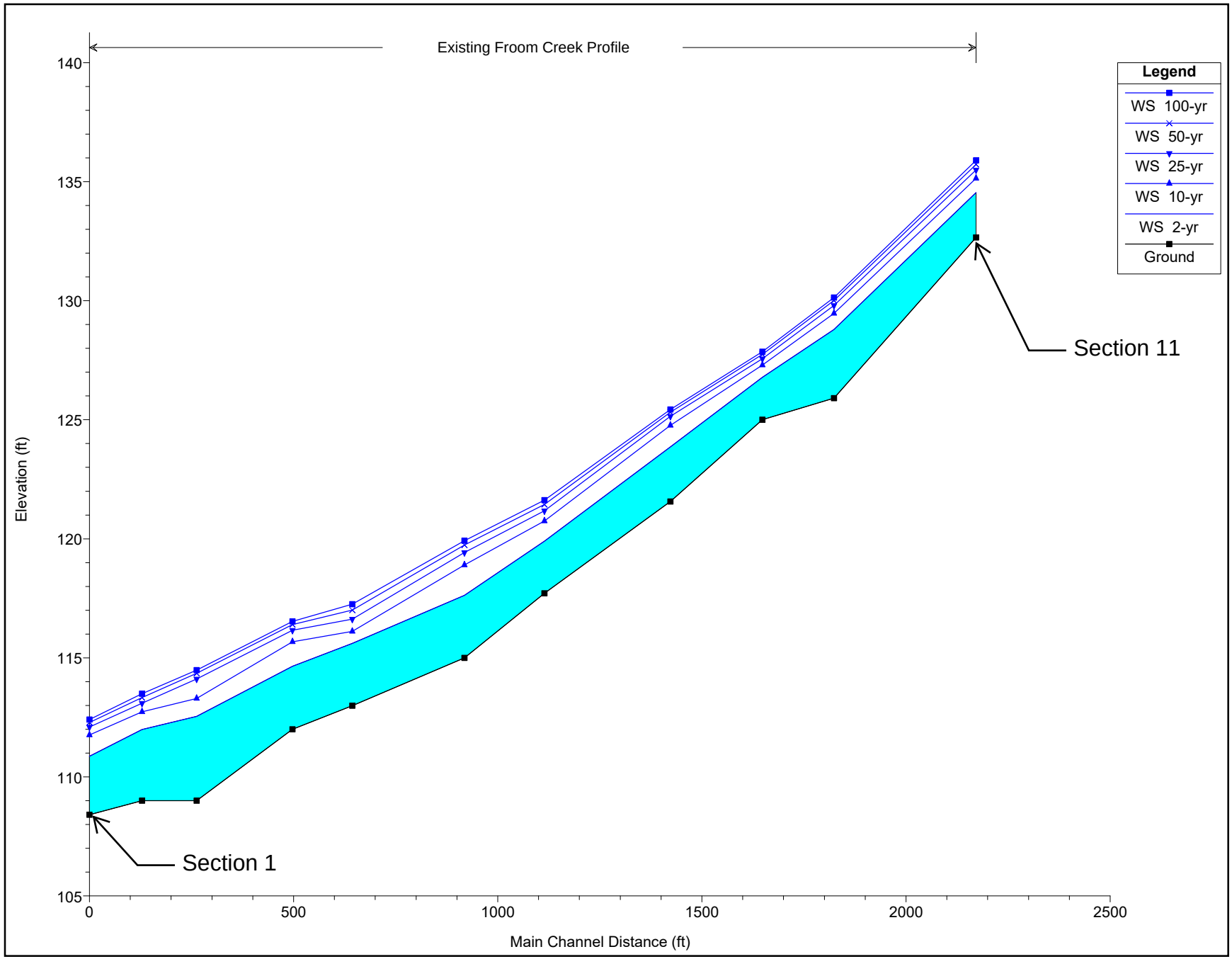

Existing LOVR Ditch
Cross Section: 8
.035
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
117.0
116.5
116.0
115.5
115.0
114.5
114.0
113.5
0
100
200
300
400
500
Station (ft)

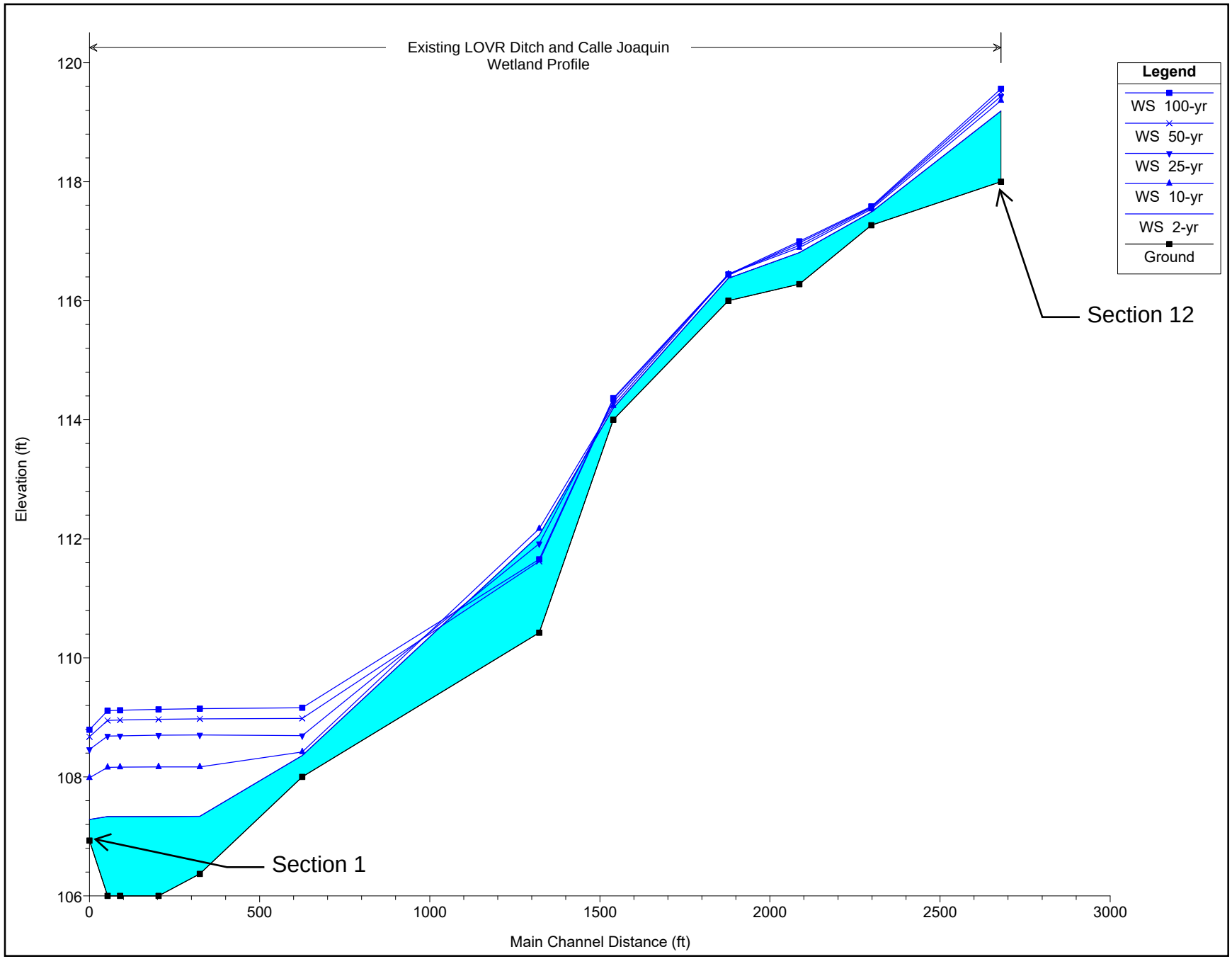

Existing LOVR Ditch
Cross Section: 9
.035
Legend
WS 25-yr
WS 10-yr
WS 100-yr
WS 50-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
118.0
117.5
117.0
116.5
116.0
0
50
100
150
200
250
300
350
400


Existing LOVR Ditch
Cross Section: 10
.035
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
120.0
119.5
119.0
118.5
118.0
117.5
117.0
116.5
116.0
0
50
100
150
200
250
300
350
400
Station (ft)


Existing LOVR Ditch
Cross Section: 11
.035
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
120.5
120.0
119.5
119.0
118.5
118.0
117.5
117.0
0
50
100
150
200
250
300
350
400
Station (ft)


Existing LOVR Ditch
Cross Section: 12
.035
.035
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
124
123
122
121
120
119
118
0
20
40
60
80
100
120
140


Existing Froom Creek Profile
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Section 11
Section 1
Elevation (ft)
Main Channel Distance (ft)
140
135
130
125
120
115
110
105
0
500
1000
1500
2000
2500


Existing LOVR Ditch and Calle Joaquin
Wetland Profile
Legend
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 2-yr
Ground
Section 12
Section 1
Elevation (ft)
Main Channel Distance (ft)
120
118
116
114
112
110
108
106
0
500
1000
1500
2000
2500
3000

Existing Froom Creek Tabular Results (1)

HEC-RAS Plan: .Plan 01

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Froom Creek Exis	2444.37	2-yr	201.93	132.66	134.73	134.73	135.26	0.018466	5.86	34.47	33.36	1.02
Froom Creek Exis	2444.37	10-yr	419.94	132.66	135.43	135.43	136.17	0.016526	6.89	60.95	42.41	1.01
Froom Creek Exis	2444.37	25-yr	577.16	132.66	135.83	135.83	136.66	0.015700	7.28	79.23	48.81	1.01
Froom Creek Exis	2444.37	50-yr	701.37	132.66	136.09	136.09	136.99	0.015386	7.61	92.17	52.38	1.01
Froom Creek Exis	2444.37	100-yr	792.91	132.66	136.26	136.26	137.21	0.015003	7.83	101.22	54.03	1.01
Froom Creek Exis	2096.2	2-yr	201.93	125.91	128.88		129.07	0.005310	3.49	57.88	47.27	0.56
Froom Creek Exis	2096.2	10-yr	419.94	125.91	129.61		129.88	0.006130	4.21	99.65	68.65	0.62
Froom Creek Exis	2096.2	25-yr	577.16	125.91	129.96		130.29	0.006367	4.57	126.16	79.17	0.64
Froom Creek Exis	2096.2	50-yr	701.37	125.91	130.18		130.55	0.006449	4.88	143.65	82.55	0.65
Froom Creek Exis	2096.2	100-yr	792.91	125.91	130.32		130.73	0.006497	5.09	155.64	84.39	0.66
Froom Creek Exis	1921.22	2-yr	201.93	125.00	127.00	127.00	127.44	0.019712	5.32	37.97	44.70	1.02
Froom Creek Exis	1921.22	10-yr	419.94	125.00	127.59	127.59	128.17	0.017302	6.08	69.05	60.29	1.00
Froom Creek Exis	1921.22	25-yr	577.16	125.00	127.90	127.90	128.56	0.016545	6.51	88.72	67.73	1.00
Froom Creek Exis	1921.22	50-yr	701.37	125.00	128.11	128.11	128.82	0.016093	6.78	103.41	72.63	1.00
Froom Creek Exis	1921.22	100-yr	792.91	125.00	128.25	128.25	129.00	0.015814	6.97	113.83	75.83	1.00
Froom Creek Exis	1695.61	2-yr	201.93	121.57	123.87		124.17	0.008370	4.38	46.08	38.13	0.70
Froom Creek Exis	1695.61	10-yr	419.94	121.57	124.76		125.00	0.008282	3.95	106.41	102.70	0.68
Froom Creek Exis	1695.61	25-yr	577.16	121.57	125.15		125.37	0.007778	3.76	153.34	151.71	0.66
Froom Creek Exis	1695.61	50-yr	701.37	121.57	125.32		125.56	0.007361	3.92	178.91	159.80	0.65
Froom Creek Exis	1695.61	100-yr	792.91	121.57	125.43		125.68	0.007067	4.02	197.05	164.16	0.65
Froom Creek Exis	1387.15	2-yr	201.93	117.71	119.89	119.89	120.51	0.017672	6.36	31.77	26.18	1.02
Froom Creek Exis	1387.15	10-yr	419.94	117.71	120.76	120.76	121.51	0.015888	6.95	60.41	40.29	1.00
Froom Creek Exis	1387.15	25-yr	577.16	117.71	121.16	121.16	122.01	0.015632	7.40	78.00	46.83	1.01
Froom Creek Exis	1387.15	50-yr	701.37	117.71	121.45	121.45	122.35	0.014926	7.62	92.03	51.06	1.00
Froom Creek Exis	1387.15	100-yr	792.91	117.71	121.63	121.63	122.58	0.014684	7.80	101.61	53.76	1.00
Froom Creek Exis	1191.25	2-yr	201.93	115.00	117.43		117.81	0.008375	4.98	40.53	27.23	0.72
Froom Creek Exis	1191.25	10-yr	419.94	115.00	118.51		118.99	0.007380	5.57	75.36	38.90	0.71
Froom Creek Exis	1191.25	25-yr	577.16	115.00	119.15	118.44	119.64	0.006428	5.58	103.36	48.06	0.67
Froom Creek Exis	1191.25	50-yr	701.37	115.00	119.45		119.99	0.006798	5.94	118.10	52.25	0.70
Froom Creek Exis	1191.25	100-yr	792.91	115.00	119.65		120.23	0.006975	6.16	128.82	55.09	0.71
Froom Creek Exis	916.4	2-yr	201.93	112.99	116.31		116.48	0.002911	3.25	62.22	34.41	0.43
Froom Creek Exis	916.4	10-yr	419.94	112.99	117.50		117.72	0.002857	3.73	112.61	50.60	0.44
Froom Creek Exis	916.4	25-yr	577.16	112.99	118.08		118.33	0.003344	3.99	144.70	66.79	0.48
Froom Creek Exis	916.4	50-yr	701.37	112.99	118.40		118.67	0.003209	4.23	166.00	67.83	0.48
Froom Creek Exis	916.4	100-yr	792.91	112.99	118.62		118.92	0.003121	4.38	181.17	68.57	0.47
Froom Creek Exis	770.3	2-yr	201.93	112.00	114.80	114.80	115.57	0.016881	7.03	28.72	18.73	1.00
Froom Creek Exis	770.3	10-yr	419.94	112.00	115.87	115.87	116.83	0.015062	7.85	53.50	27.43	0.99
Froom Creek Exis	770.3	25-yr	577.16	112.00	116.46	116.46	117.35	0.015793	7.56	76.31	43.17	1.00
Froom Creek Exis	770.3	50-yr	701.37	112.00	116.70	116.70	117.71	0.015594	8.07	86.94	43.99	1.01
Froom Creek Exis	770.3	100-yr	792.91	112.00	116.87	116.87	117.97	0.015547	8.41	94.26	44.55	1.02
Froom Creek Exis	535.09	2-yr	253.28	109.00	113.57		113.74	0.002594	3.32	76.26	38.65	0.42
Froom Creek Exis	535.09	10-yr	521.50	109.00	114.77		114.99	0.003058	3.78	138.13	65.61	0.46
Froom Creek Exis	535.09	25-yr	714.26	109.00	115.30		115.56	0.002965	4.08	174.98	71.91	0.46
Froom Creek Exis	535.09	50-yr	867.58	109.00	115.67		115.95	0.002943	4.30	201.92	76.19	0.47
Froom Creek Exis	535.09	100-yr	980.40	109.00	115.88		116.19	0.002940	4.49	218.32	76.70	0.47
Froom Creek Exis	401.44	2-yr	253.28	109.00	112.27	112.27	112.98	0.016648	6.74	37.57	26.48	1.00
Froom Creek Exis	401.44	10-yr	521.50	109.00	113.23	113.23	114.13	0.015455	7.64	68.24	37.91	1.00
Froom Creek Exis	401.44	25-yr	714.26	109.00	113.72	113.72	114.73	0.015083	8.03	88.91	45.17	1.01
Froom Creek Exis	401.44	50-yr	867.58	109.00	114.08	114.08	115.13	0.014572	8.23	105.46	50.23	1.00
Froom Creek Exis	401.44	100-yr	980.40	109.00	114.38	114.38	115.38	0.014803	8.01	122.47	61.54	1.00
Froom Creek Exis	272.83	2-yr	253.28	108.41	110.86	110.61	111.25	0.010001	4.96	51.10	40.17	0.77
Froom Creek Exis	272.83	10-yr	521.50	108.41	111.76	111.48	112.17	0.010004	5.10	102.17	77.07	0.78
Froom Creek Exis	272.83	25-yr	714.26	108.41	112.10	111.84	112.57	0.010003	5.50	129.96	87.76	0.80
Froom Creek Exis	272.83	50-yr	867.58	108.41	112.30	112.06	112.83	0.010016	5.87	147.74	90.39	0.81
Froom Creek Exis	272.83	100-yr	980.40	108.41	112.43	112.19	113.02	0.010012	6.12	160.25	92.16	0.82
Wetland	2794.8	2-yr	15.86	118.00	119.19	118.73	119.24	0.002682	1.70	9.30	13.37	0.36
Wetland	2794.8	10-yr	23.68	118.00	119.36	118.89	119.43	0.003198	2.01	11.75	15.00	0.40
Wetland	2794.8	25-yr	27.49	118.00	119.44	118.95	119.51	0.003387	2.14	12.86	15.68	0.42
Wetland	2794.8	50-yr	30.78	118.00	119.50	119.00	119.58	0.003403	2.20	13.97	16.34	0.42
Wetland	2794.8	100-yr	34.04	118.00	119.56	119.05	119.64	0.003496	2.28	14.92	16.88	0.43
Wetland	2413.92	2-yr	15.86	117.27	117.49		117.51	0.009060	1.19	13.34	83.53	0.52
Wetland	2413.92	10-yr	23.68	117.27	117.54	117.46	117.57	0.008093	1.33	17.79	86.41	0.52
Wetland	2413.92	25-yr	27.49	117.27	117.56		117.59	0.008013	1.41	19.55	86.80	0.52
Wetland	2413.92	50-yr	30.78	117.27	117.57		117.61	0.008595	1.50	20.51	87.06	0.55
Wetland	2413.92	100-yr	34.04	117.27	117.59	117.50	117.63	0.008729	1.56	21.76	87.82	0.55
Wetland	2201.97	2-yr	15.86	116.28	116.81		116.82	0.001641	0.70	22.63	86.98	0.24
Wetland	2201.97	10-yr	23.68	116.28	116.89		116.90	0.001678	0.77	30.69	105.93	0.25
Wetland	2201.97	25-yr	27.49	116.28	116.93		116.94	0.001608	0.79	35.08	115.03	0.25
Wetland	2201.97	50-yr	30.78	116.28	116.97		116.98	0.001433	0.77	40.08	124.35	0.24
Wetland	2201.97	100-yr	34.04	116.28	117.00		117.01	0.001428	0.79	43.42	130.20	0.24

Existing Froom Creek Tabular Results (2)

HEC-RAS Plan: .Plan 01 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Wetland	1993.69	2-yr	15.86	116.00	116.38		116.39	0.002734	0.79	20.02	93.90	0.30
Wetland	1993.69	10-yr	23.68	116.00	116.45		116.46	0.002760	0.87	27.06	110.13	0.31
Wetland	1993.69	25-yr	27.49	116.00	116.45		116.47	0.003577	1.00	27.47	110.99	0.35
Wetland	1993.69	50-yr	30.78	116.00	116.43		116.45	0.005702	1.23	25.07	105.79	0.44
Wetland	1993.69	100-yr	34.04	116.00	116.44		116.47	0.006128	1.29	26.33	108.56	0.46
Wetland	1654.9	2-yr	15.86	114.00	114.20	114.20	114.26	0.026913	1.38	8.94	78.13	0.82
Wetland	1654.9	10-yr	23.68	114.00	114.24	114.24	114.30	0.027447	1.51	12.79	104.47	0.84
Wetland	1654.9	25-yr	27.49	114.00	114.30	114.26	114.33	0.013814	1.17	20.14	150.88	0.61
Wetland	1654.9	50-yr	30.78	114.00	114.35		114.37	0.006634	0.96	28.94	176.75	0.44
Wetland	1654.9	100-yr	34.04	114.00	114.36		114.38	0.006188	0.98	31.57	178.20	0.43
Wetland	1437.42	2-yr	15.86	110.42	112.06	111.32	112.08	0.002035	0.89	17.91	56.30	0.28
Wetland	1437.42	10-yr	23.68	110.42	112.17	111.49	112.19	0.002075	0.96	24.56	69.07	0.29
Wetland	1437.42	25-yr	27.49	110.42	111.92	111.56	112.00	0.008579	2.25	12.21	27.57	0.60
Wetland	1437.42	50-yr	30.78	110.42	111.62	111.62	111.93	0.022051	4.48	6.87	10.99	1.00
Wetland	1437.42	100-yr	34.04	110.42	111.65	111.65	112.00	0.023557	4.71	7.23	11.28	1.04
Wetland	741.18	2-yr	15.86	108.00	108.36	108.36	108.45	0.032518	2.42	6.54	36.65	1.01
Wetland	741.18	10-yr	23.68	108.00	108.42	108.42	108.53	0.030880	2.63	8.99	42.83	1.01
Wetland	741.18	25-yr	27.49	108.00	108.69		108.71	0.002943	1.12	24.51	72.02	0.34
Wetland	741.18	50-yr	30.78	108.00	108.98		108.99	0.000595	0.59	52.19	121.27	0.16
Wetland	741.18	100-yr	34.04	108.00	109.16		109.17	0.000280	0.44	77.13	157.16	0.11
Wetland	440.14	2-yr	15.86	106.37	107.34		107.34	0.000049	0.19	83.46	164.15	0.05
Wetland	440.14	10-yr	23.68	106.37	108.17		108.17	0.000004	0.08	279.81	286.72	0.02
Wetland	440.14	25-yr	27.49	106.37	108.70		108.70	0.000001	0.06	446.07	333.12	0.01
Wetland	440.14	50-yr	154.99	106.37	108.98		108.98	0.000026	0.29	539.73	355.45	0.04
Wetland	440.14	100-yr	249.79	106.37	109.15		109.15	0.000050	0.42	601.47	372.06	0.06
Wetland	318.73	2-yr	15.86	106.00	107.33		107.33	0.000006	0.09	181.44	241.37	0.02
Wetland	318.73	10-yr	23.68	106.00	108.17		108.17	0.000001	0.06	415.05	311.26	0.01
Wetland	318.73	25-yr	184.65	106.00	108.70		108.70	0.000027	0.31	593.03	357.78	0.04
Wetland	318.73	50-yr	312.15	106.00	108.97		108.97	0.000050	0.45	691.57	372.30	0.06
Wetland	318.73	100-yr	406.95	106.00	109.14		109.14	0.000063	0.54	753.93	372.30	0.07
Wetland	205.35	2-yr	15.86	106.00	107.33		107.33	0.000005	0.08	189.34	242.51	0.02
Wetland	205.35	10-yr	157.79	106.00	108.16		108.16	0.000051	0.36	444.33	349.79	0.06
Wetland	205.35	25-yr	354.36	106.00	108.69		108.70	0.000086	0.55	639.13	383.37	0.08
Wetland	205.35	50-yr	510.97	106.00	108.95		108.96	0.000114	0.69	741.89	394.26	0.09
Wetland	205.35	100-yr	627.14	106.00	109.12		109.13	0.000132	0.78	807.50	402.20	0.10
Wetland	169	2-yr	15.86	106.00	107.33		107.33	0.000005	0.08	195.96	255.54	0.02
Wetland	169	10-yr	157.79	106.00	108.16		108.16	0.000047	0.37	423.63	293.43	0.05
Wetland	169	25-yr	354.36	106.00	108.69		108.69	0.000091	0.61	585.17	318.94	0.08
Wetland	169	50-yr	510.97	106.00	108.95		108.96	0.000122	0.76	668.85	318.94	0.09
Wetland	169	100-yr	627.14	106.00	109.11		109.12	0.000143	0.87	720.99	318.94	0.10
Wetland	115.55	2-yr	15.86	106.93	107.28	107.20	107.33	0.010019	1.68	9.41	37.68	0.59
Wetland	115.55	10-yr	157.79	106.93	107.98	107.81	108.14	0.009992	3.16	49.96	77.70	0.69
Wetland	115.55	25-yr	354.36	106.93	108.46	108.24	108.66	0.010001	3.56	99.60	129.73	0.72
Wetland	115.55	50-yr	510.97	106.93	108.68	108.49	108.91	0.010004	3.92	130.47	146.85	0.73
Wetland	115.55	100-yr	627.14	106.93	108.79	108.61	109.07	0.010002	4.25	147.63	146.85	0.75

Existing (After 2013) Froom Creek Analysis (100-yr Event)				
Existing Froom Creek			Existing Wetland	
Section	Q_{Total} (cfs)	$Q_{overflow}$ (cfs)	Section	Q_{total} (cfs)
1	980.4	0.0	1	627.1
2	980.4	266.4	2	627.1
3	980.4	593.1	3	627.1
4	792.9	372.9	4	407.0
5	792.9	252.9	5	287.0
6	792.9	0.0	6	34.0
7	792.9	0.0	7	34.0
8	792.9	0.0	8	34.0
9	792.9	0.0	9	34.0
10	792.9	0.0	10	34.0
11	792.9	0.0	11	34.0
			12	34.0

APPENDIX H.3

Preliminary Sediment Transportation Analysis and Calculations

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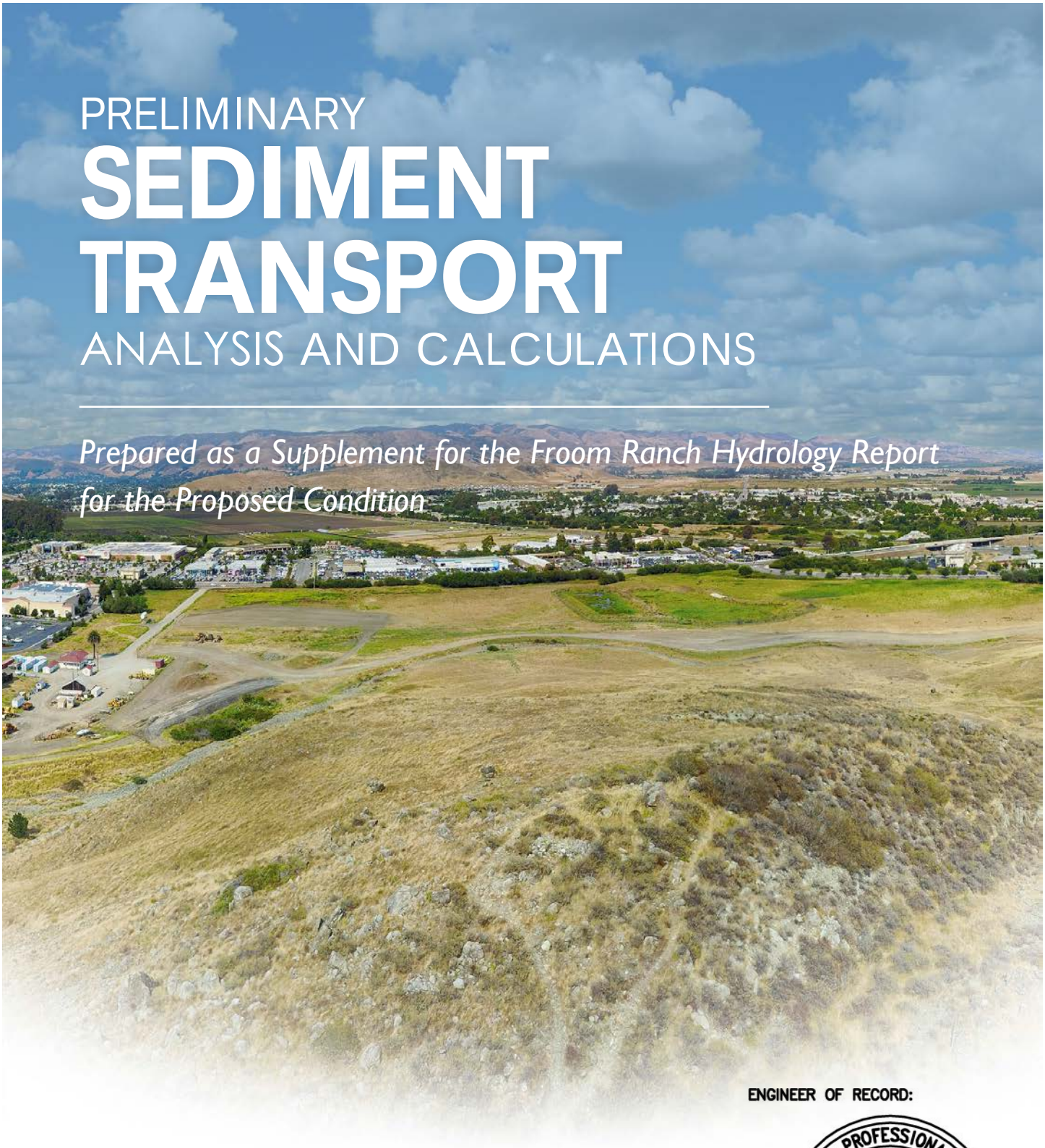
PRELIMINARY

SEDIMENT TRANSPORT

ANALYSIS AND CALCULATIONS

Prepared as a Supplement for the Froom Ranch Hydrology Report for the Proposed Condition



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Date: 07-16-2019
Prepared by RRM Design Group
Prepared for John and Susan Madonna Trust and Villaggio Communities

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1. Introduction

At the request of the City of San Luis Obispo, RRM Design Group has prepared a sediment transport model of the Proposed Condition of Froom Creek. The sediment transport model analyzes the proposed Froom Creek low-flow channel, which has the capacity to carry a 2-year storm event. A one-dimensional sediment transport model has been developed to address the following primary questions related to reaching the primary project goals:

1. What is the anticipated spatial and temporal distribution of deposited sediment?

2. Will the proposed low-flow channel erode and ultimately flow to the adjacent Calle Joaquin Wetland?

Since this is a new creek corridor, there is a lack of measured sediment discharge and geometric data over time. Because of this, the model cannot be calibrated to match any sort of observed historic conditions. This analysis is based on historical rainfall data, dating back to October 2016. The model represents anticipated erosivity and flow line movement in the Froom Creek low-flow channel and creek bottom during the scenarios modeled, based on the proposed design. This model can be calibrated in the future based on more detailed design elements in the final construction document phase.

2. Method & Assumptions

2.1: Modeling Software

The US Army Corps of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) Version 5.0.3 was chosen for this analysis. The study uses both the hydraulic and sediment transport modules within the HEC-RAS software.

The basic requirements for hydraulic calculations in HEC-RAS are channel cross sectional geometry, Manning's n-values for the cross sections, riverbank locations, distances between the cross sections, flow information, and flow boundary information. The HEC-RAS sediment transport module calculates transport capacity for non-cohesive and cohesive soil using hydraulic variables (velocity, flow depth, and shear stress) and sediment properties.

The results from this analysis are a representation of sediment transport that is anticipated for the proposed project. This analysis should serve to identify areas of concern and the overall impact of sediment transport.

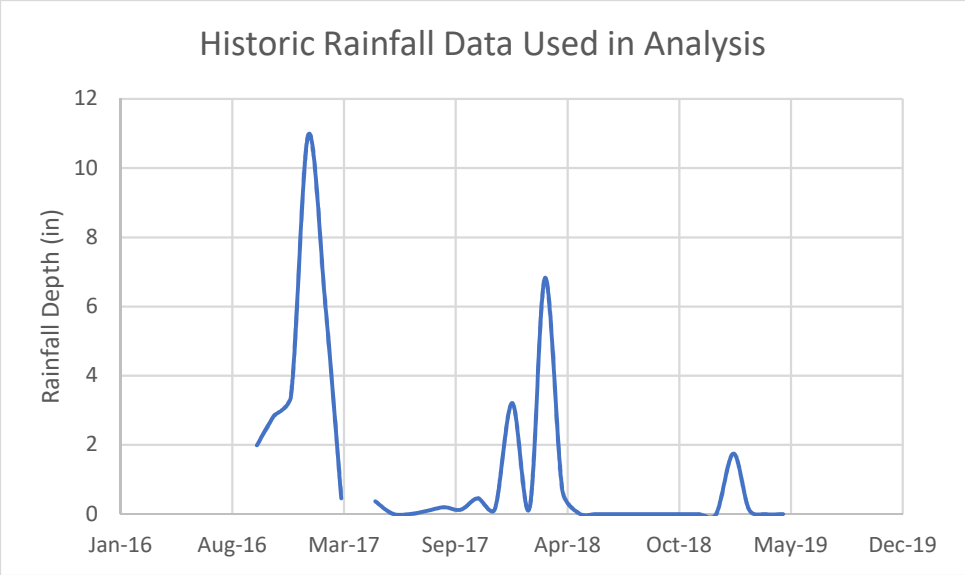
2.2: Geometry

The geometric data inputs for this model are derived from the proposed condition of Froom Creek, associated with the project. This proposed condition includes a low-flow channel, which has the capacity to carry a 2-year storm event. The proposed condition matches into the Existing Froom Creek geometric alignment after section 1429.43 (see p. 24 for section).

2.3: Hydrology

The flow considered in this analysis is historical data from October 1, 2016 to May 31, 2019. The proposed Froom Creek channel receives water from Watershed indexes #3, #6, and #7 (see Appendix 2

from report prepared by RRM Design Group, titled “Preliminary Hydrologic and Hydraulic Calculations,” dated February 22, 2019). The total contributing area is 944.7 acres. See the graph below, which shows the historical rainfall data.



2.4: Sediment

The sediment file provides the model with sediment data required for execution of the sediment transport simulations. It contains the properties of both the bed material and incoming sediment loads, which are considered consistent throughout the creek. Sediment grain sizes, grain size distributions, sediment mass density, porosity of deposited sediment, bed material properties, and sediment loads flowing in the creek are contained in the input files. Sediment gradation table is shown below.

Diameter (mm)	% Finer
0.004	10
0.008	13
0.016	16
0.032	18
0.0625	22
0.125	29
0.25	36
0.5	43
1	50
2	50
4	50
8	50
16	50
32	50
64	60
128	80
256	100

Several equations are available in HEC-RAS to calculate sediment transport, bed sorting, and fall velocity. The equation used in the model is selected on the sediment input screen. Bed sorting calculations are required to simulate how the bed material composition may change over time. For example, if the bed material becomes coarser due to the preferential removal of fine material it may become armored. Once the armoring effect takes place, it protects the sub-surface sediments and limits the amount of sediment that can be removed from the riverbed for transportation. The fall velocity is required to determine its mobility, which is how easy it is to settle the material and to re-entrain it once settled on the riverbed.

For this analysis the Ackers-White sediment transport function, the Active Layer sorting equation, and the Ruby fall velocity equation were selected.

The Ackers-White sediment transport theory predicts the movement of non-cohesive sediments. The theory contains four empirical parameters which were determined by fitting them to observed transport data. These equations are widely used to calculate sediment transport, morphological change in channels, the size of stable alluvial channels and to design physical models.

The Active Layer sorting equation is an active layer method, that considers two layers. The model has an active layer thickness set to d_{90} by default. The Ruby fall velocity method is suitable for silt, sand, and gravel sizes with specific gravities of around 2.65.

One of the limitations of the HEC-RAS sediment transport modeling is that only one sediment gradation can be defined per cross-section. This is an important observation because the sediment properties on the surface and sub-surface often differ especially if the channel has armored.

2.5: Quasi-Unsteady Flow

The quasi-unsteady flow file is used to define a flow hydrograph for the HEC-RAS model. The flows are entered as a flow series for a specified duration. The computational increment is specified as a part of the flow series. This increment determines how often calculations are performed.

The temperature of the creek water must be specified for calculating sediment particle fall velocities. A constant water temperature of 55 degrees Fahrenheit was used for all simulations.

3. Sediment

3.1: Sediment Inputs

Since this is a new creek corridor, there is a lack of measured sediment discharge and geometric data over time. Because of this, the model cannot be calibrated to match any sort of observed historic conditions. This analysis is based on historic rainfall data, dating back to October 2016. The model represents anticipated erosivity and flow line movement in the Froom Creek low-flow channel and creek bottom during the scenarios modeled, based on the proposed design. This model can be calibrated in the future based on more detailed design elements in the final construction document phase, as well as after construction.

3.2: Computational Increment

For this analysis, computational increments were performed every hour. It was determined that a 60-minute computational increment would provide the best balance between model stability and run time.

3.3: Sediment Gradation

Sediment data was entered into the program based on the anticipated sediment gradation in the proposed condition. The proposed project seeks to add river rock to the bed of the channel to limit the effects of erosion, scour, and sediment transport. For more details of the proposed creek bed, see Chapter 2 of the report titled, "Preliminary Hydrologic and Hydraulic Calculations," prepared by RRM Design Group.

3.4: Allowable Depth of Scour and Erodible Bed Limits

HEC-RAS allows a set of maximin scour depths and erodible bed limits (horizontal extents of allowable scour) that are applied during simulation. The scour depth limits that were tested ranges from 0 to 5 feet. The bank stations were used as boundaries for the erodible bed limits. All the results indicate significantly less than 5 feet of scour in the final condition, so this limit is within the bounds of what needs to be analyzed. See pages 6-31 for detailed scour depth outputs.

4. Analysis Results

The analysis results are included in Appendix I. The Froom Creek profile output (p. 7) shows the anticipated creek profile elevation after applying the historical rain data and running the model. The Froom Creek Cross-Section outputs (pages 8-31) show the extents of erosion that takes place in each cross-section. Based on these results, it can be observed that the banks of Froom Creek do not erode.

The analysis results for section 1757.69 show some scour of the wetland. This model uses a manning's roughness coefficient of 0.035 to represent the proposed swale condition, which doesn't account for the vegetation in the wetland. When the of vegetation in the wetland is considered, it is anticipated that no erosion of the wetland will take place.

The analysis also shows a significant amount of erosion at cross-section 3210.45. This section shows significantly more scour due to the change in slope that occurs at this point in the proposed low-flow channel. This condition has been anticipated by RRM and will be mitigated with an appropriate armoring method along the channel of the creek.

5. Conclusion

As discussed in the introduction, there are two main questions to be address by the sediment transport model results.

1. What is the anticipated spatial and temporal distribution of deposited sediment?

The profile output (Appendix I, p. 7) graphically shows what the anticipated creek profile will look like after several years of rain events. As discussed earlier in the report, the armoring effect will take place, which will limit the amount of erosion that takes place in the future. Although erosion of the creek bed is anticipated, it will be minimal after the first few heavy rains, as evidenced by the Invert Change Vs.

Time graphs provided in Appendix I. All the Invert Change Vs. Time graphs show a steep decline in sediment transport after the initial rain events. This is a result of the armoring effect, which limits sediment transport after the fine grain soils on the surface are transported by flow.

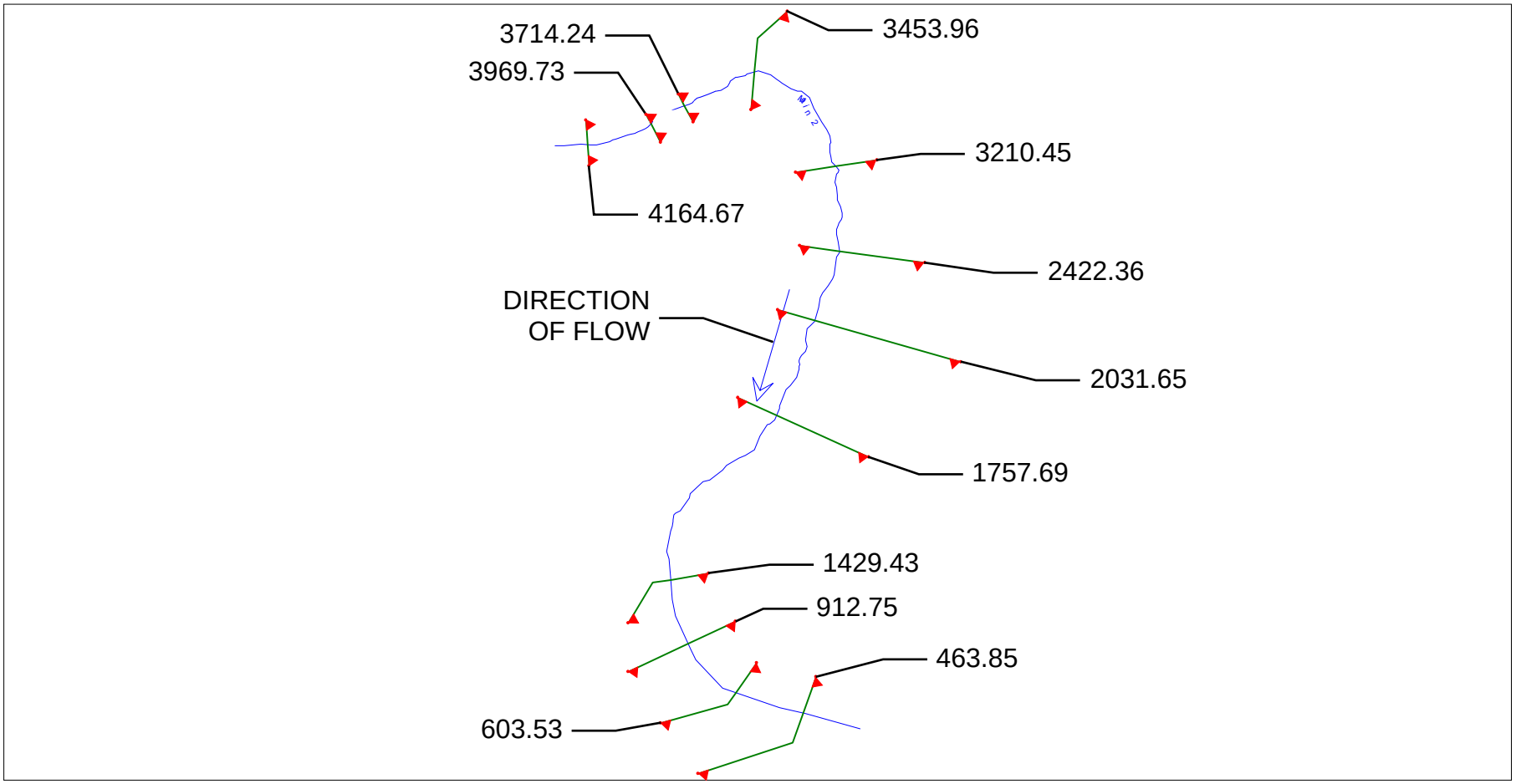
2. Will the proposed low-flow channel erode and ultimately flow to the adjacent Calle Joaquin Wetland?

All the Froom Creek Cross-Section results show that although the flowline of the creek may erode slightly, none of the results indicate that the creek banks will erode, or that the flow line will move horizontally. The minimal erosion that is predicted will take place along the bed of Froom Creek, not along the banks.

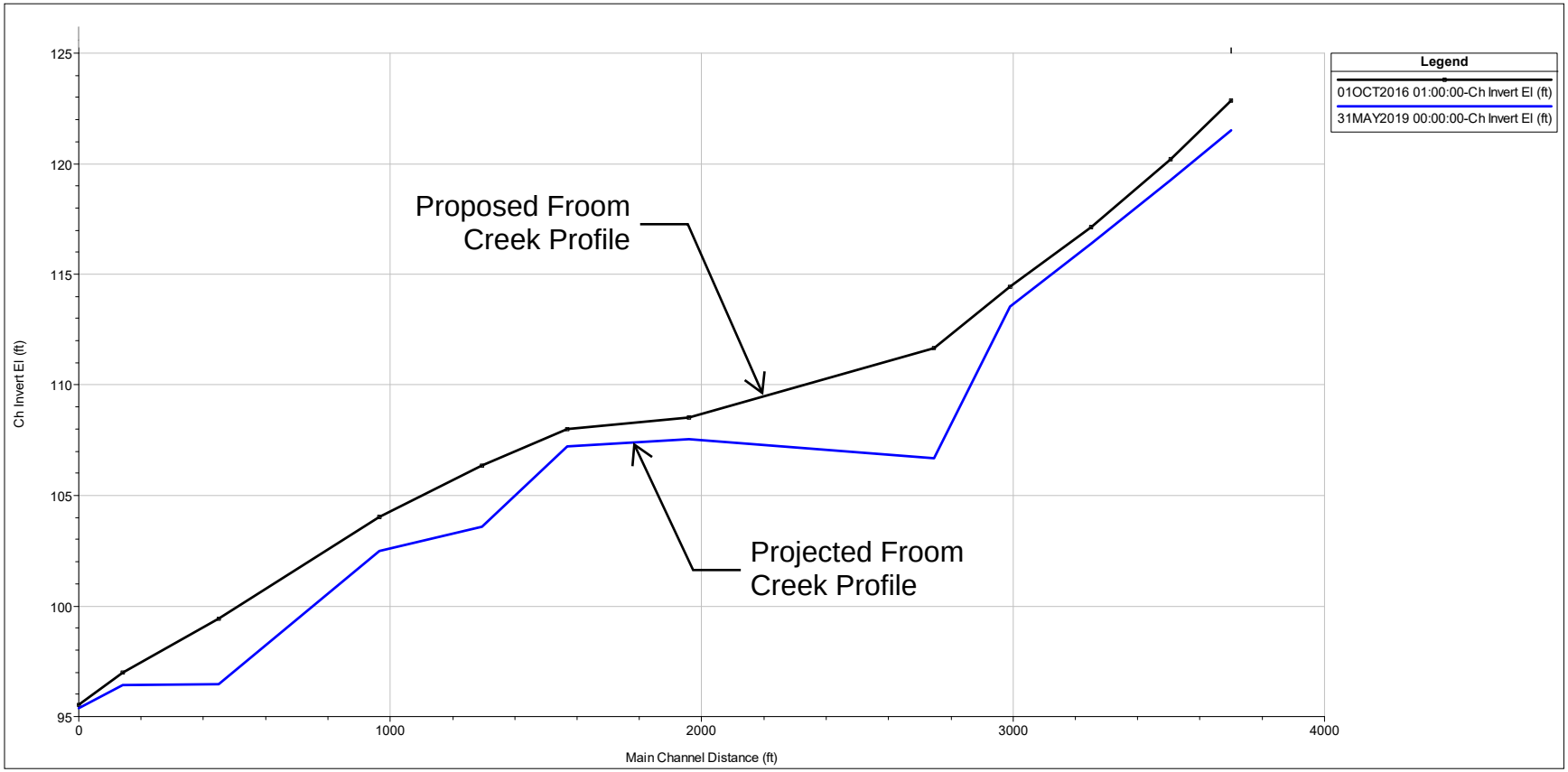
Based on the results obtained in this analysis, RRM anticipates minimal sediment transport and erosion to occur after armoring occurs. Although some erosion of the Froom Creek bed is anticipated, RRM sees no indication that the channel banks will erode.

Appendix I

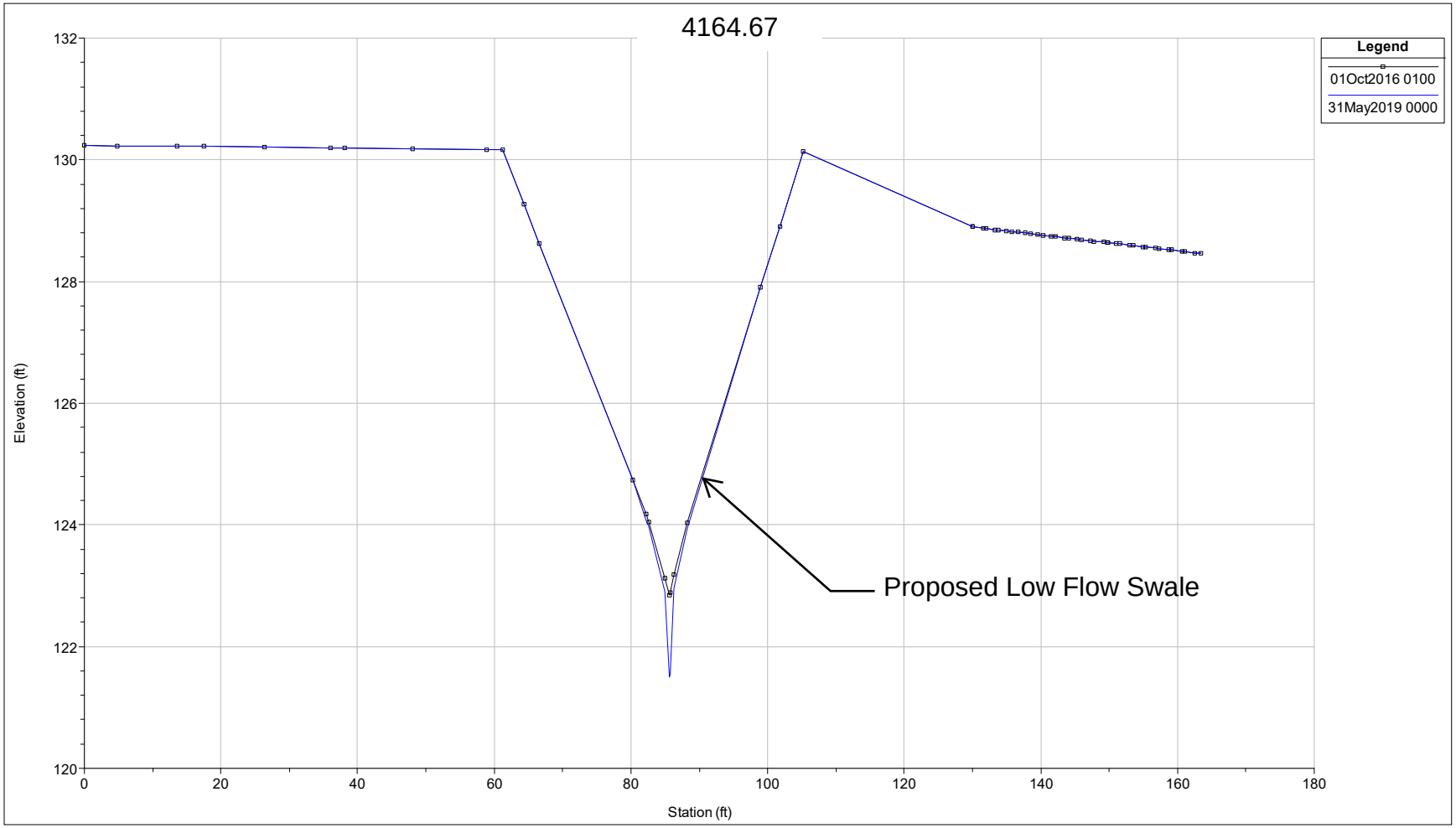
Proposed Froom Creek Alignment

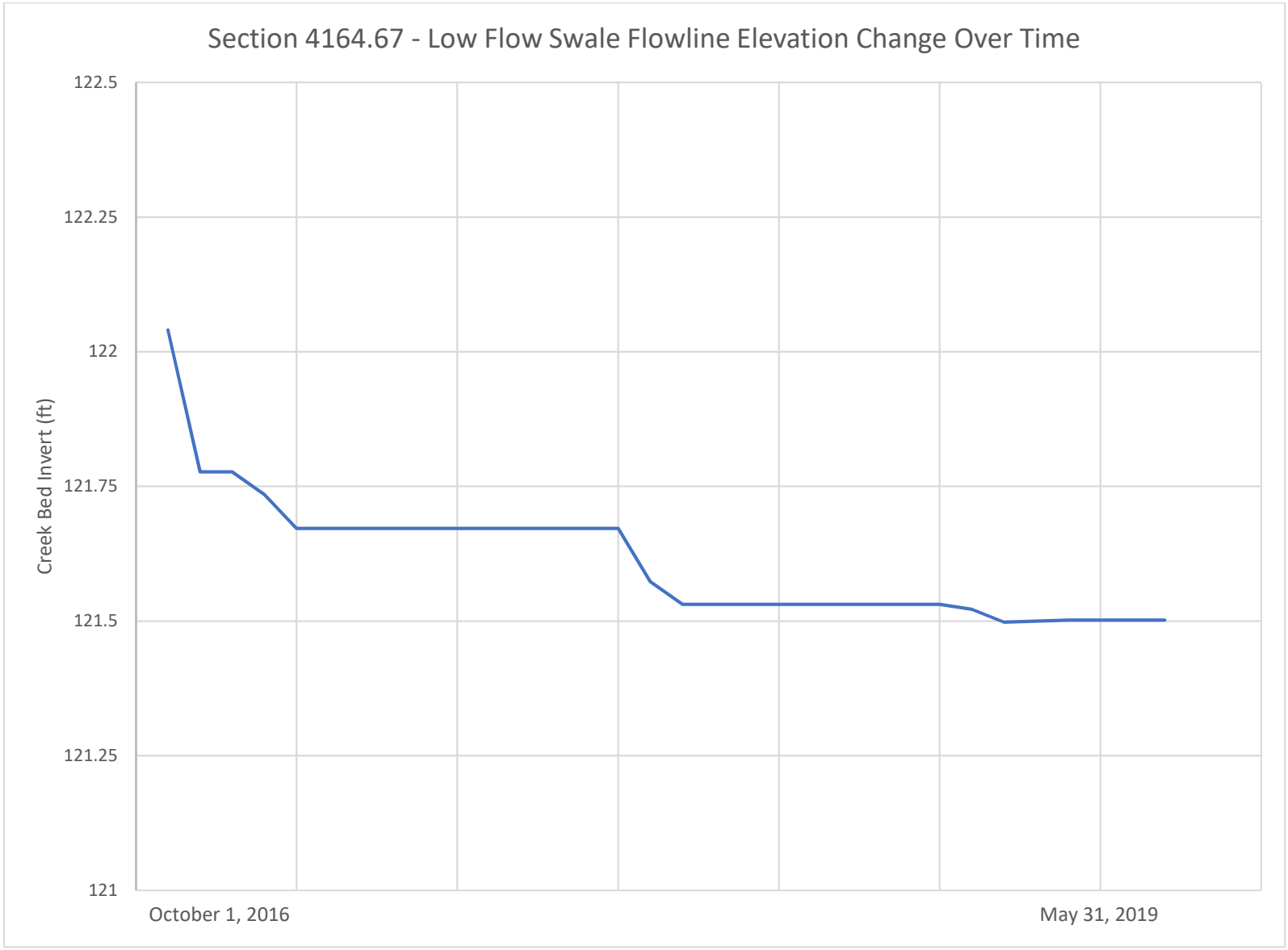


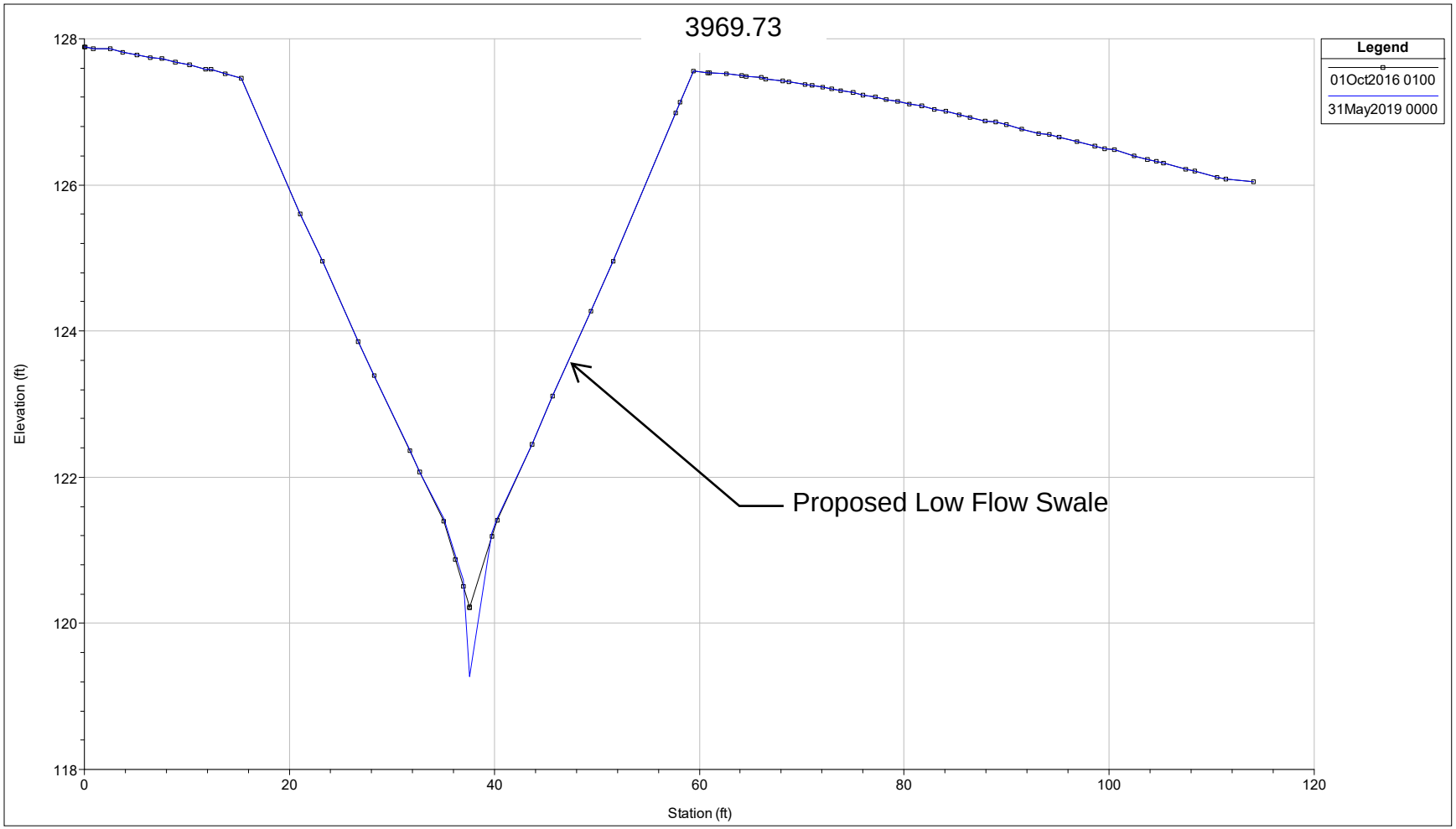
Proposed Froom Creek Profile Output

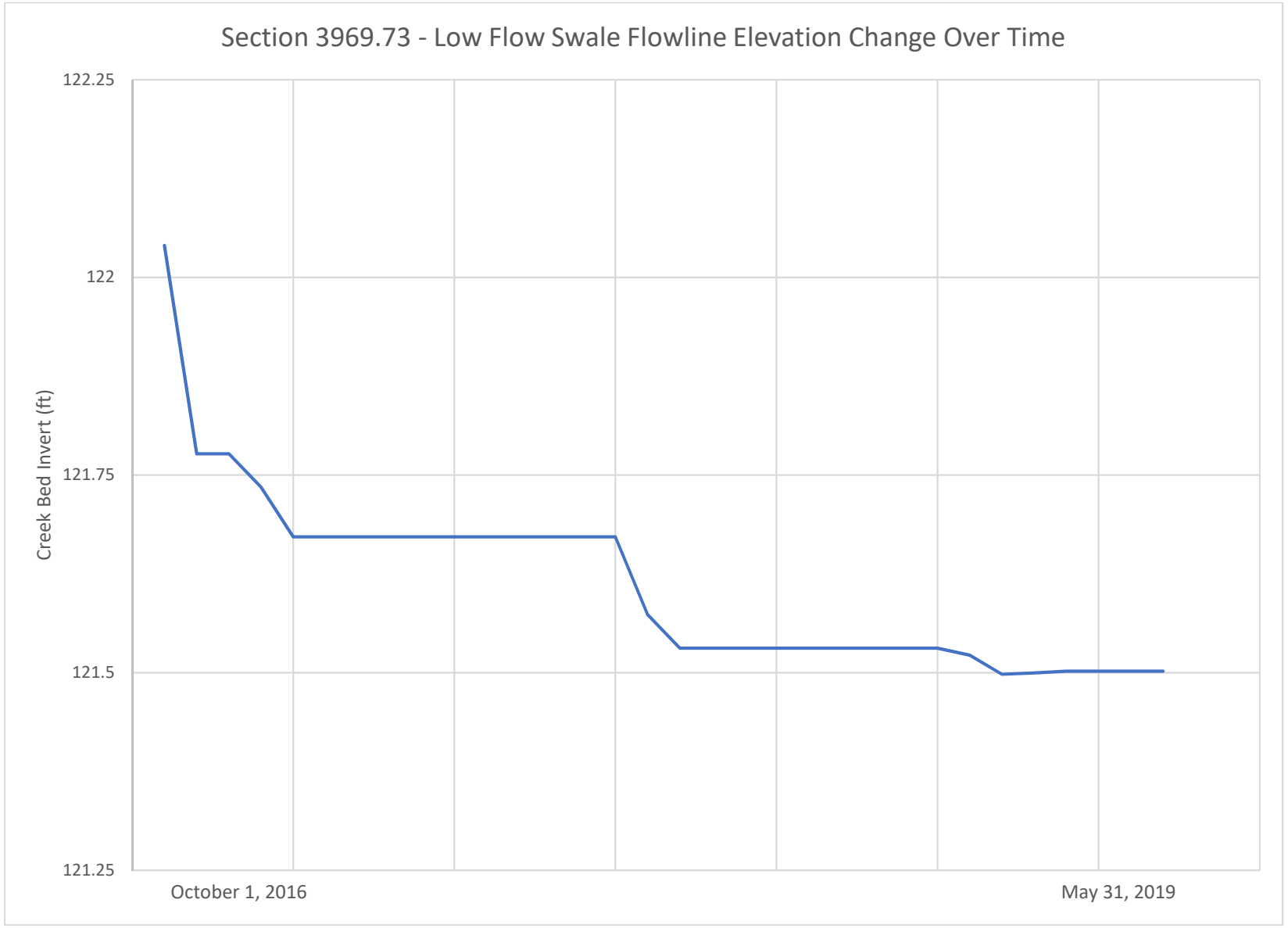


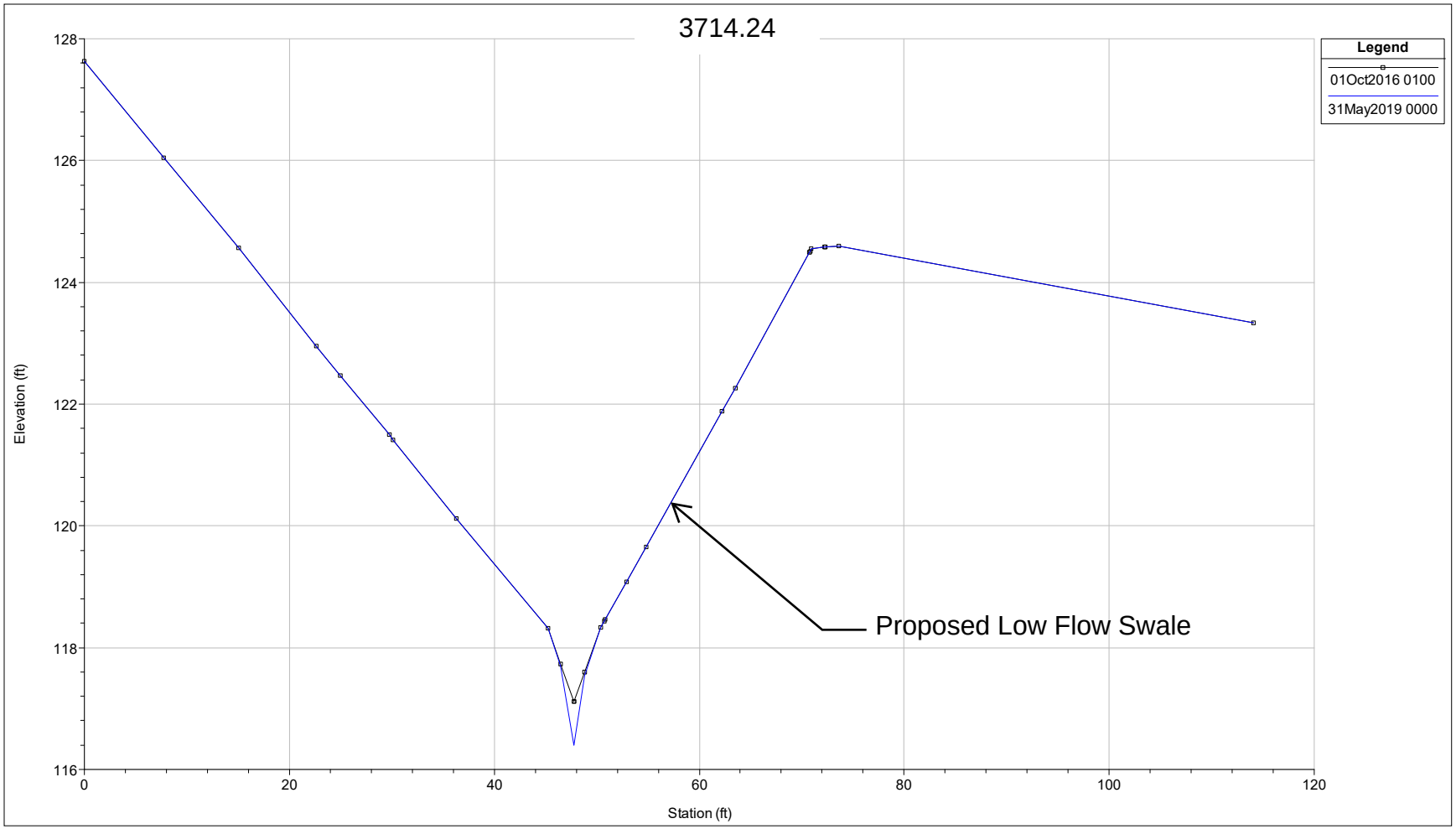
Froom Creek Cross-Section Outputs

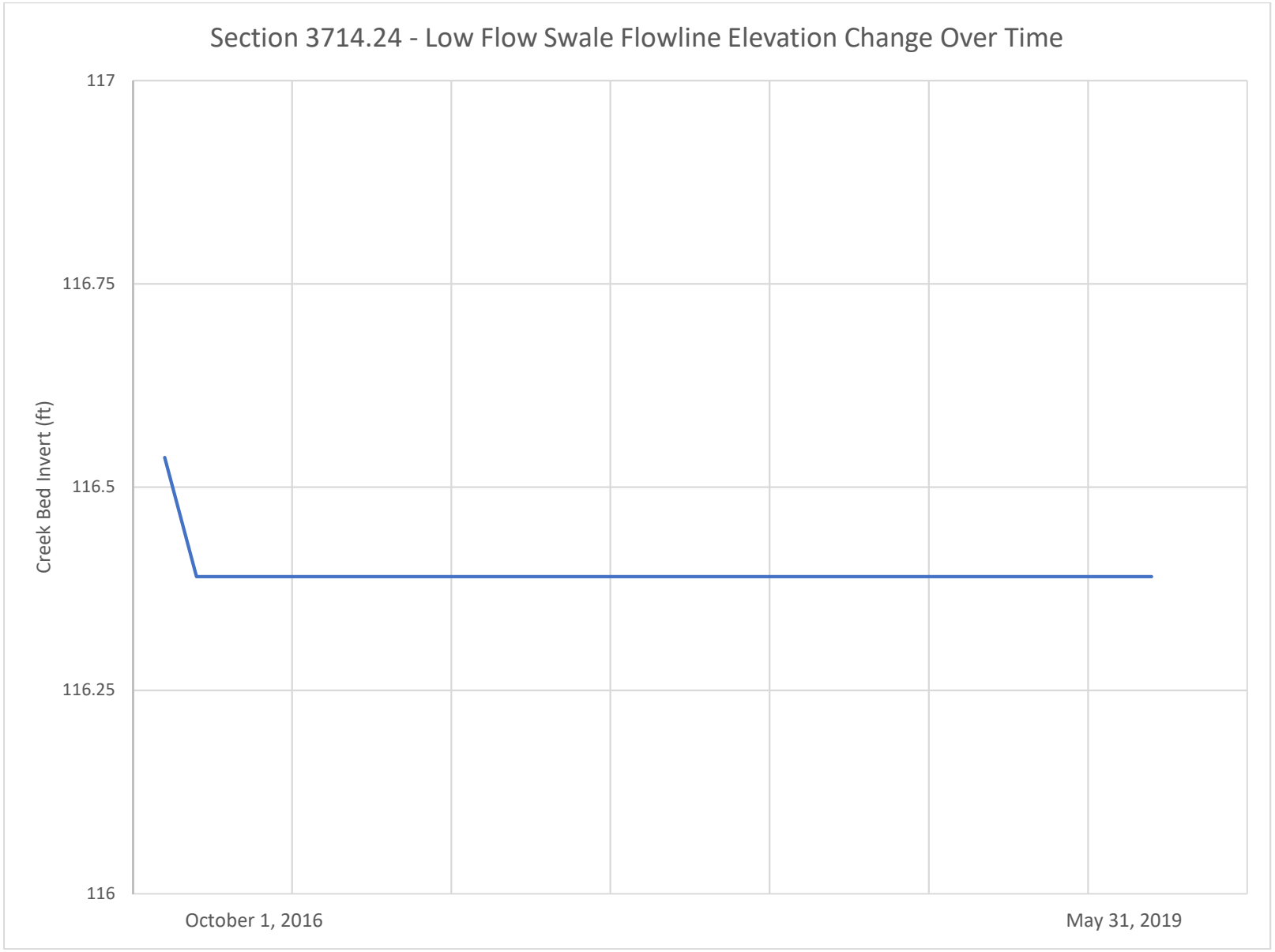


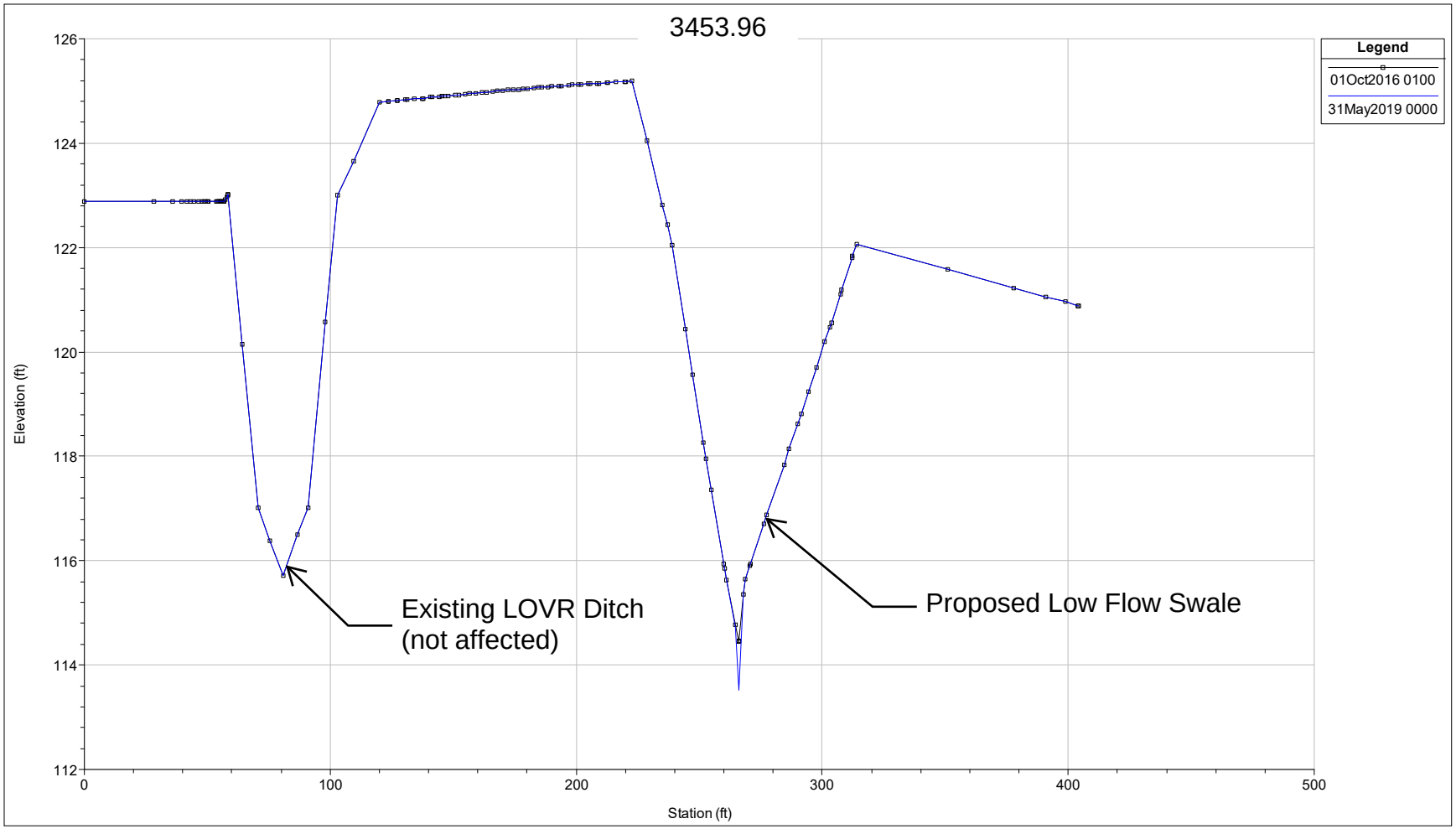

Section 4164.67 - Low Flow Swale Flowline Elevation Change Over Time
Creek Bed Invert (ft)
122.5
122.25
122
121.75
121.5
121.25
121
October 1, 2016
May 31, 2019

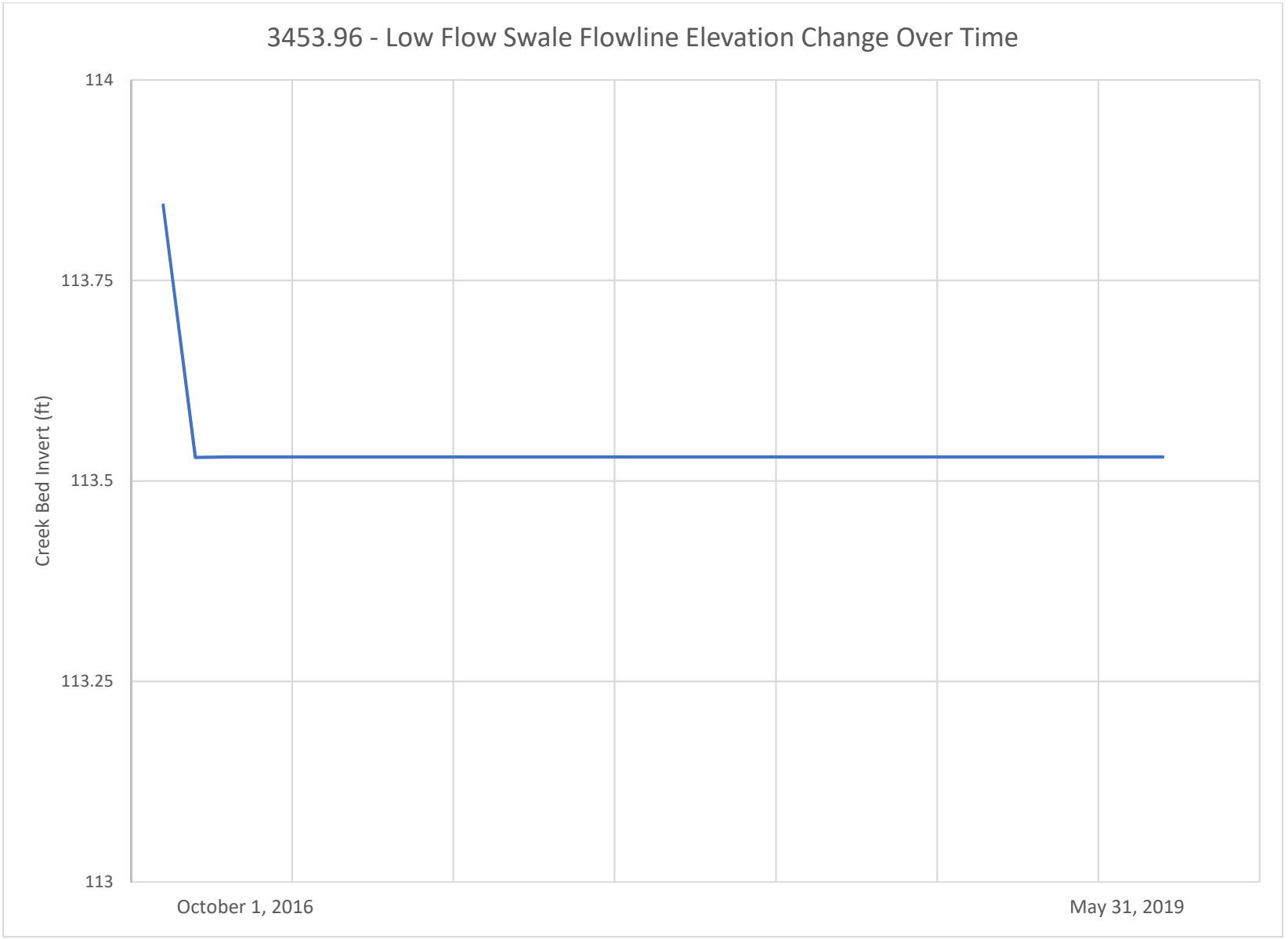

3969.73
Legend
01Oct2016 0100
31May2019 0000
Proposed Low Flow Swale
Elevation (ft)
Station (ft)
128
126
124
122
120
118
0
20
40
60
80
100
120

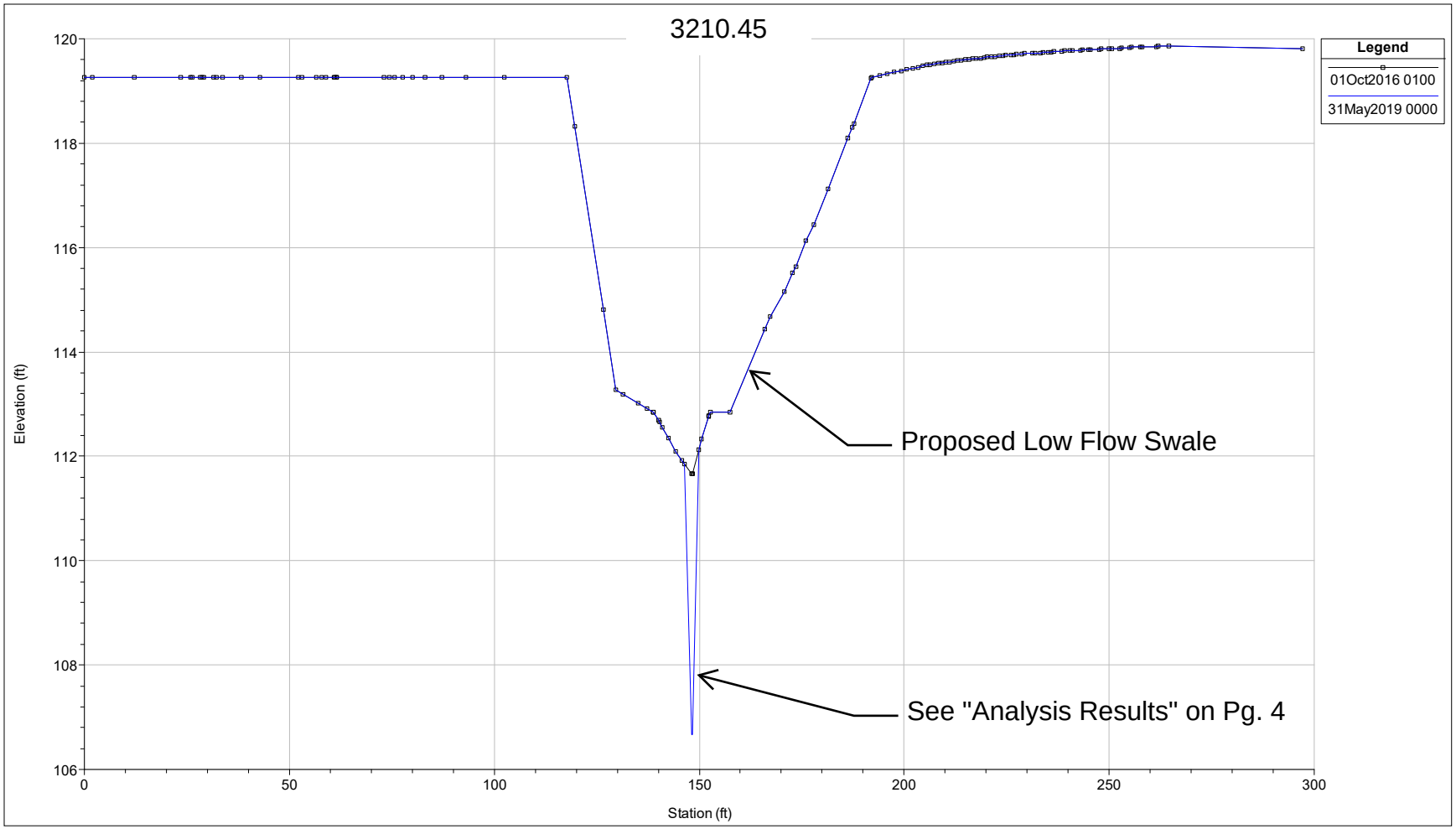

Section 3969.73 - Low Flow Swale Flowline Elevation Change Over Time
122.25
122
121.75
121.5
121.25
Creek Bed Invert (ft)
October 1, 2016
May 31, 2019

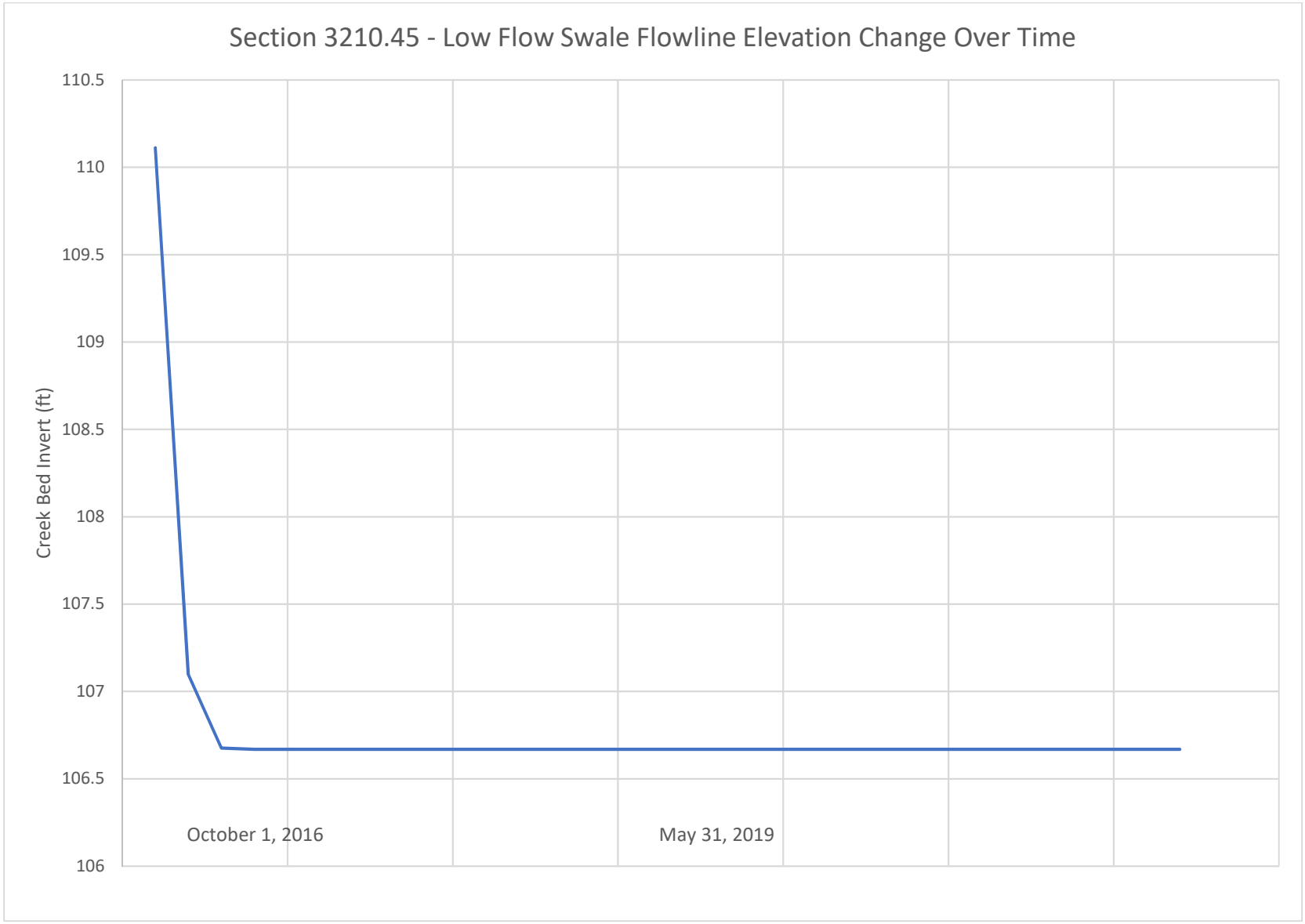

3714.24
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
128
126
124
122
120
118
116
0
20
40
60
80
100
120
Proposed Low Flow Swale

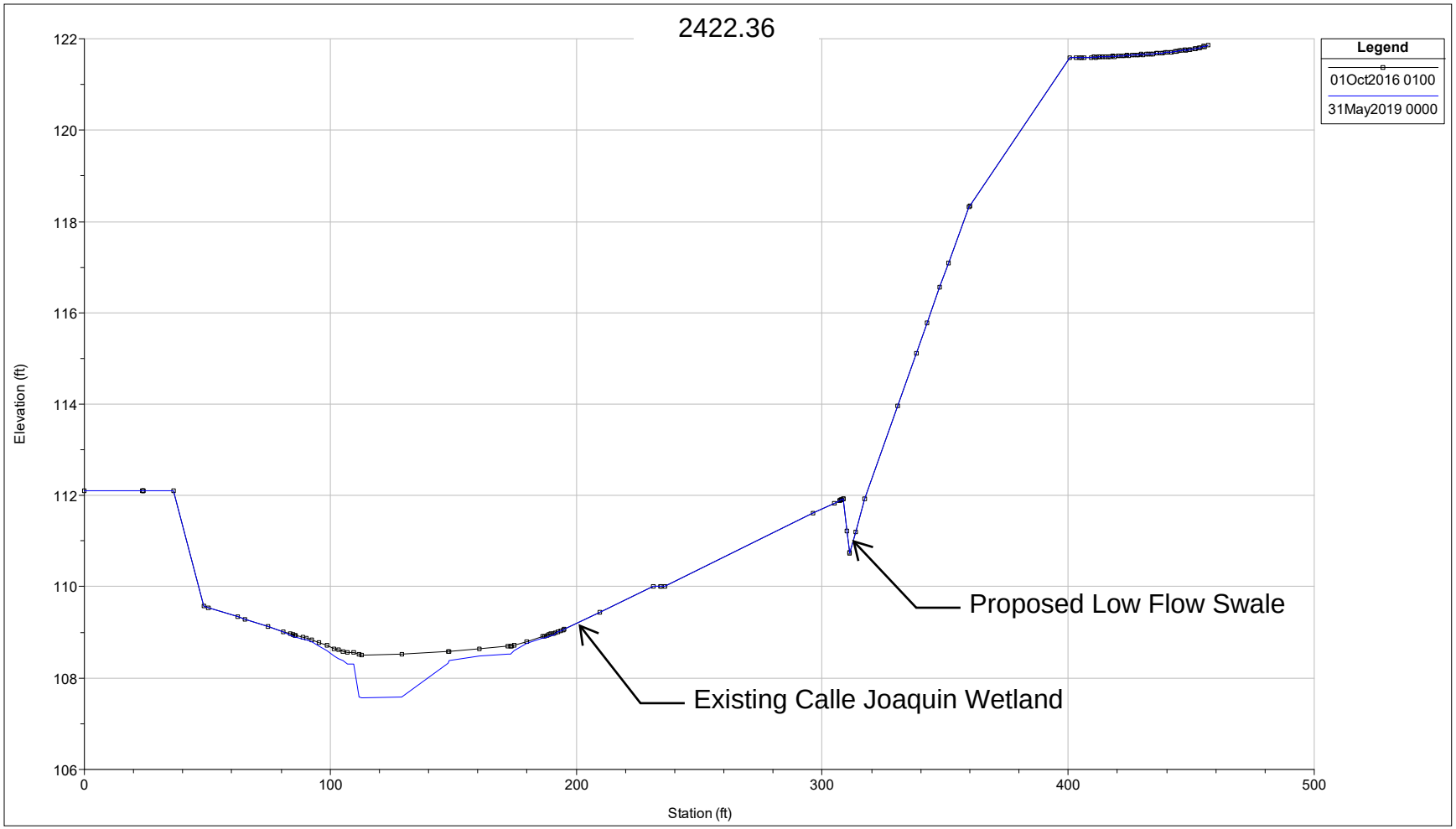

Section 3714.24 - Low Flow Swale Flowline Elevation Change Over Time
117
116.75
116.5
116.25
116
Creek Bed Invert (ft)
October 1, 2016
May 31, 2019

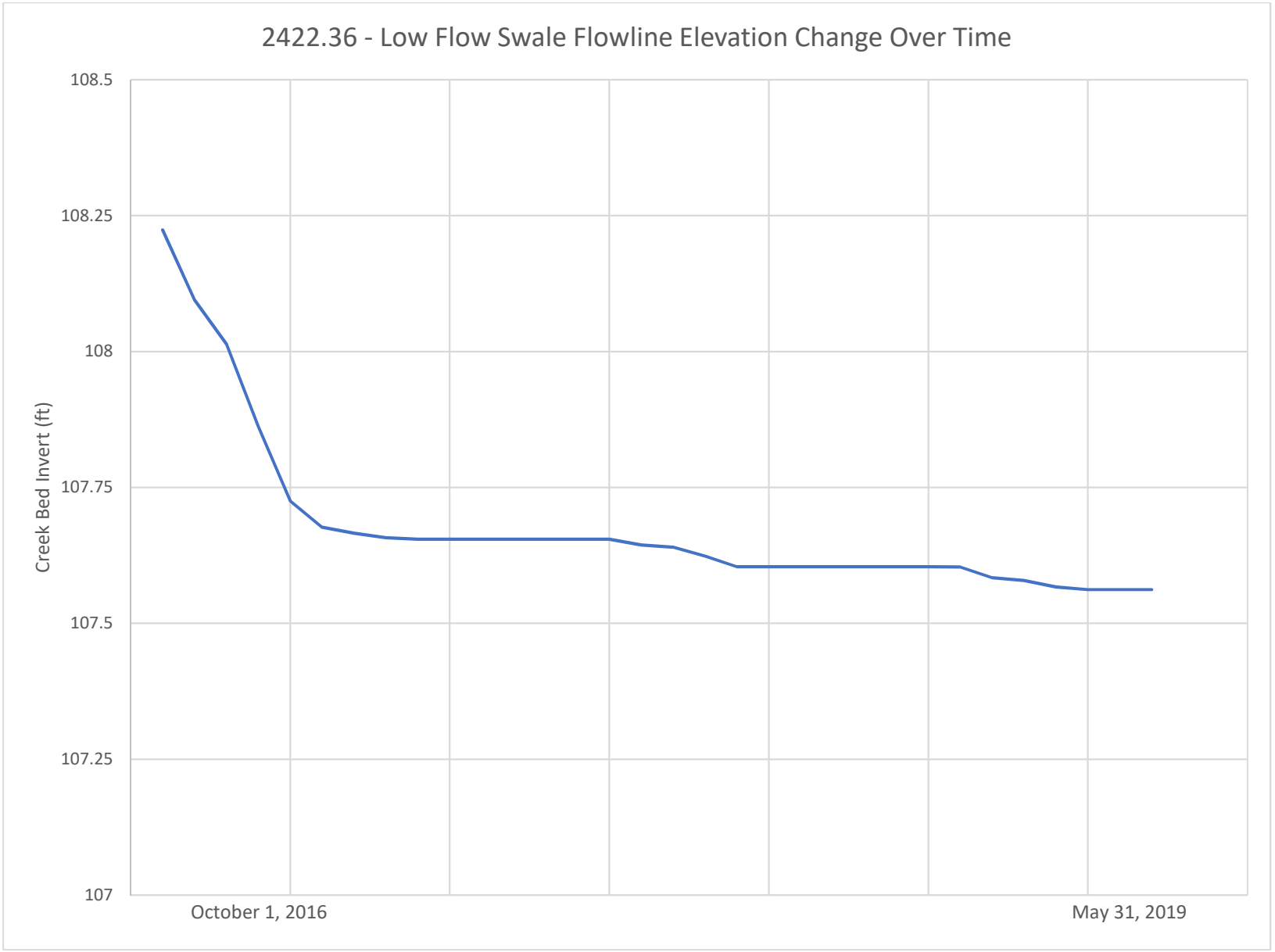

3453.96
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
126
124
122
120
118
116
114
112
0
100
200
300
400
500
Existing LOVR Ditch
(not affected)
Proposed Low Flow Swale

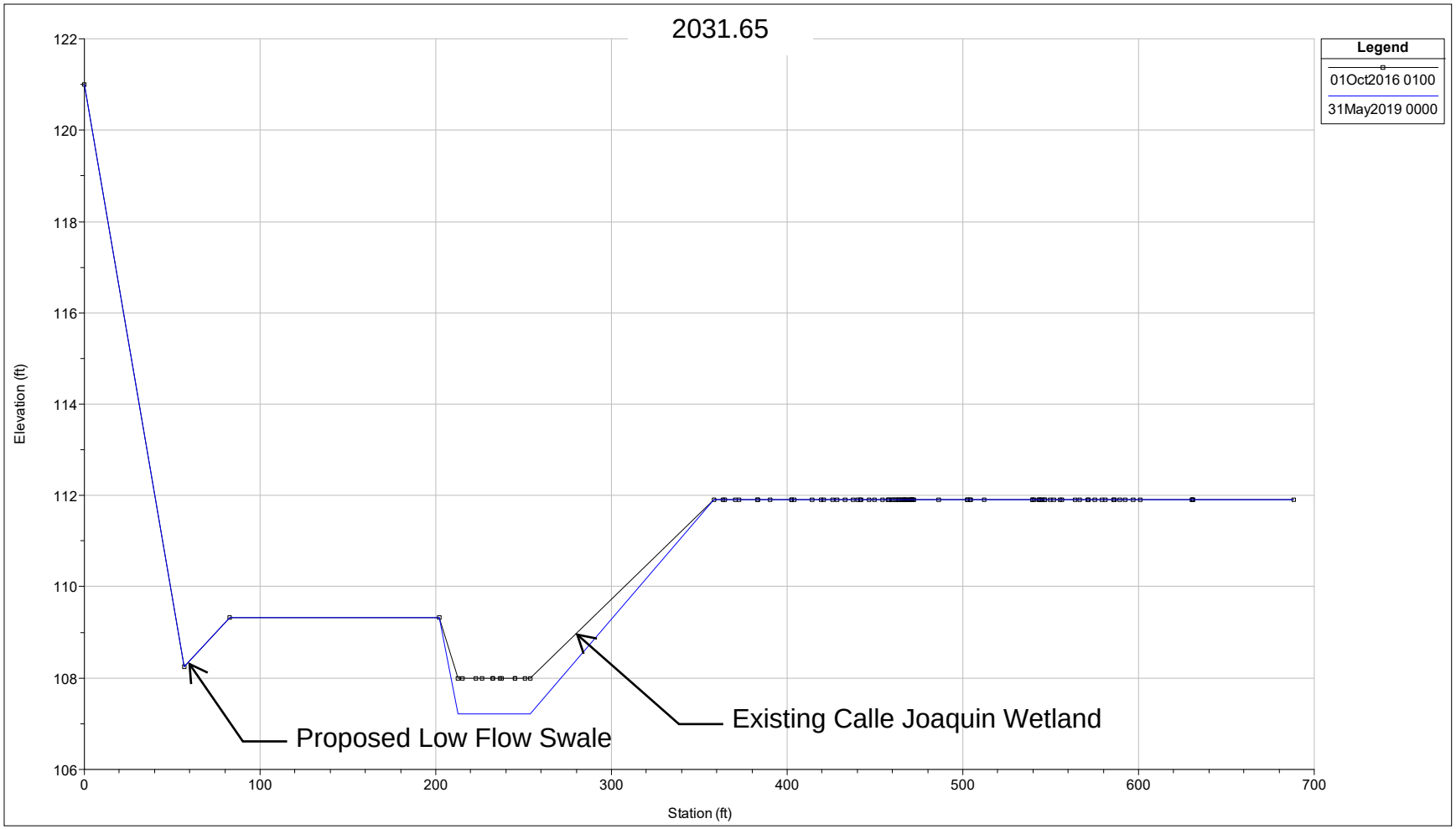

3453.96 - Low Flow Swale Flowline Elevation Change Over Time
114
113.75
113.5
113.25
113
Creek Bed Invert (ft)
October 1, 2016
May 31, 2019

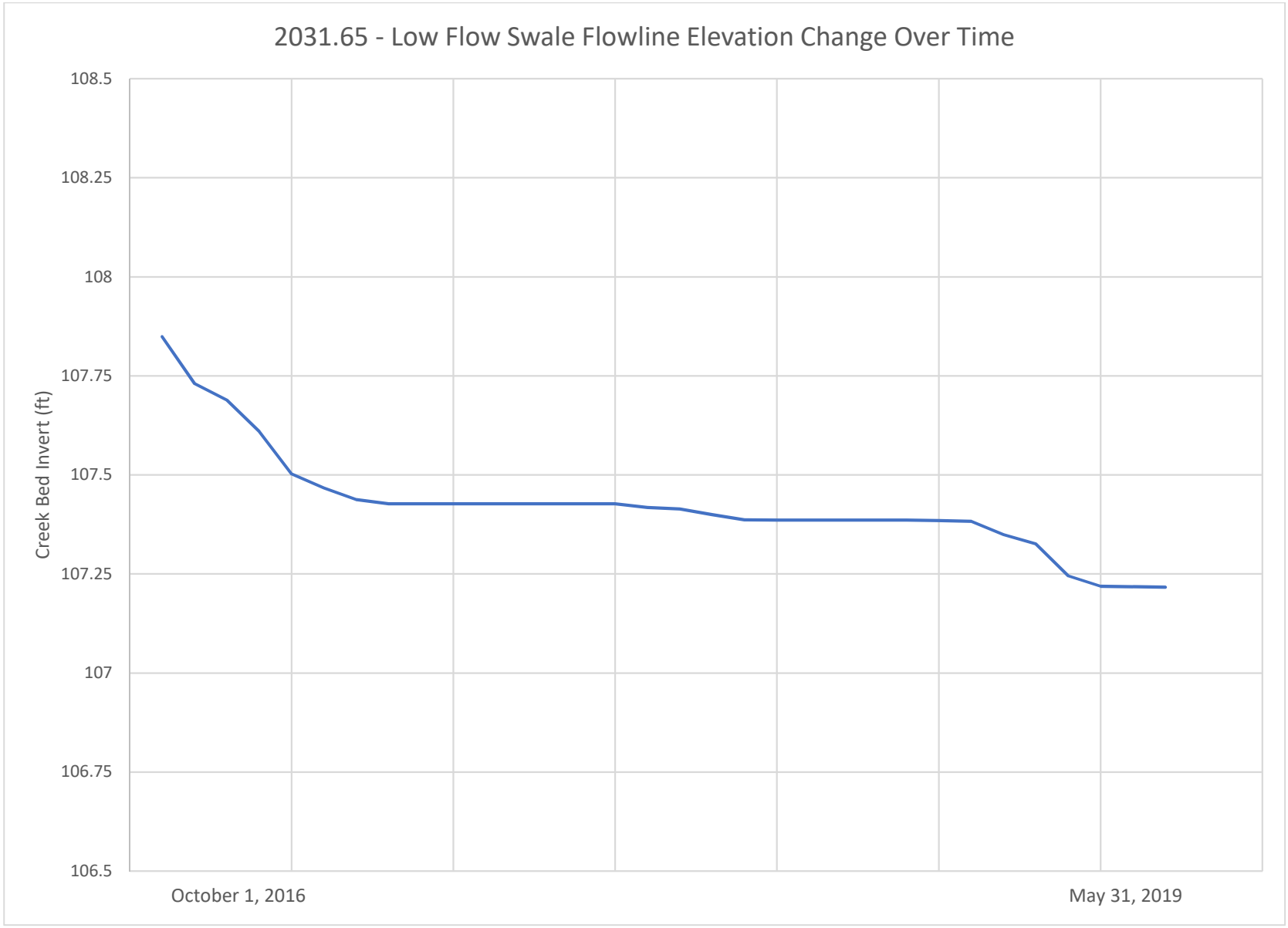

3210.45
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
120
118
116
114
112
110
108
106
0
50
100
150
200
250
300
Proposed Low Flow Swale
See "Analysis Results" on Pg. 4

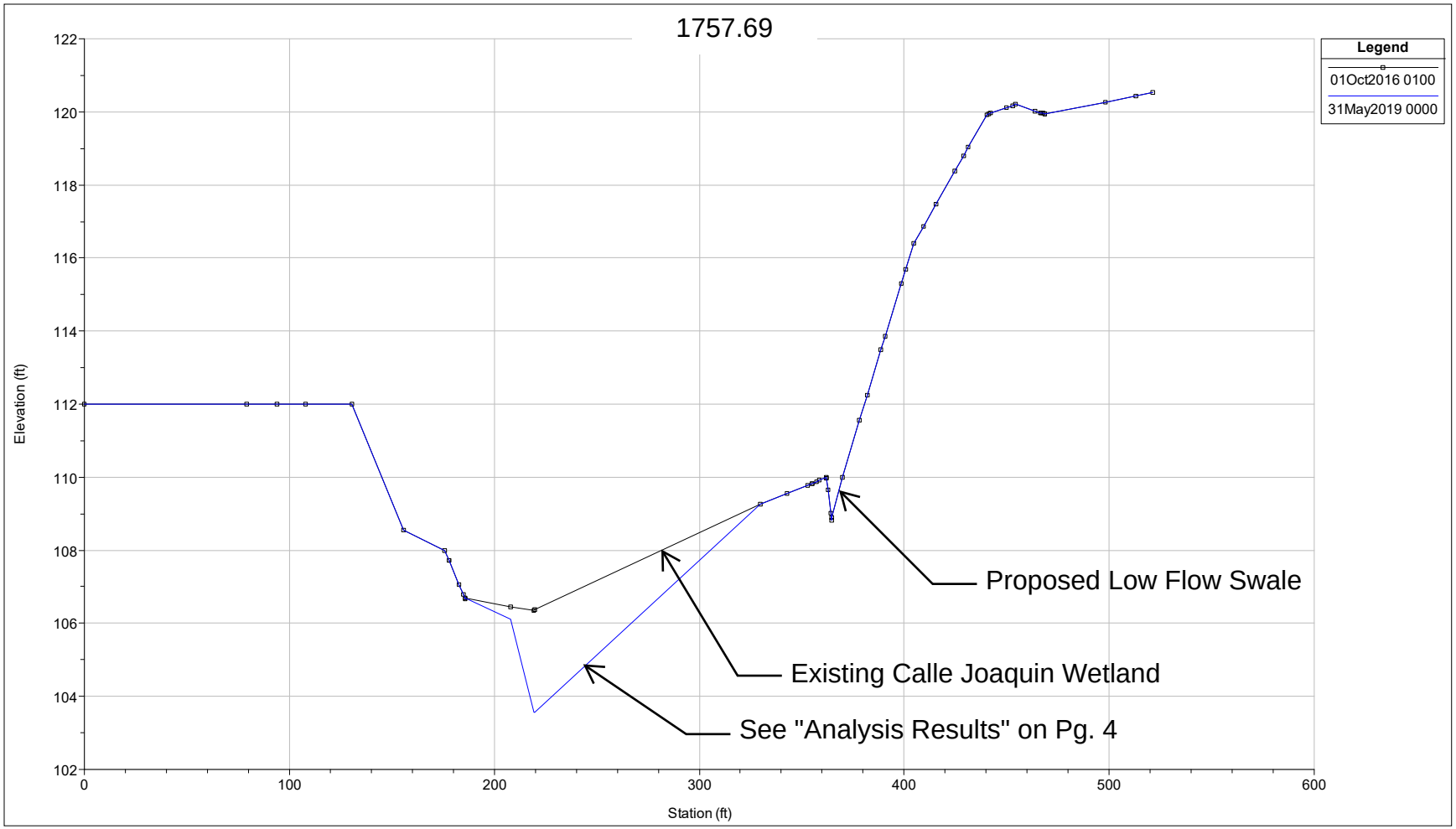

Section 3210.45 - Low Flow Swale Flowline Elevation Change Over Time
Creek Bed Invert (ft)
110.5
110
109.5
109
108.5
108
107.5
107
106.5
106
October 1, 2016
May 31, 2019

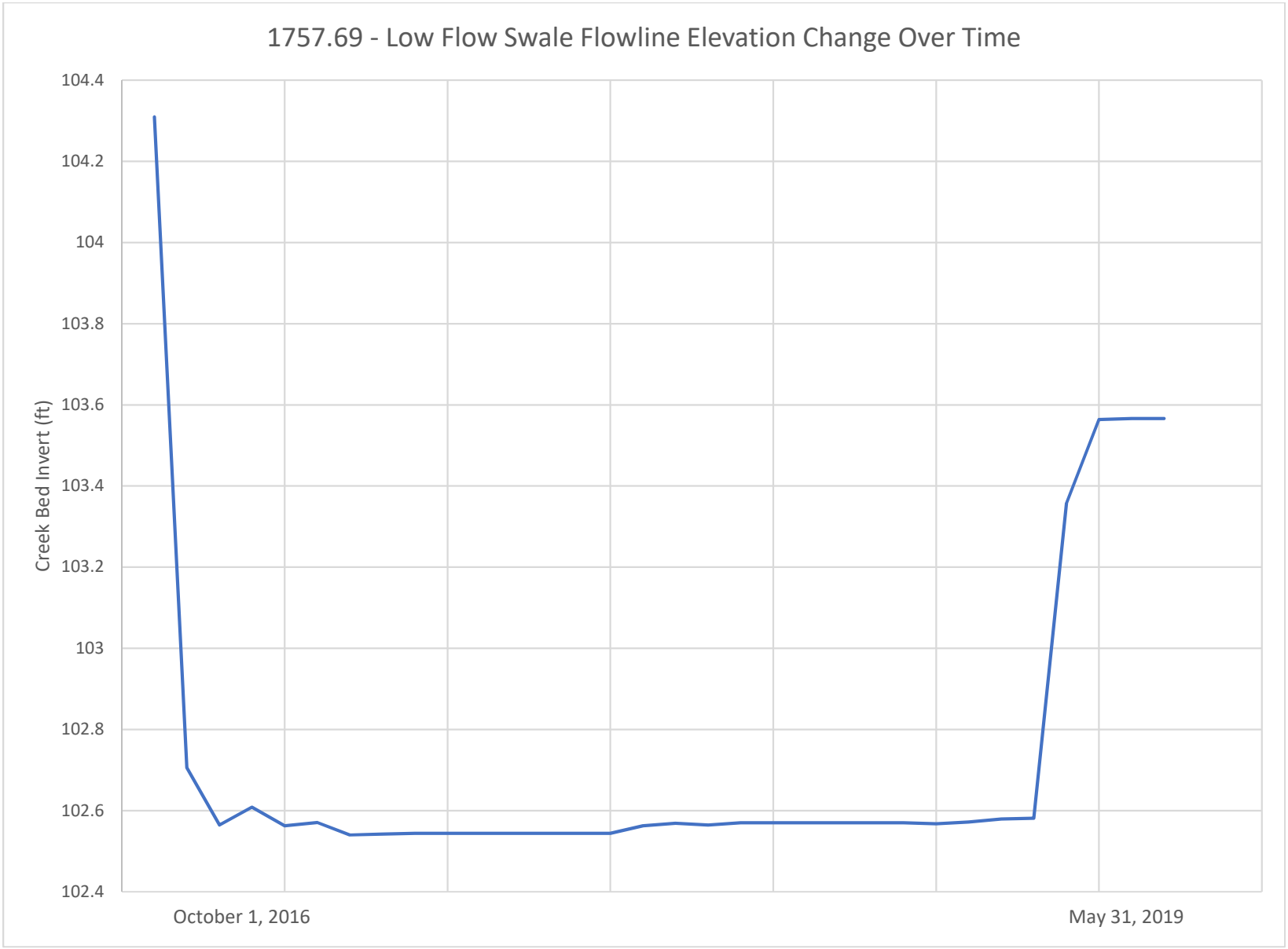

2422.36
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
122
120
118
116
114
112
110
108
106
0
100
200
300
400
500
Proposed Low Flow Swale
Existing Calle Joaquin Wetland

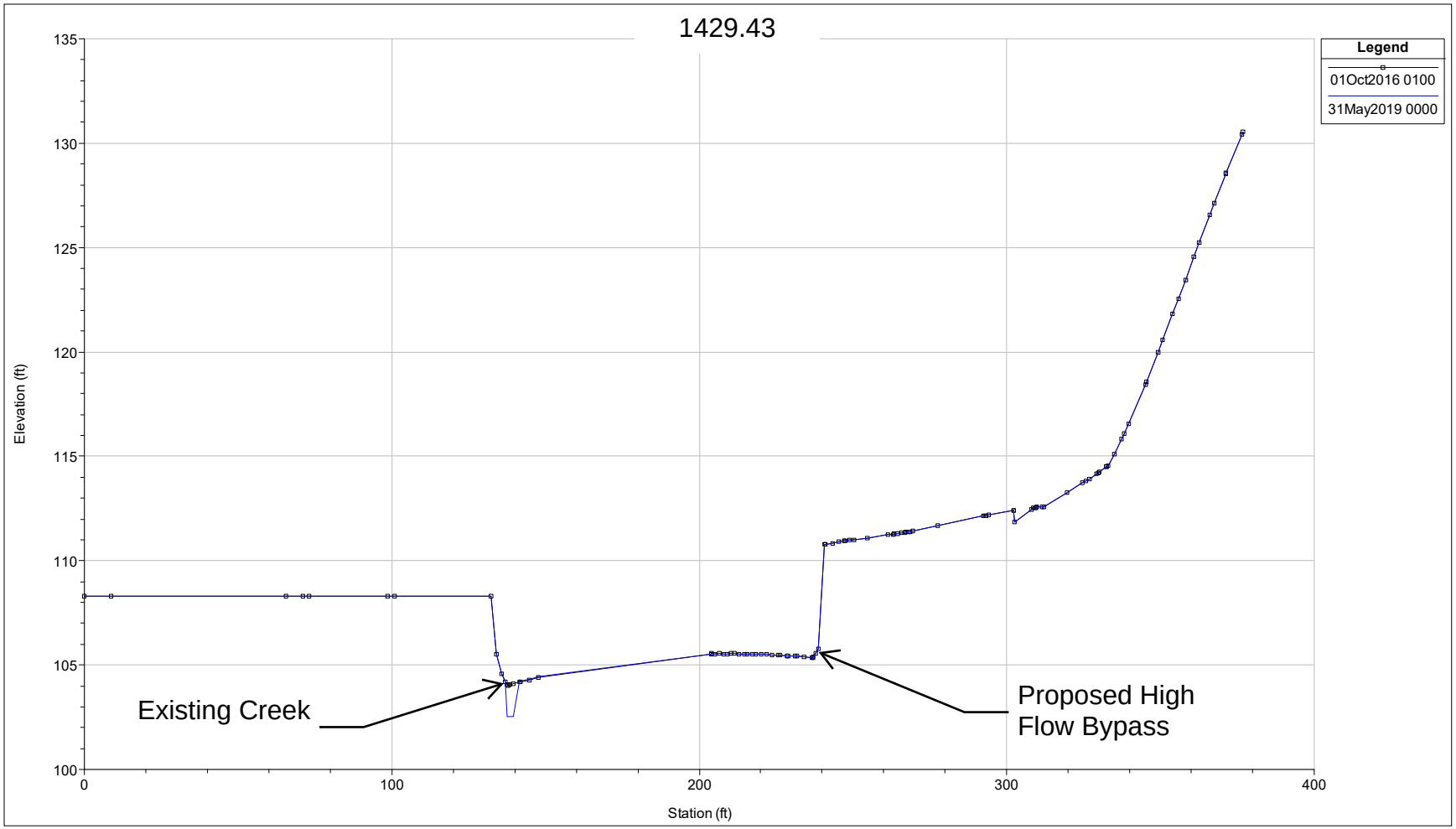

2422.36 - Low Flow Swale Flowline Elevation Change Over Time
Creek Bed Invert (ft)
108.5
108.25
108
107.75
107.5
107.25
107
October 1, 2016
May 31, 2019

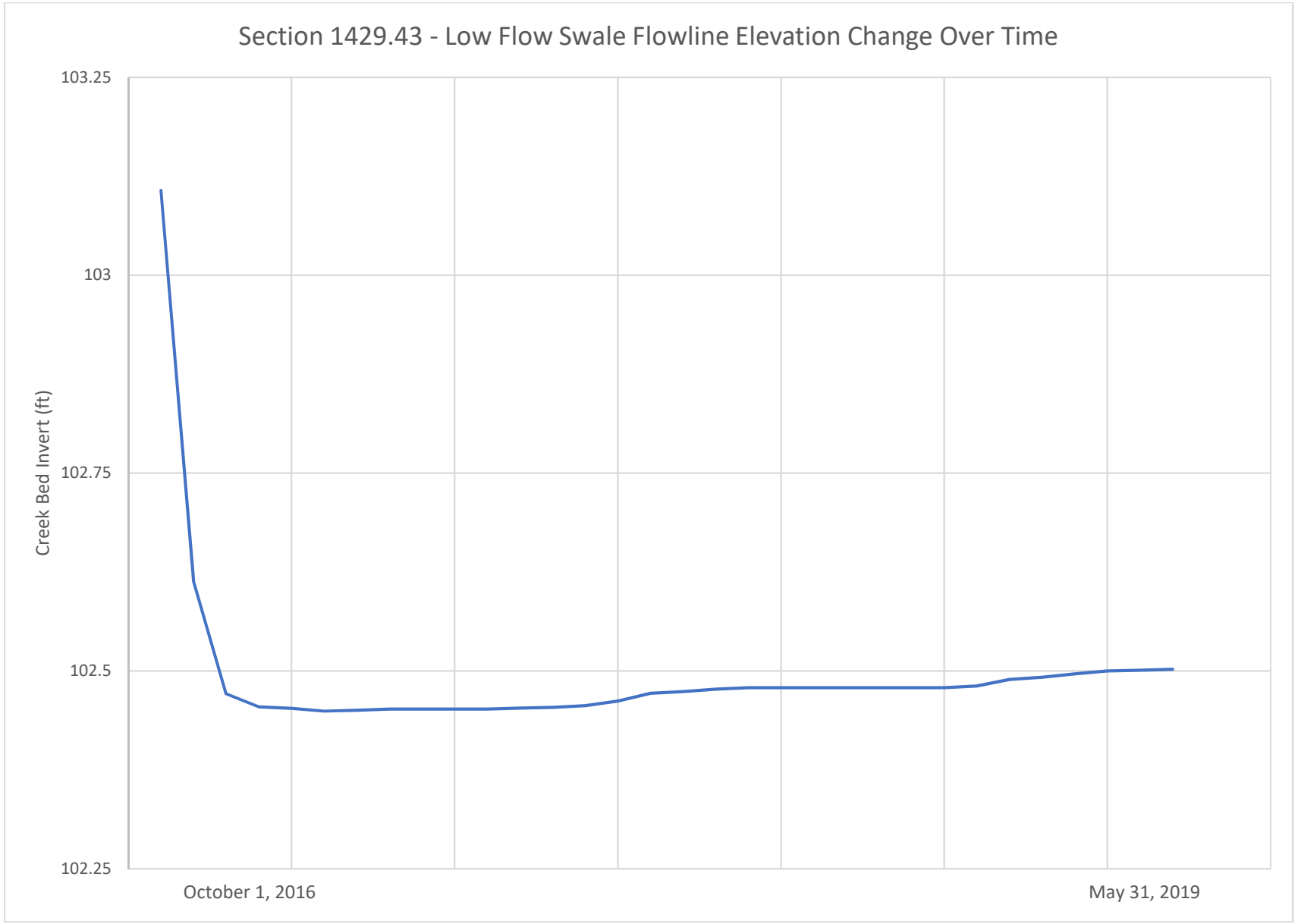

2031.65
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
122
120
118
116
114
112
110
108
106
0
100
200
300
400
500
600
700
Proposed Low Flow Swale
Existing Calle Joaquin Wetland

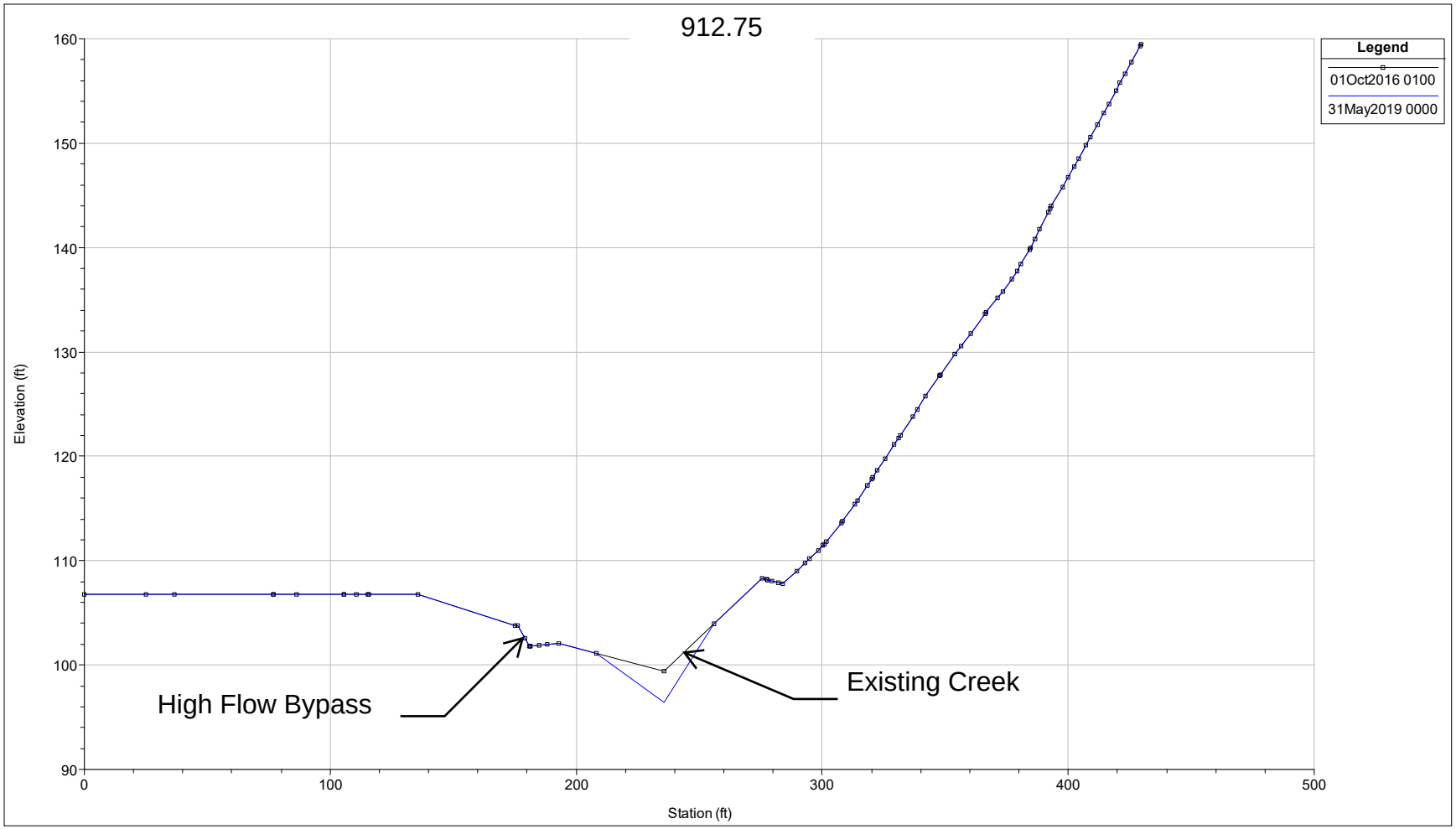

2031.65 - Low Flow Swale Flowline Elevation Change Over Time
Creek Bed Invert (ft)
108.5
108.25
108
107.75
107.5
107.25
107
106.75
106.5
October 1, 2016
May 31, 2019

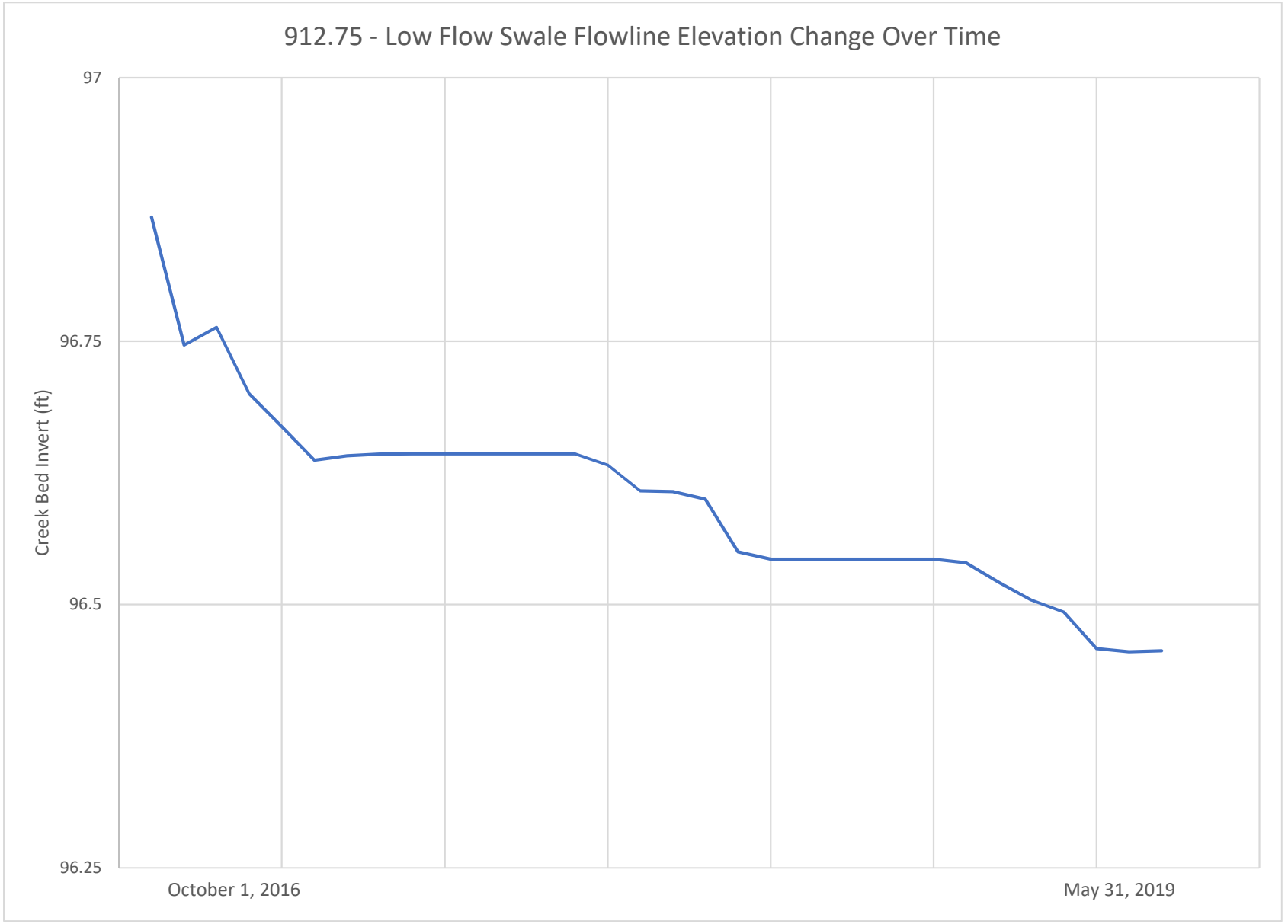

1757.69
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
122
120
118
116
114
112
110
108
106
104
102
0
100
200
300
400
500
600
Proposed Low Flow Swale
Existing Calle Joaquin Wetland
See "Analysis Results" on Pg. 4

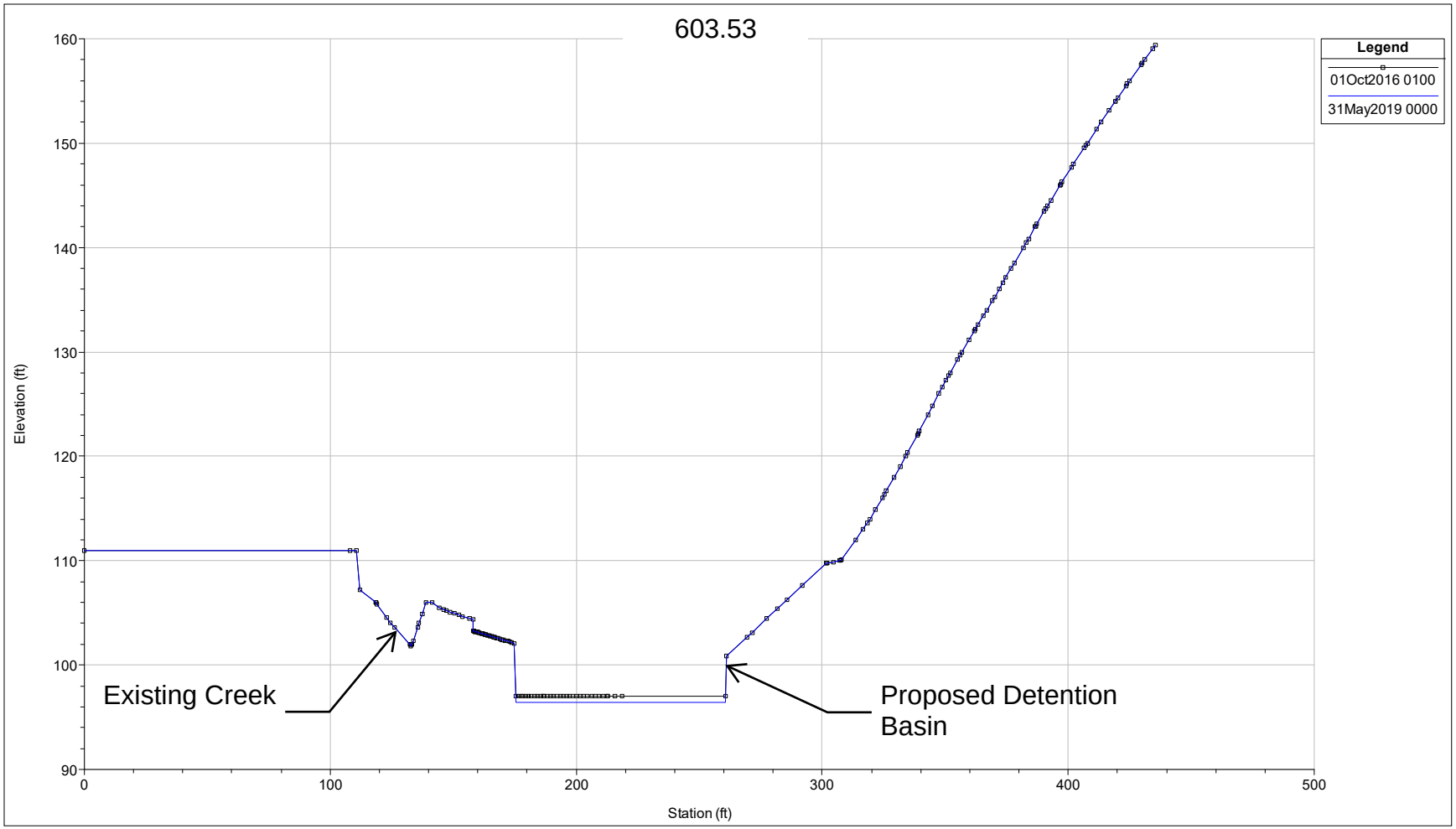

1757.69 - Low Flow Swale Flowline Elevation Change Over Time
Creek Bed Invert (ft)
104.4
104.2
104
103.8
103.6
103.4
103.2
103
102.8
102.6
102.4
October 1, 2016
May 31, 2019

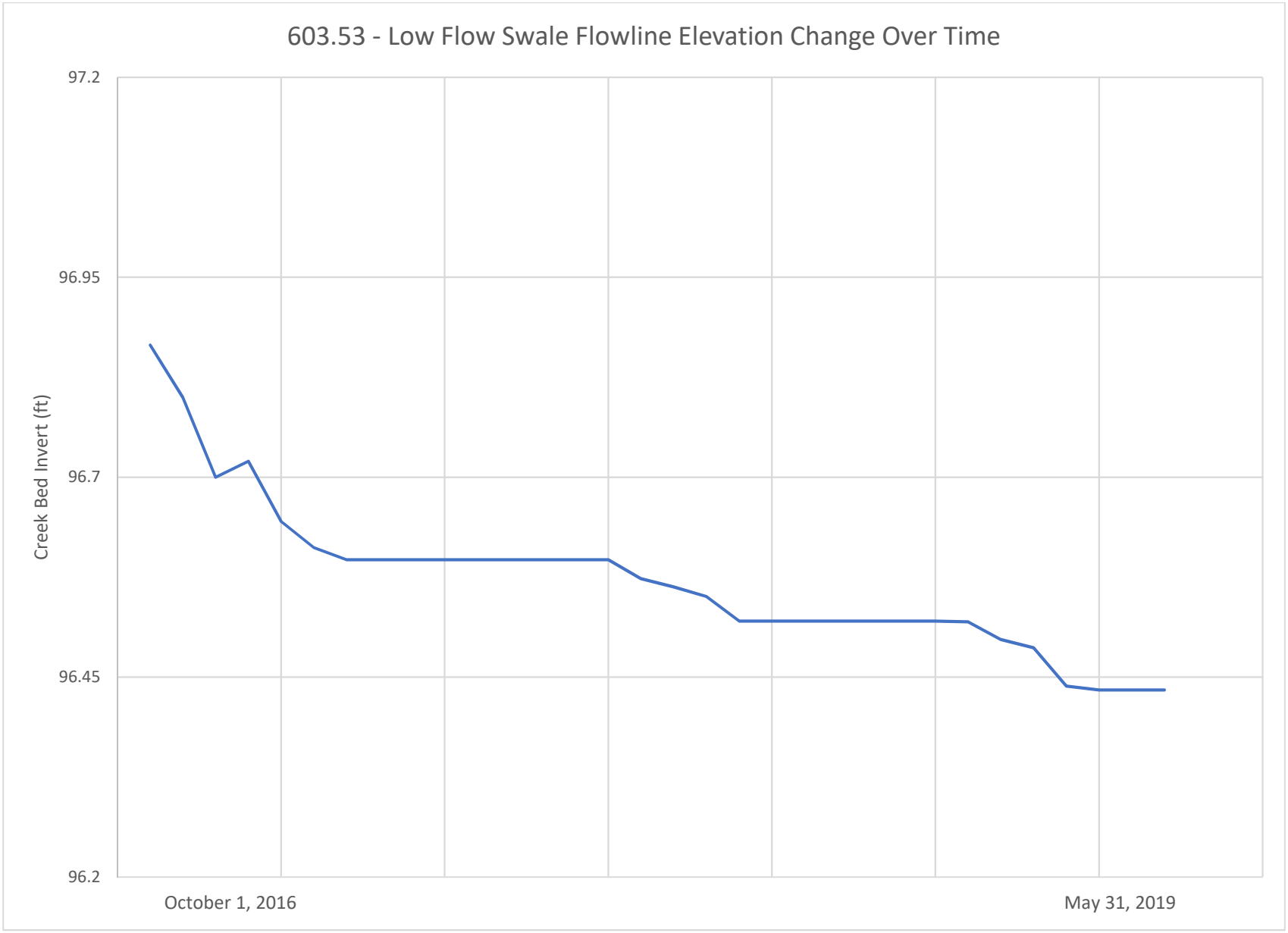

1429.43
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
135
130
125
120
115
110
105
100
0
100
200
300
400
Existing Creek
Proposed High
Flow Bypass

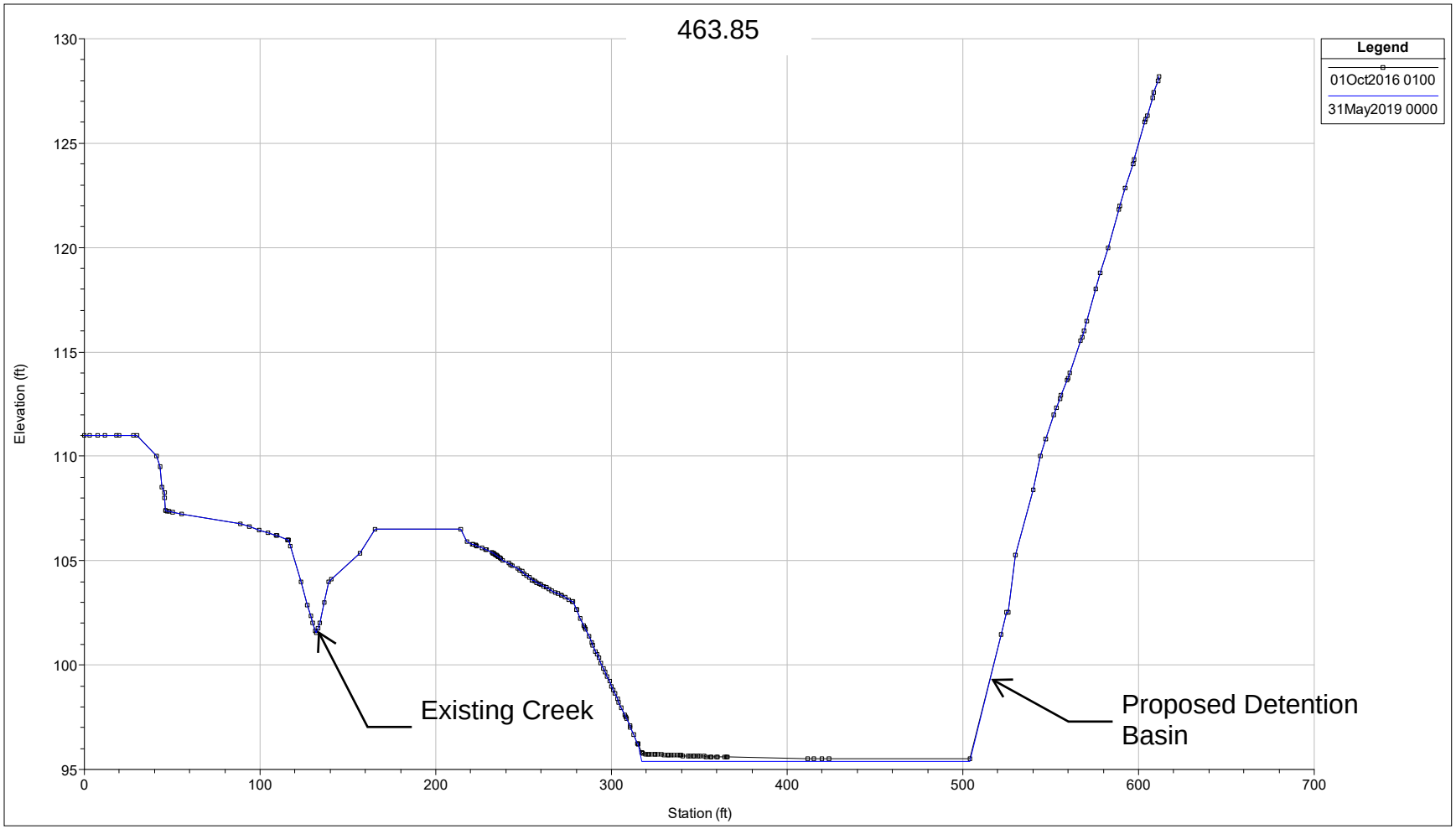

Section 1429.43 - Low Flow Swale Flowline Elevation Change Over Time
103.25
103
102.75
102.5
102.25
Creek Bed Invert (ft)
October 1, 2016
May 31, 2019

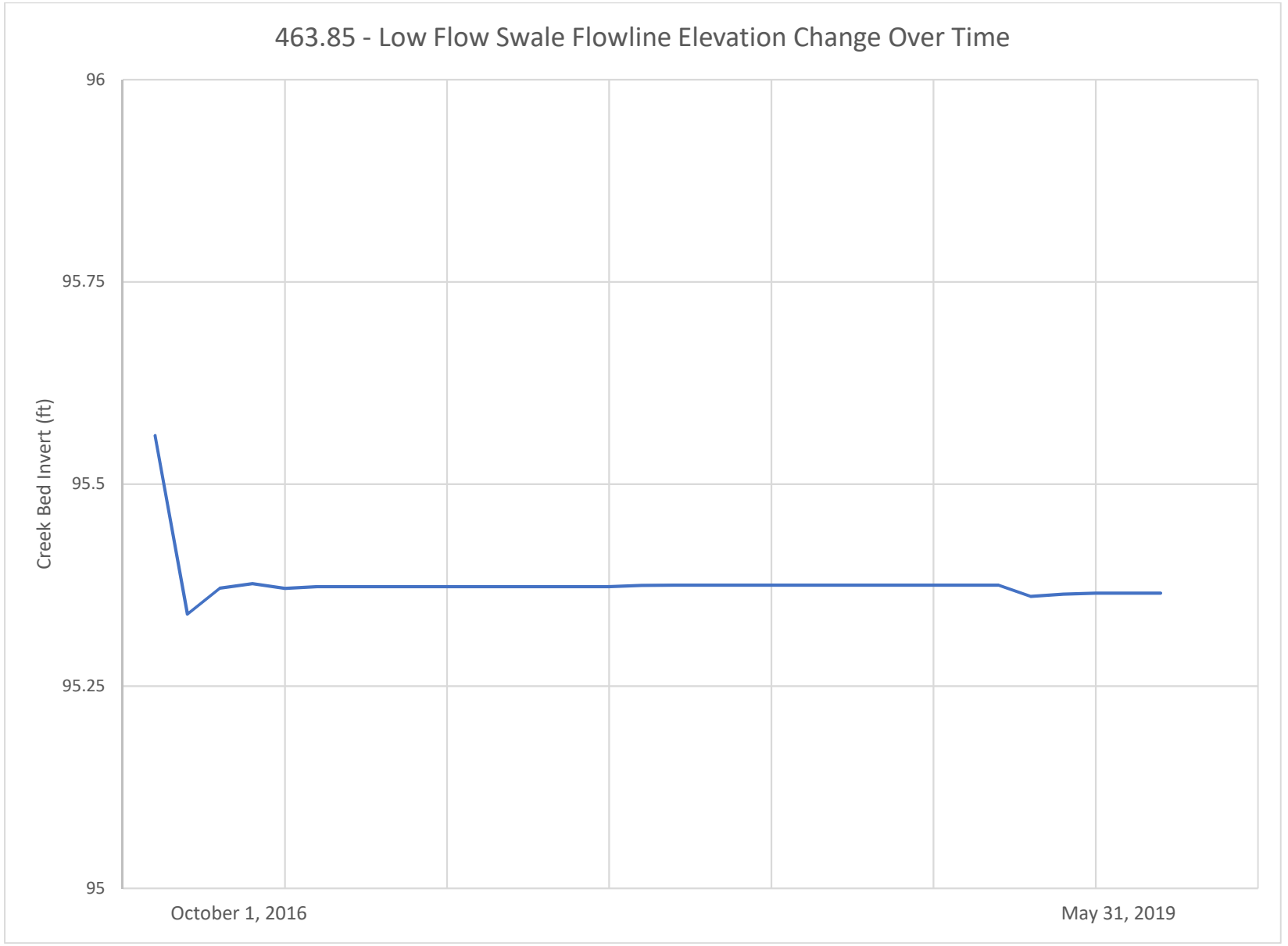

912.75
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
160
150
140
130
120
110
100
90
0
100
200
300
400
500
High Flow Bypass
Existing Creek


912.75 - Low Flow Swale Flowline Elevation Change Over Time
97
96.75
96.5
96.25
Creek Bed Invert (ft)
October 1, 2016
May 31, 2019


603.53
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
160
150
140
130
120
110
100
90
0
100
200
300
400
500
Existing Creek
Proposed Detention Basin


603.53 - Low Flow Swale Flowline Elevation Change Over Time
97.2
96.95
96.7
96.45
96.2
Creek Bed Invert (ft)
October 1, 2016
May 31, 2019


463.85
Legend
01Oct2016 0100
31May2019 0000
Elevation (ft)
Station (ft)
130
125
120
115
110
105
100
95
0
100
200
300
400
500
600
700
Existing Creek
Proposed Detention Basin


463.85 - Low Flow Swale Flowline Elevation Change Over Time
96
95.75
95.5
95.25
95
Creek Bed Invert (ft)
October 1, 2016
May 31, 2019