Hydraulic Analyses and Results for Coyote Creek and Nyhan Creek in Marin County

Coyote Creek Levee Evaluation

Contract Number: CON0089583

Marin County Flood Control and Water Conservation District

January 27, 2016

Table of Contents

Figures

Tables

Appendices

1 Introduction

1.1 Background and Purpose

The Marin County Flood Control and Water Conservation District (District), has contracted GEI Consultants Inc. (GEI) to perform an engineering evaluation of the Coyote Creek levee system located within the unincorporated community of Tamalpais Valley. HDR Inc. (HDR), a subcontractor to GEI, is responsible for providing the hydraulic evaluation of the Coyote Creek levee system. This report provides the results of the hydraulics evaluations of creek water surface elevations under various riverine flow and tidal scenarios, which will be incorporated by GEI into their comprehensive geotechnical and structural assessment of the current levee system conditions to develop recommendations for both short- and long-term levee improvements that meet the U.S Army Corps of Engineers (Corps) and Federal Emergency Management Agency (FEMA) regulations, standards, policies, and guidance. GEI's comprehensive geotechnical and structural assessment is in-progress and results will be presented in separate reports.

The Corps constructed the Coyote Creek Local Flood Protection Project in 1963 to protect a portion of the Tamalpais Valley community from high flood elevations in Coyote Creek and Nyhan Creek. In addition, the project protects the community from high tides from Richardson Bay. After construction, the Coyote Creek Local Flood Protection Project was transferred to the District for operation and maintenance and is presently subject to the Corps Rehabilitation and Inspection Program (RIP) per Public Law 84-99. As part of the RIP, the Corps requires the District to maintain the Coyote Creek Local Flood Protection Project to its original design specification, which is to convey the 5-percent annual exceedance probability (AEP) flow that was developed for the design of the channel (Corps Design Flow).

1.2 Study Area Description

The Coyote Creek Local Flood Protection Project consists of a concrete channel and a system of earthen levees, situated along an approximately 7,800 feet section of Coyote Creek extending from just upstream of Maple Street to the Mill Valley – Sausalito Pathway at Richardson Bay. In addition, a second 450 feet segment of earthen levees along the left embankment of Nyhan Creek runs from its confluence with Coyote Creek upstream to Marin Avenue. The Project Area and the location of the streams reaches of interest are shown in **Figure 1-1** - Stream Study Reaches.

Study Stream

Figure 1-1 - Stream Study Reaches

Hydraulic Analysis For Coyote Creek and Nyhan Creek Levee Evaluation

Service Layer Copyright:© 2011 National Geographic Society, i-cubed
National Geographic, Esri, DeLorme, NAVTEQ, UNEP-WCMC, USGS,
NASA, ESA, METI, NRCAN, GEBCO, NOAA, iPC
Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.
Projection is NAD 83 CA State Plane Zone III

1.3 Hydraulic Analysis Scope of Work

HDR is contracted with preparing a baseline model representing existing conditions as well as evaluating the impacts of proposed remediation alternatives on flow characteristics of the channel. This memorandum focuses on the evaluation of the water surface elevations under various scenarios of flow and tides using the existing channel geometry as described in Section 2.2. GEI performs a geotechnical and structural assessment of the levee system, and identified remedial measures for the reaches of levee that present geotechnical deficiencies based on District goals, objectives, and site constraints. The hydraulic impact of the proposed remediation alternatives were also analyzed and documented within this report.

Scope of work items for the hydraulic analyses included:

- Review of available documentation and data
- Overview of field visit
- Review of existing hydraulic model
- Perform updates to the Noble Hydraulic Model 2013
- Development of six (6) existing conditions scenarios
- Evaluate results for multiple riverine and tidal conditions
- Evaluate scour potential within the channel and at hydraulic structures
- Evaluation of sediment loading on the channel and its impacts to flood protection
- Development of a remediation alternative scenario
- Evaluation of remediation alternative scenario

1.3.1 Review of Documentation and Data

A review of available documentation, data and models was conducted to understand the development of the hydraulic model and to determine whether updates to the model were needed for use in the levee evaluation. The following documents were reviewed:

- *Draft Report Hydraulic Analysis for Coyote Creek Sediment Removal Project, Upper and Middle Reach* by Noble Consultants, Inc., dated June 3, 2013
- HEC-HMS model prepared by Marin County Flood Control and Water Conservation District, dated August 07, 2014
- *HEC-HMS Hydrologic Modeling for the Arroyo Corte Madera del Presidion Creek Watershed* by Stetson Engineers Inc., dated June 2009
- *Middle Reach of Coyote Creek Sediment Management and Maintenance Plan* by Philip Williams and Associates, Ltd., dated July 2012
- *Coyote Creek Maintenance Dredging Flood Control Zone #3* by County of Marin Department of Public Works, dated May 20, 1991

- *Topographic Survey of Portion of Coyote Creek City of Mill Valley"* by Meridian Surveying Engineering, Inc., dated March 15, 2013
- *Draft Coyote Creek Operation & Maintenance Manual* Marin County Flood Control and Water Conservation District Flood Control Zone No. 3, dated June 2012
- *Reassessment of Coyote Creek Channel Management Requirements* by Philip Williams and Associates, Ltd., dated January 10, 2005
- *Draft Memorandum 5 Hydraulic Analysis* by Noble Consultants, Inc., dated May 7, 2013
- *Draft Memorandum 4 Project Description* by Noble Consultants, Inc., dated April 3, 2013
- *Detailed Project Report on Coyote Creek*, *Marin County, California* by Corps, San Francisco, dated May 1959

1.3.2 Overview of Field Visit

A field visit was performed to ensure that the hydraulically significant components were previously included in the model with appropriate configurations. The field visit also captured additional parameters/components that needed to be included in the updated hydraulic model. **Appendix A** contains the field visit notes.

1.3.3 Review of Existing Hydraulic Model

The existing conditions hydraulic analyses are based on a HEC-RAS hydraulic model provided by the District for Coyote Creek and Nyhan Creek within the project area. This model was developed by the District's consultant, in 2013 by Noble Consultants, Inc. (herein referred to as the Noble Hydraulic Model 2013) to assess current conditions and sediment removal needs. The model used an unsteady flow simulation method to simulate a steady-flow condition by modeling a constant flow rate. This approach utilizes the momentum equations that are used by HEC-RAS in an unsteady flow simulation and to increase the number of computation iterations to compute a stable water surface elevation for the sensitive super-critical flow regime occurring in the upper reach of Coyote Creek. The upper reach of Coyote Creek is a concrete lined channel with a relatively steep slope. Based on the model reviewed and field visit, HDR modified the HEC-RAS model geometry to better represent the existing conditions of the levee system and the channel hydraulics. Updates that were introduced to the model are documented in the following section.

1.3.4 Updates to Noble Hydraulic Model 2013

Based on the review of the documentation and the field visit, the Noble Hydraulic Model 2013 model was updated to better represent the existing conditions of the system. The following updates were made to the model:

- Cross sections downstream of Mill Valley Sausalito Path on Coyote Creek were deleted and reconfigured.
- The Mill Valley Sausalito Path Bridge was updated to reflect a more accurate configuration. The model was updated to include the northern bridge opening, the southern bridge opening was updated, and the deck thickness and also the pier width were updated. Updates were based on the field visit.

- Downstream cross sections that extend across Bothin Marsh South were updated to reflect topography. The cross sections were also detailed with ineffective flow areas to represent the proper conveyance through the cross sections.
- Cross sections from river station 27+00 to 25+00 downstream of Highway (Hwy) 1 were extended to the south to contain flows.
- Lateral structures upstream of Rose Drive Bridge were updated to reflect the existing top of floodwall profile.
- The modeling approaches to the bridges upstream of and Rose Drive Bridge were updated to be modeled as lidded cross sections.
- The pedestrian bridge downstream of Hwy 1 was updated to reflect the correct geometric configuration; a pier was added to bridge configuration.
- The pedestrian path along the right bank of Coyote Creek located from river station 38+50 to 35+70 downstream of the confluence of Coyote Creek and Nyhan Creek was added to the model.
- Interpolated cross sections were removed.
- Cross section were extended upstream of Marin Ave Bridge on Nyhan Creek on the right floodplain.
- HTab parameters for cross sections were updated to be above the bridge weir elevation and underneath the water surface elevation result. Also, the Maximum Flow parameter was removed to not limit the flow being conveyed across the structures.
- Bridge modeling approaches were updated to reflect the Momentum method for low flows methods on bridges that have obstructions (piers) within the bridge opening. In addition, the Pressure and/or weir option was enabled for high flow method.
- Lateral structure weir coefficients were set to 0 to contain flow within the channel conveyance area.
- Levees were introduced at the end of cross sections to contain flow within the channel conveyance area; this was done to eliminate error messages that are due to the water surface elevation being above the channel banks.
- Channel Manning's n values were updated to 0.0155 from 0.014 at stations 64+87 and 63+18 to provide stability in the model.
- Removed contraction and expansion coefficients on Upper Reach of Coyote Creek (See Section 2.8).

1.3.5 Existing Conditions Scenarios

After the existing conditions geometry was established, six (6) existing conditions scenarios were modeled using HEC-RAS. Each plan consists of the existing conditions geometry with a different combination of riverine flow, downstream boundary and tidal boundary condition assumptions. The riverine flows used in the various scenarios that were evaluated include the

Corps Design Flows, effective FEMA flows, and the District developed flows (See Section 2.3). The tidal water surface elevation evaluated include 1960s Mean High High Water (MHHW), present day MHHW, estimated 2050 MHHW, FEMA estimated 1-percent AEP tide (so called "100-year tide event") and FEMA estimated 1-percent AEP tide plus a potential three (3) feet of sea level rise (See Section 2.4). The scenarios include:

- *Baseline* –upstream and downstream boundary conditions used in the design of the Corps project in the 1960s (5-percent AEP event 1960s Corps design riverine flow and 1960s tidal MHHW elevations at Richardson Bay).
- *Updated* –District revised upstream and downstream boundary conditions that reflect present day conditions equivalent to the design of the Corps project in the 1960s (4-percent AEP event District riverine flow plus 15-persent and present day tidal MHHW elevation at Richardson Bay).
- *Enhanced A (District 2-percent AEP event)* - District revised upstream and downstream boundary (2-percent AEP event District riverine flow plus 15-percent and present day tidal MHHW elevation at Richardson Bay).
- *Enhanced B (District 1-percent AEP event)* - District revised upstream and downstream boundary conditions (1-percent-AEP event District riverine flow plus 15-percent and present day tidal MHHW elevation at Richardson Bay).
- *Existing FEMA Accredited* - FEMA upstream and downstream boundary conditions (1-AEP event FEMA riverine flow and present day tidal MHHW elevation at Richardson Bay).
- *Existing FEMA Accredited with Sea Level Rise (SLR)* - captures existing channel/levee conditions, and FEMA upstream and downstream boundary conditions accounting for SLR (1-AEP event FEMA riverine flow and estimated year 2050 tidal MHHW elevation at Richardson Bay).

These six (6) scenarios are discussed further in Section 2.4 - Hydraulic Model Setup. The following sections describe hydraulic analysis subtasks conducted for the levee evaluation.

1.3.6 Remediation Alternative Scenario

GEI's geotechnical evaluation included developing a proposed alternative for flood control upgrades that captured the geotechnical deficiencies of the existing levees. Based on the District goals, objectives, and site constraints a Remediation Alternative was developed. The Remediation Alternative model development and analysis is discussed in Section 5.

2 Existing Conditions Hydraulic Model Development

2.1 Cross Section Layout

Cross sections were developed as part of the Noble Hydraulic Model 2013. The cross section layout was oriented to be perpendicular to the direction of flow. The lateral ends of the cross sections were placed to capture either the levees, channel banks, or the high grounds above the projected water surface elevations (WSE). **Figures 2-1** through **2-4** illustrate the cross section layout used for this hydraulic analysis.

2.2 Topography, Surveying, and Aerial Imagery

As part of the development of the Noble Hydraulic Model 2013, a topographic and bathymetric survey was conducted by Meridian Surveying Engineering, Inc. in March 2013. The survey was limited to the channel and levee system. The survey covered the Coyote Creek from the upstream limit of the concrete channel, upstream of Maple Street to the confluence with Richardson Bay. The survey also covered Nyhan Creek from the confluence with Coyote Creek to approximately 150 feet upstream of the Enterprise Concourse crossing. The survey was conducted with a combination of hydrographic and ground surveying to provide a complete condition survey for the project area, data was used to develop a Digital Terrain Model (DTM). The terrain surfaces were later converted to a Digital Elevation Model (DEM) with a cell size of 0.25 foot by 0.25 foot, from which the channel geometry was derived for the Noble Hydraulic Model 2013. The horizontal coordinate system adopted in the survey and in this hydraulic analysis is California State Plane, North American Datum of 1983 (NAD83), Zone 3. The vertical datum is North American Vertical Datum of 1988 (NAVD 88). Project units are US Survey Feet. The Meridian Surveying Engineering, Inc. March 2013 survey is the most current topographic data that is available for Coyote Creek and Nyhan Creek within the project area.

A supplemental terrain was used to refine the Noble Hydraulic Model 2013 to include topographic data that was outside of the channel and levee system. The supplemental terrain used was provided by the District, herein referred to as the County DEM, and was developed from multiple sources of surface models developed for Marin County, California. The best available surface data for analytical and cartographic uses was used. The data sets were fused into a single ESRI Terrain and the supplemental terrain data was added to the HEC-RAS model outside of the channel. The data used to develop County DEM included:

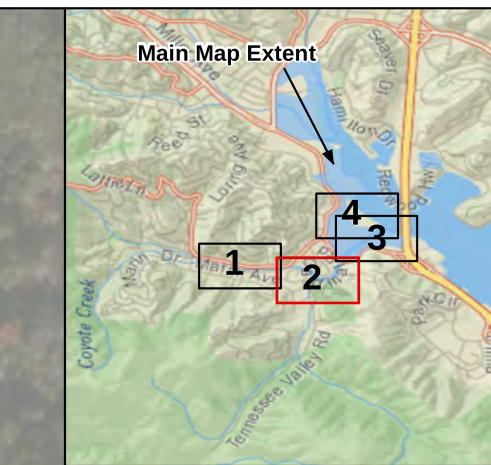
- LiDAR data, published by FEMA, flown and processed by Dewberry in 2007.
- LiDAR data set of NCALM GeoEarth Scope, flown and processed in 2008, obtained from OpenTopography.org.
- Sounding data obtained from the National Geophysical Data Center, National Ocean Survey Hydrographic Survey Data portal map.ngdc.noaa.
- LiDAR from ARRA Golden Gate (2ppsm) flown in April/May 2010 obtained from San Francisco State University.

- CSMP bathymetry obtained from Cal State Monterey Bay website, CAOPC.
- NOAA LiDAR, flown in 2010, obtained from NOAA Digital Coast website.
- Channel soundings purchased from USACE by FOIA request in 2010.
- LiDAR data from lower Lagunitas Creek (2 ppsm), obtained by Marin Municipal Water District from an Airborne 1 flight with data files dated April 4, 2009.

Figure 2 - 1
Hydraulic Model Cross Section Layout

Hydraulic Analysis For Coyote Creek and Nyhan Creek Levee Evaluation

Service Layer Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.
Projection is NAD 83 CA State Plane Zone III



HDR

Cross Section

Coyote Creek Upper Reach (Concrete Channel)

Nyman Creek Lower Reach

Coyote Creek Lower Reach

Coyote Creek Middle Reach

Highway

Local Road

0 40 80 160 Feet

0 10 20 40 Meters

Figure 2 - 2
Hydraulic Model Cross Section Layout

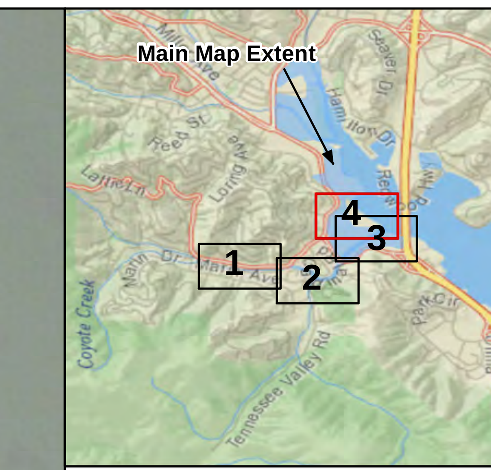
Hydraulic Analysis For Coyote Creek and Nyhan Creek Levee Evaluation

Service Layer Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.
Projection is NAD 83 CA State Plane Zone III

Figure 2 - 3
Hydraulic Model Cross Section Layout

Hydraulic Analysis For Coyote Creek and Nyhan Creek Levee Evaluation

Service Layer Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.
Projection is NAD 83 CA State Plane Zone III



Cross Section

Coyote Creek Lower Reach

Highway

Major Road

Local Road

0 40 80 160 Feet
0 10 20 40 Meters

Figure 2 - 4
Hydraulic Model Cross Section Layout

Hydraulic Analysis For Coyote Creek and Nyhan Creek Levee Evaluation

Service Layer Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.
Projection is NAD 83 CA State Plane Zone III

2.3 Peak Discharges

The Coyote Creek Local Flood Protection Project was designed to provide flood protection for the 5-percent-annual-chance design flood. The design flows computed by the Corps in 1963 are listed in **Table 1** - Coyote Creek Local Flood Protection Project 5-percent-annual-chance Design Flows from 1963. The Coyote Creek Local Flood Protection Project documentation did not include flows for Nyhan Creek. It was assumed that the flow for Nyhan Creek is the flow difference seen on Coyote Creek upstream and downstream of the confluence.

Table 1. Coyote Creek Local Flood Protection Project 5-percent-Annual Exceedance Probability Corps Design Flows from 1963

Station	Location	Discharge Flows (cfs)
Coyote Creek		
76+32	Upstream of Ash Street	900
73+80	Private Driveway[1]	900
68+00	Downstream of Pine Street	1,000
54+50	Upstream of Ross Drive	1,100
40+40	At confluence with Nyhan Creek	1,750
Nyhan Creek		
10+54	Upstream of Enterprise Concourse	650[2]

1 - Spruce Street District Gage for Coyote Creek

2 - Assumed flow; flow is the difference seen on Coyote Creek upstream and downstream of the confluence.

In the recent past, the District and FEMA performed several separate hydrologic analyses on the watersheds that contribute flow to streams within the study area. In 2014, the District developed a HEC-HMS model for the Coyote Creek watershed; the model included the development of the 4-, 2-, and 1-percent-annual-chance event flows. The recent hydrologic analyses have found that the 1963 Corps design flows are conservative based on the results from the District's evaluation of the 2014 HEC-HMS model and the 1963 Corps design flows. **Table 2** - Coyote Creek Peak Flows at Spruce Street District Gage shows a comparison of flows at the Spruce Street District Gage. For this evaluation, the updated 2014 District flows and FEMA effective flows will be run in addition to the 1963 Corps design flows. The updated District hydrology is based on a design storm using the 2006 New Year's storm (December 31, 2005 – January 1, 2006) rainfall pattern with 10-minute, 1 hour, 2 day and 4 day storm totals to match the values in the NOAA Atlas 14 for California. Flows for the 4-percent AEP event were calculated instead of the 5-percent AEP event flows; because NOAA Atlas 14 does not provide values for the 4-percent AEP event. (It provides values for the 10-, 4-, 2-, and 1-percent AEP events.)

Table 2. Coyote Creek Peak Flows at Spruce Street District Gage

Hydrology Source	10-Percent Annual Exceedance Probability (cfs)	5-, 4- Percent Annual Exceedance Probability (cfs)	2- Percent Annual Exceedance Probability (cfs)	1- Percent Annual Exceedance Probability (cfs)
Updated 2014 District Flows (NY2006 fit to NOAA 14 peaks)	322	411[1]	482	557
Updated 2014 District Flows plus 15% (NY2006 fit to NOAA 14 peaks)	370	473	555	461
FEMA Flows[2]	540	653	800	910
1963 Corps Flows	830	900	1030	1170
PWA 2005 HMS Study Flows[3]	--	1172	--	--

-- Data not computed
[1] District hydrology values for 4-percent annual exceedance probability event; others values for 5-percent annual exceedance probability event
[2] FEMA flows are reported for Ash Street; approximately 1 block from Spruce (District gage)
[3] PWA report notes that its results approximately 6- to 12-percent larger than Corps 5-percent annual exceedance probability event flow

2.4 Boundary Conditions

The downstream boundary for Coyote Creek is influenced by ocean tides. The design water surface profile was computed by the Corps in the 1960s for the 5-percent AEP event flow discharge coincident with a tide in Richardson Bay corresponding to an elevation of 5.4 feet, NAVD 88[1], which was referred to as the Mean Higher High Water (MHHW). The present day MHHW has been re-established at 5.9 feet, NAVD88 (data provided by the District). For this evaluation, a constant water surface elevation of 5.9 feet, NAVD88, was used for MHHW.

The FEMA 1-percent AEP still water elevation (SWEL) for the San Francisco Bay was determined to be elevation 9.7 feet, NAVD88, under the current draft FEMA bay coastal flood studies. To account for future SLR, the District recommended a 36-inch rise in the bay tide level to produce a future 1-percent AEP SWEL that would include SLR, of 12.8 feet, NAVD88. The additional 36-inches of SLR corresponds closer to a projected estimate for year 2070 rather than a projected estimate for 2050; however, for the purposes of this study, the estimate was deemed appropriate and in line with other levee design projects located in the San Francisco Bay. **Table 3** - Hydraulics Downstream Boundary Condition Assumptions below summarizes the hydraulic downstream boundary condition assumed for modeling.

Table 3. Hydraulics Downstream Boundary Condition Assumptions

Tidal Assumption	Boundary Condition Elevations (ft, NAVD88)
MHHW (1960s)	5.4
MHHW (present day)	5.9
MHHW (2050)	8.9
FEMA 1-percent AEP SWEL	9.7
FEMA 1-percent AEP SWEL + SLR	12.7

[1] The computed difference between NGVD29 and NAVD88 in Coyote Creek is +2.7 ft. In 2012, the District established a control point along Coyote Creek by running a control survey back to the NOAA station in Sausalito. In 2013, Meridian Surveying used this control point to determine the vertical difference in datum.

2.5 Hydraulic Model Setup

A total of six (6) HEC-RAS plans were developed as part of this analysis and are summarized in **Table 4** – Existing Conditions Scenarios Descriptions. Each plan consists of a different combination of riverine flow and tidal boundary condition assumptions. The *Baseline* scenario captures the existing channel conditions to verify if the original design objectives of the channel are still being met. The *Updated* scenario captures the existing channel conditions modeled with the District's current design requirements. The *Enhanced A (District 2-percent AEP event)* scenario captures the existing channel conditions to determine what is necessary to increase the channel's level of protection to a 2-percent AEP event. The *Enhanced B (District 1-percent AEP event)* scenario captures the existing channel conditions to determine what is necessary to increase the channel's level of protection to a 1-percent AEP event. *The Existing FEMA Accredited* scenario captures the existing channel condition to determine what is necessary to secure FEMA accreditation for project levees. The *Existing FEMA Accredited with SLR* scenario captures the existing channel conditions to determine what is necessary to secure FEMA accreditation for the year 2050.

To obtain FEMA accreditation for future constructed levees/floodwalls, the top of levee/floodwall elevation will be set using composite water surface profile generated from the controlling flooding source, either tidal or riverine 1-percent AEP event. FEMA's 44 CFR 65.10 freeboard requirements for both coastal and riverine levees will be considered to ensure a seamless level of 1-percent-annual-chance level of flood protection.

The six (6) HEC-RAS plan components are summarized in **Table 4** – Description Existing Conditions Scenarios Descriptions.

Table 4. Description of Existing Conditions Scenarios

Scenarios Name	1 Baseline	2 Updated	3a Enhanced A (District 2-percent annual exceedance probability event)	3b Enhanced B (District 1-percent annual exceedance probability event)	4 FEMA Accredited	5 FEMA Accredited with SLR
Geometry Description	Existing Topography Conditions[1]					
Riverine Hydraulics Flow Assumption	5-percent annual exceedance probability event (1960s Corps Design Flow) Coyote Creek 900 cfs[2] Nyhan Creek 650 cfs[3]	4-percent annual exceedance probability event (District Flow + 15%) Coyote Creek 473 cfs[2] Nyhan Creek 473 cfs[3]	2-percent annual exceedance probability event (District Flow + 15%) Coyote Creek 555 cfs[2] Nyhan Creek 559 cfs[3]	1-percent annual exceedance probability event (District Flow + 15%) Coyote Creek 641 cfs[2] Nyhan Creek 651 cfs[3]	1-percent annual exceedance probability event (FEMA Flow) Coyote Creek 910 cfs[4] Nyhan Creek 920 cfs[3]	1-percent annual exceedance probability event (FEMA Flow) Coyote Creek 910 cfs[4] Nyhan Creek 920 cfs[3]
Riverine Hydraulics Downstream Boundary Condition Assumption	MHHW (1960s - 5.4 ft)	MHHW (Present day 5.9 ft)				MHHW (2050 - 8.9 ft)
Tidal Downstream Boundary Condition	MHHW (1960s - 5.4 ft)	MHHW (Present day 5.9 ft)	FEMA 1-percent annual exceedance probability event and still water elevation (9.7 ft)			FEMA 1-percent annual exceedance probability event and still water elevation + Sea Level Rise (2050 - 12.7 ft)

1. - Existing topography per *Topographic Survey of Portion of Coyote Creek City of Mill Valley* survey by Meridian Surveying Engineering Inc., dated March 2013. Flow is assumed to be contained to the channel.
2. - Flow at Spruce Street District Gage.
3. - Flow at Confluence with Coyote Creek.
4. - Flow at Ash Street; approximately one city block upstream of Spruce Street (District gage).

2.6 Hydraulic Structure Modeling

Hydraulic modeling parameters for structures in the Noble Hydraulic Model 2013 were adjusted to produce stable and accurate results for the modeled flows. Structure modeling methods for hydraulic structures included in the model are provided in **Table 5** - Structure Modeling Methods. Modeling of the bridges in the concrete portion of the Coyote Creek reaches proved to be problematic due to the steepness of the channel and the resultant velocities within the channel, which resulted in spurious spikes in water surface profiles going above and across the bridge decks when the structures were modeled using the standard bridge modeling methods. The standard approach conservatively adds the velocity head to the water surface and, with the higher velocities, the total is above the soffit, triggering pressure flow and creating the spikes in the profiles. This was resolved by using lidded cross sections to model the bridges. With the lidded sections, the velocity head is not added to the water surface and, therefore, at the same flow, the computed water surface in the channel does not contact the soffit and open channel characteristics are maintained. A Priessmann's slot was added to the lids to properly compute pressure flow if soffit contact should occur. The use of lidded cross section is appropriate under these conditions per the HEC-RAS user manual.

Table 5. Structure Modeling Method

Hydraulic Structure Name	HEC-RAS River STA (ft)	Bridge ID	Type of Structure	Modeling Method Used
Coyote Creek				
Ash St.	7600	COC 1400	Bridge (no piers)	Lidded Cross Sections
Private Driveway	7368	COC 1300	Bridge (no piers)	Lidded Cross Sections
Spruce St.	7276	COC1200	Bridge (no piers)	Lidded Cross Sections
Private Driveway	7154	COC 1100	Bridge (no piers)	Lidded Cross Sections
Private Driveway	7060	COC 1000	Bridge (no piers)	Lidded Cross Sections
Pine St.	6966	COC 900	Bridge (no piers)	Lidded Cross Sections
Poplar St.	6652	COC 800	Bridge (no piers)	Lidded Cross Sections
Laurel Way	6402	COC 700	Bridge (no piers)	Lidded Cross Sections
Ross Dr.	5294	COC 600	Bridge (no piers)	Lidded Cross Sections
Energy Dissipator Baffles	5014 and 5006		Baffles	Blocked Obstructions
Flamingo Rd.	4430	COC 500	Bridge	Momentum
Pedestrian Bridge Upstream of Shoreline Hwy	2943	COC 400	Bridge (no piers)	Energy (Standard Step)
Shoreline Hwy	2871	COC 300	Bridge	Momentum
Pedestrian Bridge Downstream of Shoreline Hwy	2837	COC 200	Bridge	Momentum
Mill Valley Sausalito Path	1211	COC 100	Bridge	Energy (Standard Step)
Nyhan Creek				
Enterprise Concourse	913	NYC 200	Bridge (no piers)	Momentum
Marin Ave.	556	NYC 100	Bridge	Energy (Standard Step)

2.7 Manning's n Values

Manning's n-values for the existing conditions HEC-RAS model were taken from the Noble Hydraulic Model 2013 and were only modified at stations 64+87 and 63+18. The adjustments include the updating of the Manning's n values for the channel from 0.014 to 0.0155. The adjustment was done to provide stability to the model.

Based on the report associated with the Noble Hydraulic Model 2013, the same Manning's n-values were also used in the Corps 1960s design of the channel. For the Noble Hydraulic Model 2013 model, Manning's n-values were established based upon channel and overbank conditions. Manning's n-values vary with channel finish, vegetation, condition, material, channel sedimentation/erosion and other factors. The study area streams are comprised of channels that are characterized as float finish concrete lined channel and an earthen channel with short grass and few weeds. Based on the HEC-RAS Reference Manual, the range for a Float Finish Concrete Lined Channel is 0.013 to 0.017 and an Earthen Channel with short grass and few weeds is 0.022 to 0.033. For consistency between the Manning's n-values used by the Corps for the design of the channel, Manning's n-values used in the Noble Hydraulic Model 2013 would be based on the channel design report, 0.025 for the earthen channel, and 0.014 for the concrete channel.

During the development of the Noble Hydraulic Model 2013, sensitivity analysis was conducted to test how the Manning's n-values impact the computed water surface elevation of the study streams. The sensitivity analysis consisted of changing the Manning's n-values within the respective ranges of the channel characteristics. The sensitivity analysis indicated that the study streams are sensitive to the change in Manning's n-values.

2.8 Contraction and Expansion Coefficients

Contraction and expansion coefficients are typically not used in unsteady flow models. Energy losses due to contraction and expansions are accounted for by the momentum equation used for unsteady flow computations. HEC-RAS is a one-dimensional unsteady flow model, and the one-dimensional momentum equation does not always capture all of the forces acting on the flow field at a sharp contraction and/or expansion zone, but there are no locations in the existing Coyote Creek channel where this limitation would be a factor. Therefore, the contraction and expansion coefficients were set to the default setting of 0.0.

At the downstream end of the concrete channel reach there are several energy dissipating baffles that have been covered with sediment. If the model is updated to reflect the removal of the sediment and uncovers the energy dissipating baffles, contraction and expansion coefficients may need to be considered to account for the energy losses that would be seen across the baffles.

2.9 Ineffective Flow Areas

Ineffective flow areas were used where appropriate to limit flow conveyance to portions of the channel cross-section upstream and downstream of bridge constrictions. Ineffective flow areas were also used at other cross-sections to eliminate areas of backwater, ponding and zero conveyance as appropriate.

2.10 Blocked Obstructions

There are two (2) raised wood boardwalks that are parallel to the flow of Coyote Creek, one (1) downstream of the confluence with Nyhan Creek to upstream of Shoreline Hwy and the other downstream of Shoreline Hwy to the Mill Valley Sausalito Path. The boardwalks were represented in the model as Blocked Obstructions with the top elevation at the surveyed deck elevation.

3 Existing Conditions Hydraulic Model Results

3.1 Hydraulic Characteristics

Coyote Creek has two (2) flow regimes for the range of flows examined: supercritical flow on the Upper Reach and subcritical flow for Middle and Lower Reaches. The two (2) different flow regimes are due to differences in slope (0.7-percent) on the Upper Reach of Coyote Creek with milder slopes on the Middle (0.1-percent) and Lower Reaches (0.03-percent). This effect was accounted for by using the Mixed Flow Regime option within HEC-RAS. A hydraulic jump occurs in the channel at the downstream end of the Upper Reach.

Nyhan Creek is characterized by subcritical flow throughout its length. Its slope is similar to that of Coyote Creek Middle Reach (0.4-percent).

There are energy dissipating baffles that are currently covered with sediment deposits located at the downstream portion of the Coyote Creek Upper Reach. If they were to be uncovered, the model will likely need to be modified to account for the energy losses that would be introduced.

3.2 HEC-RAS Existing Alternatives Water Surface Elevations

Water surface elevations results are in **Appendix B** - HEC-RAS Existing Alternatives Results Table. The WSE results are also shown as channel profiles in **Appendix C** - HEC-RAS Existing Alternatives Water Surface Profiles.

3.3 Overtopping of Channel Embankments

3.3.1 Riverine Analysis

Several of the scenarios resulted in overtopping of channel embankments due to high riverine flows. In the Upper Reaches of Coyote Creek, from Laurel Way to downstream of Ross Drive, both sides of the concrete channel are overtopped with the *Baseline* scenario, *FEMA Accredited* scenario, and *FEMA Accredited with SLR* scenario.

Overtopping in the Middle Reaches of the Coyote Creek occurred on both embankments immediately upstream and downstream of Flamingo Road Bridge with the *FEMA Accredited with SLR* scenario. Overtopping of the left channel embankment continued for several hundred feet downstream of the Flamingo Road Bridge.

Overtopping occurred in the Lower Reaches of the Coyote Creek downstream of Hwy 1 on the left embankment and upstream of Mill Valley-Sausalito Path on the right embankment with the *FEMA Accredited with SLR* scenario.

Each of the scenarios showed overtopping on Nyhan Creek upstream of the project levee.

The locations of channel embankment overtopping are shown on the water surface profiles that are located in **Appendix C.**

3.3.2 FEMA 1-Percent AEP SWEL Tidal Analysis

Results showed overtopping of the embankments from the FEMA 1-percent AEP SWEL Tidal Analysis. In the Upper Reaches of the Coyote Creek upstream and downstream of Ross Drive, both sides of the concrete channel are overtopped. The areas that showed overtopping in the Middle Reaches of the Coyote Creek were upstream and downstream of Flamingo Road. The overtopping continued along the left channel embankment to 100 feet downstream of the confluence with Nyhan Creek. The areas that showed overtopping in the Lower Reaches of the Coyote Creek were downstream of Hwy 1 on the left embankment and upstream of Mill Valley-Sausalito Path on the right embankment. Nyhan Creek also showed overtopping upstream of the project levee. The locations of channel embankment overtopping are shown on the water surface profiles that are located in **Appendix C**.

3.3.3 FEMA 1-Percent AEP SWEL Plus Sea Level Rise 2050 Tidal Analysis

Results showed a severe overtopping of the embankments from the FEMA 1-percent AEP SWEL plus Sea Level Rise 2050 Tidal Analysis. Overtopping occurs along the Coyote Creek both embankments downstream of Laurel Way to the confluence with Nyhan Creek. Overtopping also occurs on the left embankment from the confluence with Nyhan Creek to downstream of Hwy 1 and upstream of Mill Valley-Sausalito Path on the right embankment. On Nyhan Creek, both embankments and creek banks upstream of the project levees are overtopped. The locations of channel embankment overtopping are shown on the water surface profiles that are located in **Appendix C**.

3.4 HEC-RAS Computation Parameters and Errors/Warnings Output

The models were configured to reduce the number of errors in the simulation results for each of the model runs. The water surface calculation tolerance parameter was set to 0.05 ft (HEC-RAS default setting 0.02 ft). The number time step iterations for each of the models was set to 40 (HEC-RAS default setting 20 iterations). In addition the Theta Implicit Weighting Factor was set to 0.6 (HEC-RAS default setting 1); the factor is used in the finite difference solution of the unsteady flow equations. A Theta Implicit Weighting Factor of 0.6 will provide the most accurate solution. All other computation options and tolerances were set to the HEC-RAS default settings.

Errors were reviewed to ensure that the model results were accurate and that the errors would not significantly affect the results. The errors are present due to the model not converging to a result that is within the tolerance of the model parameters within the allocated iterations. No errors were found for the *Enhanced A (District 2-percent AEP event)*, *Enhanced B (District 1-percent AEP event)*, and *FEMA Accredited with SLR*. Errors were reduced to three (3) errors on the *Baseline* scenario (present on Nyhan Creek) and are less than 0.067 ft. Errors were reduced to three (3) errors on the *Updated* scenario (present on Nyhan Creek) and are less than 0.082 ft. Errors were reduced to six (6) errors on the *FEMA Accredited* scenario (present on Nyhan Creek) and are less than 0.064 ft.

The model also exhibited several warnings during the simulation period for each Scenario. Warnings were reviewed to ensure that model refinements were not needed. The following are the warnings that were present in the models and the outcome of the reviews.

- Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
    - The conveyance is directly proportional to cross sectional area and inversely proportional to cross sectional Manning's n-value. Since the n-values are consistent for cross sections of the same reach. The conveyance ratio is less than 0.7 or greater than 1.4 due to cross section profile variation. The review determined that cross sections in the model are well spaced and sufficient to define each reach. Further increase in a number of cross sections may not necessarily lead to improvement of model's performance. (This is a warning found in nearly all HEC-RAS models of any complexity).
- Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
    - The drastic change in velocity head can be explained by the variation in a slope of the channel for Upper and Middle reaches. This combined with low Manning's n-values causes flow to transition from subcritical to supercritical flow. The mixed flow regime is used to account for such transitions. This is a warning found in nearly all HEC-RAS models of any complexity.
- Warning: Divided flow computed for this cross-section.
    - For a number of cross sections where block obstructions due to structures introduced the software determined that main flow is divided by such obstructions or natural land masses. All locations with divided flow were reviewed for reasonableness of the flow split. No further action to clear the warning deems necessary.

3.5 Scour Potential of Channel and Hydraulic Structures

Part of this hydraulic evaluation included the evaluation of the channel hydraulic characteristics to determine if the potential for scour within the channel and around hydraulic structures exists. The evaluation of potential scour was based on a modified version of the existing conditions scenario *Enhanced B (District 1-percent AEP event)*. The existing conditions scenario *Enhanced B (District 1-percent AEP event)* was modified to achieve the maximum scour potential within the channel. This was accomplished by updating the downstream model boundary to be set to normal depth using a slope of 0.0002. Once the model was updated an two scour evaluations were performed; Channel Scour and Hydraulic Structure Scour.

3.5.1 Channel Scour

River channel scour for the modified existing conditions scenario *Enhanced B (District 1-percent AEP event)* was calculated using the Bureau of Reclamation's *Computing Degradation and Local Scour* report, dated January 1984. Three empirical equations, Neill, Lacey, and Blench, were used to compute general scour depth throughout the project reach. Equations and input parameters are shown below.

Equation 1. Neill Equation for Channel Scour

$$d_f = d_i \left(\frac{q_f}{q_i}\right)^m$$

Where,

d_f = Scoured depth below design flood water level, ft
d_i = Average depth at bankfull discharge in incised reach, ft
q_f = Design flood discharge per unit width, ft^3/s / ft
q_i = Bankfull discharge in incised reach per unit width, ft^3/s / ft
m = Exponent, 0.67 for sand

Scour depth results are then multiplied by the Z factor, where Z = 0.5 for straight channel, 0.6 for moderate bend and 0.7 for severe bends.

Equation 2. Lacey Equation for Channel Scour

$$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3}$$

Where,

d_m = Mean depth at design discharge, ft
Q = Design discharge, ft^3/s
f = Lacey's silt factor equal to 1.76 $(D_m)^{1/2}$ where D_m equals mean grain size of bed material in millimeters

Scour depth results are then multiplied by the Z factor, where Z = 0.25 for straight channel, 0.5 for moderate bend and 0.75 for severe bends.

Equation 3. Blench Equation for Channel Scour

$$d_{fo} = \frac{q_f^{\,2/3}}{F_{bo}^{\,1/3}}$$

Where,

D_{fo} = Depth for zero bed sediment transport, ft
q_f = Design flood discharge per unit width, ft^3/s / ft
F_{bo} = Blench's zero bed factor, ft/s^2

Scour depth results are then multiplied by the Z factor, where Z factor, where Z = 0.6 for straight channel, 0.6 for moderate bend and 0.6 for severe bends.

Results from three different methods indicate that a range of 1 to 3 feet of scour may occur within the channel if no erosion protection is to be installed. Evaluation was conducted at five (5) representative location for straight, moderate bend, and severe bend. **Table 6** below summarizes the computation results while calculations are included in **Appendix D**.

Table 6 Channel Scour Results

Channel	River Station	Channel Alignment	Neill Equation Depth of Scour (ft)	Lacey Equation Depth of Scour (ft)	Blench Equation Depth of Scour (ft)	Avg. Scour Depth (ft)
Coyote Creek	4975	Moderate Bend	1.1	2.8	3.5	2.5
Coyote Creek	4650	Straight	1.4	1.4	2.7	1.8
Coyote Creek	3350	Severe Bend	2.0	5.1	3.6	3.6
Nyhan Creek	408	Straight	1.5	1.3	4.5	2.4
Nyhan Creek	681	Straight	0.3	1.2	2.6	1.4

3.5.2 Hydraulic Structure Scour

Estimated Hydraulic Structure scour depths were computed using HEC-18 procedures. The scour analysis reflects the estimated depths based on the modified existing conditions scenario *Enhanced B (District 1-percent AEP event)*.

Recent and historic soil data found during site investigation was used for scour analysis. **Table 7** shows the structure, corresponding boring and soil characteristics

Table 7. Soils Data

River	Reach	Bridge RS	Bridge ID	Location	Boring	Soil Characteristics
Coyote Creek	Middle Upper	4430	COC-500	Flamingo Rd Bridge (NCI/MSE 2013 survey)	GEI B-8	D50= 5mm (top 2 ft of soil) (GC)
Coyote Creek	Middle Lower	2943	COC-400	West (New) Hwy 1 Pedestrain Bridge (NCI/MSE survey)	B-8 (2009) B-9 (2009)	B-8 (2009) Brown Sandy Lean Clay with Gravel (CL) B-9 (2009) Gravy poorly faded gravel with clay (GP-GC)
Coyote Creek	Middle Lower	2871	COC-300	Hwy 1 Bridge (NCI/MSE survey)	B-8 (2009) B-9 (2009)	B-8 (2009) Brown Sandy Lean Clay with Gravel (CL) B-9 (2009) Gravy poorly faded gravel with clay (GP-GC)
Coyote Creek	Middle Lower	2837	COC-200	East Hwy 1 Pedestrain Bridge (NCI/MSE survey)	B-8 (2009) B-9 (2009)	B-8 (2009) Brown Sandy Lean Clay with Gravel (CL) B-9 (2009) Gravy poorly faded gravel with clay (GP-GC)
Coyote Creek	Middle Lower	1211	COC-100	Trestle Bridge (NCI/MSE survey)	B-1 (2009) 2f-20 (1964)	Dark gray silty fat clay (CH) bay mud 2f-20(1964) sandy clay fill, light brown and tan moist soft med plasticity gravel to 1" max size
Nyhan Creek	Lower	913	NYC_200	Enterprise Concourse Bridge (NCI/MSE survey)	GEI CPT 9-CONE PENETRATION TEST	Clay
Nyhan Creek	Lower	556	NYC_100	Marin Ave Bridge (NCI/MSE survey)	KB-3 (2007)	Gravely Clay/Clayey Gravel -dark brown, moist, loose/medium dense, fine to coarse and, angular gravel to 0.75" diameter fill (GC/CL)

Boring GEI B-8 reported a D50 particle size of 5mm, based on the sieve analysis. The remaining corresponding boring holes' sieve analysis data was not available; therefore, for the remaining structures a minimum D50 of 0.2 mm was assumed appropriate for the scour computations based on boring holes note provided in the *Compiled Coyote Creek GDR_FINAL REV1* geotechnical report compiled by GEI Consultants.

Structure parameters were also obtained during field visits and was incorporated into the HEC-RAS model and used for scour computations at each structure. Contraction scour was computed for all structures and local scour was computed when appropriate. At the structures modeled in the Coyote Creek HEC-RAS model, contraction scour occurs when the flow area is contracted by the structure and/or encroaching embankments that constrict the floodplain or channel. Local scour is the scour occurs around the piers and abutments. The resulting scour depths are summarized in **Table 8** while calculations are included in **Appendix E**.

Table 8 Scour Depth Summary Data Sheet

Scour Type	COC-100	COC-200	COC-300	COC-400	COC-500	NYC-100	NYC-200
Contraction	2.00 ft	1.00 ft	1.00 ft	1.00 ft	0.00 ft	0.00 ft	0.00 ft
Local (around the piers and abutments)	3.00 ft	3.00 ft	5.00 ft	0.00 ft	3.00 ft	5.00 ft	4.00 ft

4 Channel Sediment Loading

Chanel sediment loading rate was determined to be 0.8 inches per year based on the Sedimentation Analysis that was performed by Noble Consultants, Inc., see **Appendix F** for Noble Consultants, Inc. Memorandum. Noble Consultants performed the sedimentation analysis for the District 2013. The sedimentation analysis was developed from three sedimentation quantities that were calculated:

1. 1999 to Design. Shoaling between the design template and the 1999 condition survey.
2. 2013 to Design. Shoaling between the design template and the 2013 condition survey.
3. 2003 to 2013. Shoaling between the 2003 post-excavation survey and the 2013 condition survey.

Using the sediment loading rate developed by Noble Consultants the impacts to flood protection were evaluated at six (6) location within the Coyote Creek and Nyhan Creek channels. The evaluation consisted of applying the sediment loading rate to the existing channel geometry at the six (6) locations over four (4) time durations (+1 year, +5 year, +15 year and +30 year). Once new channel geometries, that included the sediment loading, were developed normal depth calculations were done to determine the water surface elevation increase from the sediment loading. This evaluation utilized the Districts 1-percent annual exceedance probability event flows plus a 15 percent flow increase. Normal depth calculations were done using Bentley FlowMaster V8i (Select series 1) computer program.

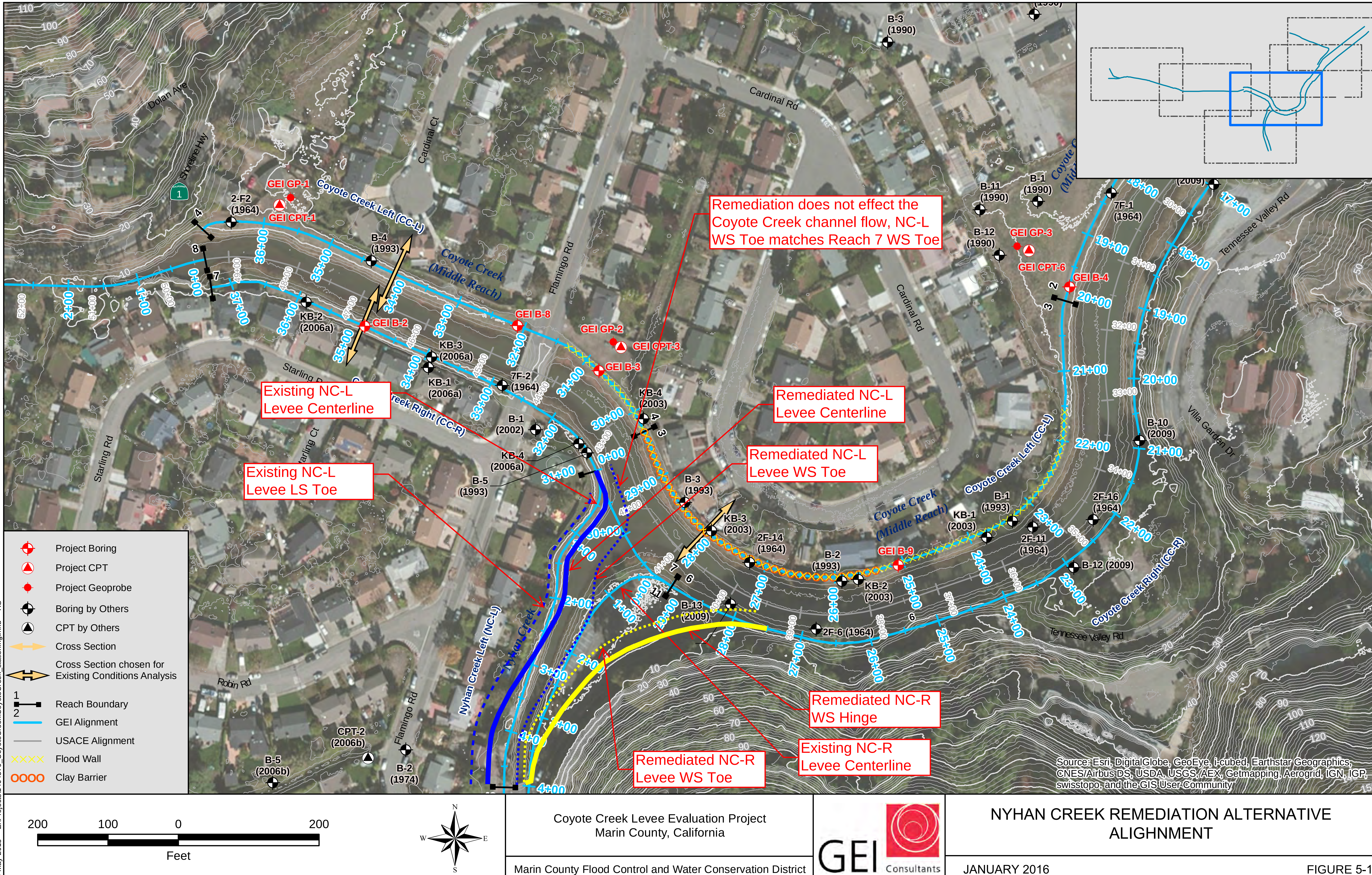
The evaluation showed an average water surface elevation increase of 0.03 ft, 0.13 ft , 0.44 ft and a 1.09 ft for a plus one (1) year, plus five (5) year, plus fifteen (15) year and a plus thirty (30) year span respectively. See **Appendix E** for Model outputs and calculations

5 Remediation Alternative

Part of GEI's geotechnical evaluation included the development of a proposed alternative for flood control upgrades that captured the geotechnical deficiencies of the existing levees. Based on the District goals, objectives, and site constraints a potential Remediation Alternative was developed, that could impact the hydraulic analysis. See **Figure 5-1** for Remediation Alternative configuration. The Remediation Alternative included re-configuring of Nyhan stream downstream of Marin Avenue to the confluence with Coyote Creek. The revised alignment allowed the West levee to have a crown elevation of 15.7 ft with side slopes of 3:1

(Horizontal:Vertical). For embankment stability 3:1 side slopes were also used on the East embankments. The channel bottom width varied from 10.5 ft downstream of Marin Avenue Bridge to 140 ft at the confluence with Coyote Creek. The Remediation Alternative was evaluated under the same boundary conditions as the existing scenarios.

The results of the evaluation of the Remediation Alternative showed that the channel re-alignment had limited affects on Nyhan Creek and no affects on Coyote Creek. Based on HEC-RAS modeling of the Remediation Alternative a reduction of water surface elevations are seen on Nyhan Creek. The reduction of water surface elevations ranged from 0 ft to 0.59 ft, see **Appendix H** for model results.



Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

NYHAN CREEK REMEDIATION ALTERNATIVE ALIGNMENT

JANUARY 2016

FIGURE 5-1

26-May-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS

6 Recommendations

It is recommended to perform a wind and wave run-up evaluation and/or review available studies recently completed covering the project area to ensure that the proposed project configuration accounts for the effects of wind and wave run-up. This analysis will help determine if the flood protecting structure has proper freeboard and if armoring on the structure is needed.

It is recommended that debris be removed from baffles that are located at the downstream for the concrete channel. Maintenance of the baffles should be incorporated into the Owners Manual to ensure proper maintenance/debris removed from the structure is performed on a routine basis.

It is also recommended that a more detailed evaluation of channel and hydraulic structures scour be performed during design to determine if bank revetment or armoring is needed around hydraulic structures.

7 Model Electronic Files

Table 9. List of HEC-RAS Model Files and Descriptions

Type of File	File Description	File Name
HEC-RAS Project File	Coyote Creek Levee Evaluation	.prj
	Noble Hydraulic Model 2013	
Plan	Noble -Unsteady, Existing, bridges+weirs	.p06
Geometry File	Noble - Exis geo, brid+lateral weirs	.g03
Unsteady Flow File	Noble - 20-yr flow hydro, w brid+weirs	.u06
	HEC-RAS Plan for Viewing Profiles	
Plan	Plan for Viewing Profiles	.p02
Geometry File	Geometry for Viewing Profiles	.g02
Unsteady Flow File	N/A	N/A
	Scenario 1 – Baseline	
Plan	Exist Base (20Y Des. Q 1960s)No Q Out	.p11
Geometry File	Exist Cond Lid Brid - NoQ out	.g04
Unsteady Flow File	20Y Design Flows	.u04
	Scenario 2 – Updated	
Plan	Existing Updated (25Y District Q + 15%)	.p03
Geometry File	Existing Conditions Lidded Bridge	.g01
Unsteady Flow File	25Y Distict Flows + 15%	.u02
	Scenario 3a – Enhanced (District 50-Yr Event)	
Plan	Existing Enhanced "A" (50Y Dist Q + 15%)	.p04
Geometry File	Existing Conditions Lidded Bridge	.g01
Unsteady Flow File	50Y Distict Flows + 15%	.u03
	Scenario 3b – Enhanced (District 100-Yr Event)	
Plan	Exist Enhan "B"(100Y Dist Q+15%)No Q Out	.p10
Geometry File	Exist Cond Lid Brid - NoQ out	.g04
Unsteady Flow File	100Y Distict Flows + 15%	.u05
	Scenario 4 – FEMA Accredited	
Plan	Exist FEMA Accred (100Y FEMA Q) No Q Out	.p12
Geometry File	Exist Cond Lid Brid - NoQ out	.g04
Unsteady Flow File	100Y FEMA Flow Present Day MHHW	.u08
	Scenario 5 – FEMA Accredited With Sea Level Rise	
Plan	ExistFEMAAccredW/SLR(100Y FEMA Q)NoQ Out	.p13
Geometry File	Exist Cond Lid Brid - NoQ out	.g04
Unsteady Flow File	100Y FEMA Flow Present Day MHHW 2050	.u09
	Scenario 3b – Enhanced (District 100-Yr Event) Scour Evaluation	
Plan	Exist Enhan "B"(100Y Dist Q+15%)No Q Out	.p15
Geometry File	Exist Cond Lid Brid - NoQ out	.g04
Unsteady Flow File	100Y Distict Flows + 15%_Scour_NorDep	.u07
	Remediation Alternative Scenario 1 – Baseline	
Plan	Exist Base (20Y Des. Q 1960s)No Q Out	.p08
Geometry File	Alt Cond Lid Brid - NoQ out	.g06
Unsteady Flow File	20Y Design Flows	.u04
	Remediation Alternative Scenario 2 – Updated	
Plan	Existing Updated (25Y District Q + 15%)	.p01
Geometry File	Alt Cond Lid Brid - NoQ out	.g06
Unsteady Flow File	25Y Distict Flows + 15%	.u02

Type of File	File Description	File Name
Remediation Alternative Scenario 3a – Enhanced (District 50-Yr Event)		
Plan	Existing Enhanced "A" (50Y Dist Q + 15%)	.p05
Geometry File	Alt Cond Lid Brid - NoQ out	.g06
Unsteady Flow File	50Y Distict Flows + 15%	.u03
Remediation Alternative Scenario 3b – Enhanced (District 100-Yr Event)		
Plan	Exist Enhan "B"(100Y Dist Q+15%)No Q Out	.p07
Geometry File	Alt Cond Lid Brid - NoQ out	.g06
Unsteady Flow File	100Y Distict Flows + 15%	.u05
Remediation Alternative Scenario 4 – FEMA Accredited		
Plan	Exist FEMA Accred (100Y FEMA Q) No Q Out	.p09
Geometry File	Alt Cond Lid Brid - NoQ out	.g06
Unsteady Flow File	100Y FEMA Flow Present Day MHHW	.u08
Remediation Alternative Scenario 5 – FEMA Accredited With Sea Level Rise		
Plan	ExistFEMAAccredW/SLR(100Y FEMA Q)NoQ Out	.p14
Geometry File	Alt Cond Lid Brid - NoQ out	.g04
Unsteady Flow File	100Y FEMA Flow Present Day MHHW 2050	.u09

Appendix A

Field Visit Notes

Hydraulic Structure Field Visit Form

Project Name: Coyote Creek Levee Evaluation
AEC: HDR Inc.
Date of Filed Visit: 5/14/2014

AEC Field Engineers: Chris Acosta & Chris Buller
Reviewed by: Wazhma Bahramand

Structure Location: Coyote Creek @ Trestle Ped. Bridge
River Mile: 0.022 Miles to confluence of Bay

Structure Type: Bridge
Structure ID: COC_100a

Description: Pedestrian Bridge
Trestle Bridge (NCI/MSE survey)

Bridge

# of Piers 8 @ with 17" diameter peirs (in HEC_RAS model provided by District 8 @ 12")
# of Columns/Pier 5
Pier Shape: Circular
Deck Width (ft): 10' (in HEC_RAS model provided by District 10')
Deck Thickness (ft): 2.5' (in HEC_RAS model provided by District 2.37')
Rail Height (ft): 4.33' from top of rail to sofit
Deck Skewed: No
Pier Skewed: No
Channel Lining: No lining
Abutments: N/A
Weir Location: Top of Road
"n" Value Variation: 0.025
Baffle: N/A

Culvert N/A

Barrel Shape: Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:
Material: Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):
Culvert Width (ft):
Culvert Height/Diameter (ft):
Depth Blocked:
Skewed: Yes, No
Inlet Type: Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge: Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):
Depth to Top of Road (ft):
Weir Location: Top of Road, Top of Rail, Comb
"n" Value Variation:
Baffle: Upstream, Downstream

Weir N/A

Weir Type: Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape: Rectangular, Trapezoidal, Ogee, V-notch
Crest Type: Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):
Weir Width (ft):
Side-Slopes (ft):
Crest Height:
Gates Type: Sluice, Radial, Overflow
# of Gates:
Gate Width (ft):
Gate Height (ft):
Channel Lining: No lining, Concrete, Rock, Other
"n" Value Variation:
Baffle: Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream: COC_100a _DSF_001
Structure Face Upstream: COC_100a _USF_002
Downstream Channel: COC_100a _DSC_003
Upstream Channel: COC_100a _USC_004

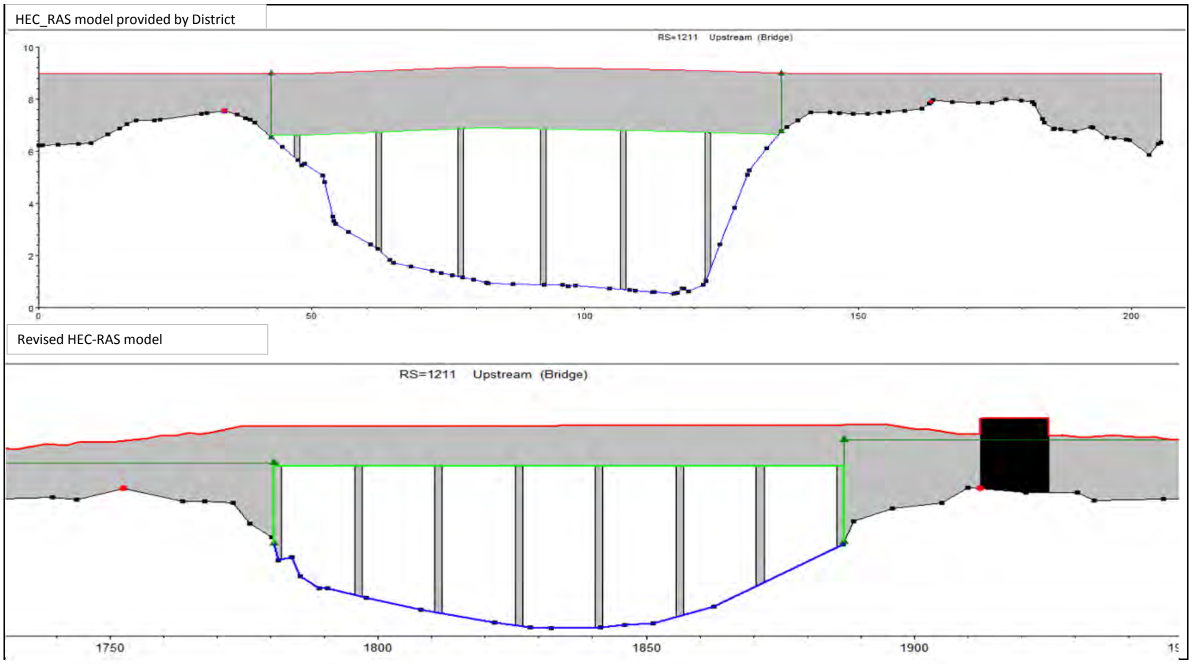
Road (right): COC_100a _TODR_005
Road (left): COC_100a _TODL_006

Sketch

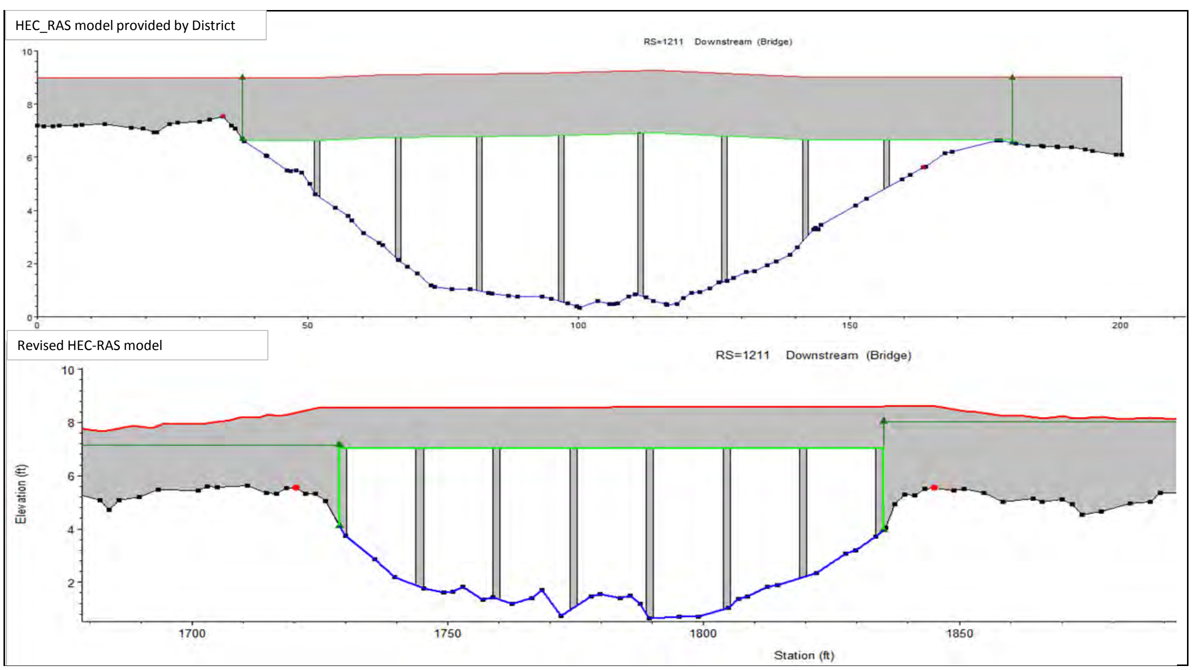
Structure Type: Bridge

Structure ID: COC_100a

Upstream



Downstream



Elevation adjusment +/- ______________________

Structure Face Downstream: COC_100a _DSF_001

Downstream Channel: COC_100a _DSC_003

Structure Face Upstream: COC_100a _DSF_002

Upstream Channel: COC_100a _USC_004

Road (right): COC_100a _TODR_005

Road (left): COC_100a _TODL_006

Hydraulic Structure Field Visit Form

Project Name: Coyote Creek Levee Evaluation
AEC: HDR Inc.
AEC Field Engineers: Chris Acosta & Chris Buller
Date of Filed Visit: 5/14/2014
Reviewed by: Wazhma Bahramand

Structure Location: Coyote Creek @ Trestle Ped. Bridge
Structure Type: Bridge
River Mile: 0.022 Miles to confluence of Bay
Structure ID: COC_100b

Description: Pedestrian Bridge
Trestle Bridge (NCI/MSE survey)
Note: Bridge not in model provided by the District

Bridge

# of Piers	2 @ with 11" diameter peirs
# of Columns/Pier	
Pier Shape:	Circular
Deck Width (ft):	10'
Deck Thickness (ft):	1.17'
Rail Height (ft):	4.33' from top of rail to sofit
Deck Skewed:	No
Pier Skewed:	No
Channel Lining:	No lining
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.025
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

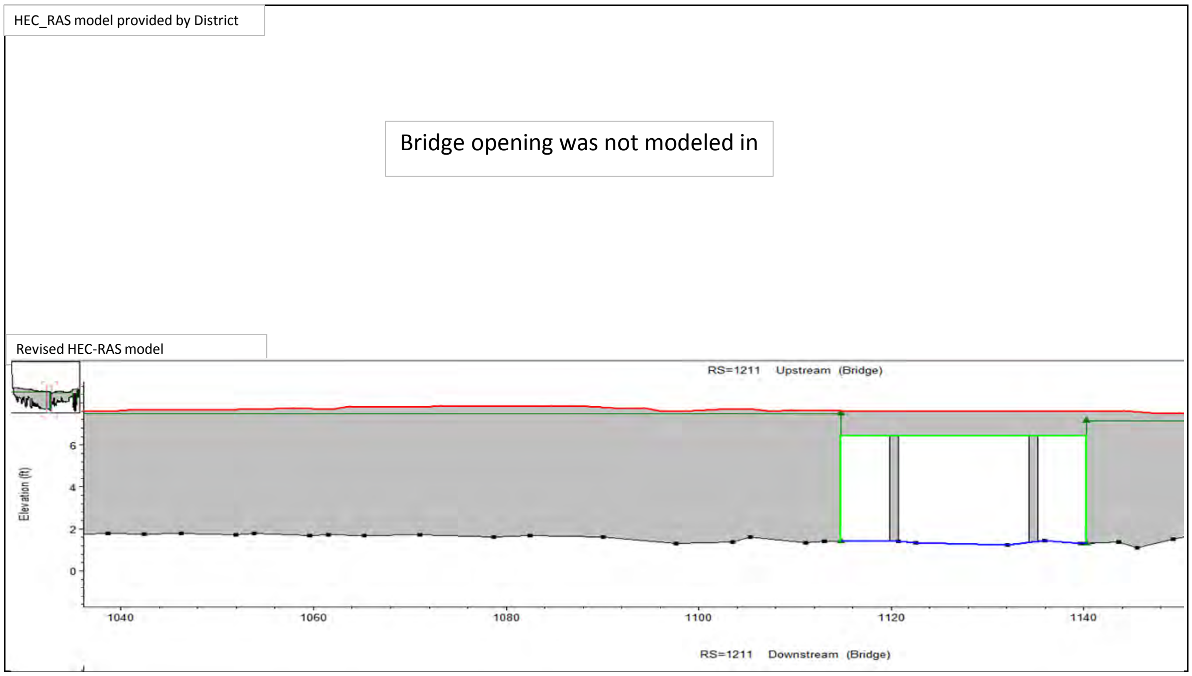
Photo IDs:

Structure Face Downstream:	COC_100b _DSF_007	Road (right):	COC_100b _TODR_011
Structure Face Upstream:	COC_100b _USF_008	Road (left):	COC_100b _TODL_012
Downstream Channel:	COC_100b _DSC_009		
Upstream Channel:	COC_100b _USC_010		

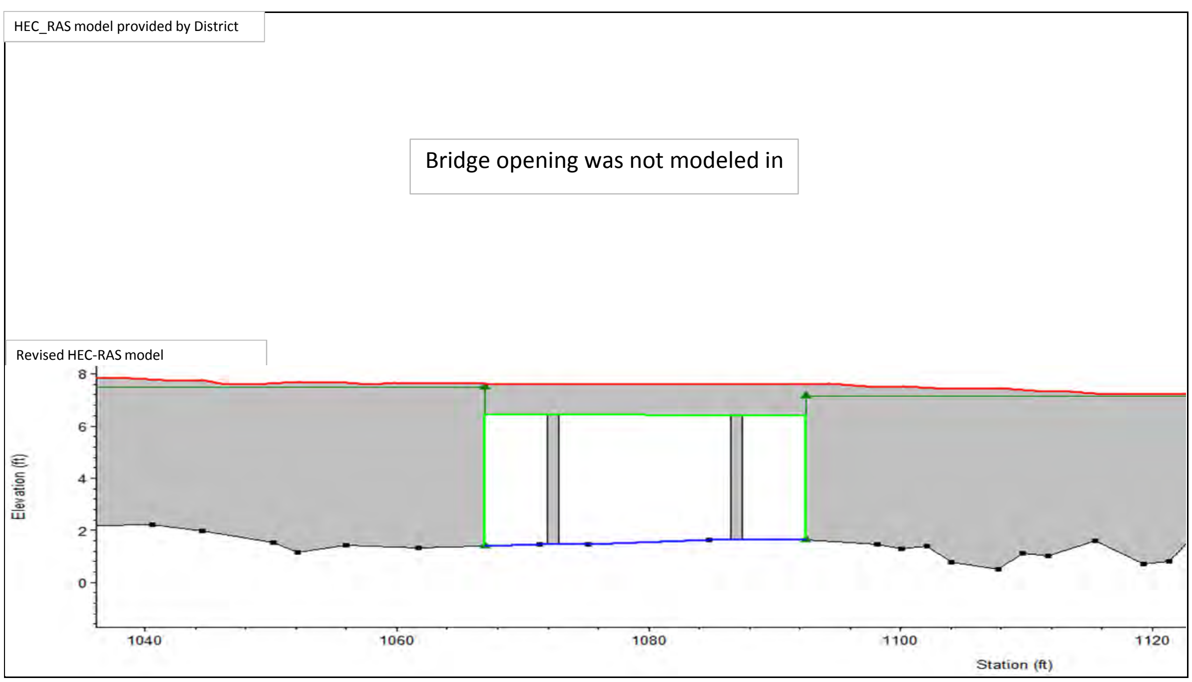
Sketch

Structure Type: Bridge
Structure ID: COC_100b

Upstream



Downstream



Elevation adjusment +/- ______________________

Structure Face Downstream: COC_100b _DSF_007

Downstream Channel: COC_100b _DSC_009

Structure Face Upstream: COC_100b _USF_008

Upstream Channel: COC_100b _USC_010

Road (right): COC_100b _TODR_011

Road (right): COC_100b _TODR_012

Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Hwy 1 Ped. Bridge	Structure Type:	Bridge
River Mile:	0.33 Miles to confluence of Bay	Structure ID:	COC_200

Description: Pedestrian Bridge
OLD Hwy 1 Pedestrain Bridge (NCI/MSE survey)

Bridge

# of Piers	5 @ with 12" diameter peirs (in HEC_RAS model provided by District 4 @ 12")
# of Columns/Pier	2
Pier Shape:	Circular
Deck Width (ft):	5.7' (in HEC_RAS model provided by District 6')
Deck Thickness (ft):	1.54' (in HEC_RAS model provided by District 1.58')
Rail Height (ft):	5.8'
Deck Skewed:	No
Pier Skewed:	No
Channel Lining:	No lining
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.025
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

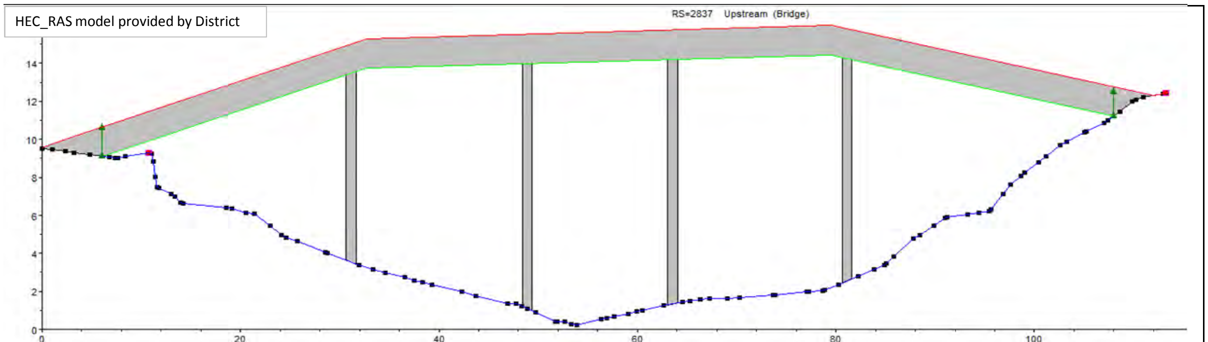
Structure Face Downstream:	COC_200 _DSF_013	Road (right):	COC_200 _TODR_017
Structure Face Upstream:	COC_200 _USF_014	Road (left):	COC_200 _TODL_018
Downstream Channel:	COC_200 _DSC_015		
Upstream Channel:	COC_200_USC_016		

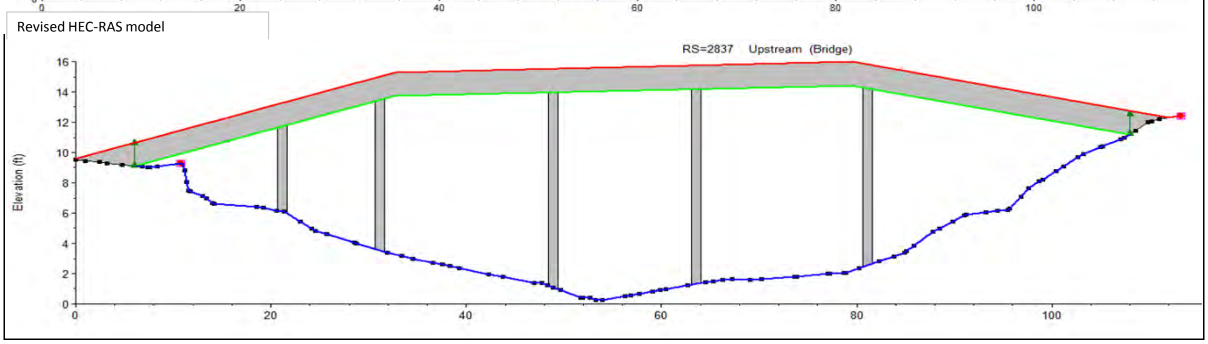
Sketch

Structure Type: Bridge

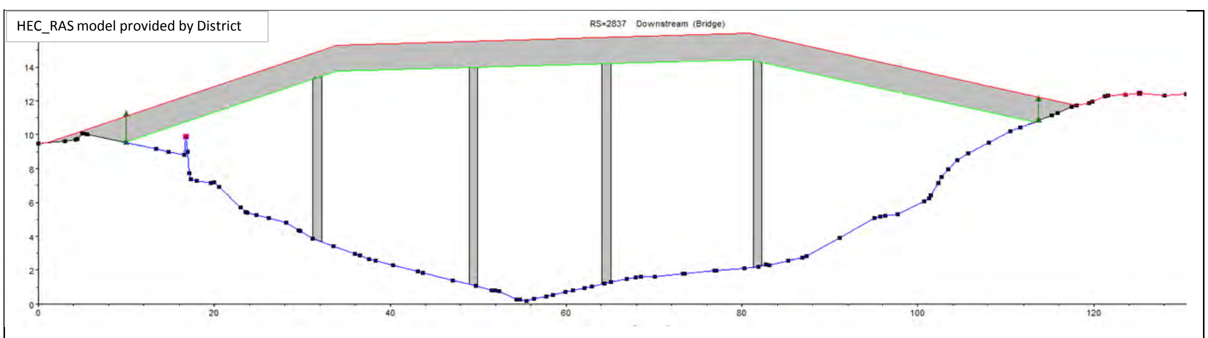
Structure ID: COC_200

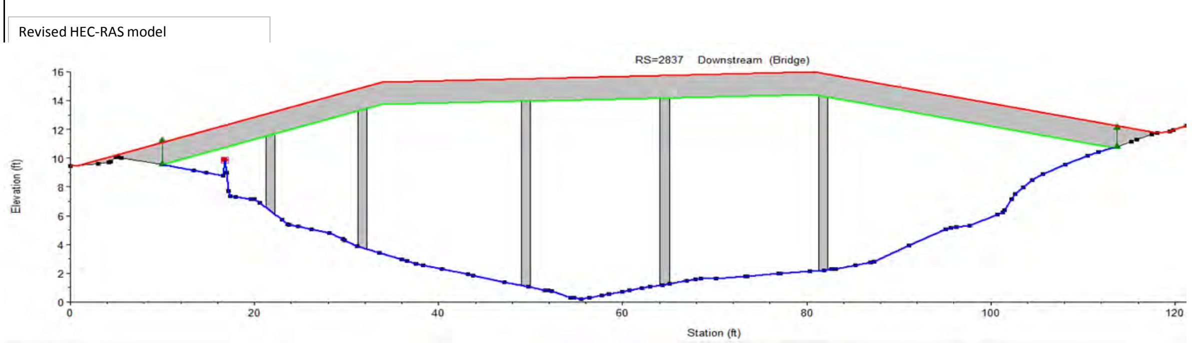
Upstream





Downstream





Elevation adjusment +/- ______________________

Structure Face Downstream: COC_200 _DSF_013

Downstream Channel: COC_200 _DSC_015

Structure Face Upstream: COC_200 _USF_014

Upstream Channel: COC_200_USC_016

Road (right): COC_100 _TODR_017

Road (left): COC_100 _TODL_018

Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Hwy 1 Bridge	Structure Type:	Bridge
River Mile:	0.34 Miles to confluence of Bay	Structure ID:	COC_300

Description: Transportation Bridge
Hwy 1 Bridge (NCI/MSE survey)

Bridge

# of Piers	4 @ 16" diameter peirs (in HEC_RAS model provided by District 4 @ 16")
# of Columns/Pier	4
Pier Shape:	Circular
Deck Width (ft):	32' (in HEC_RAS model provided by District 32')
Deck Thickness (ft):	1.1' (in HEC_RAS model provided by District 1.1')
Rail Height (ft):	3.5'
Deck Skewed:	No
Pier Skewed:	No
Channel Lining:	No lining
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.025
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream:	COC_300 _DSF_019	Road (right):	COC_300 _TODR_020
Structure Face Upstream:	COC_300 _USF_021	Road (left):	COC_300 _TODL_022
Downstream Channel:	COC_300 _DSC_023		
Upstream Channel:	COC_200 _USC_015		

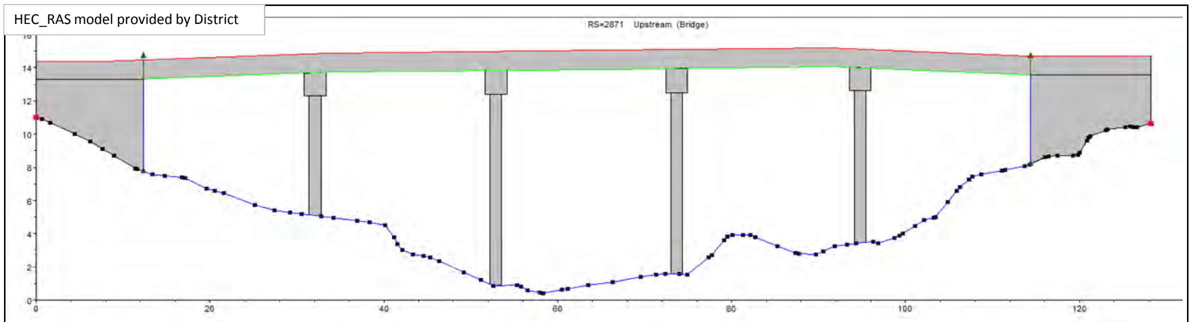
Sketch

Structure Type: Bridge

Structure ID: COC_300

Upstream

HEC_RAS model provided by District

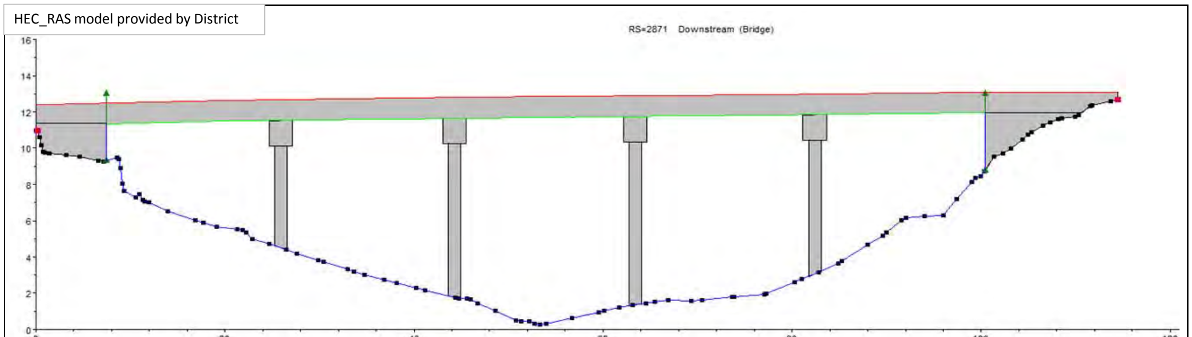


Revised HEC-RAS model

No Updates

Downstream

HEC_RAS model provided by District



Revised HEC-RAS model

No Updates

Elevation adjusment +/- ____________________

Structure Face Downstream: COC_300 _DSF_019

Downstream Channel: COC_300 _DSC_023*

Structure Face Upstream: COC_300 _USF_021

Upstream Channel: COC_300 _USC_015**

Road (right): COC_300 _TODR_020

Road (left): COC_300 _TODL_022

* Photo is downstream of pedestrian bridge downstream of Hwy 1

* * Photo is Upstream of pedestrian bridge Uptream of Hwy 1

Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Hwy 1 Ped. Bridge	Structure Type:	Bridge
River Mile:	0.35 Miles to confluence of Bay	Structure ID:	COC_400

Description: Pedestrian Bridge
New Hwy 1 Pedestrain Bridge (NCI/MSE survey)

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	N/A
Pier Shape:	N/A
Deck Width (ft):	9' (in HEC_RAS model provided by District 9')
Deck Thickness (ft):	2' (in HEC_RAS model provided by District 2')
Rail Height (ft):	6.58' from bottom of deck
Deck Skewed:	No
Pier Skewed:	N/A
Channel Lining:	No lining
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.025
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream:	COC_400 _DSF_024	Road (right):	COC_400 _TODR_025
Structure Face Upstream:	COC_400 _USF_026	Road (leftt):	COC_400 _TODL_027
Downstream Channel:	COC_400 _DSC_028		
Upstream Channel:	COC_400 _USC_023		

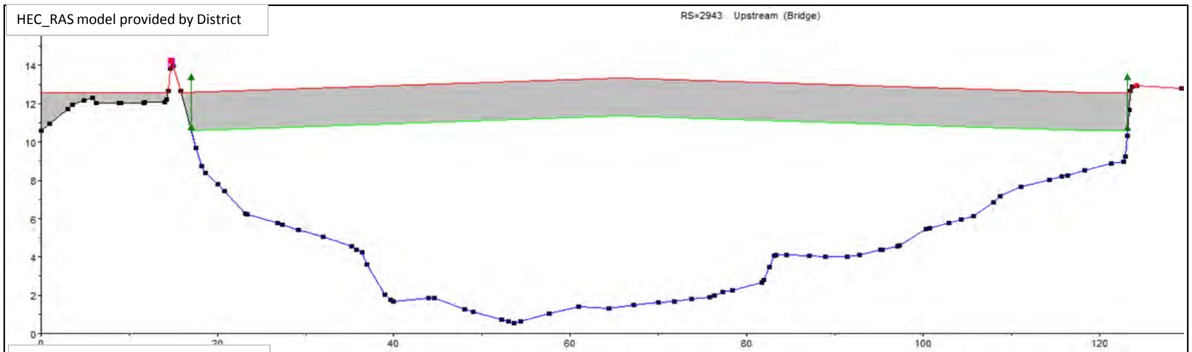
Sketch

Structure Type: Bridge

Structure ID: COC_400

Upstream

HEC_RAS model provided by District

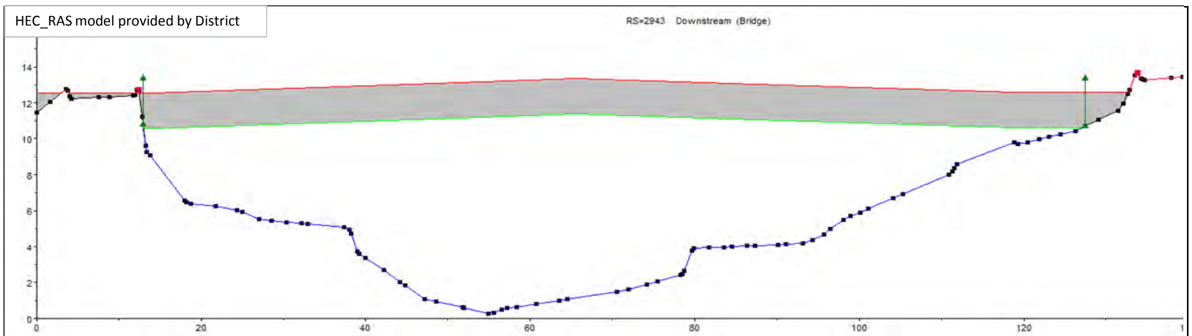


Revised HEC-RAS model

No Updates

Downstream

HEC_RAS model provided by District



Revised HEC-RAS model

No Updates

Elevation adjusment +/- ______________________________

Structure Face Downstream: COC_400 _DSF_024

Downstream Channel: COC_400 _DSC_028

Structure Face Upstream: COC_400 _USF_026

Upstream Channel: COC_400 _USC_023

Road (right): COC_400 _TODR_025

Road (leftt): COC_400 _TODL_027

Hydraulic Structure Field Visit Form

Project Name: Coyote Creek Levee Evaluation
AEC: HDR Inc.
Date of Filed Visit: 5/14/2014

AEC Field Engineers: Chris Acosta & Chris Buller
Reviewed by: Wazhma Bahramand

Structure Location: Coyote Creek @ Flamingo Rd Bridge
River Mile: 0.63 Miles to confluence of Bay

Structure Type: Bridge
Structure ID: COC_500

Description: Transportation Bridge
Flamingo Rd Bridge (NCI/MSE 2013 survey)

Bridge

# of Piers	2 @ with ?" diameter peirs (in HEC_RAS model provided by District 2)
# of Columns/Pier	3
Pier Shape:	Circular
Deck Width (ft):	42' (in HEC_RAS model provided by District 42')
Deck Thickness (ft):	2.25' (in HEC_RAS model provided by District 2.3')
Rail Height (ft):	5.4'
Deck Skewed:	No
Pier Skewed:	No
Channel Lining:	No lining
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.025
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream: COC_500 _DSF_041
Structure Face Upstream: COC_500 _USF_043
Downstream Channel: COC_500 _DSC_045
Upstream Channel: COC_500 _USC_046

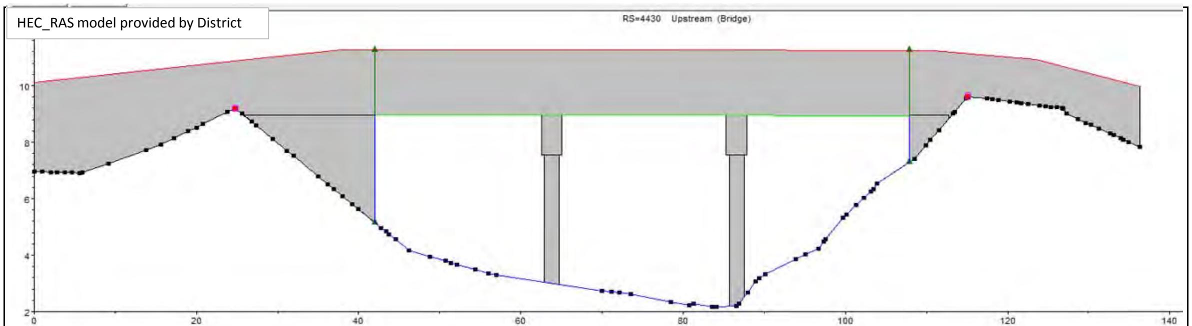
Road (right): COC_500 _TODR_042
Road (leftt): COC_500 _TODL_044

Sketch

Structure Type: Bridge

Structure ID: COC_500

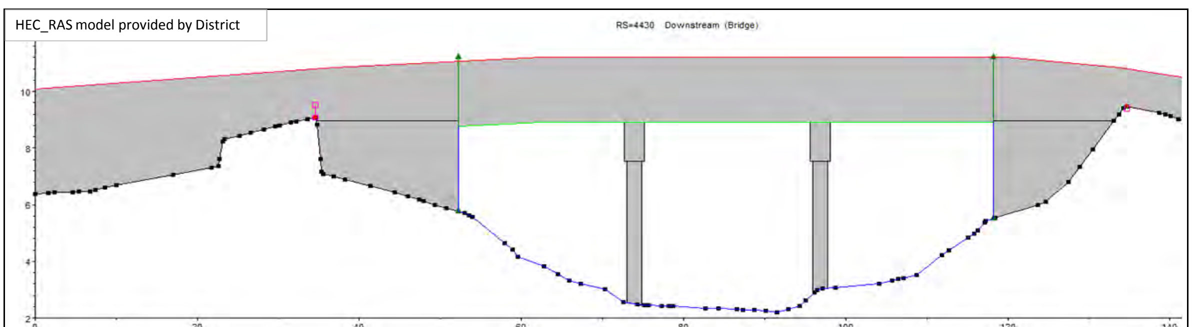
Upstream



Revised HEC-RAS model

No Updates

Downstream



Revised HEC-RAS model

No Updates

Elevation adjusment +/- ______________________________

Structure Face Downstream: COC_500 _DSF_041

Downstream Channel: COC_500 _DSC_045

Structure Face Upstream: COC_500 _USF_043

Upstream Channel: COC_500 _USC_046

Road (right): COC_500 _TODR_042

Road (leftt): COC_500 _TODL_044

Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Ross Drive Bridge	Structure Type:	Bridge
River Mile:	0.8 Miles to confluence of Bay	Structure ID:	COC_600

Description: Local Road Crossing
Ross Drive

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	
Pier Shape:	N/A
Deck Width (ft):	38' (in HEC_RAS model provided by District 38')
Deck Thickness (ft):	1.72' (in HEC_RAS model provided by District 1.72')
Rail Height (ft):	5.4' from top of Rail to top of Deck
Deck Skewed:	No
Pier Skewed:	N/A
Channel Lining:	Concrete
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.014
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream:	COC_600 _DSF_051	Road (right):	
Structure Face Upstream:	COC_600 _USF_054	Road (leftt):	
Downstream Channel:	COC_600 _DSC_052		
Upstream Channel:	COC_600 _USC_053		

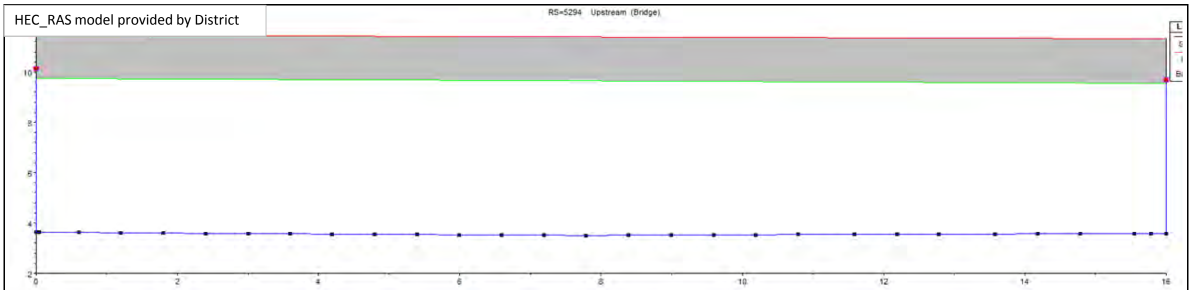
Sketch

Structure Type: Bridge

Structure ID: COC_600

Upstream

HEC_RAS model provided by District

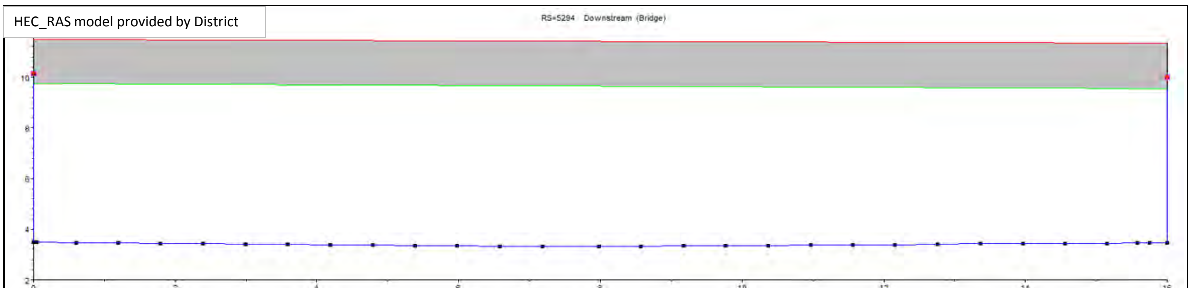


Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Downstream

HEC_RAS model provided by District



Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Elevation adjusment +/- ______________________________

Structure Face Downstream: COC_600 _DSF_051

Downstream Channel: COC_600 _DSC_052

Structure Face Upstream: COC_600 _USF_054

Upstream Channel: COC_600 _USC_053

Hydraulic Structure Field Visit Form

Project Name: Coyote Creek Levee Evaluation
AEC: HDR Inc.
AEC Field Engineers: Chris Acosta & Chris Buller
Date of Filed Visit: 5/14/2014
Reviewed by: Wazhma Bahramand

Structure Location: Coyote Creek @ Laurel Way Bridge
Structure Type: Bridge
River Mile: 1.0 Miles to confluence of Bay
Structure ID: COC_700

Description: Local Road Crossing and parking lot
Laurel Way

Bridge

# of Piers 0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier
Pier Shape: N/A
Deck Width (ft): 158.6' (in HEC_RAS model provided by District 158.6')
Deck Thickness (ft): 1.75' (in HEC_RAS model provided by District 1.75')
Rail Height (ft): 6.1' from top of rail to soffet
Deck Skewed: No
Pier Skewed: N/A
Channel Lining: Concrete
Abutments: N/A
Weir Location: Top of Road
"n" Value Variation: 0.014
Baffle: N/A

Culvert N/A

Barrel Shape: Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:
Material: Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):
Culvert Width (ft):
Culvert Height/Diameter (ft):
Depth Blocked:
Skewed: Yes, No
Inlet Type: Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge: Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):
Depth to Top of Road (ft):
Weir Location: Top of Road, Top of Rail, Comb
"n" Value Variation:
Baffle: Upstream, Downstream

Weir N/A

Weir Type: Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape: Rectangular, Trapezoidal, Ogee, V-notch
Crest Type: Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):
Weir Width (ft):
Side-Slopes (ft):
Crest Height:
Gates Type: Sluice, Radial, Overflow
# of Gates:
Gate Width (ft):
Gate Height (ft):
Channel Lining: No lining, Concrete, Rock, Other
"n" Value Variation:
Baffle: Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream: COC_700 _DSF_055
Road (right):
Structure Face Upstream: COC_700 _USF_058
Road (leftt):
Downstream Channel: COC_700 _DSC_056
Upstream Channel: COC_700 _USC_057

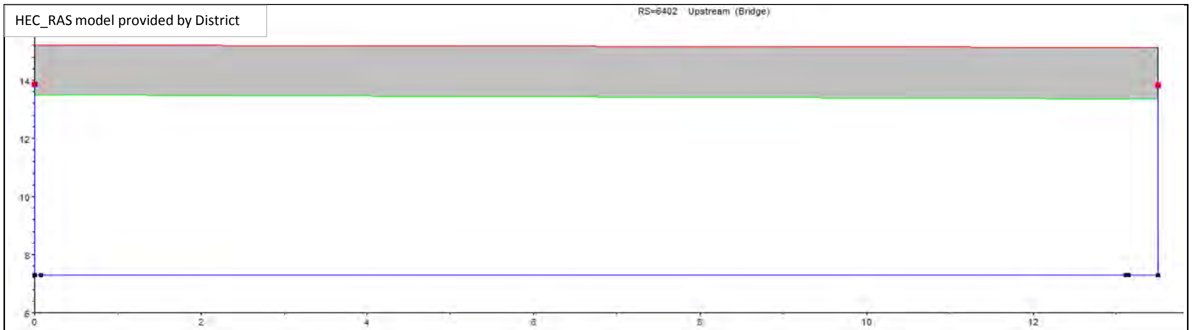
Sketch

Structure Type: Bridge

Structure ID: COC_700

Upstream

HEC_RAS model provided by District

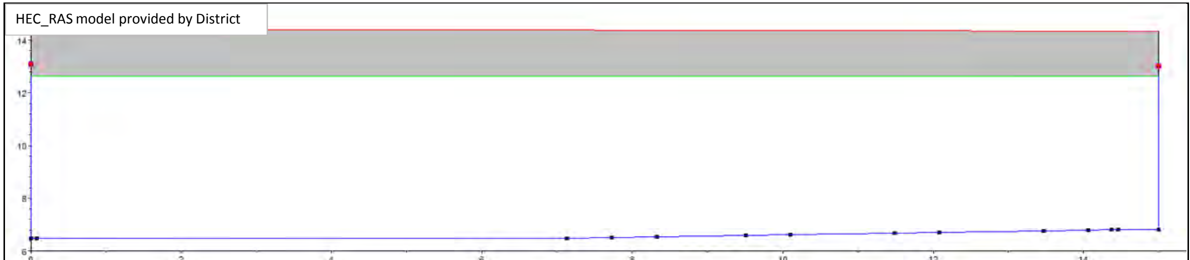


Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Downstream

HEC_RAS model provided by District



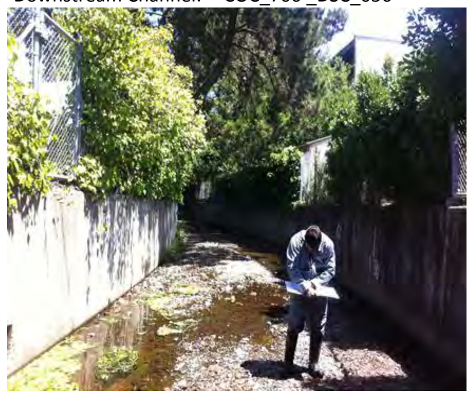
Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Elevation adjusment +/- ______________________

Structure Face Downstream: COC_700 _DSF_055

Downstream Channel: COC_700 _DSC_056



Structure Face Upstream: COC_700 _USF_058

Upstream Channel: COC_700 _USC_057

Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Poplar Street Bridge	Structure Type:	Bridge
River Mile:	1.06 Miles to confluence of Bay	Structure ID:	COC_800

Description: Local Road Crossing
Poplar Street

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	N/A
Pier Shape:	N/A
Deck Width (ft):	32.9' (in HEC_RAS model provided by District 32.9')
Deck Thickness (ft):	1.83' (in HEC_RAS model provided by District 1.85')
Rail Height (ft):	6.1' from top of rail to soffet
Deck Skewed:	No
Pier Skewed:	N/A
Channel Lining:	Concrete
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.014
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream:	COC_800 _DSF_059	Road (right):	
Structure Face Upstream:	COC_800 _USF_062	Road (leftt):	
Downstream Channel:	COC_800 _DSC_060		
Upstream Channel:	COC_800 _USC_061		

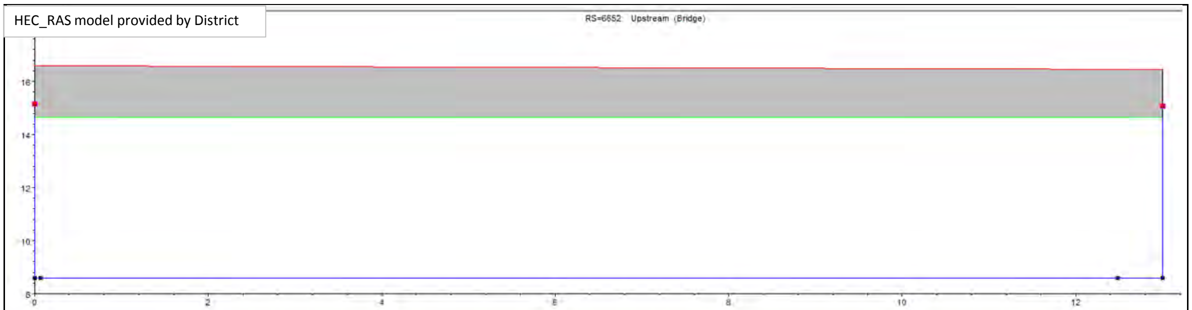
Sketch

Structure Type: Bridge

Structure ID: COC_800

Upstream

HEC_RAS model provided by District

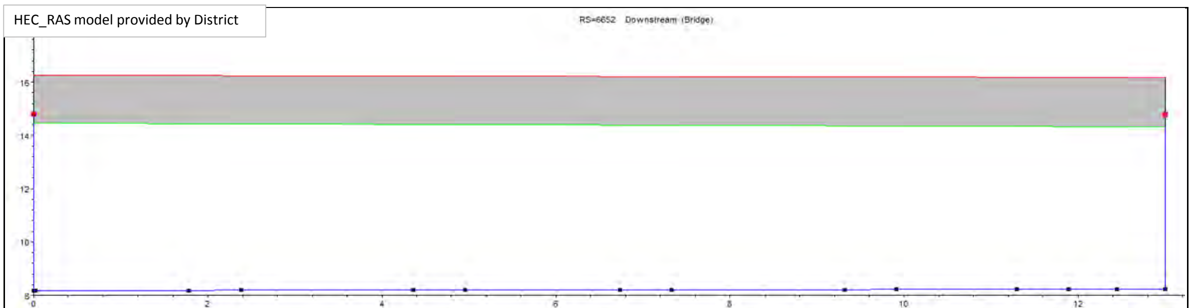


Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Downstream

HEC_RAS model provided by District

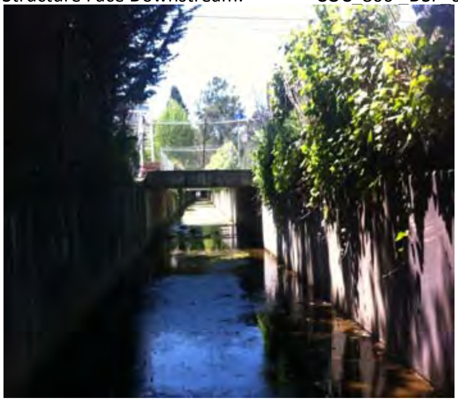


Revised HEC-RAS model

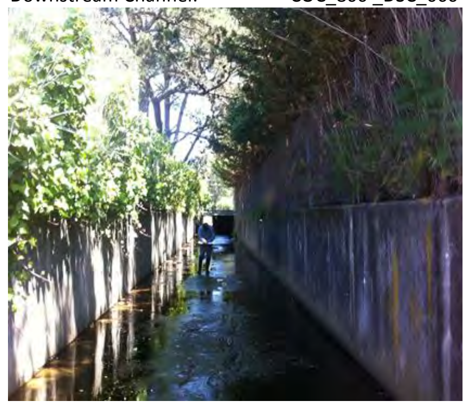
Bridge was converted to a Lidded Cross Section using the bridge configuration

Elevation adjusment +/- ______________________________

Structure Face Downstream: COC_800 _DSF_059

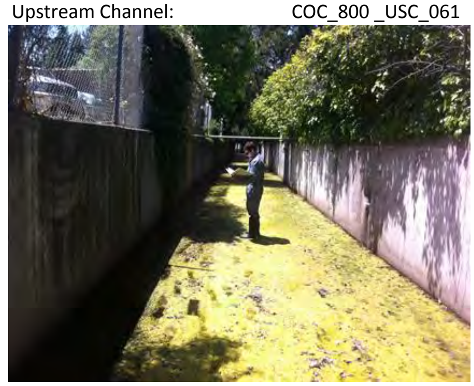


Downstream Channel: COC_800 _DSC_060



Structure Face Upstream: COC_800 _USF_062

Upstream Channel: COC_800 _USC_061



Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Pine Street Bridge	Structure Type:	Bridge
River Mile:	1.12 Miles to confluence of Bay	Structure ID:	COC_900

Description: Local Road Crossing
Pine Street

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	N/A
Pier Shape:	N/A
Deck Width (ft):	33' (in HEC_RAS model provided by District 32.9')
Deck Thickness (ft):	1.83' (in HEC_RAS model provided by District 1.79')
Rail Height (ft):	6.1' from top of rail to soffet
Deck Skewed:	No
Pier Skewed:	N/A
Channel Lining:	Concrete
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.014
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream:	COC_900 _DSF_063	Road (right):	
Structure Face Upstream:	COC_900 _USF_066	Road (leftt):	
Downstream Channel:	COC_900 _DSC_064		
Upstream Channel:	COC_900 _USC_065		

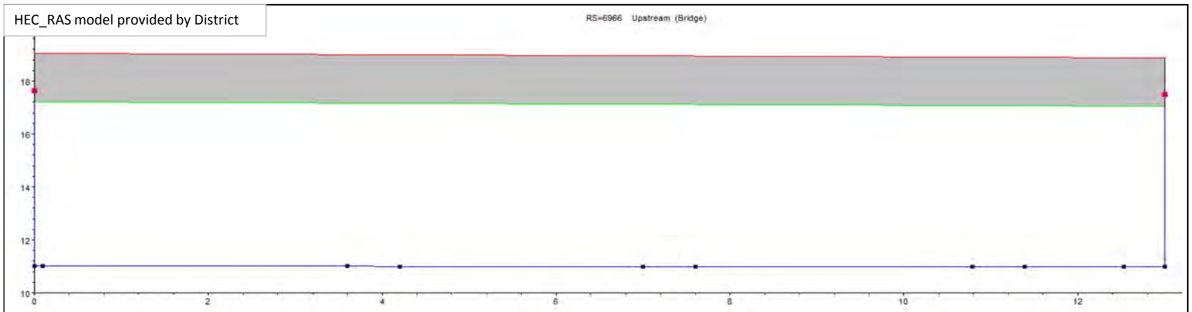
Sketch

Structure Type: Bridge

Structure ID: COC_900

Upstream

HEC_RAS model provided by District

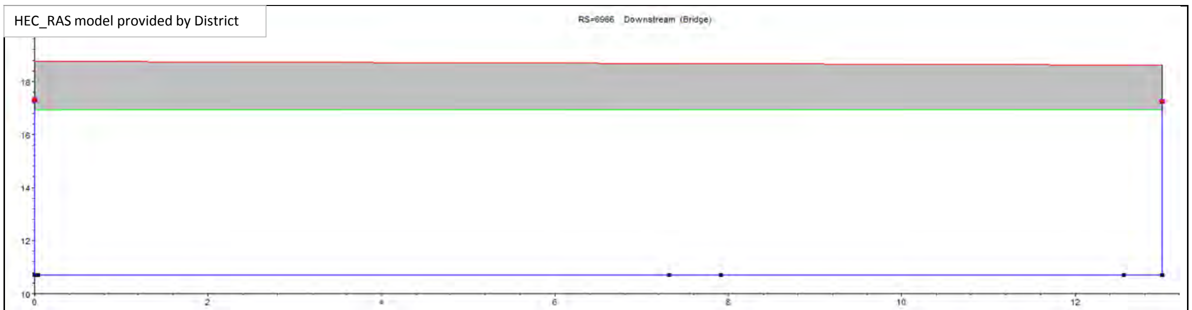


Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Downstream

HEC_RAS model provided by District

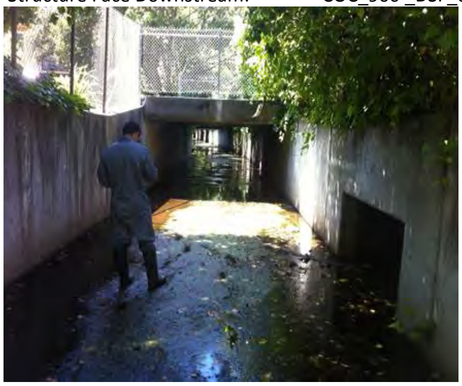


Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Elevation adjusment +/- ______________________________

Structure Face Downstream: COC_900 _DSF_063



Downstream Channel: COC_900 _DSC_064

Structure Face Upstream: COC_900 _USF_066

Upstream Channel: COC_900 _USC_065

Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Private Driveway Bridge	Structure Type:	Bridge
River Mile:	1.14 Miles to confluence of Bay	Structure ID:	COC_1000

Description: Private Driveway

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	N/A
Pier Shape:	N/A
Deck Width (ft):	15' (in HEC_RAS model provided by District 1.49')
Deck Thickness (ft):	1.83' (in HEC_RAS model provided by District 1.84')
Rail Height (ft):	6.1' from top of rail to soffet
Deck Skewed:	No
Pier Skewed:	N/A
Channel Lining:	Concrete
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.014
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream:	COC_1000 _DSF_067	Road (right):	
Structure Face Upstream:	COC_1000 _USF_070	Road (leftt):	
Downstream Channel:	COC_1000 _DSC_068		
Upstream Channel:	COC_1000 _USC_069		

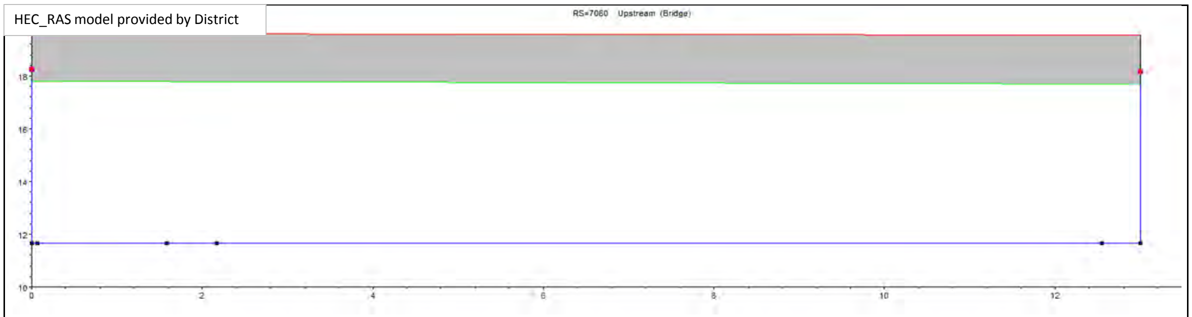
Sketch

Structure Type: Bridge

Structure ID: COC_1000

Upstream

HEC_RAS model provided by District

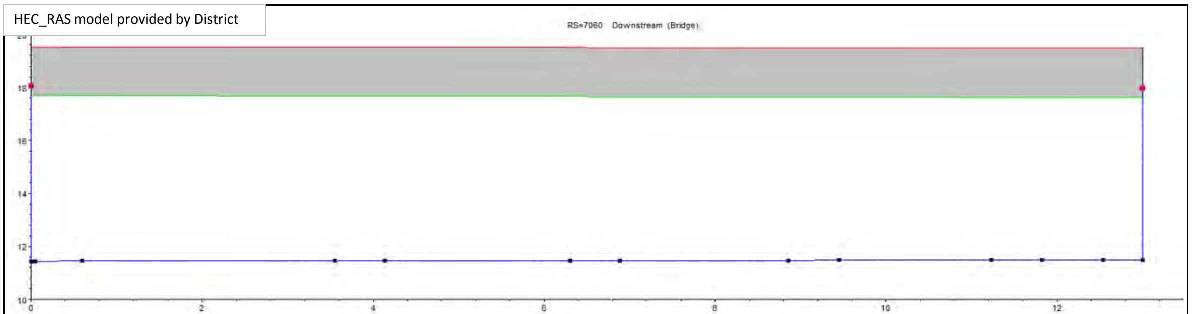


Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Downstream

HEC_RAS model provided by District



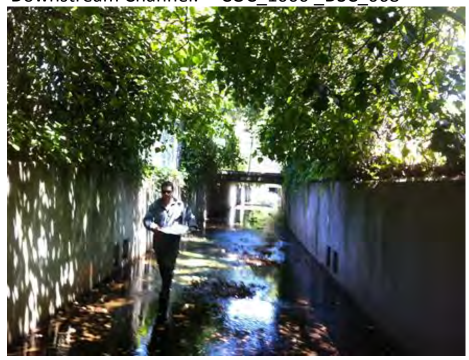
Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Elevation adjusment +/- ______________________________

Structure Face Downstream: COC_1000 _DSF_067

Downstream Channel: COC_1000 _DSC_068



Structure Face Upstream: COC_1000 _USF_070

Upstream Channel: COC_1000 _USC_069

Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Private Driveway Bridge	Structure Type:	Bridge
River Mile:	1.46 Miles to confluence of Bay	Structure ID:	COC_1100

Description: Private Driveway

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	N/A
Pier Shape:	N/A
Deck Width (ft):	15.3
Deck Thickness (ft):	1.1-1.83
Rail Height (ft):	6.1' from top of rail to soffet
Deck Skewed:	No
Pier Skewed:	N/A
Channel Lining:	Concrete
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.014
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream:	COC_1100 _DSF_071	Road (right):	
Structure Face Upstream:	COC_1100 _USF_074	Road (leftt):	
Downstream Channel:	COC_1100 _DSC_072		
Upstream Channel:	COC_1100 _USC_073		

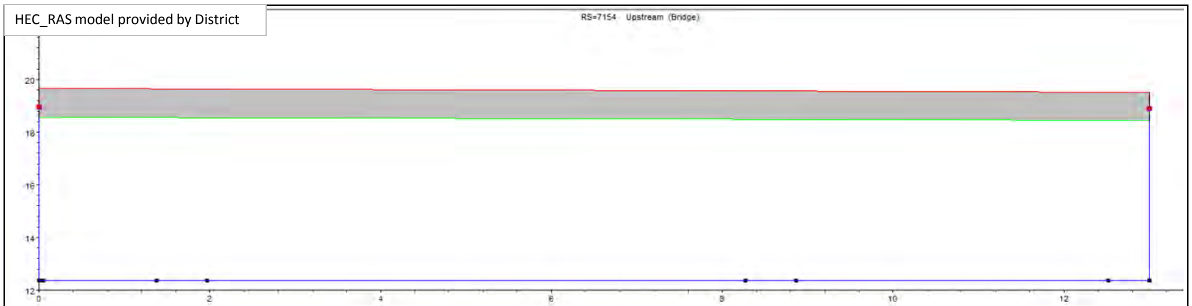
Sketch

Structure Type: Bridge

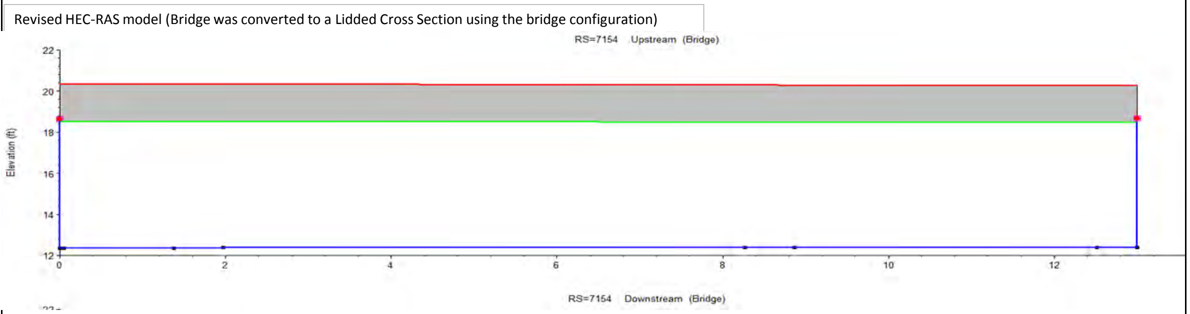
Structure ID: COC_1100

Upstream

HEC_RAS model provided by District

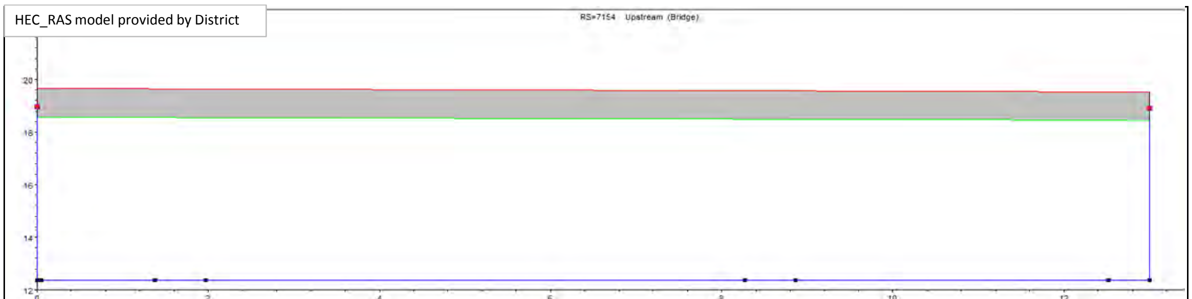


Revised HEC-RAS model (Bridge was converted to a Lidded Cross Section using the bridge configuration)

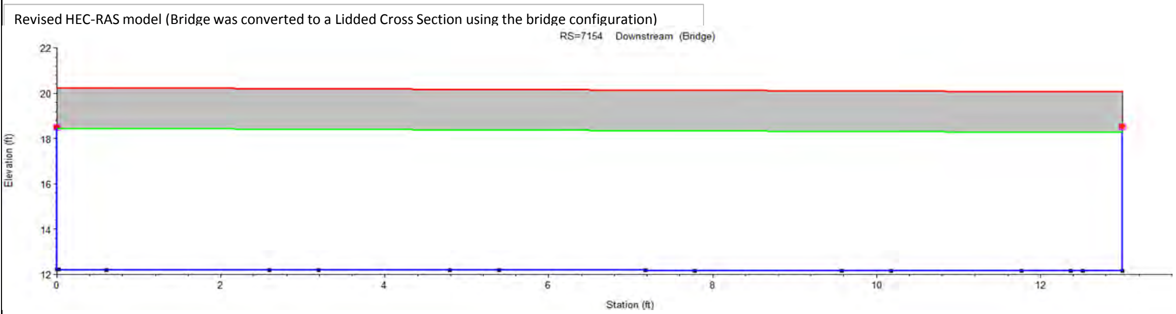


Downstream

HEC_RAS model provided by District

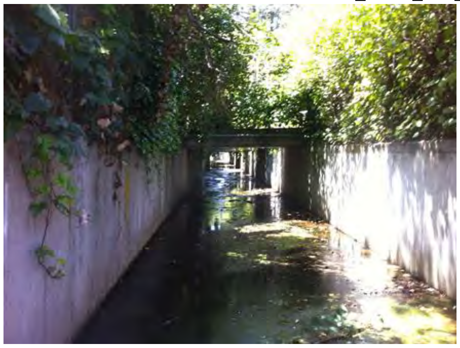


Revised HEC-RAS model (Bridge was converted to a Lidded Cross Section using the bridge configuration)



Elevation adjusment +/- ______________________________

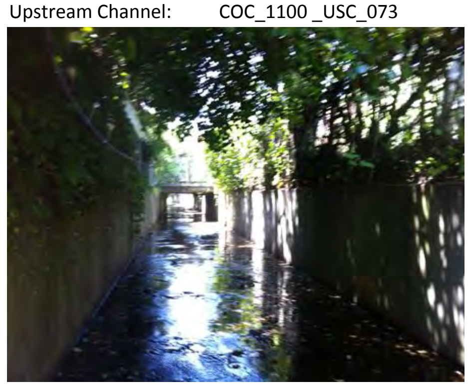
Structure Face Downstream: COC_1100 _DSF_071



Downstream Channel: COC_1100 _DSC_072

Structure Face Upstream: COC_1100 _USF_074

Upstream Channel: COC_1100 _USC_073



Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Spruce Street Bridge	Structure Type:	Bridge
River Mile:	1.48 Miles to confluence of Bay	Structure ID:	COC_1200

Description: Local Road Crossing
Spruce Street

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	N/A
Pier Shape:	N/A
Deck Width (ft):	34' (in HEC_RAS model provided by District 33.8')
Deck Thickness (ft):	1.83' (in HEC_RAS model provided by District 0.99'-1.91')
Rail Height (ft):	6.1' from top of rail to soffet
Deck Skewed:	Yes, No
Pier Skewed:	N/A
Channel Lining:	No lining, Concrete, Rock, Other
Abutments:	N/A
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	0.014
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

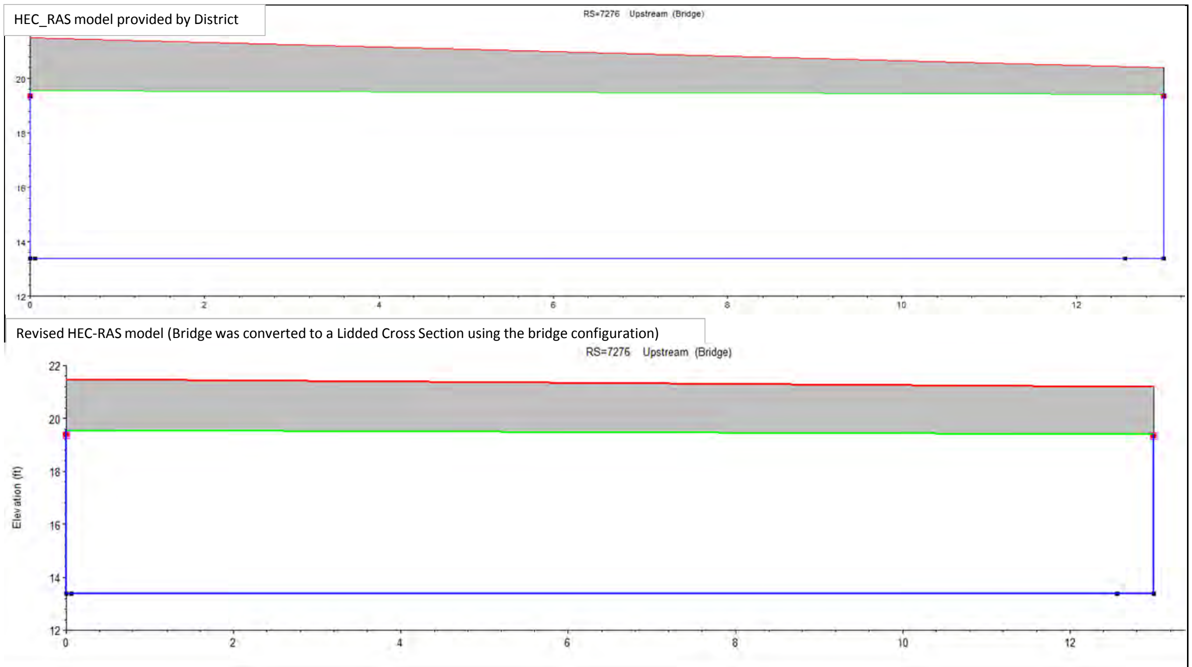
Structure Face Downstream:	COC_1200 _DSF_075	Road (right):	COC_1200 _TODR_079
Structure Face Upstream:	COC_1200 _USF_076	Road (leftt):	COC_1200 _TODL_080
Downstream Channel:	COC_1200 _DSC_077		
Upstream Channel:	COC_1200 _USC_078		

Sketch

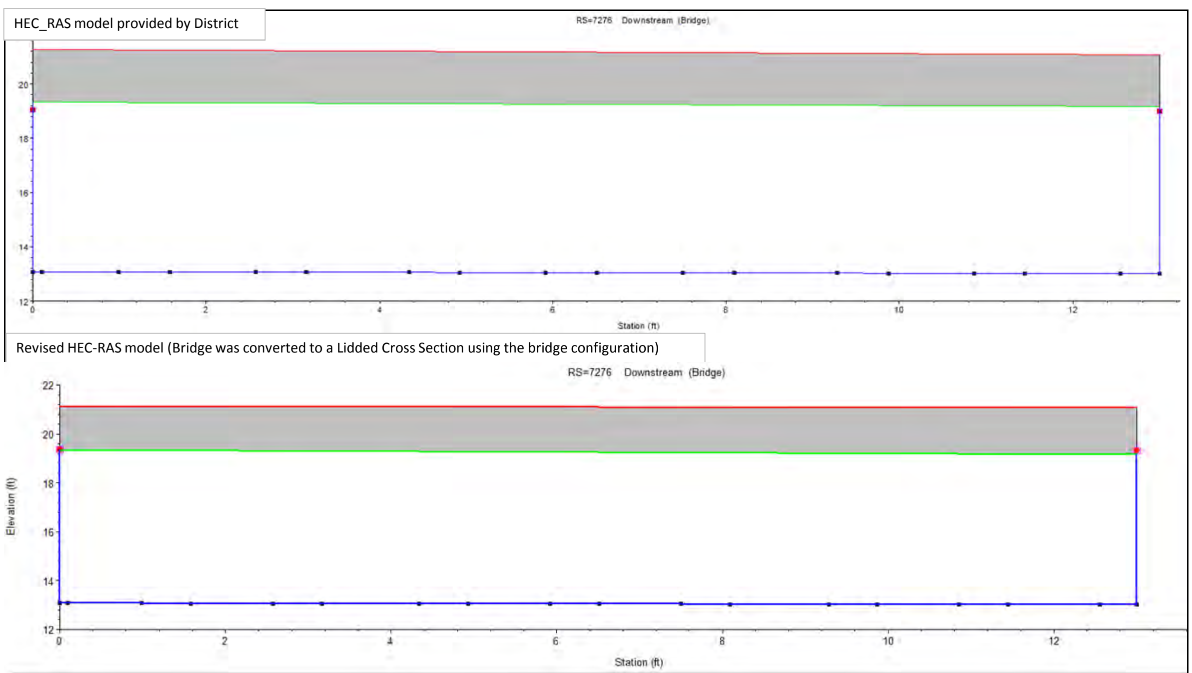
Structure Type: Bridge

Structure ID: COC_1200

Upstream

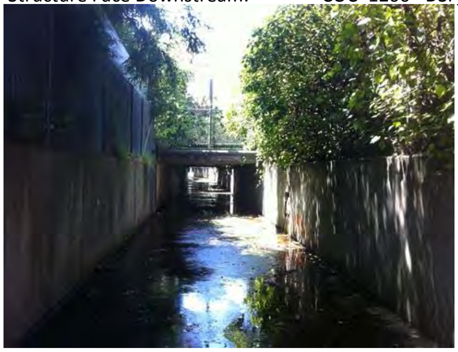


Downstream



Elevation adjusment +/- ______________________________

Structure Face Downstream: COC_1200 _DSF_075



Downstream Channel: COC_1200 _DSC_077

Structure Face Upstream: COC_1200 _USF_076

Upstream Channel: COC_1200 _USC_078

Road (right): COC_1200 _TODR_080

Road (leftt): COC_1200 _TODL_079

Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Private Driveway Bridge	Structure Type:	Bridge
River Mile:	"--" Miles to confluence of Bay	Structure ID:	COC_1300

Description: Private Driveway structure is in the model do not see it in aerial imagery

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	N/A
Pier Shape:	N/A
Deck Width (ft):	14.9
Deck Thickness (ft):	0.96-1.01
Rail Height (ft):	6.1' from top of rail to soffet
Deck Skewed:	Yes, No
Pier Skewed:	N/A
Channel Lining:	No lining, Concrete, Rock, Other
Abutments:	N/A
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	0.014
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

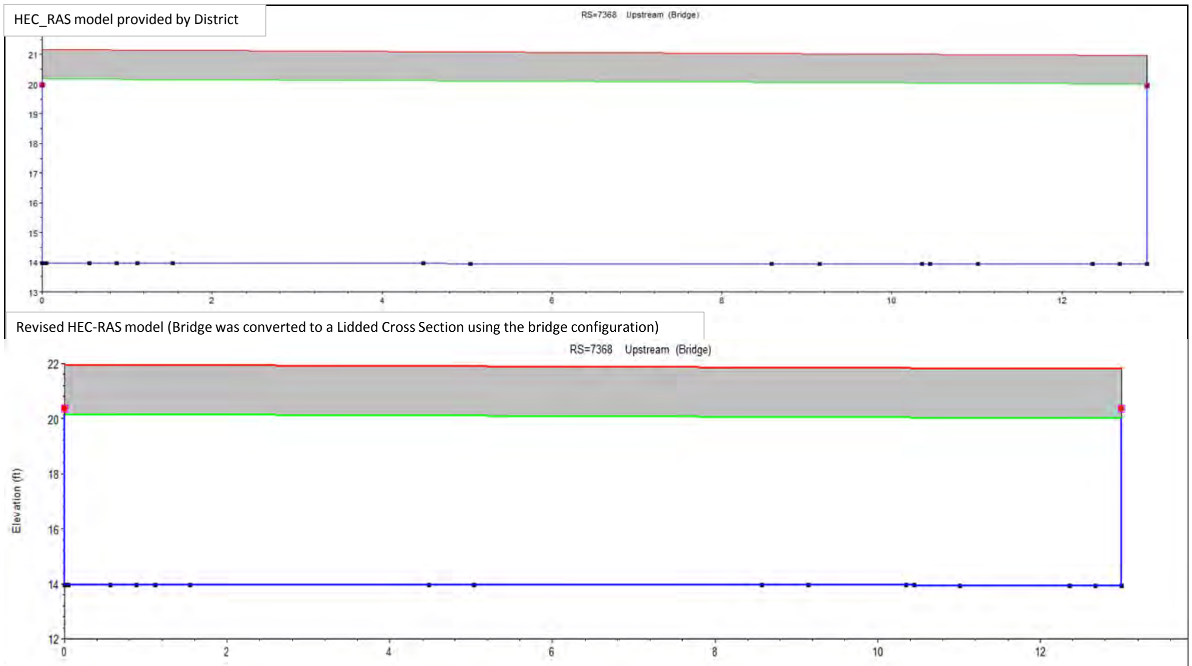
Photo IDs:

Structure Face Downstream:	COC_1300 _DSF_077	Road (right):	
Structure Face Upstream:	COC_1300 _USF_080	Road (leftt):	
Downstream Channel:	COC_1300 _DSC_078		
Upstream Channel:	COC_1300 _USC_079		

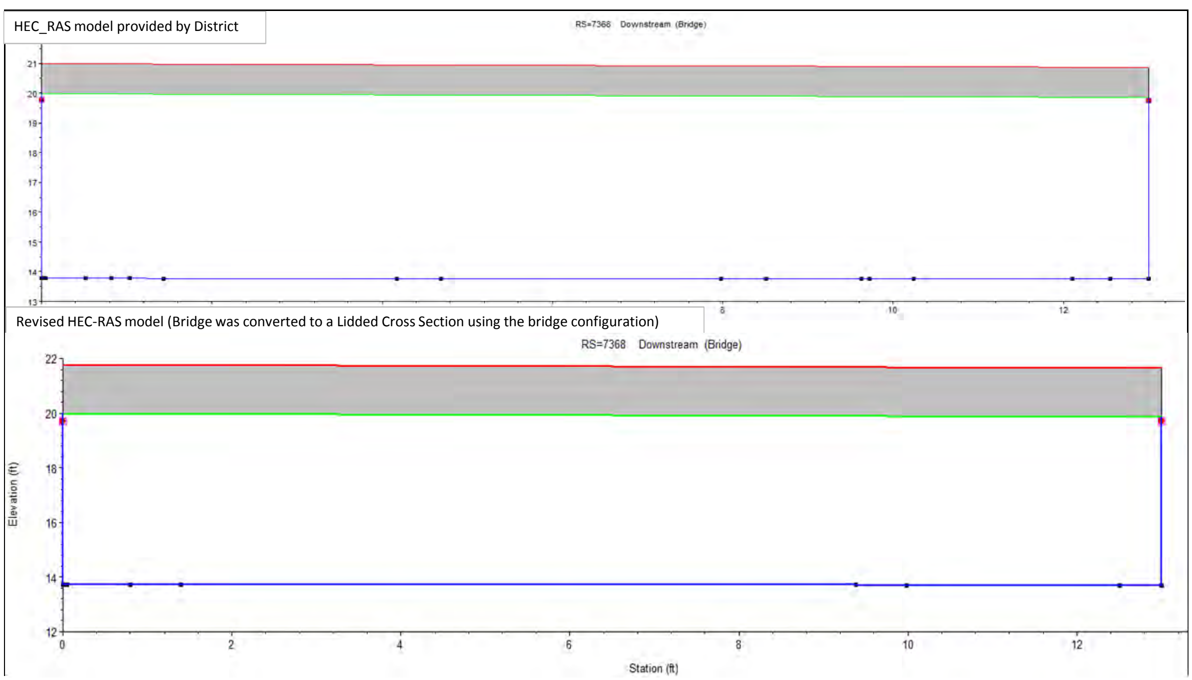
Sketch

Structure Type: Bridge
Structure ID: COC_1300

Upstream



Downstream



Elevation adjusment +/- ______________________

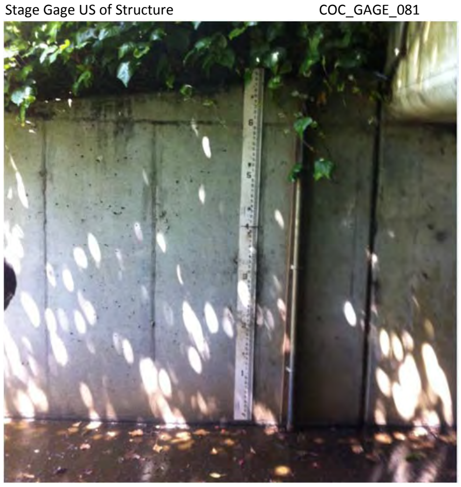
Structure Face Downstream: COC_1300 _DSF_077

Downstream Channel: COC_1300 _DSC_078

Structure Face Upstream: COC_1300 _USF_080

Upstream Channel: COC_1300 _USC_079

Stage Gage US of Structure COC_GAGE_081



Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:		Structure Type:	Bridge
River Mile:		Structure ID:	1350

Description: Old pedestrian bridge not in model

Bridge

# of Piers	
# of Columns/Pier	N/A
Pier Shape:	Circular, Square-nose, Semi-Circular, Elliptical, Triangular, Other
Deck Width (ft):	4.3'
Deck Thickness (ft):	0.83
Rail Height (ft):	6.1' from top of rail to soffet
Deck Skewed:	Yes, No
Pier Skewed:	N/A
Channel Lining:	No lining, Concrete, Rock, Other
Abutments:	N/A
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream:	COC_1350 _DSF_081	Road (right):	
Structure Face Upstream:	COC_1350 _USF_084	Road (leftt):	
Downstream Channel:	COC_1350 _DSC_082		
Upstream Channel:	COC_1350 _USC_083		

Sketch

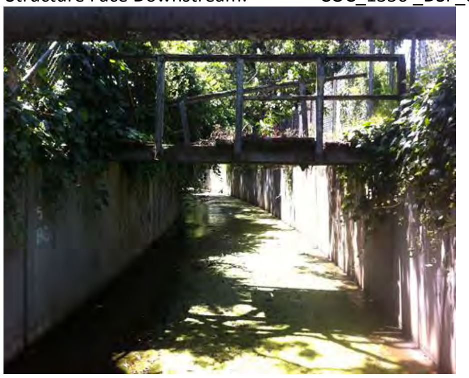
Structure Type: Bridge
Structure ID: COC_1350

Upstream

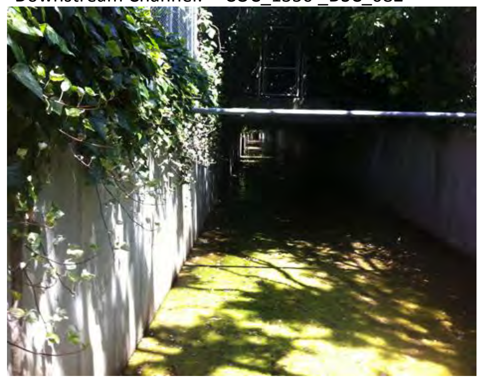
Downstream

Elevation adjusment +/- ____________________

Structure Face Downstream: COC_1350 _DSF_081



Downstream Channel: COC_1350 _DSC_082



Structure Face Upstream: COC_1350 _USF_084

Upstream Channel: COC_1350 _USC_083

Hydraulic Structure Field Visit Form

Project Name:	Coyote Creek Levee Evaluation		
AEC:	HDR Inc.	AEC Field Engineers:	Chris Acosta & Chris Buller
Date of Filed Visit:	5/14/2014	Reviewed by:	Wazhma Bahramand
Structure Location:	Coyote Creek @ Ash Street Bridge	Structure Type:	Bridge
River Mile:	1.54 Miles to confluence of Bay	Structure ID:	COC_1400

Description: Local Road Crossing
Ash Street

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	N/A
Pier Shape:	N/A
Deck Width (ft):	41.51' (in HEC_RAS model provided by District 41.5')
Deck Thickness (ft):	1.83' (in HEC_RAS model provided by District 1.69')
Rail Height (ft):	6.1' from top of rail to soffet
Deck Skewed:	No
Pier Skewed:	N/A
Channel Lining:	Concrete
Abutments:	N/A
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	0.014
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

Structure Face Downstream:	COC_1400 _DSF_085	Road (right):	COC_1400 _TODR_047
Structure Face Upstream:	COC_1400 _USF_086	Road (leftt):	COC_1400 _TODL_048
Downstream Channel:	COC_1400 _DSC_049		
Upstream Channel:	COC_1400 _USC_050		

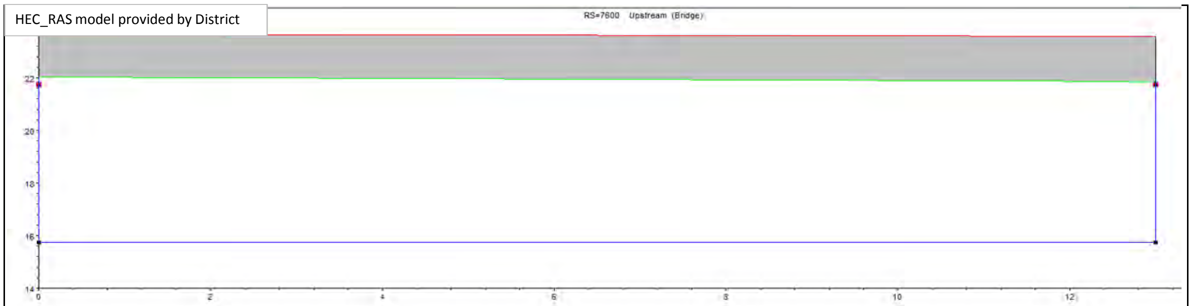
Sketch

Structure Type: Bridge

Structure ID: COC_1400

Upstream

HEC_RAS model provided by District

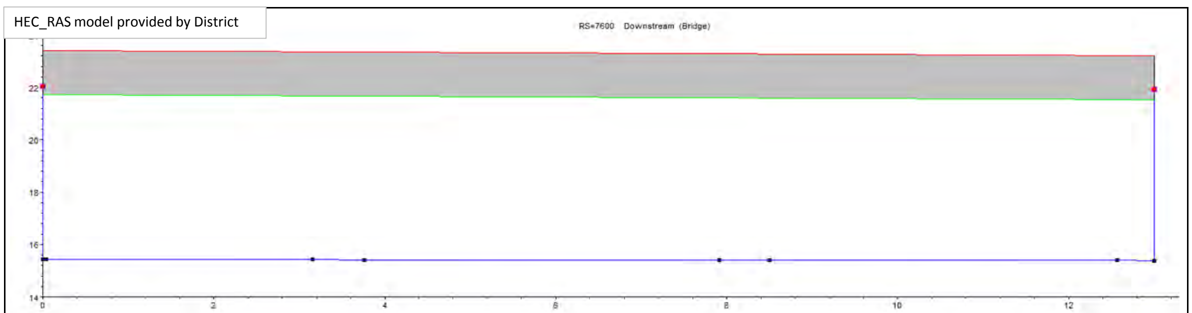


Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Downstream

HEC_RAS model provided by District



Revised HEC-RAS model

Bridge was converted to a Lidded Cross Section using the bridge configuration

Elevation adjusment +/- ______

Structure Face Downstream: COC_1400 _DSF_085

Downstream Channel: COC_1400 _DSC_049

Structure Face Upstream: COC_1400 _USF_086

Upstream Channel: COC_1400 _USC_050

Road (right): COC_1400 _TODR_047

Road (leftt): COC_1400 _TODL_048

Hydraulic Structure Field Visit Form

Project Name: Coyote Creek Levee Evaluation
AEC: HDR Inc.
AEC Field Engineers: Chris Acosta & Chris Buller
Date of Filed Visit: 5/14/2014
Reviewed by: Wazhma Bahramand

Structure Location: Nyhan Creek @ Marin Ave Bridge
Structure Type: Bridge
River Mile: 0.09 Miles to confluence with Coyote Creek
Structure ID: NYC_100

Description: Local Road Crossing
Marin Ave bridge (NCI/MSE survey)

Bridge

# of Piers	0 peir (in HEC_RAS model provided by District 0)
# of Columns/Pier	N/A
Pier Shape:	N/A
Deck Width (ft):	38.5' (in HEC_RAS model provided by District 39')
Deck Thickness (ft):	1.26'-1.52' (in HEC_RAS model provided by District 1.26'-1.52')
Rail Height (ft):	4.9
Deck Skewed:	No
Pier Skewed:	No
Channel Lining:	No lining
Abutments:	N/A
Weir Location:	Top of Road
"n" Value Variation:	0.025
Baffle:	N/A

Culvert N/A

Barrel Shape:	Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:	
Material:	Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):	
Culvert Width (ft):	
Culvert Height/Diameter (ft):	
Depth Blocked:	
Skewed:	Yes, No
Inlet Type:	Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge:	Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):	
Depth to Top of Road (ft):	
Weir Location:	Top of Road, Top of Rail, Comb
"n" Value Variation:	
Baffle:	Upstream, Downstream

Weir N/A

Weir Type:	Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape:	Rectangular, Trapezoidal, Ogee, V-notch
Crest Type:	Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):	
Weir Width (ft):	
Side-Slopes (ft):	
Crest Height:	
Gates Type:	Sluice, Radial, Overflow
# of Gates:	
Gate Width (ft):	
Gate Height (ft):	
Channel Lining:	No lining, Concrete, Rock, Other
"n" Value Variation:	
Baffle:	Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

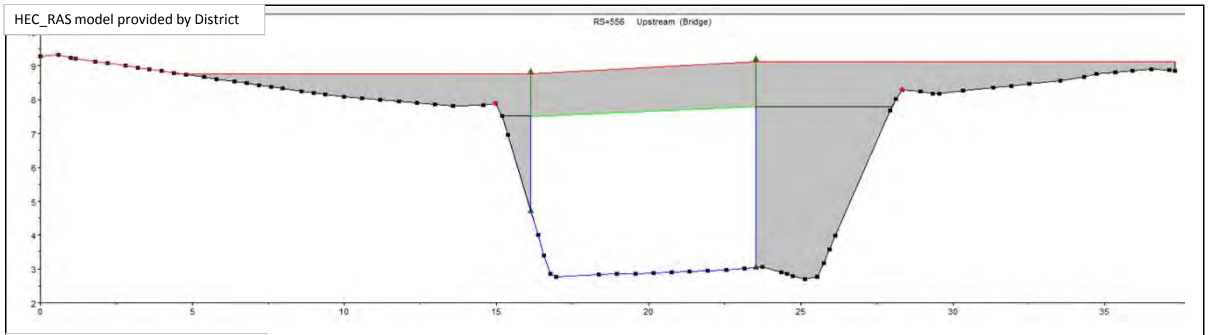
Structure Face Downstream: NYC_100 _DSF_029
Road (right): NYC_100 _TODR_030
Structure Face Upstream: NYC_100 _USF_031
Road (leftt): NYC_100 _TODL_032
Downstream Channel: NYC_100 _DSC_033
Upstream Channel: NYC_100 _USC_034

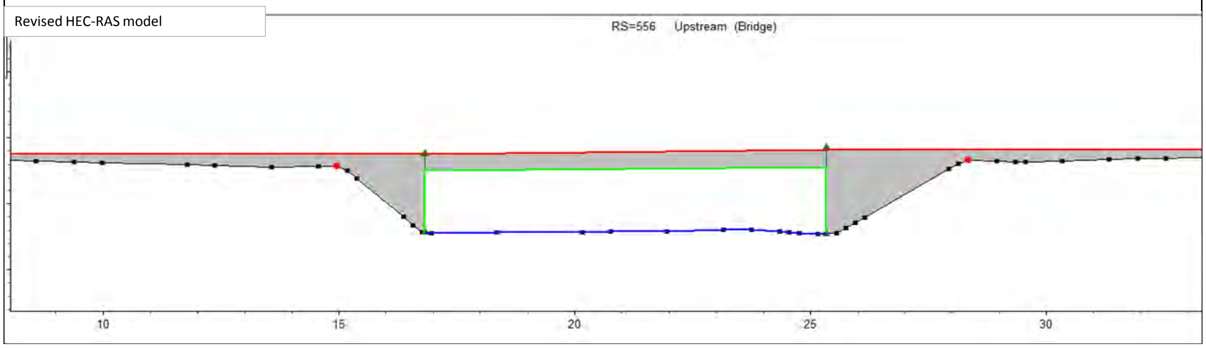
Sketch

Structure Type: Bridge

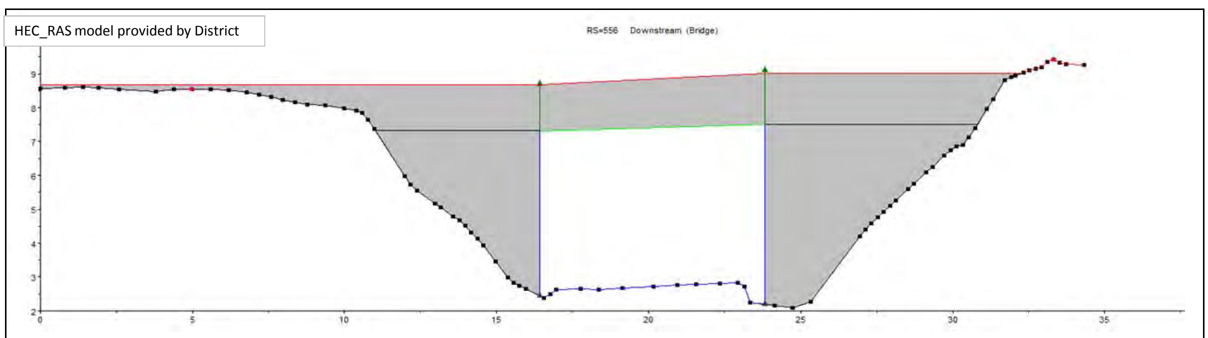
Structure ID: NYC_100

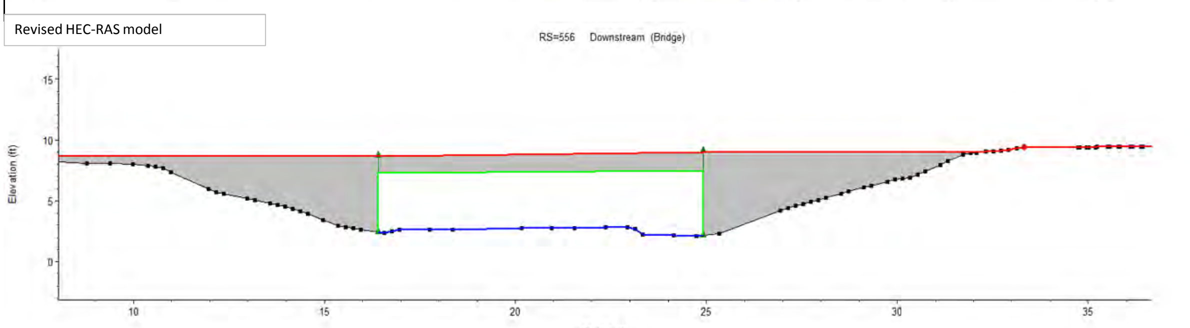
Upstream





Downstream





Elevation adjusment +/- ______________________

Structure Face Downstream: NYC_100 _DSF_029

Downstream Channel: NYC_100 _DSC_033

Structure Face Upstream: NYC_100 _USF_031

Upstream Channel: NYC_100 _USC_034

Road (right): NYC_100 _TODR_030

Road (leftt): NYC_100 _TODL_032

Hydraulic Structure Field Visit Form

Project Name: Coyote Creek Levee Evaluation
AEC: HDR Inc.
AEC Field Engineers: Chris Acosta & Chris Buller
Date of Filed Visit: 5/14/2014
Reviewed by: Wazhma Bahramand

Structure Location: Nyhan Creek @ Enterprise Concourse Bridge
Structure Type: Bridge
River Mile: 0.15 Miles to confluence with Coyote Creek
Structure ID: NYC_200

Description: Local Road Crossing
Enterprise Concourse Bridge (NCI/MSE survey)

Bridge

# of Piers 1 @ with 11.5" diameter peir (in HEC_RAS model provided by District 1 @ 1')
# of Columns/Pier
Pier Shape: Circular
Deck Width (ft): 34' (in HEC_RAS model provided by District 34')
Deck Thickness (ft): 2.1' (in HEC_RAS model provided by District 2.33')
Rail Height (ft): 4.6
Deck Skewed: No
Pier Skewed: No
Channel Lining: No lining
Abutments: N/A
Weir Location: Top of Road
"n" Value Variation: 0.025
Baffle: N/A

Culvert N/A

Barrel Shape: Circular, Box, Elliptical, Semi-circle, Arch, Other
# of Barrels:
Material: Concrete, Corrugated Metal, HDPE, Other
Culvert Length (ft):
Culvert Width (ft):
Culvert Height/Diameter (ft):
Depth Blocked:
Skewed: Yes, No
Inlet Type: Projecting, Mitered to slope, Tapered Inlet, Headwall, Headwall Skewed, Wingwalls Flared
Inlet Edge: Square edge, Groove end, Beveled, Chamfered, Rounded
Roadway Width (ft):
Depth to Top of Road (ft):
Weir Location: Top of Road, Top of Rail, Comb
"n" Value Variation:
Baffle: Upstream, Downstream

Weir N/A

Weir Type: Inline Weir, Lateral Weir, Grade Control, Drop Structure, Road, Other
Weir Shape: Rectangular, Trapezoidal, Ogee, V-notch
Crest Type: Broad Crest, Sharp Crest, Long Crest, Other
Weir Length (ft):
Weir Width (ft):
Side-Slopes (ft):
Crest Height:
Gates Type: Sluice, Radial, Overflow
# of Gates:
Gate Width (ft):
Gate Height (ft):
Channel Lining: No lining, Concrete, Rock, Other
"n" Value Variation:
Baffle: Upstream, Downstream

Note: If HEC_RAS model provided by District was reasonable with respects to the measurements done during field visit model was not updated.

Photo IDs:

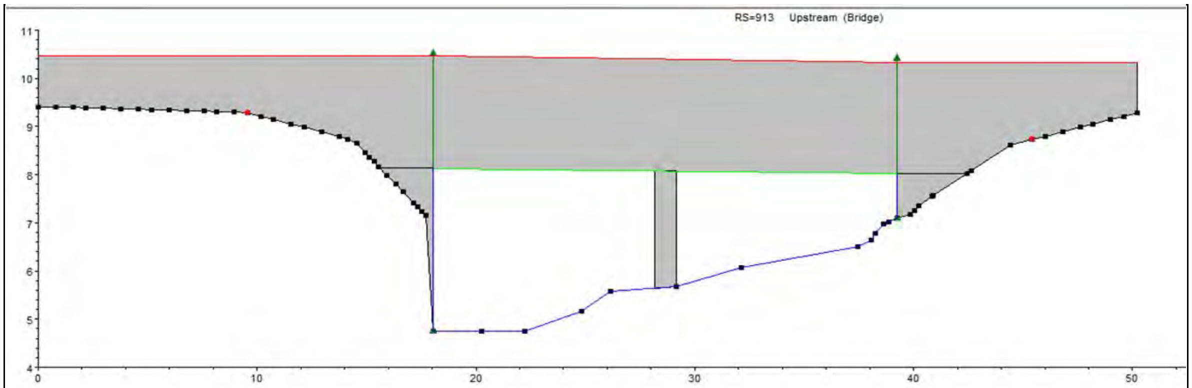
Structure Face Downstream: NYC_200 _DSF_035
Road (right): NYC_200 _TODR_036
Structure Face Upstream: NYC_200 _USF_037
Road (leftt): NYC_200 _TODL_038
Downstream Channel: NYC_200 _DSC_039
Upstream Channel: NYC_200 _USC_040

Sketch

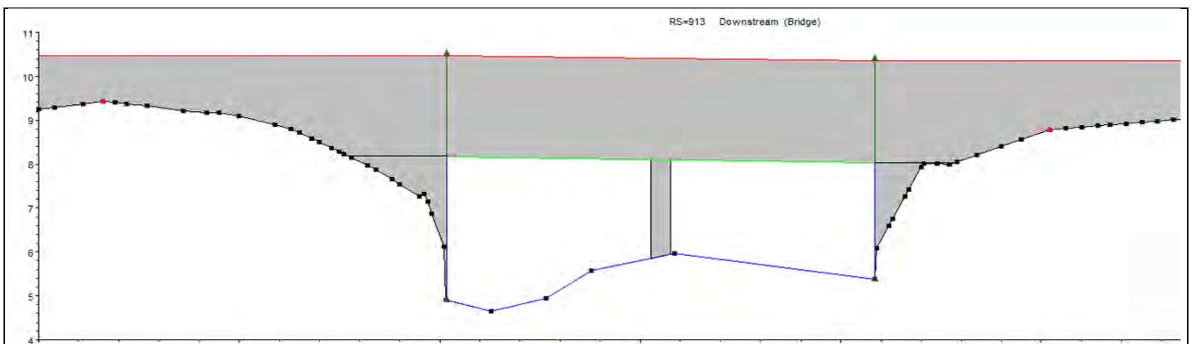
Structure Type: Bridge

Structure ID: NYC_200

Upstream



Downstream



Elevation adjusment +/- ______________________________

Structure Face Downstream: NYC_200 _DSF_035

Downstream Channel: NYC_200 _DSC_039

Structure Face Upstream: NYC_200 _USF_037

Upstream Channel: NYC_200 _USC_040

Road (right): NYC_200 _TODR_036

Road (leftt): NYC_200 _TODL_038

Channel Photo Field Visit

Project Name: Coyote Creek Levee Evaluation
AEC: HDR Inc.
Date of Filed Visit: 5/14/2014

AEC Field Engineers: Chris Acosta & Chris Buller
Reviewed by: Wazhma Bahramand

Photo Location

Photo

COC_DSC_001

Photo Location

Photo

COC_DSC_002

COC_USC_003

Photo Location

Photo

COC_USC_004

COC_USC_005

Appendix B

HEC-RAS Existing Alternatives Results Table

			Scenario 1: Baseline			Scenario 2: Updated			Scenario 3a: Enhanced (District 2-percent-annual-chance Event)			Scenario 3b: Enhanced (District 1-percent-annual-chance Event)			Scenario 4: FEMA Accredited			Scenario 5: FEMA Accredited w/ SLR		
River	Reach	Cross Section	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)
Nyhan Creek	Lower Reach	1054	650	11.38	3.1	355	10.48	2.3	420	10.71	2.5	489	10.96	2.6	920	11.96	3.5	920	11.94	3.5
Nyhan Creek	Lower Reach	1008	650	11.37	2.8	355	10.47	2.2	420	10.70	2.3	489	10.95	2.4	920	11.94	3.3	920	11.93	3.3
Nyhan Creek	Lower Reach	969	650	11.35	3.1	355	10.45	2.4	420	10.68	2.6	489	10.93	2.7	920	11.92	3.5	920	11.90	3.5
Nyhan Creek	Lower Reach	938	650	11.32	4.2	355	10.43	3.5	420	10.66	3.7	489	10.91	3.9	920	11.88	4.6	920	11.87	4.6
Nyhan Creek	Lower Reach	892	650	10.74	3.0	355	9.57	3.4	420	9.80	3.4	489	10.18	3.2	920	11.66	2.9	920	11.61	2.9
Nyhan Creek	Lower Reach	867	650	10.74	2.2	355	9.51	2.2	420	9.75	2.3	489	10.17	2.1	920	11.66	2.3	920	11.61	2.3
Nyhan Creek	Lower Reach	815	650	10.70	3.3	355	9.46	3.9	420	9.70	3.9	489	10.12	3.4	920	11.62	3.2	920	11.57	3.3
Nyhan Creek	Lower Reach	763	650	10.65	3.7	355	9.41	3.3	407	9.65	3.5	489	10.08	3.5	920	11.58	3.9	920	11.52	4.0
Nyhan Creek	Lower Reach	719	650	10.63	3.7	355	9.38	3.0	407	9.63	3.2	489	10.06	3.3	920	11.54	4.0	920	11.49	4.1
Nyhan Creek	Lower Reach	681	650	10.60	3.8	355	9.35	3.2	407	9.60	3.4	489	10.03	3.5	920	11.52	4.2	920	11.46	4.2
Nyhan Creek	Lower Reach	645	650	10.56	4.3	355	9.32	3.6	406	9.57	3.9	489	10.00	4.0	920	11.48	4.7	920	11.43	4.8
Nyhan Creek	Lower Reach	607	650	10.54	4.1	373	9.29	3.6	422	9.54	3.8	513	9.97	3.9	920	11.46	4.5	920	11.41	4.6
Nyhan Creek	Lower Reach	581	650	10.51	5.0	373	9.27	4.7	422	9.51	4.9	513	9.94	5.0	920	11.44	5.2	920	11.38	5.3
Nyhan Creek	Lower Reach	528	650	8.94	6.1	372	7.90	4.6	440	8.24	5.0	512	8.60	5.3	920	9.56	7.3	920	10.15	6.2
Nyhan Creek	Lower Reach	496	650	8.89	4.0	372	7.91	2.8	440	8.23	3.1	512	8.57	3.3	920	9.51	5.0	920	10.12	4.5
Nyhan Creek	Lower Reach	462	650	8.85	5.2	396	7.84	4.1	467	8.17	4.4	544	8.51	4.7	920	9.45	6.1	920	10.08	5.1
Nyhan Creek	Lower Reach	408	650	8.76	5.5	474	7.75	5.1	559	8.09	5.5	650	8.43	5.9	920	9.34	6.8	920	10.00	5.9
Nyhan Creek	Lower Reach	352	650	8.69	4.9	474	7.68	4.6	559	8.00	5.0	650	8.33	5.3	920	9.23	6.1	920	9.93	5.2
Nyhan Creek	Lower Reach	306	650	8.66	4.1	474	7.64	4.0	559	7.96	4.3	650	8.28	4.6	920	9.16	5.2	920	9.90	4.4
Nyhan Creek	Lower Reach	252	650	8.65	3.2	474	7.63	3.1	559	7.94	3.3	650	8.25	3.5	920	9.13	4.1	920	9.90	3.4
Nyhan Creek	Lower Reach	200	650	8.68	1.9	474	7.65	1.7	559	7.96	1.9	649	8.28	2.0	920	9.15	2.4	920	9.94	2.0
Nyhan Creek	Lower Reach	146	650	8.70	1.2	474	7.66	1.1	559	7.98	1.2	649	8.29	1.3	920	9.17	1.6	920	9.95	1.4
Coyote Creek	Upper Reach (Concrete Channel)	7632	900	19.94	16.9	473	18.45	13.9	554	18.75	14.6	641	19.06	15.3	910	19.99	16.8	910	20.00	16.8
Coyote Creek	Upper Reach (Concrete Channel)	7630	900	19.92	16.9	473	18.44	13.9	554	18.74	14.6	641	19.05	15.3	910	19.97	16.9	910	19.98	16.8
Coyote Creek	Upper Reach (Concrete Channel)	7623.5	900	19.88	16.8	473	18.39	13.8	554	18.69	14.6	641	19.00	15.2	910	19.93	16.8	910	19.94	16.8
Coyote Creek	Upper Reach (Concrete Channel)	7574	900	19.51	16.9	473	18.02	13.9	554	18.32	14.6	641	18.63	15.3	910	19.57	16.8	910	19.58	16.8
Coyote Creek	Upper Reach (Concrete Channel)	7550	900	19.33	16.9	473	17.84	14.0	554	18.14	14.7	641	18.45	15.3	910	19.39	16.8	910	19.41	16.8
Coyote Creek	Upper Reach (Concrete Channel)	7500	900	18.97	16.8	473	17.47	13.8	554	17.77	14.6	641	18.08	15.2	910	19.03	16.7	910	19.05	16.6
Coyote Creek	Upper Reach (Concrete Channel)	7450	900	18.60	16.7	473	17.10	13.8	554	17.40	14.5	641	17.71	15.2	910	18.68	16.6	910	18.70	16.5
Coyote Creek	Upper Reach (Concrete Channel)	7416	900	18.36	16.9	473	16.85	14.0	554	17.15	14.7	641	17.46	15.4	910	18.44	16.7	910	18.46	16.6
Coyote Creek	Upper Reach (Concrete Channel)	7400	900	18.24	16.8	473	16.73	13.9	554	17.03	14.6	641	17.34	15.3	910	18.33	16.6	910	18.35	16.5
Coyote Creek	Upper Reach (Concrete Channel)	7380	900	18.10	16.7	473	16.58	13.8	554	16.88	14.5	641	17.20	15.2	910	18.19	16.5	910	18.22	16.4
Coyote Creek	Upper Reach (Concrete Channel)	7350	900	17.88	16.6	473	16.36	13.7	554	16.66	14.4	641	16.98	15.1	910	17.99	16.4	910	18.02	16.2
Coyote Creek	Upper Reach (Concrete Channel)	7327	900	17.72	16.7	473	16.19	13.8	554	16.50	14.5	641	16.81	15.2	910	17.83	16.4	910	17.86	16.3
Coyote Creek	Upper Reach (Concrete Channel)	7300	900	17.53	16.7	473	16.00	13.9	554	16.30	14.6	641	16.62	15.2	910	17.65	16.4	910	17.69	16.2
Coyote Creek	Upper Reach (Concrete Channel)	7254	900	17.20	16.7	473	15.66	13.9	554	15.96	14.6	641	16.28	15.2	910	17.35	16.3	910	17.39	16.1
Coyote Creek	Upper Reach (Concrete Channel)	7250	900	17.17	16.7	473	15.62	13.9	554	15.93	14.6	641	16.25	15.2	910	17.32	16.3	910	17.37	16.1
Coyote Creek	Upper Reach (Concrete Channel)	7227	900	17.00	16.6	473	15.45	14.0	554	15.76	14.6	641	16.08	15.2	910	17.17	16.2	910	17.22	16.0
Coyote Creek	Upper Reach (Concrete Channel)	7200	900	16.82	16.5	473	15.25	13.9	554	15.56	14.6	641	15.88	15.2	910	17.00	16.0	910	17.05	15.8
Coyote Creek	Upper Reach (Concrete Channel)	7167	900	16.59	16.4	473	15.00	13.8	554	15.32	14.5	641	15.64	15.1	910	16.79	15.9	910	16.85	15.6
Coyote Creek	Upper Reach (Concrete Channel)	7142	900	16.42	16.3	473	14.82	13.8	554	15.13	14.4	641	15.46	15.0	910	16.64	15.7	910	16.71	15.5
Coyote Creek	Upper Reach (Concrete Channel)	7100	900	16.14	16.3	473	14.52	13.8	554	14.83	14.4	641	15.17	15.0	910	16.39	15.5	910	16.47	15.2
Coyote Creek	Upper Reach (Concrete Channel)	7073	900	15.96	16.1	473	14.32	13.6	554	14.64	14.3	641	14.98	14.8	910	16.24	15.3	910	16.33	15.0
Coyote Creek	Upper Reach (Concrete Channel)	7050	900	15.81	15.9	473	14.16	13.5	554	14.49	14.1	641	14.83	14.7	910	16.11	15.1	910	16.21	14.8
Coyote Creek	Upper Reach (Concrete Channel)	7018	900	15.61	16.0	473	13.94	13.7	554	14.26	14.3	641	14.61	14.8	910	15.94	15.0	910	16.05	14.7
Coyote Creek	Upper Reach (Concrete Channel)	7000	900	15.50	15.8	473	13.81	13.5	554	14.14	14.1	641	14.49	14.6	910	15.85	14.8	910	15.96	14.5
Coyote Creek	Upper Reach (Concrete Channel)	6987	900	15.42	15.7	473	13.73	13.3	554	14.06	13.9	641	14.41	14.5	910	15.79	14.6	910	15.90	14.3
Coyote Creek	Upper Reach (Concrete Channel)	6944	900	15.17	15.5	473	13.44	13.2	554	13.78	13.8	641	14.14	14.3	910	15.58	14.3	910	15.71	14.0
Coyote Creek	Upper Reach (Concrete Channel)	6900	900	14.92	15.2	473	13.17	13.1	554	13.51	13.6	641	13.88	14.1	910	15.38	14.0	910	15.53	13.6
Coyote Creek	Upper Reach (Concrete Channel)	6850	900	14.65	14.8	524	12.84	14.1	613	13.19	14.7	709	13.56	15.2	910	15.18	13.5	910	15.34	13.0
Coyote Creek	Upper Reach (Concrete Channel)	6800	900	14.40	14.4	524	12.49	14.0	613	12.85	14.6	709	13.23	15.1	910	14.99	13.0	910	15.16	12.6
Coyote Creek	Upper Reach (Concrete Channel)	6750	1000	14.15	15.7	524	12.14	13.9	613	12.52	14.4	709	12.91	14.9	1120	14.77	15.6	1120	14.97	15.1
Coyote Creek	Upper Reach (Concrete Channel)	6700	1000	13.88	15.4	524	11.81	13.7	613	12.20	14.2	709	12.60	14.6	1120	14.53	15.2	1120	14.75	14.6
Coyote Creek	Upper Reach (Concrete Channel)	6674	1000	13.74	14.9	524	11.66	13.1	613	12.05	13.7	709	12.45	14.1	1120	14.38	14.9	1120	14.61	14.3
Coyote Creek	Upper Reach (Concrete Channel)	6631	1000	13.51	14.5	524	11.42	12.5	613	11.82	13.1	709	12.23	13.6	1120	14.10	14.6	1120	14.32	14.1
Coyote Creek	Upper Reach (Concrete Channel)	6600	1000	13.36	14.7	524	11.26	12.9	613	11.66	13.4	709	12.08	13.8	1120	13.93	14.9	1120	14.16	14.3
Coyote Creek	Upper Reach (Concrete Channel)	6550	1000	13.13	14.3	524	11.00	12.4	613	11.41	12.9	709	11.83	13.4	1120	13.72	14.5	1120	13.97	13.9
Coyote Creek	Upper Reach (Concrete Channel)	6500	1000	12.93	13.9	524	10.77	11.9	613	11.18	12.4	709	11.61	12.9	1120	13.52	14.1	1120	13.79	13.5
Coyote Creek	Upper Reach (Concrete Channel)	6487	1000	12.86	13.3	524	10.71	11.4	613	11.12	11.9	709	11.55	12.4	1120	13.45	13.6	1120	13.72	13.5
Coyote Creek	Upper Reach (Concrete Channel)	6318	1000	11.97	12.4	524	10.02	10.1	613	10.44	10.6	709	10.87	11.0	1120	12.32	13.0	1120	12.60	12.4

			Scenario 1: Baseline			Scenario 2: Updated			Scenario 3a: Enhanced (District 2-percent-annual-chance Event)			Scenario 3b: Enhanced (District 1-percent-annual-chance Event)			Scenario 4: FEMA Accredited			Scenario 5: FEMA Accredited w/ SLR		
River	Reach	Cross Section	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)
Coyote Creek	Upper Reach (Concrete Channel)	6300	1000	11.90	11.7	524	9.96	9.7	613	10.38	10.1	709	10.82	10.5	1120	12.25	12.3	1120	12.52	11.8
Coyote Creek	Upper Reach (Concrete Channel)	6250	1000	11.77	11.5	524	9.84	9.4	613	10.26	9.8	709	10.70	10.2	1120	12.11	12.2	1120	12.41	11.6
Coyote Creek	Upper Reach (Concrete Channel)	6230	1000	11.73	11.5	524	9.79	9.3	613	10.21	9.7	709	10.65	10.1	1120	12.06	12.1	1120	12.36	11.5
Coyote Creek	Upper Reach (Concrete Channel)	6200	1000	11.65	11.5	524	9.72	9.4	613	10.14	9.8	709	10.58	10.2	1120	11.98	12.2	1120	12.29	11.5
Coyote Creek	Upper Reach (Concrete Channel)	6167	1000	11.57	11.6	524	9.64	9.4	613	10.07	9.8	709	10.50	10.2	1120	11.90	12.2	1120	12.22	11.6
Coyote Creek	Upper Reach (Concrete Channel)	6150	1000	11.53	11.6	524	9.60	9.5	613	10.03	9.9	709	10.47	10.3	1120	11.85	12.3	1120	12.18	11.6
Coyote Creek	Upper Reach (Concrete Channel)	6100	1000	11.40	11.6	524	9.48	9.5	613	9.90	9.9	709	10.35	10.3	1120	11.71	12.3	1120	12.06	11.6
Coyote Creek	Upper Reach (Concrete Channel)	6073	1000	11.33	11.5	524	9.41	9.3	613	9.84	9.7	709	10.28	10.1	1120	11.64	12.1	1120	12.00	11.4
Coyote Creek	Upper Reach (Concrete Channel)	6050	1000	11.28	11.4	524	9.36	9.2	613	9.79	9.6	709	10.23	10.0	1120	11.58	12.1	1120	11.95	11.4
Coyote Creek	Upper Reach (Concrete Channel)	6000	1000	11.16	11.2	524	9.25	8.9	613	9.68	9.3	709	10.13	9.7	1120	11.46	11.9	1120	11.85	11.1
Coyote Creek	Upper Reach (Concrete Channel)	5950	1000	11.05	11.0	524	9.16	8.6	613	9.59	9.1	709	10.03	9.5	1120	11.34	11.7	1120	11.75	11.0
Coyote Creek	Upper Reach (Concrete Channel)	5900	1000	10.95	10.8	524	9.07	8.4	613	9.50	8.8	709	9.94	9.3	1120	11.22	11.6	1120	11.65	10.8
Coyote Creek	Upper Reach (Concrete Channel)	5850	1000	10.85	10.7	524	8.98	8.2	613	9.41	8.7	709	9.86	9.1	1120	11.11	11.4	1120	11.56	10.7
Coyote Creek	Upper Reach (Concrete Channel)	5800	1000	10.75	10.6	524	8.91	8.0	613	9.33	8.5	709	9.77	9.0	1120	11.00	11.4	1120	11.47	10.6
Coyote Creek	Upper Reach (Concrete Channel)	5750	1000	10.66	10.4	550	8.83	8.3	644	9.25	8.8	744	9.69	9.3	1120	10.90	11.2	1120	11.38	10.4
Coyote Creek	Upper Reach (Concrete Channel)	5700	1000	10.57	10.3	550	8.75	8.0	644	9.17	8.6	744	9.61	9.1	1120	10.79	11.1	1120	11.30	10.3
Coyote Creek	Upper Reach (Concrete Channel)	5650	1000	10.48	10.2	550	8.68	7.9	644	9.10	8.4	744	9.53	8.9	1120	10.69	11.0	1120	11.22	10.2
Coyote Creek	Upper Reach (Concrete Channel)	5600	1000	10.39	10.1	550	8.62	7.7	644	9.03	8.3	744	9.46	8.8	1120	10.59	10.9	1120	11.14	10.1
Coyote Creek	Upper Reach (Concrete Channel)	5575	1000	10.35	10.0	550	8.58	7.6	644	8.99	8.2	744	9.42	8.7	1120	10.55	10.8	1120	11.10	10.0
Coyote Creek	Upper Reach (Concrete Channel)	5550	1000	10.31	10.0	550	8.55	7.6	644	8.96	8.2	744	9.39	8.7	1120	10.50	10.8	1120	11.06	10.0
Coyote Creek	Upper Reach (Concrete Channel)	5500	1000	10.23	10.0	550	8.49	7.6	644	8.89	8.1	744	9.31	8.7	1120	10.40	10.8	1120	10.99	9.9
Coyote Creek	Upper Reach (Concrete Channel)	5473	1000	10.18	9.9	556	8.46	7.6	651	8.86	8.2	752	9.28	8.7	1120	10.35	10.8	1120	10.95	9.9
Coyote Creek	Upper Reach (Concrete Channel)	5450	1000	10.15	9.9	556	8.43	7.5	651	8.83	8.1	752	9.24	8.6	1120	10.31	10.8	1120	10.91	9.8
Coyote Creek	Upper Reach (Concrete Channel)	5400	1100	10.06	10.8	556	8.37	7.4	651	8.76	8.0	752	9.18	8.6	1120	10.22	10.7	1120	10.84	9.8
Coyote Creek	Upper Reach (Concrete Channel)	5350	1100	9.96	10.8	556	8.31	7.4	651	8.70	8.0	751	9.11	8.5	1120	10.12	10.7	1120	10.77	9.8
Coyote Creek	Upper Reach (Concrete Channel)	5319	1100	9.87	11.3	556	8.28	7.4	651	8.66	8.0	751	9.06	8.5	1120	10.03	11.5	1120	10.69	11.5
Coyote Creek	Upper Reach (Concrete Channel)	5270	1100	9.69	11.0	556	8.23	7.2	651	8.60	7.8	750	8.98	8.4	1120	9.95	11.2	1120	10.60	11.2
Coyote Creek	Upper Reach (Concrete Channel)	5250	1100	9.64	10.9	556	8.21	7.1	651	8.57	7.7	750	8.95	8.3	1120	9.90	10.6	1120	10.55	9.7
Coyote Creek	Upper Reach (Concrete Channel)	5200	1100	9.54	11.0	556	8.15	7.2	651	8.52	7.8	746	8.88	8.4	1120	9.80	10.8	1120	10.48	9.8
Coyote Creek	Upper Reach (Concrete Channel)	5150	1100	9.44	11.0	556	8.10	7.0	651	8.46	7.7	744	8.82	8.2	1120	9.71	10.7	1120	10.41	9.7
Coyote Creek	Upper Reach (Concrete Channel)	5100	1100	9.34	10.8	556	8.06	6.8	651	8.41	7.5	740	8.76	8.0	1120	9.62	10.5	1120	10.34	9.4
Coyote Creek	Upper Reach (Concrete Channel)	5074	1100	9.29	10.8	556	8.03	6.8	651	8.38	7.5	737	8.73	8.0	1120	9.58	10.6	1120	10.31	9.4
Coyote Creek	Upper Reach (Concrete Channel)	5050	1100	9.24	10.9	556	8.01	6.8	651	8.35	7.5	735	8.71	7.9	1120	9.53	10.6	1120	10.28	9.4
Coyote Creek	Upper Reach (Concrete Channel)	5030	1100	9.21	10.7	556	7.99	6.7	651	8.33	7.4	732	8.69	7.8	1120	9.50	10.5	1120	10.25	9.3
Coyote Creek	Upper Reach (Concrete Channel)	5014	1098	9.18	9.4	556	7.98	5.9	651	8.32	6.5	729	8.67	6.8	1120	9.47	9.1	1120	10.24	8.1
Coyote Creek	Upper Reach (Concrete Channel)	5006	1098	9.17	8.8	556	7.98	5.5	651	8.31	6.1	728	8.66	6.4	1120	9.46	8.5	1120	10.23	7.5
Coyote Creek	Upper Reach (Concrete Channel)	5000	1098	9.16	8.3	556	7.98	5.2	651	8.31	5.7	727	8.66	6.0	1120	9.46	8.1	1120	10.23	7.1
Coyote Creek	Middle Reach	4975	1097	9.14	5.6	555	8.01	3.6	650	8.33	3.9	768	8.68	4.3	1120	9.44	5.5	1120	10.21	3.9
Coyote Creek	Middle Reach	4950	1097	9.14	5.0	555	8.01	3.2	650	8.34	3.4	757	8.67	3.7	1120	9.44	4.8	1120	10.25	2.6
Coyote Creek	Middle Reach	4922	1097	9.17	3.6	555	8.04	2.3	650	8.37	2.5	754	8.70	2.7	1120	9.48	3.4	1120	10.24	2.8
Coyote Creek	Middle Reach	4900	1097	9.17	3.4	555	8.03	2.3	650	8.36	2.5	753	8.70	2.6	1120	9.48	3.2	1120	10.24	2.7
Coyote Creek	Middle Reach	4875	1097	9.17	3.1	555	8.03	2.1	650	8.36	2.2	754	8.70	2.4	1120	9.48	3.0	1120	10.24	2.6
Coyote Creek	Middle Reach	4850	1097	9.14	3.4	555	8.02	2.3	650	8.35	2.4	754	8.68	2.6	1120	9.46	3.2	1120	10.22	2.8
Coyote Creek	Middle Reach	4824	1097	9.13	3.4	555	8.02	2.2	650	8.35	2.4	753	8.68	2.6	1120	9.45	3.2	1120	10.22	2.8
Coyote Creek	Middle Reach	4800	1097	9.12	3.3	555	8.01	2.2	650	8.34	2.4	753	8.67	2.5	1120	9.44	3.2	1120	10.21	2.8
Coyote Creek	Middle Reach	4750	1097	9.10	3.4	555	8.00	2.2	650	8.33	2.4	753	8.66	2.6	1120	9.42	3.3	1120	10.20	2.8
Coyote Creek	Middle Reach	4700	1098	9.08	3.4	555	7.99	2.2	650	8.31	2.4	753	8.64	2.6	1120	9.41	3.2	1120	10.18	2.8
Coyote Creek	Middle Reach	4650	1098	9.05	3.5	555	7.97	2.3	650	8.30	2.4	753	8.63	2.6	1120	9.38	3.3	1120	10.17	2.8
Coyote Creek	Middle Reach	4600	1098	9.04	3.3	555	7.97	2.2	650	8.29	2.4	753	8.62	2.5	1120	9.37	3.2	1120	10.16	2.7
Coyote Creek	Middle Reach	4550	1100	9.02	3.2	555	7.96	2.1	650	8.28	2.3	752	8.61	2.4	1120	9.36	3.1	1120	10.16	2.6
Coyote Creek	Middle Reach	4500	1100	9.01	3.1	555	7.95	2.0	650	8.28	2.2	752	8.60	2.3	1120	9.35	2.9	1120	10.15	2.5
Coyote Creek	Middle Reach	4457	1100	8.99	3.1	555	7.94	2.0	650	8.27	2.1	752	8.59	2.3	1120	9.33	3.0	1120	10.14	2.6
Coyote Creek	Middle Reach	4400	1100	8.73	3.1	555	7.68	1.9	650	7.99	2.1	752	8.31	2.3	1120	9.19	2.9	1120	9.96	2.6
Coyote Creek	Middle Reach	4350	1100	8.71	3.0	555	7.67	2.0	650	7.98	2.1	752	8.30	2.3	1120	9.18	2.8	1120	9.96	2.4
Coyote Creek	Middle Reach	4300	1100	8.69	3.1	555	7.66	2.0	650	7.97	2.2	752	8.29	2.3	1120	9.17	2.9	1120	9.94	2.5
Coyote Creek	Middle Reach	4250	1100	8.67	3.1	555	7.65	2.0	650	7.96	2.2	752	8.28	2.3	1120	9.15	2.9	1120	9.93	2.5
Coyote Creek	Middle Reach	4200	1100	8.70	2.2	555	7.66	1.4	650	7.98	1.5	752	8.29	1.6	1120	9.17	2.1	1120	9.95	1.8
Coyote Creek	Middle Reach	4039.5	1750	8.70	4.4	1029	7.66	3.4	1209	7.98	3.6	1402	8.29	3.9	2040	9.17	4.6	2040	9.95	3.8
Coyote Creek	Middle Reach	4038	1750	8.67	4.4	1029	7.64	3.4	1209	7.95	3.6	1402	8.27	3.9	2040	9.14	4.7	2040	9.94	3.8
Coyote Creek	Middle Reach	4000	1750	8.63	4.5	1029	7.62	3.4	1209	7.93	3.7	1402	8.24	3.9	2040	9.11	4.7	2040	9.91	4.0
Coyote Creek	Middle Reach	3971	1750	8.61	4.5	1029	7.60	3.3	1209	7.91	3.6	1402	8.23	3.9	2040	9.09	4.7	2040	9.89	4.1
Coyote Creek	Middle Reach	3950	1750	8.59	4.6	1029	7.59	3.4	1209	7.90	3.7	1402	8.21	4.0	2040	9.07	4.9	2040	9.87	4.2
Coyote Creek	Middle Reach	3900	1750	8.55	4.8	1029	7.56	3.6	1209	7.86	3.9	1402	8.17	4.2	2040	9.02	5.1	2040	9.84	4.4

			Scenario 1: Baseline			Scenario 2: Updated			Scenario 3a: Enhanced (District 2-percent-annual-chance Event)			Scenario 3b: Enhanced (District 1-percent-annual-chance Event)			Scenario 4: FEMA Accredited			Scenario 5: FEMA Accredited w/ SLR		
River	Reach	Cross Section	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)	Total Flow (cfs)	Water Surface Elevation (ft) NAVD 88	Velocity in the Channel (ft/sec)
Coyote Creek	Middle Reach	3850	1750	8.52	4.3	1029	7.54	3.2	1209	7.84	3.5	1402	8.15	3.8	2040	9.00	4.6	2040	9.83	3.9
Coyote Creek	Middle Reach	3800	1750	8.48	4.6	1029	7.51	3.3	1209	7.81	3.6	1402	8.11	3.9	2040	8.95	4.9	2040	9.80	4.2
Coyote Creek	Middle Reach	3750	1750	8.43	4.8	1029	7.48	3.5	1209	7.77	3.8	1402	8.07	4.2	2040	8.90	5.2	2040	9.76	4.5
Coyote Creek	Middle Reach	3700	1750	8.38	5.0	1029	7.45	3.6	1209	7.74	3.9	1402	8.04	4.3	2040	8.85	5.3	2040	9.73	4.6
Coyote Creek	Middle Reach	3650	1750	8.34	4.8	1029	7.42	3.5	1209	7.71	3.8	1402	8.01	4.2	2040	8.81	5.1	2040	9.71	4.4
Coyote Creek	Middle Reach	3600	1750	8.31	4.7	1029	7.40	3.4	1209	7.69	3.7	1402	7.98	4.0	2040	8.78	4.9	2040	9.69	4.2
Coyote Creek	Middle Reach	3570	1750	8.28	4.8	1029	7.38	3.5	1209	7.66	3.8	1402	7.95	4.1	2040	8.75	5.1	2040	9.67	4.3
Coyote Creek	Middle Reach	3550	1750	8.26	4.8	1029	7.37	3.6	1209	7.65	3.9	1402	7.94	4.2	2040	8.73	5.1	2040	9.67	4.2
Coyote Creek	Middle Reach	3500	1750	8.23	4.3	1029	7.35	3.1	1209	7.63	3.4	1402	7.92	3.7	2040	8.70	4.6	2040	9.66	3.8
Coyote Creek	Middle Reach	3450	1750	8.19	4.3	1029	7.33	3.1	1209	7.60	3.4	1402	7.89	3.7	2040	8.67	4.5	2040	9.65	3.7
Coyote Creek	Middle Reach	3400	1750	8.14	4.8	1029	7.28	3.5	1209	7.56	3.8	1402	7.84	4.1	2040	8.61	4.9	2040	9.61	4.0
Coyote Creek	Middle Reach	3350	1750	8.08	4.9	1048	7.24	3.6	1231	7.51	4.0	1428	7.79	4.3	2040	8.56	5.1	2040	9.58	4.1
Coyote Creek	Middle Reach	3300	1750	8.04	4.7	1079	7.21	3.5	1267	7.48	3.8	1468	7.75	4.2	2040	8.51	4.9	2040	9.56	4.0
Coyote Creek	Middle Reach	3250	1750	8.00	4.6	1079	7.19	3.4	1267	7.45	3.8	1468	7.72	4.1	2040	8.47	4.8	2040	9.54	3.9
Coyote Creek	Middle Reach	3200	1750	7.98	4.2	1079	7.17	3.1	1267	7.43	3.5	1468	7.70	3.8	2040	8.45	4.5	2040	9.54	3.6
Coyote Creek	Middle Reach	3150	1750	7.94	4.3	1079	7.15	3.2	1267	7.40	3.5	1468	7.67	3.8	2040	8.41	4.5	2040	9.52	3.6
Coyote Creek	Middle Reach	3100	1750	7.90	4.3	1079	7.12	3.2	1267	7.38	3.5	1468	7.64	3.9	2040	8.37	4.6	2040	9.50	3.7
Coyote Creek	Middle Reach	3050	1750	7.87	4.3	1079	7.10	3.2	1267	7.35	3.5	1468	7.61	3.8	2040	8.33	4.5	2040	9.48	3.6
Coyote Creek	Middle Reach	3000	1750	7.82	4.4	1079	7.07	3.3	1267	7.32	3.6	1468	7.57	4.0	2039	8.29	4.7	2040	9.46	3.7
Coyote Creek	Middle Reach	2956	1750	7.79	4.4	1079	7.05	3.3	1267	7.29	3.6	1468	7.54	3.9	2103	8.25	4.8	2109	9.43	3.8
Coyote Creek	Middle Reach	2933	1750	7.70	4.7	1079	7.00	3.5	1267	7.23	3.8	1468	7.47	4.1	2103	8.15	5.0	2109	9.38	3.9
Coyote Creek	Middle Reach	2915	1750	7.69	4.6	1079	6.98	3.4	1267	7.21	3.8	1468	7.46	4.1	2101	8.13	5.0	2109	9.37	3.8
Coyote Creek	Middle Reach	2900	1750	7.67	4.5	1079	6.98	3.3	1267	7.21	3.6	1468	7.45	4.0	2098	8.12	4.8	2109	9.37	3.7
Coyote Creek	Lower Reach	2853	1750	7.34	4.8	1079	6.74	3.5	1267	6.96	3.9	1468	7.17	4.2	2098	7.76	5.3	2107	9.21	4.0
Coyote Creek	Lower Reach	2849	1750	7.34	4.9	1079	6.74	3.5	1267	6.95	3.9	1468	7.17	4.3	2097	7.75	5.3	2107	9.21	4.0
Coyote Creek	Lower Reach	2845	1750	7.33	4.9	1079	6.74	3.5	1267	6.95	3.9	1468	7.16	4.3	2096	7.75	5.3	2107	9.21	4.0
Coyote Creek	Lower Reach	2832	1750	7.14	4.9	1079	6.60	3.4	1267	6.79	3.8	1468	6.99	4.2	2096	7.54	5.4	2107	9.01	4.1
Coyote Creek	Lower Reach	2800	1750	7.10	5.1	1079	6.57	3.7	1267	6.76	4.1	1468	6.95	4.5	2088	7.50	5.5	2106	8.99	4.1
Coyote Creek	Lower Reach	2750	1750	7.04	4.8	1079	6.54	3.5	1267	6.72	3.8	1468	6.91	4.2	2069	7.43	5.1	2106	8.99	3.5
Coyote Creek	Lower Reach	2700	1750	6.98	4.4	1079	6.51	3.2	1267	6.69	3.5	1468	6.87	3.8	2136	7.37	4.6	2106	9.02	2.7
Coyote Creek	Lower Reach	2650	1750	6.92	4.3	1079	6.48	3.1	1267	6.65	3.5	1468	6.83	3.8	2113	7.31	4.5	2106	9.01	2.6
Coyote Creek	Lower Reach	2600	1750	6.87	4.5	1079	6.45	3.1	1267	6.62	3.5	1468	6.79	3.8	2111	7.26	4.6	2106	9.00	2.5
Coyote Creek	Lower Reach	2550	1750	6.81	4.4	1079	6.42	3.1	1267	6.58	3.5	1468	6.75	3.8	2111	7.20	4.6	2106	8.99	2.6
Coyote Creek	Lower Reach	2500	1750	6.76	4.2	1079	6.40	2.9	1267	6.55	3.3	1468	6.71	3.6	2110	7.15	4.5	2105	8.98	2.5
Coyote Creek	Lower Reach	2450	1750	6.72	4.0	1079	6.38	2.8	1267	6.52	3.1	1468	6.68	3.4	2110	7.10	4.3	2105	8.97	2.5
Coyote Creek	Lower Reach	2400	1750	6.67	3.9	1079	6.36	2.7	1267	6.50	3.0	1468	6.65	3.3	2110	7.06	4.1	2105	8.97	2.3
Coyote Creek	Lower Reach	2350	1750	6.62	4.0	1079	6.33	2.7	1267	6.47	3.1	1468	6.61	3.4	2110	7.01	4.2	2105	8.96	2.2
Coyote Creek	Lower Reach	2300	1750	6.57	3.9	1079	6.31	2.7	1267	6.44	3.0	1468	6.57	3.3	2110	6.96	4.1	2105	8.96	2.2
Coyote Creek	Lower Reach	2250	1750	6.52	4.0	1079	6.28	2.7	1267	6.41	3.0	1468	6.54	3.3	2110	6.91	4.1	2105	8.95	2.2
Coyote Creek	Lower Reach	2200	1750	6.46	4.0	1079	6.26	2.7	1267	6.37	3.0	1468	6.50	3.3	2110	6.87	4.1	2105	8.94	2.2
Coyote Creek	Lower Reach	2150	1750	6.41	4.0	1079	6.23	2.6	1267	6.35	2.9	1468	6.47	3.3	2110	6.82	4.1	2105	8.93	2.3
Coyote Creek	Lower Reach	2100	1750	6.36	4.0	1117	6.20	2.7	1311	6.31	3.1	1519	6.43	3.4	2110	6.77	4.2	2105	8.92	2.2
Coyote Creek	Lower Reach	2050	1750	6.31	4.0	1117	6.18	2.7	1311	6.28	3.0	1519	6.39	3.4	2110	6.72	4.2	2105	8.92	2.2
Coyote Creek	Lower Reach	2000	1750	6.26	4.0	1117	6.16	2.6	1311	6.26	3.0	1519	6.36	3.3	2110	6.67	4.1	2105	8.92	2.0
Coyote Creek	Lower Reach	1950	1750	6.22	4.0	1117	6.15	2.6	1311	6.23	3.0	1519	6.33	3.3	2110	6.63	4.0	2106	8.92	1.8
Coyote Creek	Lower Reach	1900	1750	6.17	3.8	1117	6.13	2.4	1311	6.21	2.8	1519	6.31	3.1	2110	6.60	3.7	2107	8.93	1.3
Coyote Creek	Lower Reach	1850	1750	6.13	3.4	1117	6.12	2.2	1311	6.20	2.5	1519	6.29	2.8	2110	6.57	3.4	2107	8.93	1.3
Coyote Creek	Lower Reach	1800	1750	6.09	3.5	1116	6.10	2.2	1311	6.18	2.6	1519	6.26	2.9	2110	6.53	3.5	2107	8.93	1.3
Coyote Creek	Lower Reach	1750	1750	6.04	3.8	1116	6.08	2.4	1311	6.15	2.8	1519	6.23	3.1	2110	6.49	3.8	2107	8.92	1.4
Coyote Creek	Lower Reach	1700	1750	5.98	4.3	1116	6.05	2.7	1311	6.11	3.1	1518	6.18	3.5	2110	6.44	4.3	2106	8.92	1.6
Coyote Creek	Lower Reach	1650	1750	5.92	4.2	1116	6.03	2.6	1311	6.08	3.0	1518	6.15	3.3	2109	6.38	4.3	2108	8.92	1.1
Coyote Creek	Lower Reach	1600	1750	5.85	4.3	1116	6.00	2.6	1311	6.05	3.0	1518	6.11	3.4	2108	6.32	4.4	2108	8.92	1.1
Coyote Creek	Lower Reach	1550	1750	5.78	4.3	1116	5.98	2.5	1311	6.02	2.9	1518	6.07	3.3	2085	6.26	4.2	2108	8.92	1.0
Coyote Creek	Lower Reach	1500	1750	5.70	4.4	1116	5.96	2.6	1311	5.99	3.0	1518	6.03	3.4	1945	6.19	4.0	2109	8.92	1.0
Coyote Creek	Lower Reach	1450	1750	5.65	3.2	1116	5.96	1.7	1311	5.99	2.0	1518	6.02	2.3	2174	6.15	3.0	2108	8.92	0.8
Coyote Creek	Lower Reach	1400	1750	5.64	1.9	1116	5.97	1.0	1311	5.99	1.2	1518	6.02	1.3	2145	6.15	1.9	2109	8.92	0.7
Coyote Creek	Lower Reach	1350	1750	5.62	1.8	1116	5.96	0.9	1311	5.98	1.1	1518	6.01	1.2	2135	6.13	1.6	2110	8.92	0.7
Coyote Creek	Lower Reach	1300	1750	5.59	2.0	1116	5.95	1.1	1311	5.97	1.3	1518	5.99	1.5	2128	6.10	2.0	2110	8.92	0.8
Coyote Creek	Lower Reach	1250	1750	5.53	3.4	1116	5.92	2.0	1311	5.93	2.3	1518	5.95	2.7	2125	6.03	3.7	2110	8.91	1.0
Coyote Creek	Lower Reach	1162	93	5.40	0.2	78	5.90	0.1	78	5.90	0.1	135	5.90	0.2	108	5.90	0.2	203	8.90	0.1
Coyote Creek	Lower Reach	1044	75	5.40	0.0	75	5.90	0.0	75	5.90	0.0	75	5.90	0.0	75	5.90	0.0	75	8.90	0.0

Appendix C

HEC-RAS Existing Alternatives Water Surface Profiles

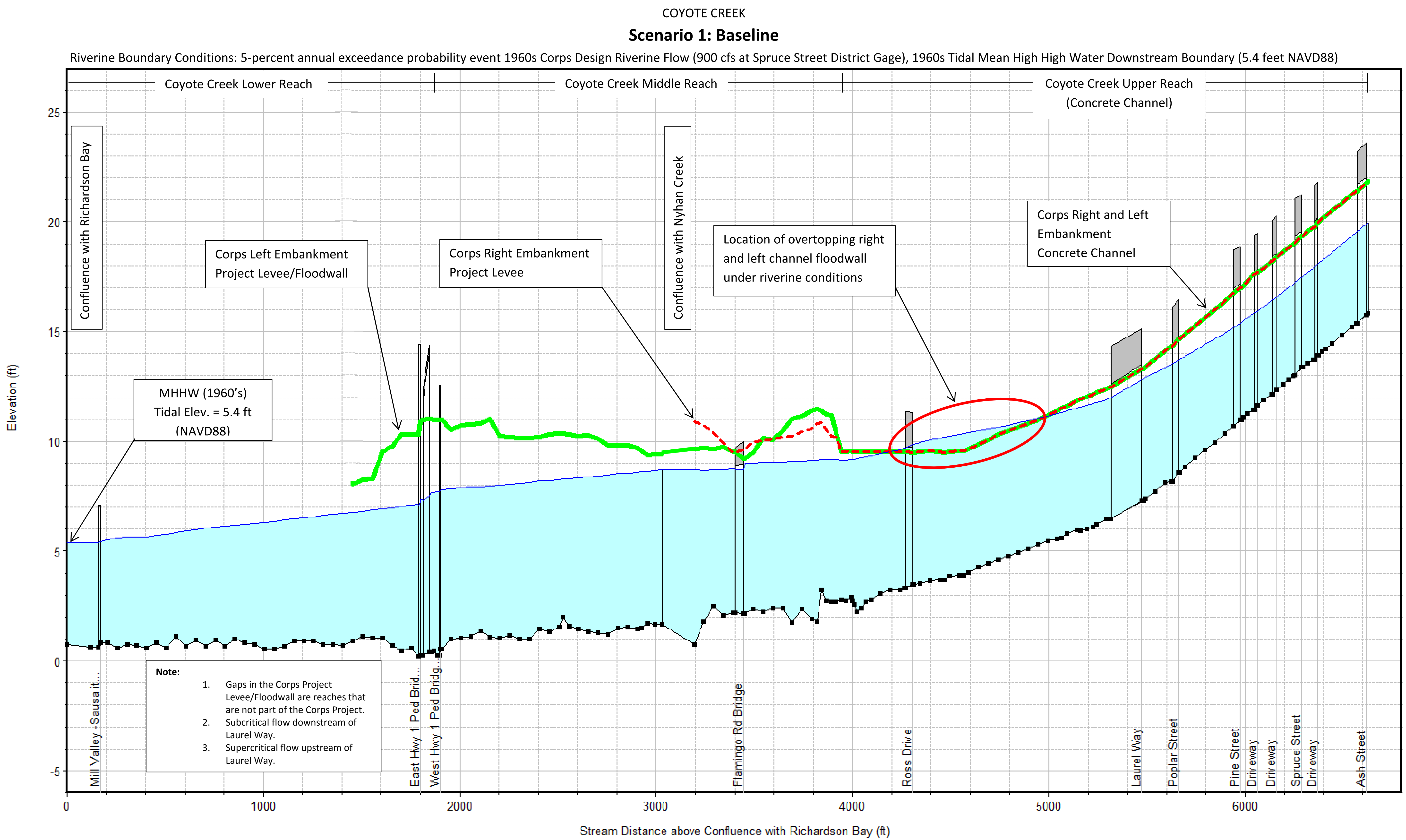
Scenarios Name	1 Baseline	2 Updated	3a Enhanced A (District 2-percent annual exceedance probability event)	3b Enhanced B (District 1-percent annual exceedance probability event)	4 FEMA Accredited	5 FEMA Accredited with SLR
Geometry Description	Existing topography conditions[1]					
Riverine Hydraulics Flow Assumption	5-percent annual exceedance probability event (1960s Corps Design Flow) Coyote Creek 900 cfs[2] Nyhan Creek 650 cfs[3]	4-percent annual exceedance probability event (District Flow + 15%) Coyote Creek 473 cfs[2] Nyhan Creek 473 cfs[3]	2-percent annual exceedance probability event (District Flow + 15%) Coyote Creek 555 cfs[2] Nyhan Creek 559 cfs[3]	1-percent annual exceedance probability event (District Flow + 15%) Coyote Creek 641 cfs[2] Nyhan Creek 651 cfs[3]	1-percent annual exceedance probability event (FEMA Flow) Coyote Creek 910 cfs[4] Nyhan Creek 920 cfs[3]	1-percent annual exceedance probability event (FEMA Flow) Coyote Creek 910 cfs[4] Nyhan Creek 920 cfs[3]
Riverine Hydraulics Downstream Boundary Condition Assumption	MHHW (1960s - 5.4 ft)	MHHW (Present day 5.9 ft)				MHHW (2050 - 8.9 ft)
Tidal Downstream Boundary Condition	MHHW (1960s - 5.4 ft)	MHHW (Present day 5.9 ft)	FEMA 1-percent annual exceedance probability event and still water elevation (9.7 ft)			FEMA 1-percent annual exceedance probability event and still water elevation + Sea Level Rise (2050 - 12.7 ft)

1.- Existing topography per “Topographic Survey of Portion of Coyote Creek City of Mill Valley” survey by Meridian Surveying Engineering Inc. Dated March 2013. All flow is assumed to be contained to the channel.

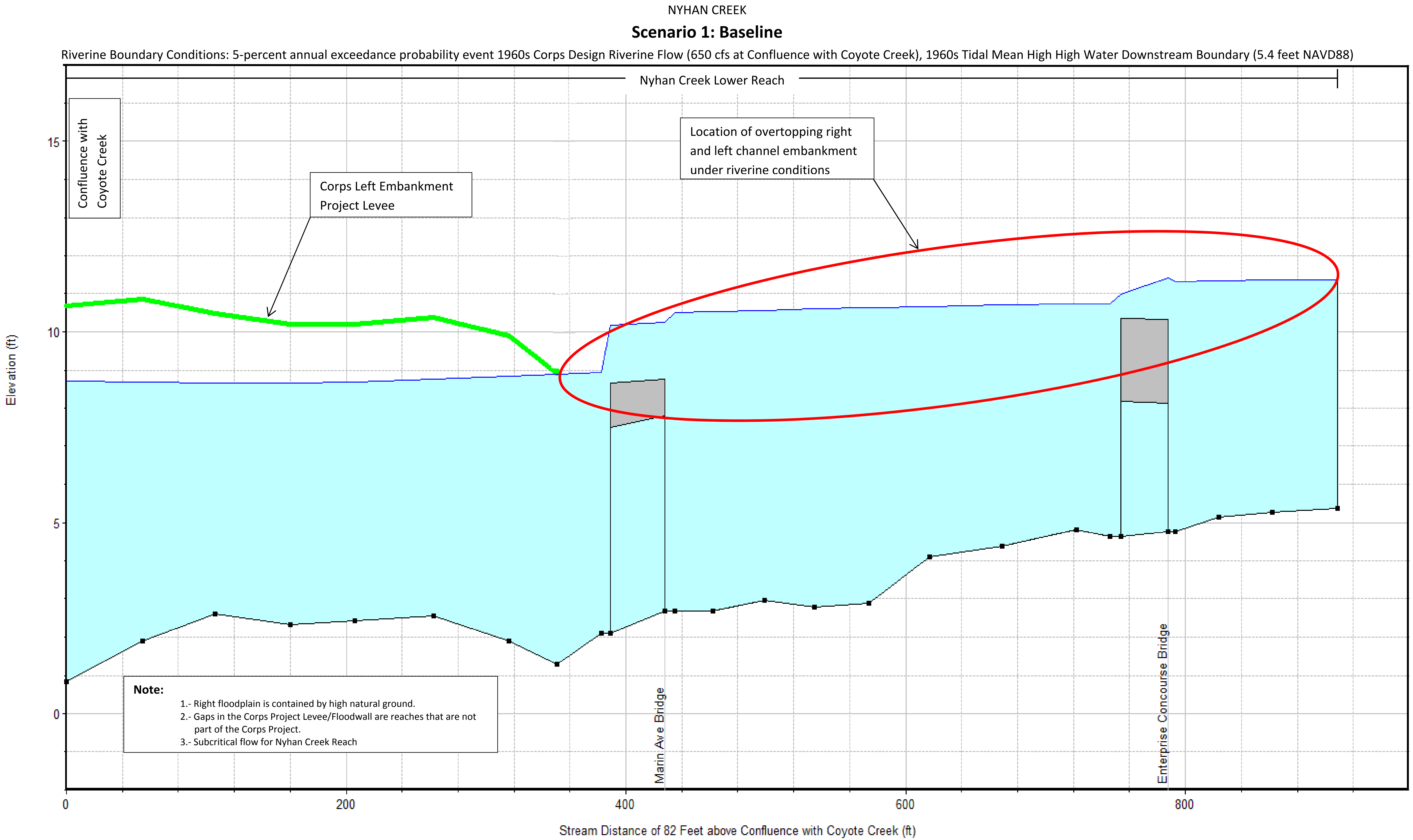
2.- Flow at Spruce Street District Gage.

3.- Flow at Confluence with Coyote Creek.

4.- Flow at Ash Street; approximately 1 city block upstream of Spruce Street (District gage).



COYOTE CREEK
Scenario 1: Baseline
Riverine Boundary Conditions: 5-percent annual exceedance probability event 1960s Corps Design Riverine Flow (900 cfs at Spruce Street District Gage), 1960s Tidal Mean High High Water Downstream Boundary (5.4 feet NAVD88)
Coyote Creek Lower Reach
Coyote Creek Middle Reach
Coyote Creek Upper Reach (Concrete Channel)
Confluence with Richardson Bay
Corps Left Embankment Project Levee/Floodwall
Corps Right Embankment Project Levee
Confluence with Nyhan Creek
Location of overtopping right and left channel floodwall under riverine conditions
Corps Right and Left Embankment Concrete Channel
MHHW (1960's) Tidal Elev. = 5.4 ft (NAVD88)
Note:
1. Gaps in the Corps Project Levee/Floodwall are reaches that are not part of the Corps Project.
2. Subcritical flow downstream of Laurel Way.
3. Supercritical flow upstream of Laurel Way.
Mill Valley -Sausalit...
East Hwy 1 Ped Brid...
West Hwy 1 Ped Bridg...
Flamingo Rd Bridge
Ross Drive
Laurel Way
Poplar Street
Pine Street
Driveway
Driveway
Spruce Street
Driveway
Ash Street
Elevation (ft)
25
20
15
10
5
0
-5
0
1000
2000
3000
4000
5000
6000
Stream Distance above Confluence with Richardson Bay (ft)

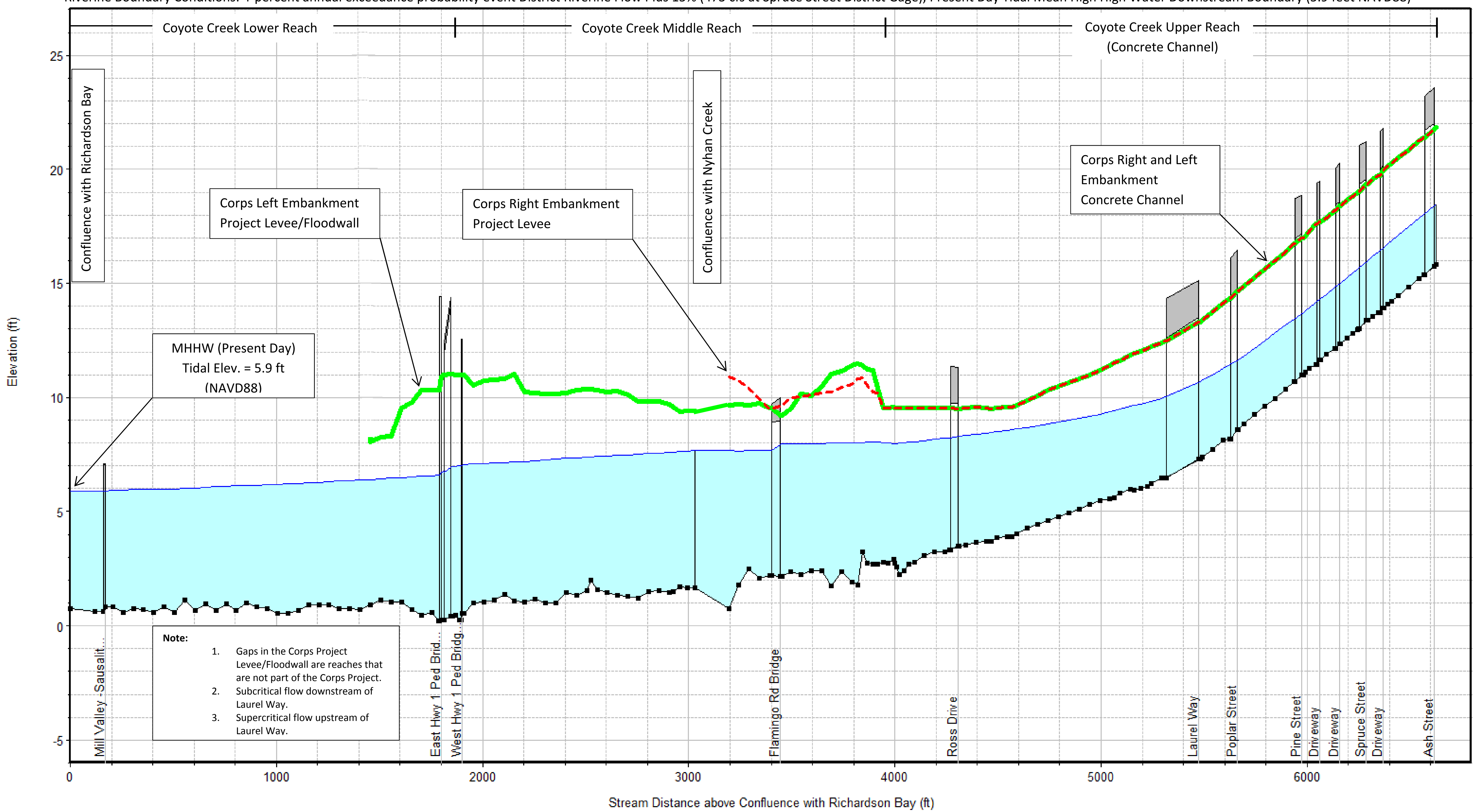


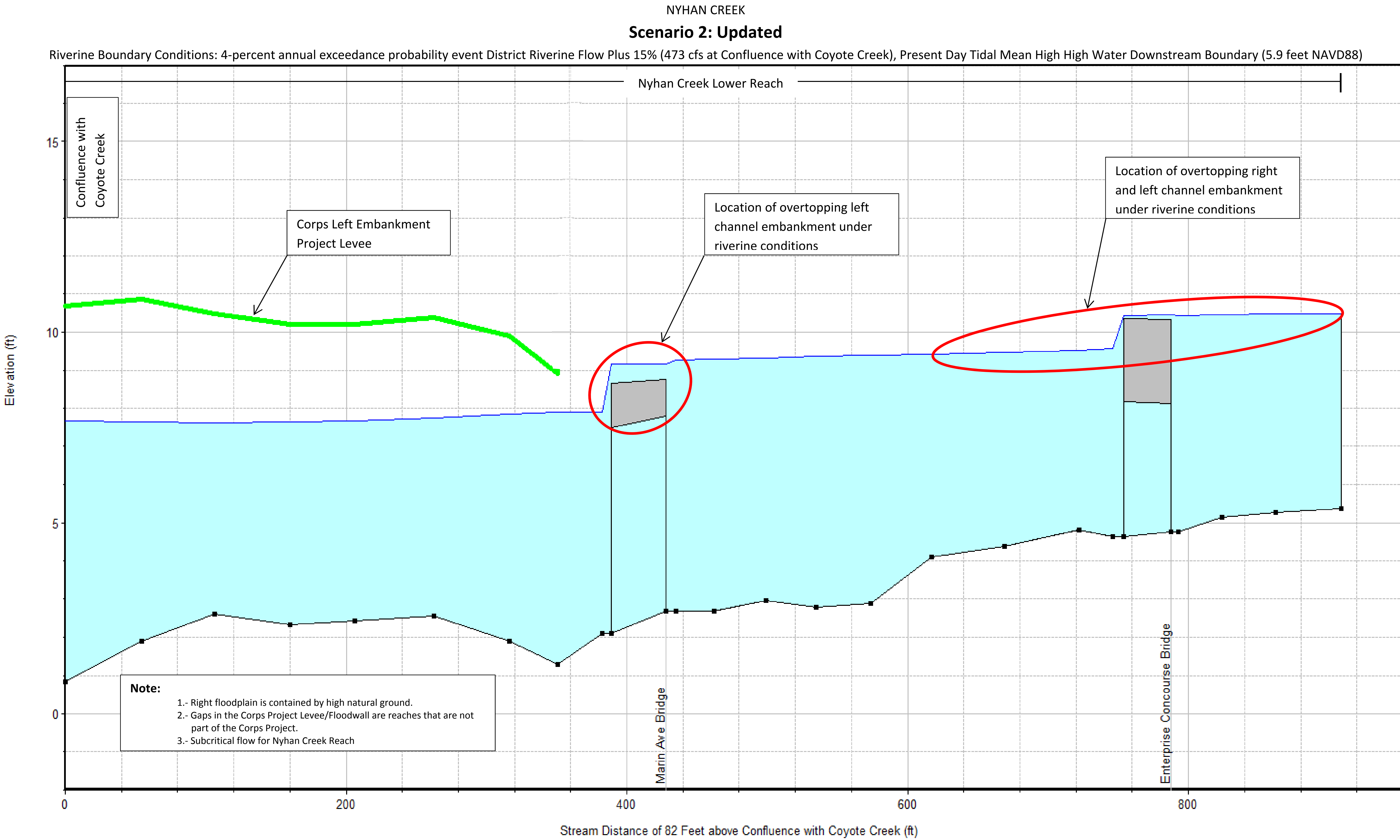
NYHAN CREEK
Scenario 1: Baseline
Riverine Boundary Conditions: 5-percent annual exceedance probability event 1960s Corps Design Riverine Flow (650 cfs at Confluence with Coyote Creek), 1960s Tidal Mean High High Water Downstream Boundary (5.4 feet NAVD88)
Nyhan Creek Lower Reach
Confluence with Coyote Creek
Corps Left Embankment Project Levee
Location of overtopping right and left channel embankment under riverine conditions
Marin Ave Bridge
Enterprise Concourse Bridge
Note:
1.- Right floodplain is contained by high natural ground.
2.- Gaps in the Corps Project Levee/Floodwall are reaches that are not part of the Corps Project.
3.- Subcritical flow for Nyhan Creek Reach
Elevation (ft)
0
5
10
15
0
200
400
600
800
Stream Distance of 82 Feet above Confluence with Coyote Creek (ft)

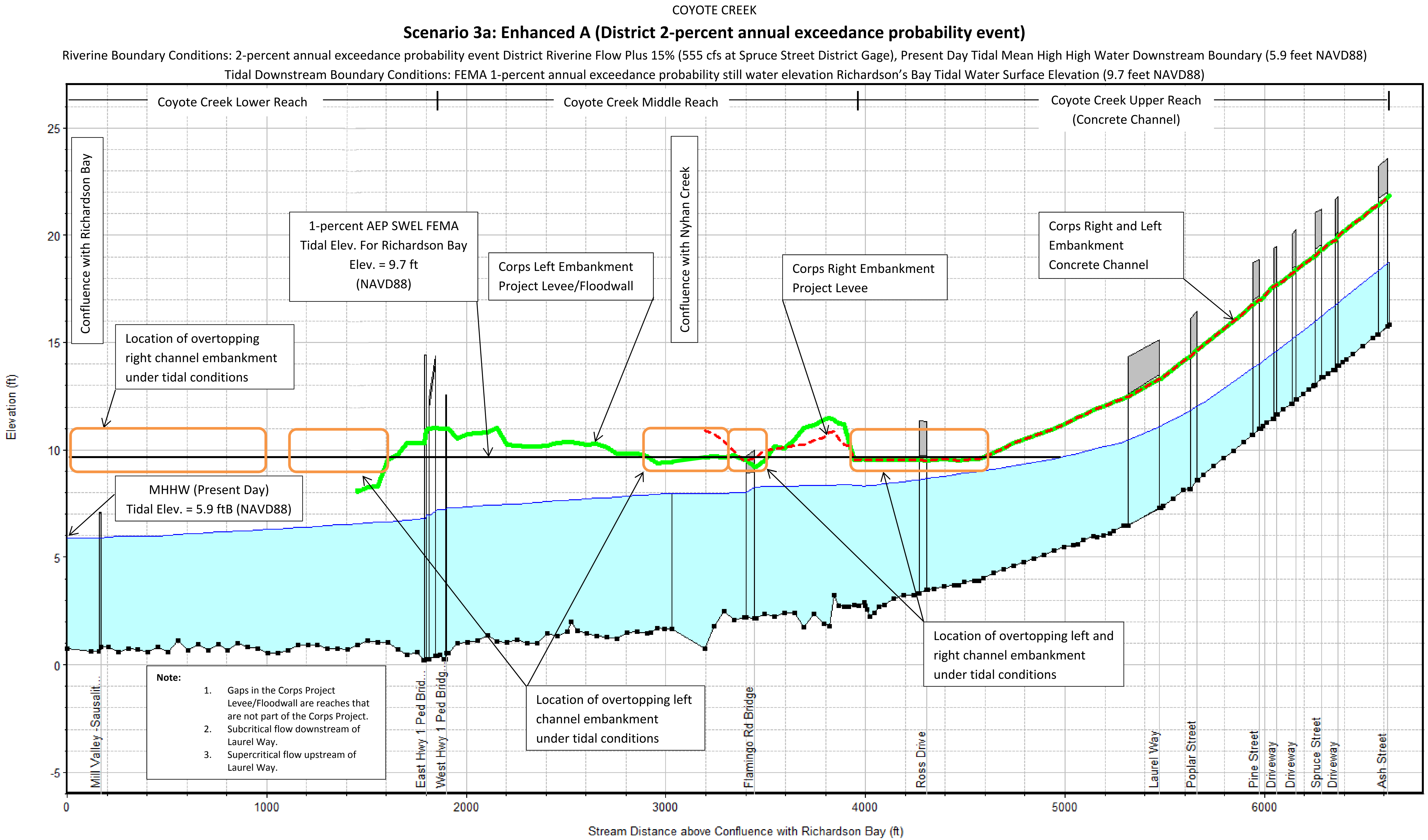
COYOTE CREEK

Scenario 2: Updated

Riverine Boundary Conditions: 4-percent annual exceedance probability event District Riverine Flow Plus 15% (473 cfs at Spruce Street District Gage), Present Day Tidal Mean High High Water Downstream Boundary (5.9 feet NAVD88)




NYHAN CREEK
Scenario 2: Updated
Riverine Boundary Conditions: 4-percent annual exceedance probability event District Riverine Flow Plus 15% (473 cfs at Confluence with Coyote Creek), Present Day Tidal Mean High High Water Downstream Boundary (5.9 feet NAVD88)
Nyhan Creek Lower Reach
Confluence with Coyote Creek
Corps Left Embankment Project Levee
Location of overtopping left channel embankment under riverine conditions
Location of overtopping right and left channel embankment under riverine conditions
Marin Ave Bridge
Enterprise Concourse Bridge
Note:
1.- Right floodplain is contained by high natural ground.
2.- Gaps in the Corps Project Levee/Floodwall are reaches that are not part of the Corps Project.
3.- Subcritical flow for Nyhan Creek Reach
Elevation (ft)
15
10
5
0
0
200
400
600
800
Stream Distance of 82 Feet above Confluence with Coyote Creek (ft)

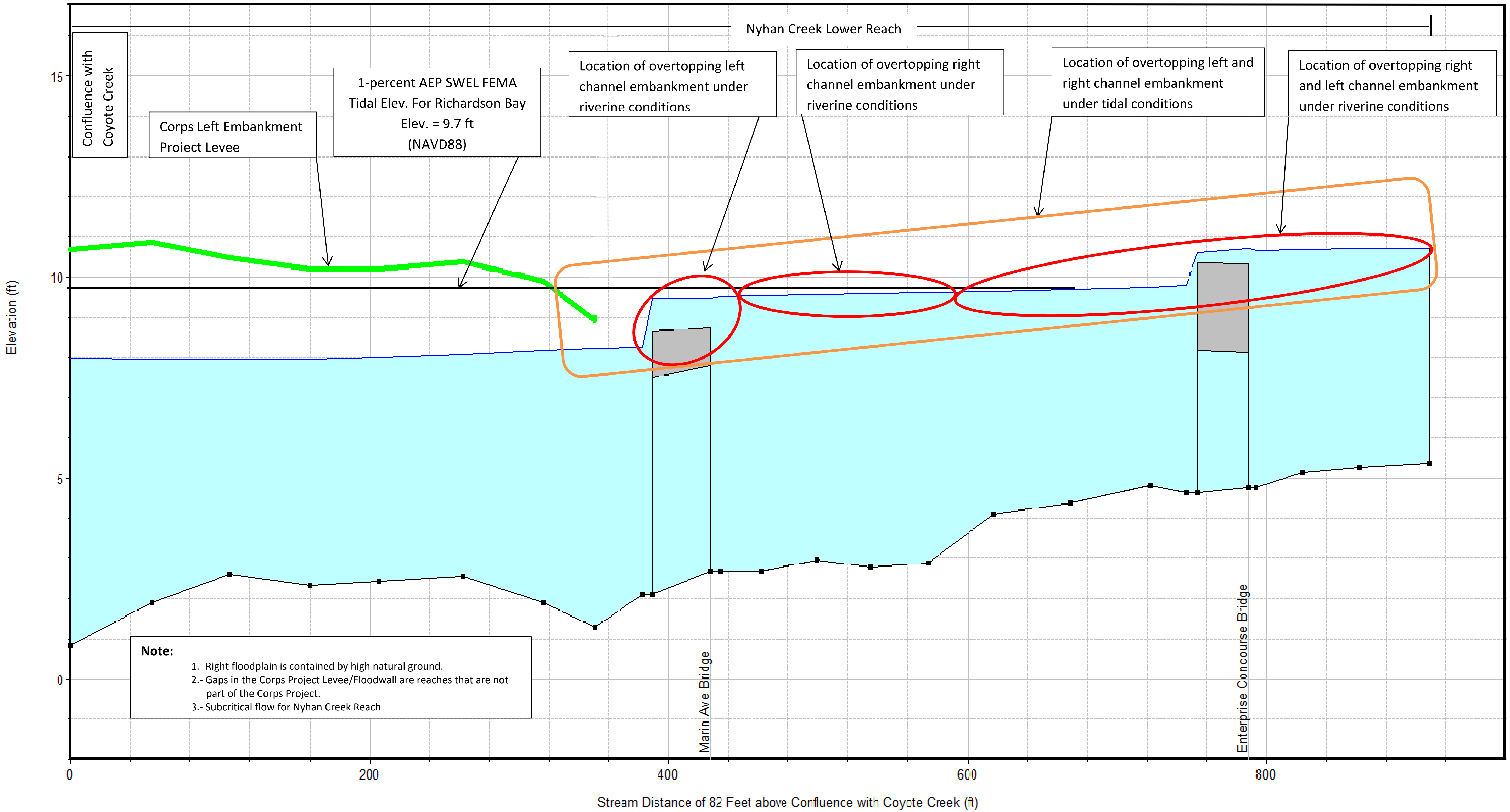

COYOTE CREEK
Scenario 3a: Enhanced A (District 2-percent annual exceedance probability event)
Riverine Boundary Conditions: 2-percent annual exceedance probability event District Riverine Flow Plus 15% (555 cfs at Spruce Street District Gage), Present Day Tidal Mean High High Water Downstream Boundary (5.9 feet NAVD88)
Tidal Downstream Boundary Conditions: FEMA 1-percent annual exceedance probability still water elevation Richardson's Bay Tidal Water Surface Elevation (9.7 feet NAVD88)
Coyote Creek Lower Reach
Coyote Creek Middle Reach
Coyote Creek Upper Reach (Concrete Channel)
Confluence with Richardson Bay
Confluence with Nyhan Creek
1-percent AEP SWEL FEMA Tidal Elev. For Richardson Bay Elev. = 9.7 ft (NAVD88)
Corps Left Embankment Project Levee/Floodwall
Corps Right Embankment Project Levee
Corps Right and Left Embankment Concrete Channel
Location of overtopping right channel embankment under tidal conditions
MHHW (Present Day) Tidal Elev. = 5.9 ftB (NAVD88)
Location of overtopping left channel embankment under tidal conditions
Location of overtopping left and right channel embankment under tidal conditions
Note:
1. Gaps in the Corps Project Levee/Floodwall are reaches that are not part of the Corps Project.
2. Subcritical flow downstream of Laurel Way.
3. Supercritical flow upstream of Laurel Way.
Mill Valley -Sausalit...
East Hwy 1 Ped Brid...
West Hwy 1 Ped Bridg...
Flamingo Rd Bridge
Ross Drive
Laurel Way
Poplar Street
Pine Street
Driveway
Driveway
Spruce Street
Driveway
Ash Street
Elevation (ft)
Stream Distance above Confluence with Richardson Bay (ft)
25
20
15
10
5
0
-5
0
1000
2000
3000
4000
5000
6000

NYHAN CREEK

Scenario 3a: Enhanced A (District 2-percent annual exceedance probability event)

Riverine Boundary Conditions: 2-percent annual exceedance probability event District Riverine Flow Plus 15% (559 cfs at Confluence with Coyote Creek), Present Day Tidal Mean High High Water Downstream Boundary (5.9 feet NAVD88)

Tidal Downstream Boundary Conditions: FEMA 1-percent annual exceedance probability still water elevation Richardson's Bay Tidal Water Surface Elevation (9.7 feet NAVD88)

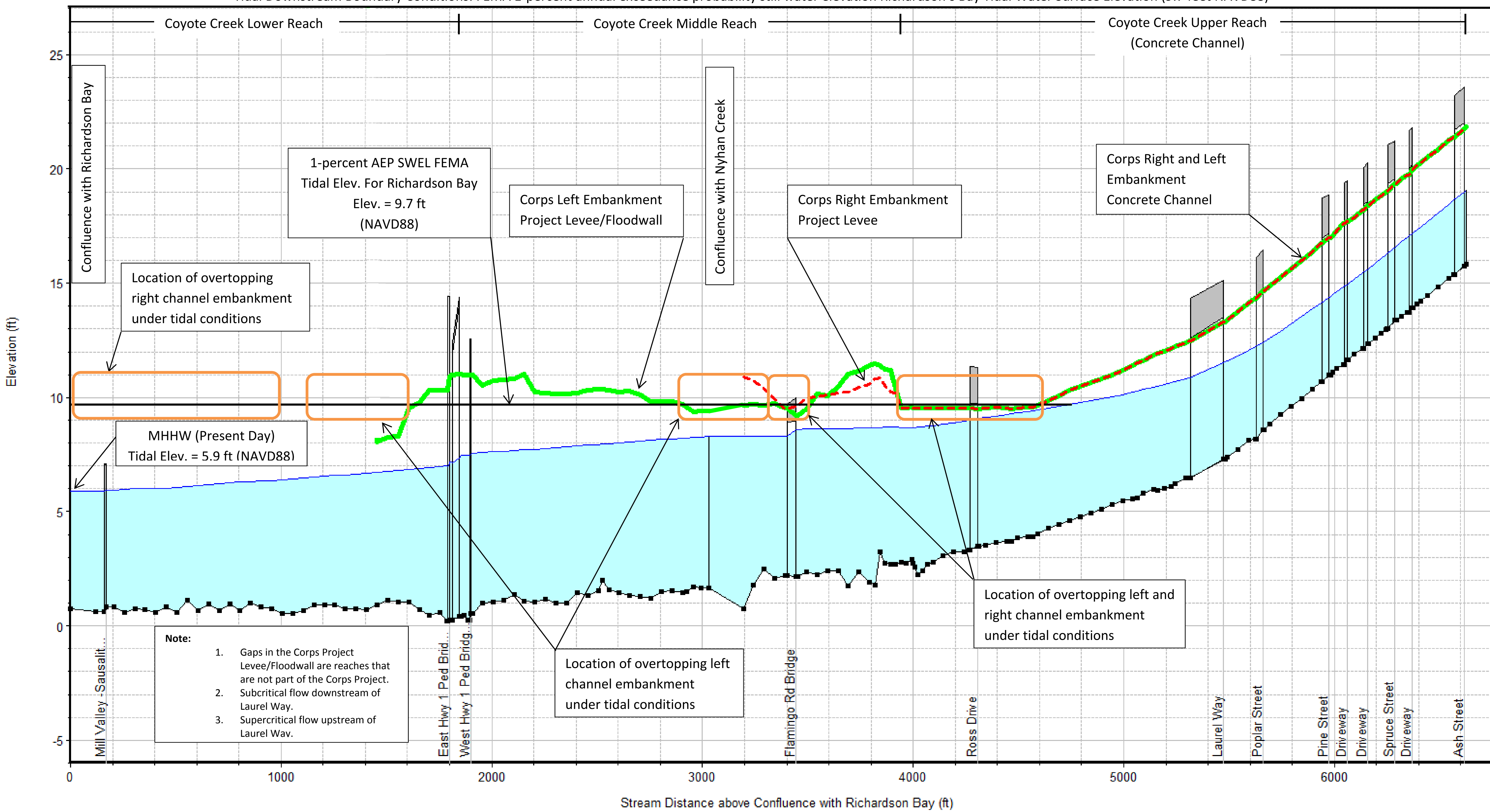


COYOTE CREEK

Scenario 3b: Enhanced B (District 1-percent annual exceedance probability event)

Riverine Boundary Conditions: 1-percent annual exceedance probability event District Riverine Flow Plus 15% (641 cfs at Spruce Street District Gage), Present Day Tidal Mean High High Water Downstream Boundary (5.9 feet NAVD88)

Tidal Downstream Boundary Conditions: FEMA 1-percent annual exceedance probability still water elevation Richardson's Bay Tidal Water Surface Elevation (9.7 feet NAVD88)

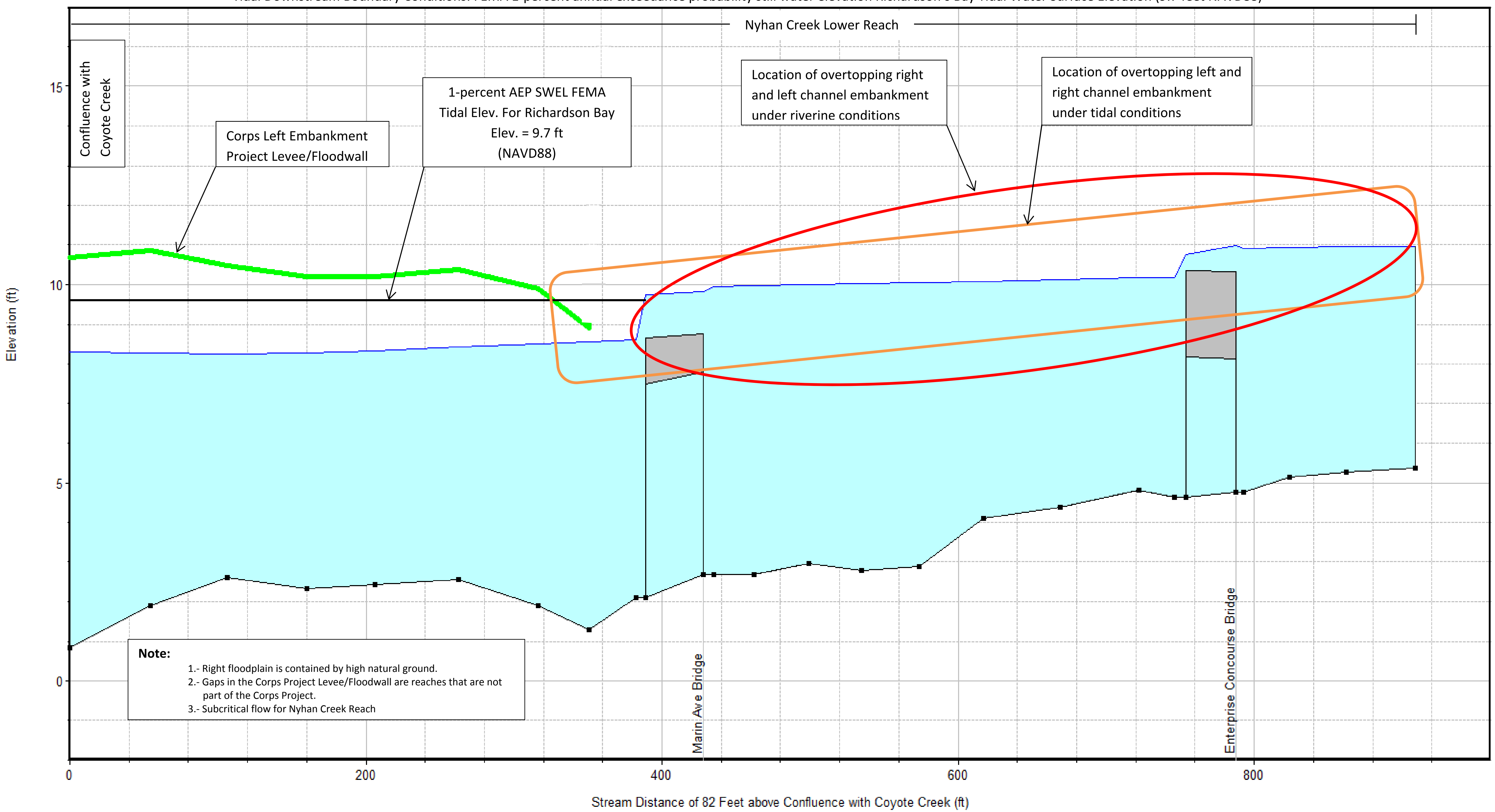


NYHAN CREEK

Scenario 3b: Enhanced B (District 1-percent annual exceedance probability event)

Riverine Boundary Conditions: 1-percent annual exceedance probability event District Riverine Flow Plus 15% (651 cfs at Confluence with Coyote Creek), Present Day Tidal Mean High High Water Downstream Boundary (5.9 feet NAVD88)

Tidal Downstream Boundary Conditions: FEMA 1-percent annual exceedance probability still water elevation Richardson's Bay Tidal Water Surface Elevation (9.7 feet NAVD88)

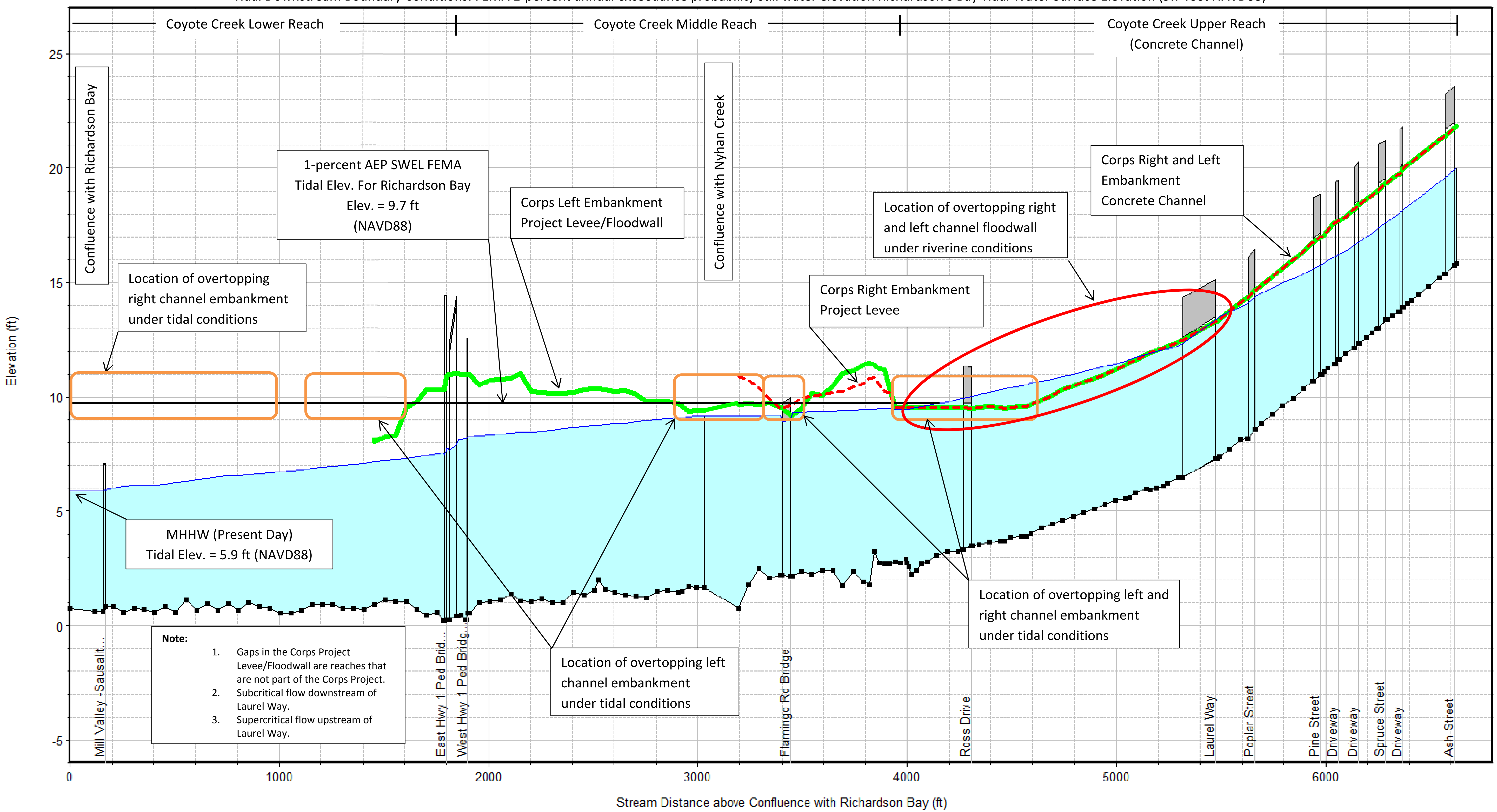


COYOTE CREEK

Scenario 4: FEMA Accredited

Riverine Boundary Conditions: 1-percent annual exceedance probability event FEMA Flow (910 cfs at Ash Street), Present Day Tidal Mean High High Water Downstream Boundary (5.9 feet NAVD88)

Tidal Downstream Boundary Conditions: FEMA 1-percent annual exceedance probability still water elevation Richardson's Bay Tidal Water Surface Elevation (9.7 feet NAVD88)

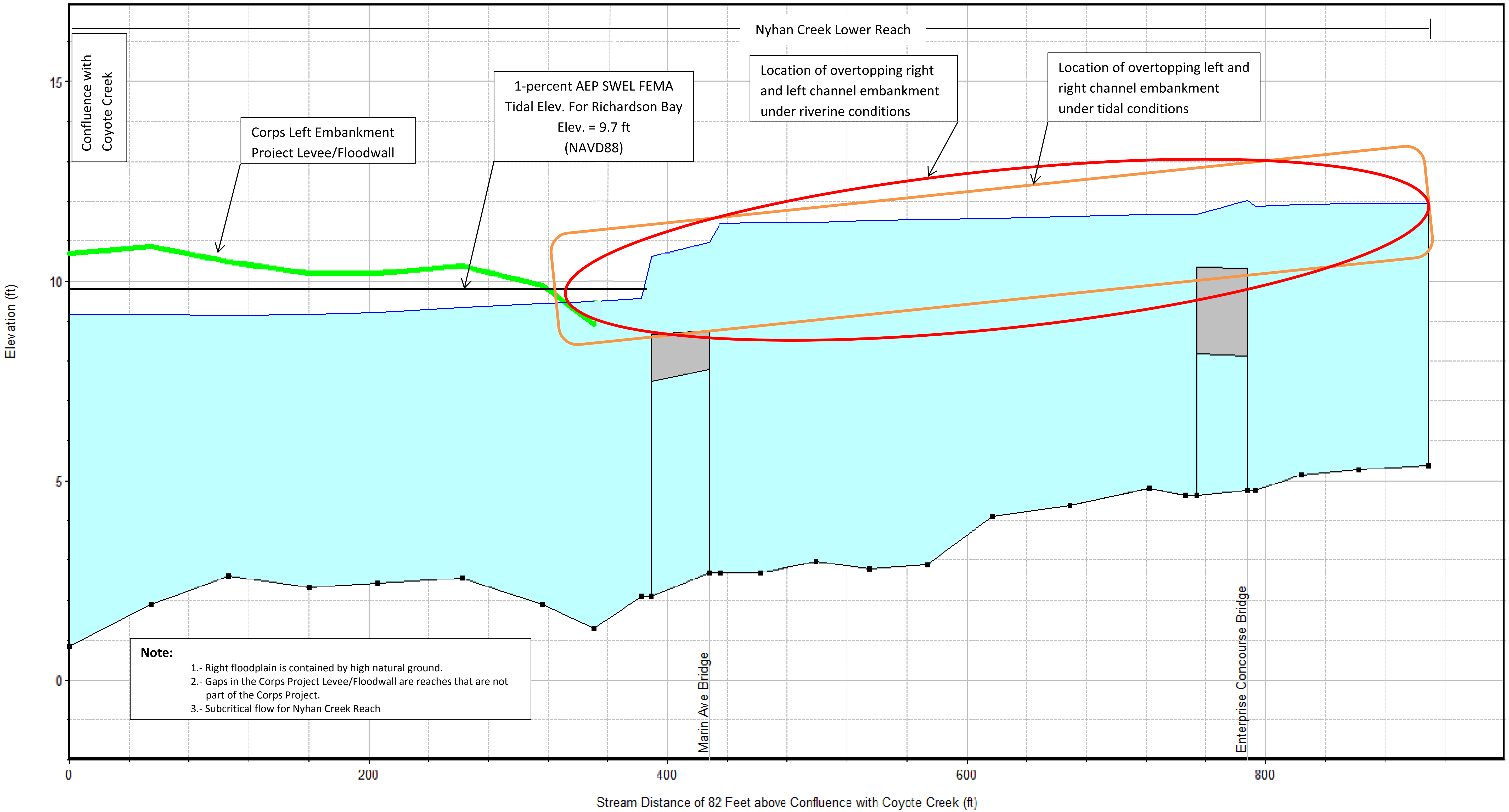


NYHAN CREEK

Scenario 4: FEMA Accredited

Riverine Boundary Conditions: 1-percent annual exceedance probability event FEMA Flow (920 cfs at Confluence with Coyote Creek), Present Day Tidal Mean High High Water Downstream Boundary (5.9 feet NAVD88)

Tidal Downstream Boundary Conditions: FEMA 1-percent annual exceedance probability still water elevation Richardson's Bay Tidal Water Surface Elevation (9.7 feet NAVD88)

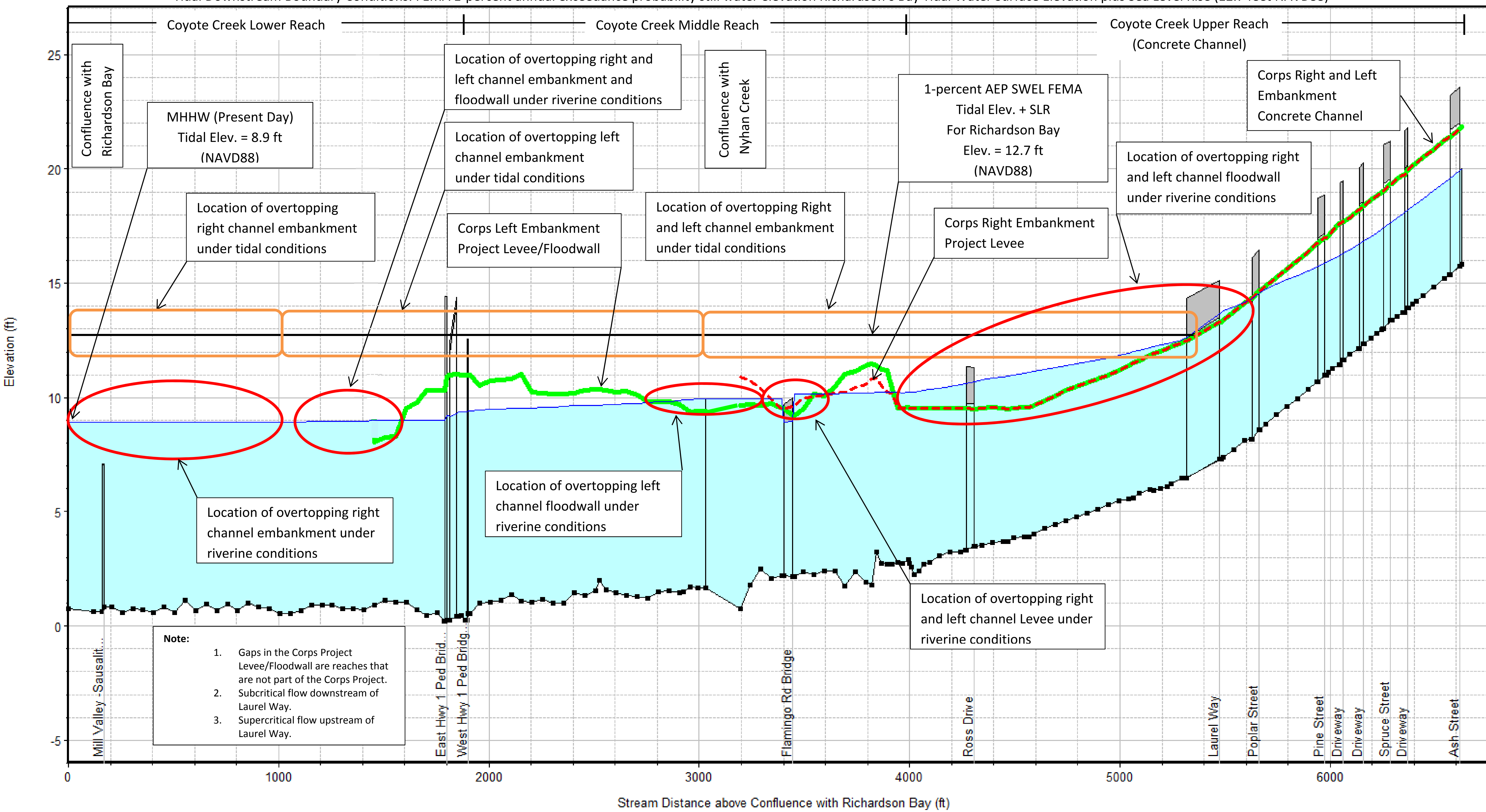


COYOTE CREEK

Scenario 5: FEMA Accredited With Sea Level Rise

Riverine Boundary Conditions: 1-percent annual exceedance probability event FEMA Flow (910 cfs at Ash Street), Estimated 2050 Tidal Mean High High Water Downstream Boundary (8.9 feet NAVD88)

Tidal Downstream Boundary Conditions: FEMA 1-percent annual exceedance probability still water elevation Richardson's Bay Tidal Water Surface Elevation plus Sea Level Rise (12.7 feet NAVD88)

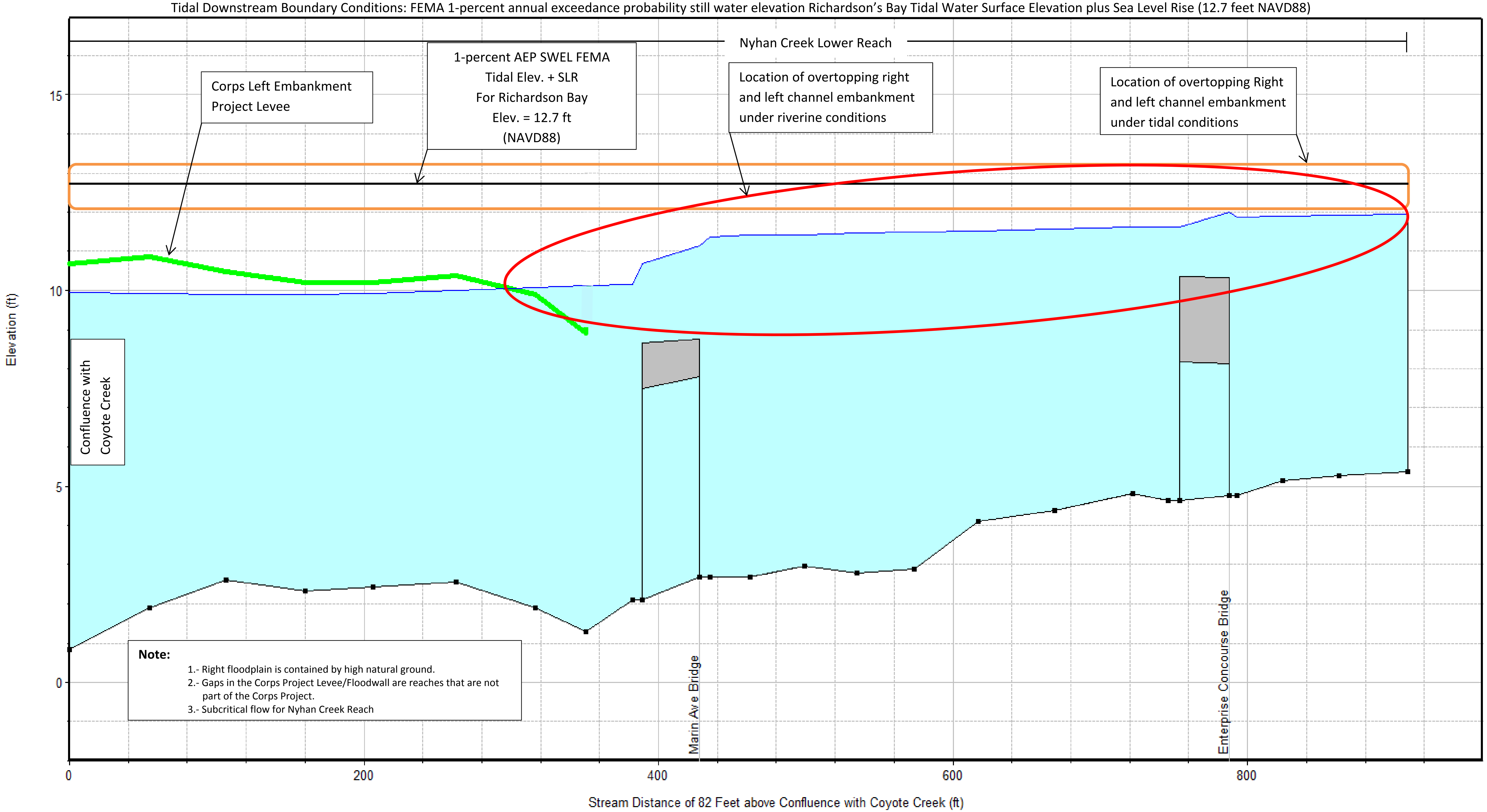


NYHAN CREEK

Scenario 5: FEMA Accredited With Sea Level Rise

Riverine Boundary Conditions: 1-percent annual exceedance probability event FEMA Flow (920 cfs at Confluence with Coyote Creek), Present Day Tidal Mean High High Water Downstream Boundary (8.9 feet)

Tidal Downstream Boundary Conditions: FEMA 1-percent annual exceedance probability still water elevation Richardson's Bay Tidal Water Surface Elevation plus Sea Level Rise (12.7 feet NAVD88)



Appendix D

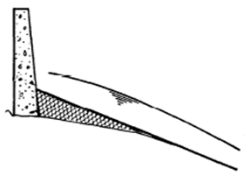
Channel Scour

2365 Iron Point Road, Suite 300, Folsom, CA
P 916-817-4700
hdrinc.com

Channel Scour Analysis

Channel	River Station	Channel Alignment	Neill (1973)							Lancey (1930)						Blench (1969)					Avg. Scour Depth (ft)
			di	q_f	q_i	m	d_f	Z	d_s	Q	D_m	f	d_m	Z	d_s	q_f	F_{bo}	d_{fo}	Z	d_s	
Coyote Creek	4975	Moderate Bend	1.0	18.1	7.5	0.7	1.8	0.6	1.1	769.1	0.074	0.5	5.5	0.5	2.8	18.1	1.6	5.9	0.6	3.5	2.5
Coyote Creek	4650	Straight	1.2	11.8	3.3	0.7	2.8	0.5	1.4	753.1	0.074	0.5	5.5	0.3	1.4	11.8	1.6	4.4	0.6	2.7	1.8
Coyote Creek	3350	Severe Bend	0.8	18.8	2.8	0.7	2.9	0.7	2.0	1428.0	0.074	0.5	6.8	0.8	5.1	18.8	1.6	6.0	0.6	3.6	3.6
Nyhan Creek	408	Straight	0.5	26.0	2.1	0.7	2.9	0.5	1.5	650.3	0.074	0.5	5.2	0.3	1.3	26.0	1.6	7.5	0.6	4.5	2.4
Nyhan Creek	681	Straight	0.3	11.3	2.9	0.7	0.6	0.5	0.3	488.0	0.074	0.5	4.7	0.3	1.2	11.3	1.6	4.3	0.6	2.6	1.4

Source: Computing Degradation and Local Scour, U.S. Department of the Interior Bureau of Reclamation, by Ernest L. Pemberton and Joseph M. Lara, January 1984



COMPUTING
DEGRADATION
AND
LOCAL SCOUR

TECHNICAL GUIDELINE FOR
BUREAU OF RECLAMATION

U.S. Department of the Interior
Bureau of Reclamation

COMPUTING
DEGRADATION AND
LOCAL SCOUR

by

Ernest L. Pemberton
Joseph M. Lara

TECHNICAL GUIDELINE FOR
BUREAU OF RECLAMATION

SI METRIC

SEDIMENTATION AND RIVER HYDRAULICS SECTION
HYDROLOGY BRANCH
DIVISION OF PLANNING TECHNICAL SERVICES
ENGINEERING AND RESEARCH CENTER

DENVER, COLORADO

JANUARY 1984

Regime equations supported by field measurements method. - This approach as suggested by Neill (1973) on recommendations by Blench (1969) involves obtaining field measurements in an incised reach of river from which the bankfull discharge and hydraluics can be determined. From the bankfull hydraulics in the incised reach of river, the flood depths can be computed by:

$$d_f = d_i \left(\frac{q_f}{q_i}\right)^m \qquad (25)$$

where:

d_f = Scoured depth below design floodwater level
d_i = Average depth at bankfull discharge in incised reach
q_f = Design flood discharge per unit width
q_i = Bankfull discharge in incised reach per unit width
m = Exponent varying from 0.67 for sand to 0.85 for coarse gravel

This method has been expanded for Reclamation use to include the empirical regime equation by Lacey (1930) and the method of zero bed-sediment transport by Blench (1969) in the form of the Lacey equation:

$$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3} \qquad (26)$$

where:

d_m = Mean depth at design discharge, ft (m)
Q = Design discharge, ft^3/s (m^3/s)
f = Lacey's silt factor equals $1.76 (D_m)^{1/2}$ where D_m equal mean grain size of bed material in millimeters

and the Blench equation for "zero bed factor":

$$d_{fo} = \frac{q_f^{\;2/3}}{F_{bo}^{\;1/3}} \qquad (27)$$

where:

d_{fo} = Depth for zero bed sediment transport, ft (m)
q_f = Design flood discharge per unit width, ft^3/s per ft (m^3/s per m)
F_{bo} = Blench's "zero bed factor" in ft/s^2 (m/s^2) from figure 9

The maximum natural channel scour depth for design of any structure placed below the streambed (i.e., siphon) or along the bank of a channel must

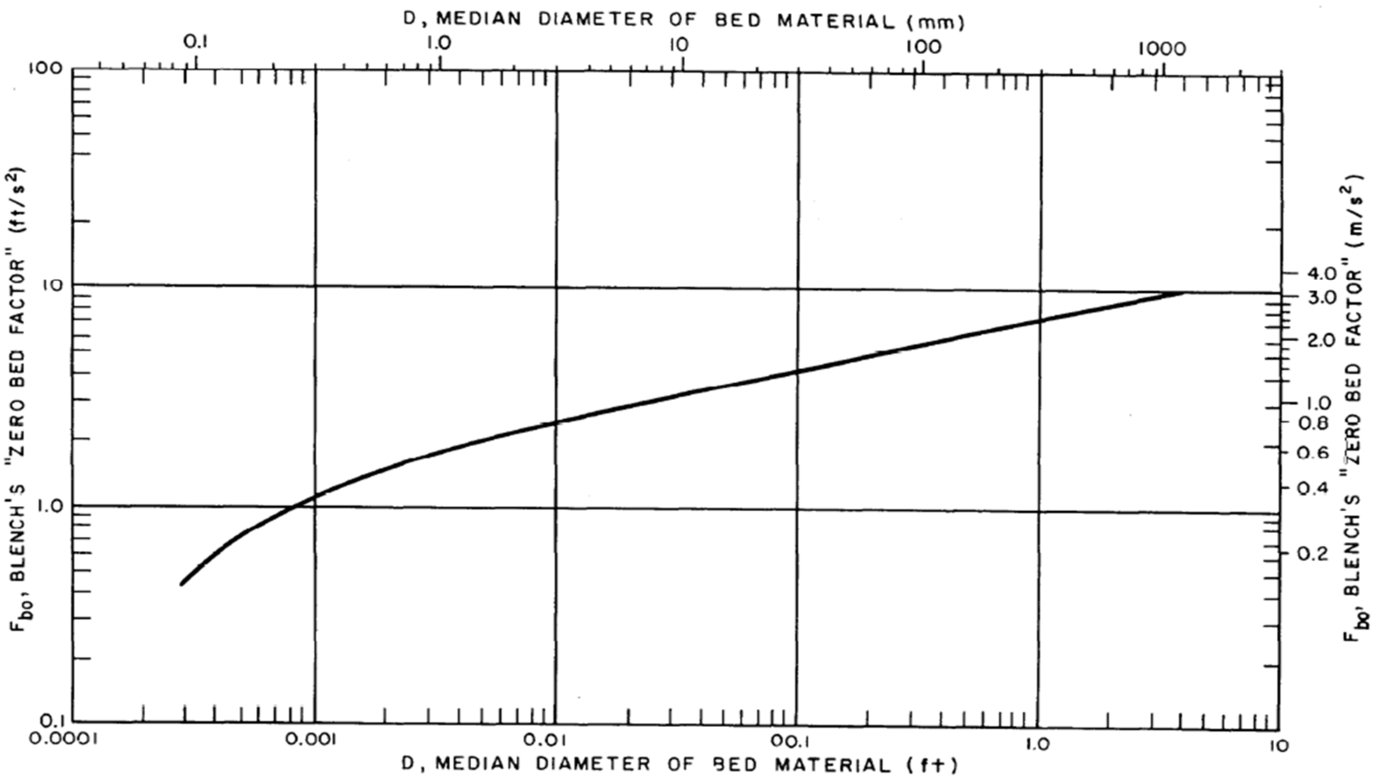


CHART FOR ESTIMATING F_{bo} (AFTER BLENCH)

Figure 9. - Chart for estimating F_{bo} (after Blench, 1969).

consider the probable concentration of floodflows in some portion of the natural channel. Equations 25, 26, or 27 for predicting this maximum depth are to be adjusted by the empirical multiplying factors, Z, shown for formula Types A and B (table 6), in table 7. An illustration of maximum scour depth associated with a flood discharge is shown in a sketch of a natural channel, figure 10. As shown in table 7 and on figure 10, the d_s equals depth of scour below streambed.

$$d_s = Z\, d_f \qquad (28)$$

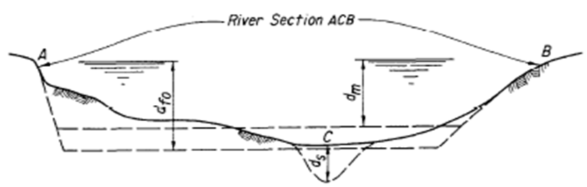
$$d_s = Z\, d_m \qquad (29)$$

$$d_s = Z\, d_{fo} \qquad (30)$$

Table 7. - Multiplying factors, Z, for use in scour depths by regime equations

Condition	Value of Z: Neill $d_s = Z\, d_f$	Value of Z: Lacey $d_s = Z\, d_m$	Value of Z: Blench $d_s = Z\, d_{fo}$
Equation Types A and B			
Straight reach	0.5	0.25	1/ 0.6 (straight reach, moderate bend, severe bend)
Moderate bend	0.6	0.5	
Severe bend	0.7	0.75	
Right angle bends		1.0	1.25
Vertical rock bank or wall		1.25	
Equation Types C and D			
Nose of piers	1.0		0.5 to 1.0
Nose of guide banks	0.4 to 0.7	1.50 to 1.75	1.0 to 1.75
Small dam or control across river		1.5	0.75 to 1.25

1/ Z value selected by USBR for use on bends in river.



NOTE: $d_{fo} > d_f > d_m$. Point C is low point of natural section.

Figure 10. - Sketch of natural channel scour by regime method.

Although not shown on figure 10, the d_f from Neill's equation 25 is usually less than the d_{fo} from Blench's equation 27 but greater than the d_m from Lacey's equation 26.

The design of a structure under a river channel such as a siphon is based on applying the scoured depth, d_s, as obtained from table 7 to the low point in a surveyed section, as shown by point C on figure 10. This criteria is considered by Reclamation as an adequate safety factor for use in design. In an alluvial streambed, designs should also be based on scour occuring at any location in order to provide for channel shifting with time.

Appendix E

Hydraulic Structure Scour

Soil Characteristic

River	Reach	Bridge RS	Bridge	Location	Boaring	Soil Characteristics	Column1
Coyote Creek	Middle Upper	4430	COC-500	Flamingo Rd Bridge (NCI/MSE 2013 survey)	GEI B-8	(GC) D50= 5mm (top 2 ft of soil)	B-8: 5mm (top 2 ft)
Coyote Creek	Middle Lower	2943	COC-400	West (New) Hwy 1 Pedestrian Bridge (NCI/MSE survey)	B-8 (2009) B-9 (2009)	B-8 (2009) Brown Sandy Lean Clay with Gravel (CL) B-9 (2009) Gravy poorly fraded gravel with clay (GP-GC)	
Coyote Creek	Middle Lower	2871	COC-300	Hwy 1 Bridge (NCI/MSE survey)	B-8 (2009) B-9 (2009)	B-8 (2009) Brown Sandy Lean Clay with Gravel (CL) B-9 (2009) Gravy poorly fraded gravel with clay (GP-GC)	
Coyote Creek	Middle Lower	2837	COC-200	East Hwy 1 Pedestrian Bridge (NCI/MSE survey)	B-8 (2009) B-9 (2009)	B-8 (2009) Brown Sandy Lean Clay with Gravel (CL) B-9 (2009) Gravy poorly fraded gravel with clay (GP-GC)	
Coyote Creek	Middle Lower	1211	COC-100	Trestle Bridge (NCI/MSE survey)	B-1 (2009) 2f-20 (1964)	Dark gray silty fat clay (CH) bay mud 2f-20(1964) sandy clay fill, light brown and tan moist soft med plasticity gravel to 1" max size	
Nyhan Creek	Lower	913	NYC_200	Enterprise Concourse Bridge (NCI/MSE survey)	GEI CPT 9-CONE PENETRATOIN TEST	Clay	
Nyhan Creek	Lower	556	NYC_100	Marin Ave Bridge (NCI/MSE survey)	KB-3 (2007)	Gravely Clay/Clayey Gravel -dark brown, moist, loose/medium dense, fine to coarse and, angular gravel to 0.75" diameter fill (GC/CL)	

MAJOR DIVISIONS			SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS OVER 50%>No. 200 SIEVE SIZE	GRAVELS MORE THAN 1/2 OF COARSE FRACTION> No. 4 SIEVE SIZE	CLEAN GRAVELS WITH LESS THAN 5% FINES	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GRAVELS WITH OVER 15% FINES	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS MORE THAN 1/2 OF COARSE FRACTION< No. 4 SIEVE SIZE	CLEAN SANDS WITH LESS THAN 5% FINES	SW	Well-graded sands or gravelly sands, little or no fines
			SP	Poorly graded sands or gravelly sands, little or no fines
		SANDS WITH OVER 15% FINES	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS OVER 50%<No. 200 SIEVE SIZE	SILTS & CLAYS LIQUID LIMIT 50% OR LESS		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS LIQUID LIMIT GREATER THAN 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils
				Caliche

0.0745 mm

Scour Calculation Results

Reference HEC 18, 5th Edition

Design Year: 100

Clear-Water contraction scour will exist. Use the Clear-Water analysis.

Do Coarse Bed Conditions Exist? Yes ("YES" or "NO")

Contractions Scour Results:

If Clear-Water Governs -1.53 ft

If Live-Bed Governs, Minimum of ysLB and ysCW 0.00 ft

100-yr Contraction Scour: -1.53 feet

Does Vertical Contractions Scour Occur? NO ("YES" or "NO")

--

-- -- --

-- -- --

-- -- --

Are there piers within the 500-year floodplain? YES ("YES" or "NO")

100-yr Local Pier Scour: 2.97 feet

Riprap Size at Abutments: R-6

Riprap Size at Piers: R-6

Note: If the super flood (500-year) scour depth is below the bottom of the footing elevation then the rock size should be as determined by the 500-year calculations.

100-yr Scour Results (ft)			
Scour Type	Abutment 1	Abutment 2	Pier
Contraction Scour	-2.00	-2.00	-2.00
Vertical Contraction Scour	--	--	--
Local Scour	--	--	3.00
Total Scour	-2.00	-2.00	1.00

Notes: (1) Local abutment scour calculations are not required when the substructure is protected with multi-layered riprap protection. (2) If multi-layered riprap protection is proposed at the piers the local pier scour depth may be reduced by 50%.

XS1

HEC-RAS, 100 Year Design

Plan: COC-500		RS:4500	Profile: 100-Yr		
E.G. Elev (ft)	8.54	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.09	Wt. n-Val.		0.025	
W.S. Elev (ft)	8.45	Reach Len. (ft)	36.66	42.65	48.74
Crit W.S. (ft)		Flow Area (sq ft)		315.8	
E.G. Slope (ft/ft)	0.000239	Area (sq ft)		315.8	
Q Total (cfs)	752.88	Flow (cfs)		752.88	
Top Width (ft)	73.75	Top Width (ft)		73.75	
Vel Total (ft/s)	2.38	Avg. Vel. (ft/s)		2.38	
Max Chl Dpth (ft)	6.09	Hydr. Depth (ft)		4.28	
Conv. Total (cfs)	48661.3	Conv. (cfs)		48661.3	
Length Wtd. (ft)	42.65	Wetted Per. (ft)		75.66	
Min Ch El (ft)	2.36	Shear (lb/sq ft)		0.06	
Alpha	1	Stream Power (lb/ft s)	120.93	20.19	104.34
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)		3.74	0
C & E Loss (ft)		Cum SA (acres)		0.53	

XS2

HEC-RAS, 100 Year Design

Plan: COC-500		RS:4430	Profile: 100-Yr	
E.G. US. (ft)	8.53	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	8.44	E.G. Elev (ft)	8.52	8.25
Q Total (cfs)	752.87	W.S. Elev (ft)	8.42	8.15
Q Bridge (cfs)	752.87	Crit W.S. (ft)	5.11	4.93
Q Weir (cfs)		Max Chl Dpth (ft)	6.25	5.96
Weir Sta Lft (ft)		Vel Total (ft/s)	2.58	2.55
Weir Sta Rgt (ft)		Flow Area (sq ft)	291.74	295.8
Weir Submerg		Froude # Chl	0.18	0.18
Weir Max Depth (ft)		Specif Force (cu ft)	801.98	797.62
Min El Weir Flow (ft)	11.27	Hydr Depth (ft)	4.79	4.85
Min El Prs (ft)	8.97	W.P. Total (ft)	87.34	85.9
Delta EG (ft)	0.28	Conv. Total (cfs)	38747.1	40094.3
Delta WS (ft)	0.28	Top Width (ft)	60.88	60.93
BR Open Area (sq ft)	324.26	Frctn Loss (ft)		
BR Open Vel (ft/s)	2.58	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.08	0.08
Br Sel Method	Momentum	Power Total (lb/ft s)	0	0

XS3

HEC-RAS, 100 Year Design

Plan: COC-500		RS:4457	Profile: 100-Yr		
E.G. Elev (ft)	8.53	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.09	Wt. n-Val.		0.025	
W.S. Elev (ft)	8.44	Reach Len. (ft)	6	6	6
Crit W.S. (ft)	4.98	Flow Area (sq ft)		315.61	
E.G. Slope (ft/ft)	0.000203	Area (sq ft)		340.93	
Q Total (cfs)	752.87	Flow (cfs)		752.87	
Top Width (ft)	83.57	Top Width (ft)		83.57	
Vel Total (ft/s)	2.39	Avg. Vel. (ft/s)		2.39	
Max Chl Dpth (ft)	6.27	Hydr. Depth (ft)		4.79	
Conv. Total (cfs)	52843.2	Conv. (cfs)		52843.2	
Length Wtd. (ft)	6	Wetted Per. (ft)		66.75	
Min Ch El (ft)	2.17	Shear (lb/sq ft)		0.06	
Alpha	1	Stream Power (lb/ft s)	136.29	24.78	115.1
Frctn Loss (ft)		Cum Volume (acre-ft)		3.42	0
C & E Loss (ft)		Cum SA (acres)		0.45	

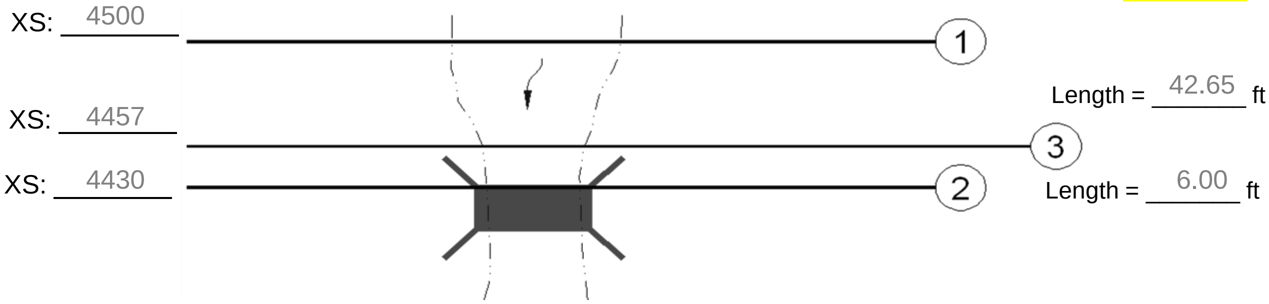
Scour 100-yr

Streambed Particle Size (D_{50}): 0.197 in.
5.0 mm
0.0164 ft.

Determined by: Grain Distribution

Note: *Set minimum D_{50} to 0.2mm (0.008-inch) for lower limit per HEC-18 6.2*

Upstream Uncontracted Cross Section (XS1):	4500		Length to XS1:	42.65	ft.
Internal Upstream Cross Section (XS2):	4430		Length to XS3:	6.00	ft.
Upstream Bounding Cross Section (XS3):	4457		Low Chord Elevation:	8.91	ft.
Long-term aggradation / degradation:	0.0	ft.	Water Surface Elevation:	8.44	ft.
			Streambed Elevation	2.17	ft.



Key
1. Upstream uncontracted cross section (XS output)
2. Internal bridge cross section (BR U or BR D in HEC-RAS output)
3. Upstream bounding cross section (XS output)

Determine Clear-Water or Live-Bed Flow Conditions

Ku coefficient (Enter 6.19 for SI units or 11.17 for English Units):	11.17	
Channel Hydraulic Depth Variable (from XS1), **y**:	4.28	ft.
Channel Velocity (from XS1), V:	**2.380**	**ft./s**

V_c is the critical velocity. Speeds at or above this level will transport bed material of D50 and smaller.
Use Equation 6.1 (HEC-18):

$$V_c = K_u \, y^{1/6} \, (D_{50})^{1/3}$$

V_c = 3.616 ft./s

If $V_c < V$ Live-Bed Scour Occurs
If Vc > V Clear-Water Scour Occurs

Clear-Water contraction scour will exist. Use the Clear-Water analysis.

K_u Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077	
W, W_1, W_2 values are taken at:	at top of channel	
For Vertical Contraction Scour:		
Does overtopping of the bridge or approach roadway occur?	No	
T Superstructure Depth (including girders, deck and parapet):	2.34	ft.

Contraction Scour 100-yr

Clear-Water Scour (GOVERNS)

K_u	Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077		
y_0	Hydraulic Depth Variable (from XS2):	4.79	ft	
W	Estimated bottom or top channel width, less pier widths (XS2):	60.88	ft	at top of channel
Q	Flow through the bridge opening, or on the set-back over bank area at the bridge associated with the width, W (from XS2):	752.87	cfs	
D_m	Diameter of the smallest nontransportable particle in the bed material, 1.25 * D_{50}:	0.02051	ft	
y_2	Average depth in the contracted section: Equation 6.4 (HEC-18) $y_2 = \left[\frac{0.0077Q^2}{D_m^{2/3}W^2}\right]^{3/7}$	3.26	ft	

y_s Average contraction scour depth: $y_s = y_2 - y_0$ **-1.53 ft**

Equation 6.5 (HEC-18)

Contraction Scour 100-yr

Live Bed Scour (NOT APPLICABLE)

y_1	Channel Hydraulic Depth Variable (from XS1):	4.28	ft
y_0	Hydraulic Depth Variable (from XS2):	4.79	ft

HEC-18, Section 6.3 Note #7 - "In sand channel streams where the contraction scour hole is filled in on the falling stage, the y_0 depth may be approximated by y_1. Sketches or surveys through the bridge can help in determining the existing bed elevation."

W_1	Estimated bottom or top channel width (XS1):	73.75	ft	at top of channel
W_2	Estimated bottom or top channel width, less pier widths (XS2):	60.88	ft	at top of channel

HEC-RAS internal bridge cross section accounts for deduction of pier and sloping abutment. Minimum of upstream and downstream.

Q_1	Channel Flow (XS1):	752.88	cfs
Q_2	Flow in the contracted channel (XS2):	752.87	cfs

HEC-18, Section 6.3 Note # - "Q2 may be the total flow going through the bridge opening as in cases 1a and 1b. It is not the total flow for Case 1c. For Case 1c contraction scour must be computed separately for the main channel and the left and/or right overbank areas."

y_2 Average depth in the contracted section: 4.79 ft
Equation 6.2 (HEC-18)

$$y_2 = y_1\left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{k_1}$$

y_s **Average contraction scour depth:** **0.00 ft**
Equation 6.3 (HEC-18)

$$y_s = y_2 - y_0$$

Contraction Scour 100-yr

Live Bed Scour, Continued (NOT APPLICABLE)

g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
S	Slope of the energy grade line (from XS1):	0.00024	
T_{SI}	Fall velocity of particles (from Fig. 6.8, HEC-18):	0.35	m/s
		1.148	*ft/s*
T	Temperature of water:	20.0	C
V*	Shear velocity (XS1): **V*** = (g x y_1 X S)$^{1/2}$	0.18	ft/s

V*/T	k1	Mode of Bed Material Transport (Fig. 6.8, HEC-18, pg. 6.11)
< 0.50	0.59	Mostly contact bed material discharge
0.50 to 2.00	0.64	Some suspended bed material discharge
> 2.00	0.69	Mostly suspended bed material discharge

V* / T = 0.16 Where T = w

k_1 = 0.59

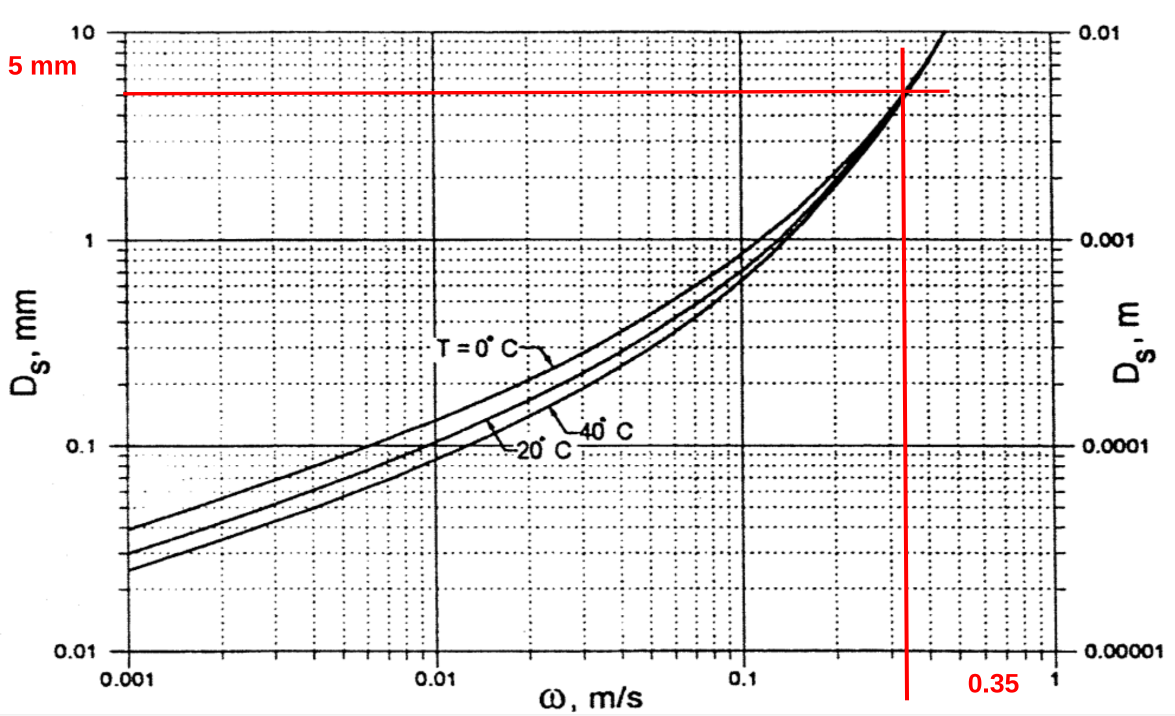


Figure 6.8 from HEC 18

Local Pier Scour 100-yr

$$y_s/y_1 = 2.0\ K_1 K_2 K_3 (a/y_1)^{0.65}\ Fr_1^{0.43}$$

- y_s Scour depth, feet
- y_1 Flow depth directly upstream of the pier, feet
- K_1 Correction factor for the pier nose shape (Figure 7.3 and Table 7.1, HEC-18)
- K_2 Correction factor for the angle of attack of flow (Table 7.2 or Equation 7.4, HEC-18)
- K_3 Correction factor for bed condition (Table 7.3, HEC-18)

- a Pier width, feet
- L Length of pier, feet
- Fr_1 Froude number directly upstream of the pier = $V_1/(gy_1)^{0.5}$
- V_1. Mean velocity of flow directly upstream of the pier, feet/second (from Velocity Distribution)
- g Acceleration of gravity (32.2 ft/s^2)

Table 7.1

Correction Factor for Pier shape	K_1
(a) Square nose	1.1
(b) Round nose	1
(c) Circular cylinder	1
(d) Group of cylinders	1
(e) Sharp nose	0.9

Table 7.3

Correction factor for bed condition		K_3
Bed Condition	Dune Height	K_3
Clear-water Scour	N/A	1.1
Planne bed/Antidune	N/A	1.1
Small dune	3>H≥0.6	1.1
Medium Dumes	9>H≥3	1.2 to 1.1
Large Dunes	H≥9	1.3

Table 7.2

Correction factor angle of attack K_2			
Angle	L/a=4	L/a=8	L/a=12
0	1	1	1
15	1.5	2	2.5
30	2	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5

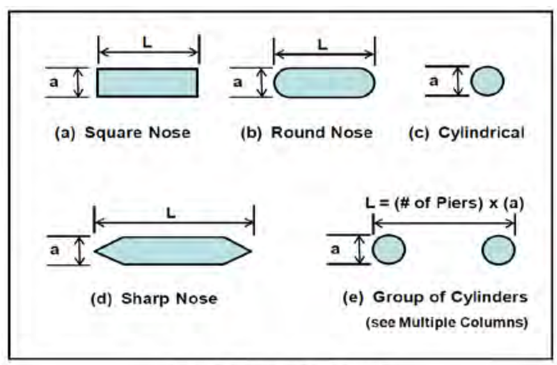


Figure 7.3 Common pier shapes

Angle of Flow: 0 Degrees

Pier Number	y_1	K_1	K_2	K_3	a	L	Fr_1	V_1	g
1 thru 2	6.25	1	1	1.1	1.83	5.49	0.182	2.58	32.2

Scour Depth
3.0

Local Pier Scour Velocity Distribution Tables 100-yr

Plan: Scour_100Y Dis Coyote Creek Middle Upper RS: 4430 BR U Profile: Max WS											
	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	Chan	24.78	115.1	752.87	291.74	87.34	100	4.79	2.58	0.08	24.78

HEC-RAS Station for Pier Centerline 63.77

Riprap Sizing 100-yr

Type of Abutment: **Vertical**

In accordance with DM4, Chapter 7, 7.2.5

V (fps)	Rock Size	D50 (feet)
up to 12	R-6 or larger	1
13 to 15	R-7 or larger	1.5
16 to 17.5	R-8	2

Table from DM4, Chapter 7

Vertical Abutment Riprap Size:

Velocity (BR Open Vel from XS2) = 2.58 ft/s

Factored Velocity for Riprap Sizing = 1.8 * BR Open Vel = 4.64 ft/s

Riprap Size at Vertical Abutments: R-6

HEC-23 Rip Rap Sizing for Vertical or Spill Through Abutments

fr $V/(gy)^{1/2}$ ≤ 0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)$

K spill through abutment = 0.89
vertical wall abutment = 1.02

fr $V/(gy)^{1/2}$ >0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)^{0.14}$

K spill through abutment = 0.61
vertical wall abutment = 0.69

Where:

fr (froude number at XS2) 0.18

Abutment type (spill through or vertical wall) Vertical

K 0.89

y Depth of flow in the contracted bridge opening (depth from XS2) 6.25 ft

V As described above for Abutments or Piers: 2.58 ft/s

S Specific Gravity: 2.65

g Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English): 32.2 ft/s²

D_{50} 0.11 ft

Riprap Abutment Size per HEC-23: R-6

Upon discussion and concurrence from PennDOT at OTS if velocities indicate a larger D50 than R-8 and there is no evidence of scour at the existing bridge then use R-8 otherwise use R-8 partially grouted.

Presence of Existing Scour in Inspection Reports: **N/A**

Final Recommended Riprap Size at Abutments: R-6

Pier Riprap Size:

Velocity (Average Upstream Velocity from XS 3) = 2.39 ft/s

Factored Velocity for Riprap Sizing = 1.5 * Avg US Vel = 3.59 ft/s

Riprap Size at Piers: R-6

If velocities are greater than 17.5 ft/s, use the FHWA formula:

$D_{50} = 0.692*V^2 / ((S-1)(2g))$

Where:

V	As described above for or Piers (with a 1.5 factor):	3.59	ft/s
S	Specific Gravity:	2.65	
g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
D_{50}		0.08	ft

V (fps)	Rock Size
0.0 to 11.99	R-6 or larger
12.0 to 15.99	R-7 or larger
16.0 to 17.5	R-8

Table from DM4, Chapter 7

Scour Calculation Results

Reference HEC 18, 5th Edition

Design Year: 100

Live bed contraction scour will exist. Use the live bed analysis.

Do Coarse Bed Conditions Exist? NO ("YES" or "NO")

Contractions Scour Results:

If Clear-Water Governs 0.49 ft

If Live-Bed Governs, Minimum of ysLB and ysCW 0.21 ft

100-yr Contraction Scour: 0.21 feet

Does Vertical Contractions Scour Occur? NO ("YES" or "NO")

--

-- -- --

-- -- --

-- -- --

Are there piers within the 500-year floodplain? NO ("YES" or "NO")

-- -- --

Riprap Size at Abutments: R-6

-- --

Note: If the super flood (500-year) scour depth is below the bottom of the footing elevation then the rock size should be as determined by the 500-year calculations.

100-yr Scour Results (ft)

Scour Type	Abutment 1	Abutment 2	Pier
Contraction Scour	1.00	1.00	--
Vertical Contraction Scour	--	--	--
Local Scour	--	--	--
Total Scour	1.00	1.00	0.00

Notes: (1) Local abutment scour calculations are not required when the substructure is protected with multi-layered riprap protection. (2) If multi-layered riprap protection is proposed at the piers the local pier scour depth may be reduced by 50%.

XS1

HEC-RAS, 100 Year Design

Plan: COC-400		RS:3000	Profile: 100-Yr		
E.G. Elev (ft)	7.57	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.28	Wt. n-Val.		0.025	
W.S. Elev (ft)	7.29	Reach Len. (ft)	42.44	44.25	45.85
Crit W.S. (ft)		Flow Area (sq ft)		345.78	
E.G. Slope (ft/ft)	0.000859	Area (sq ft)		345.78	
Q Total (cfs)	1468.21	Flow (cfs)		1468.21	
Top Width (ft)	89.16	Top Width (ft)		89.16	
Vel Total (ft/s)	4.25	Avg. Vel. (ft/s)		4.25	
Max Chl Dpth (ft)	6.3	Hydr. Depth (ft)		3.88	
Conv. Total (cfs)	50082.2	Conv. (cfs)		50082.2	
Length Wtd. (ft)	44.25	Wetted Per. (ft)		90.9	
Min Ch El (ft)	0.99	Shear (lb/sq ft)		0.2	
Alpha	1	Stream Power (lb/ft s)	146.74	17.39	0
Frctn Loss (ft)	0.04	Cum Volume (acre-ft)	12.63	14.78	0.12
C & E Loss (ft)		Cum SA (acres)	11.39	5.03	0.16

XS2

HEC-RAS, 100 Year Design

Plan: COC-400		RS:2943	Profile: 100-Yr	
E.G. US. (ft)	7.53	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	7.26	E.G. Elev (ft)	7.49	7.48
Q Total (cfs)	1468.21	W.S. Elev (ft)	7.21	7.17
Q Bridge (cfs)	1468.21	Crit W.S. (ft)	4.89	4.96
Q Weir (cfs)		Max Chl Dpth (ft)	6.65	6.9
Weir Sta Lft (ft)		Vel Total (ft/s)	4.25	4.48
Weir Sta Rgt (ft)		Flow Area (sq ft)	345.77	327.56
Weir Submerg		Froude # Chl	0.38	0.41
Weir Max Depth (ft)		Specif Force (cu ft)	1035.15	1000
Min El Weir Flow (ft)	12.6	Hydr Depth (ft)	3.94	3.66
Min El Prs (ft)	11.36	W.P. Total (ft)	90.18	92
Delta EG (ft)	0.02	Conv. Total (cfs)	50346.4	45397.6
Delta WS (ft)	0.06	Top Width (ft)	87.73	89.59
BR Open Area (sq ft)	711.72	Frctn Loss (ft)	0.01	0.01
BR Open Vel (ft/s)	4.48	C & E Loss (ft)	0	0
Coef of Q		Shear Total (lb/sq ft)	0.2	0.23
Br Sel Method	Energy only	Power Total (lb/ft s)	0	0

XS3

HEC-RAS, 100 Year Design

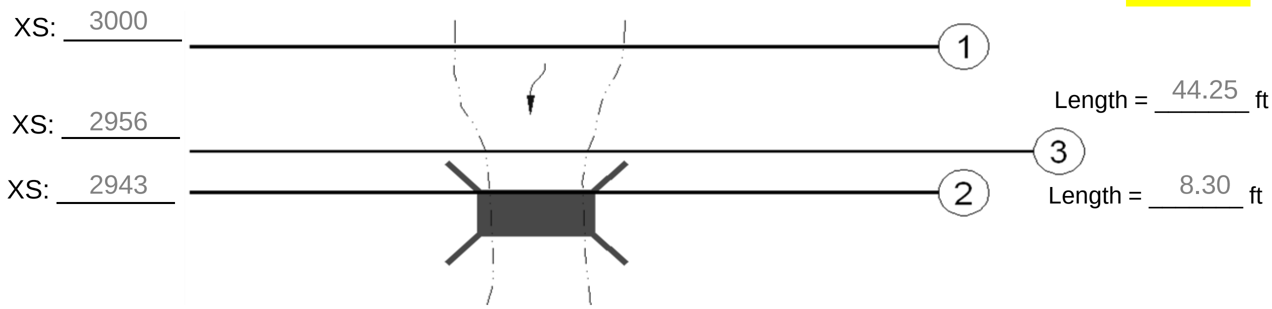
Plan: COC-400		RS:2956	Profile: 100-Yr		
E.G. Elev (ft)	7.53	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.27	Wt. n-Val.		0.025	
W.S. Elev (ft)	7.26	Reach Len. (ft)	8.3	8.3	8.3
Crit W.S. (ft)	4.89	Flow Area (sq ft)		349.84	
E.G. Slope (ft/ft)	0.000822	Area (sq ft)		349.84	
Q Total (cfs)	1468.21	Flow (cfs)		1468.21	
Top Width (ft)	88.05	Top Width (ft)		88.05	
Vel Total (ft/s)	4.2	Avg. Vel. (ft/s)		4.2	
Max Chl Dpth (ft)	6.7	Hydr. Depth (ft)		3.97	
Conv. Total (cfs)	51210.5	Conv. (cfs)		51210.5	
Length Wtd. (ft)	8.3	Wetted Per. (ft)		90.51	
Min Ch El (ft)	0.56	Shear (lb/sq ft)		0.2	
Alpha	1	Stream Power (lb/ft s)	148.13	14.7	134.93
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	12.63	14.43	0.12
C & E Loss (ft)	0	Cum SA (acres)	11.39	4.94	0.16

Scour 100-yr

Streambed Particle Size (D_{50}): 0.197 in.
5.0 mm
0.0164 ft.

Determined by: Grain Distribution
Note: *Set minimum D_{50} to 0.2mm (0.008-inch) for lower limit per HEC-18 6.2*

Upstream Uncontracted Cross Section (XS1):	3000		Length to XS1:	44.25	ft.
Internal Upstream Cross Section (XS2):	2943		Length to XS3:	8.30	ft.
Upstream Bounding Cross Section (XS3):	2956		Low Chord Elevation:	10.56	ft.
Long-term aggradation / degradation:	0.0	ft.	Water Surface Elevation:	7.26	ft.
			Streambed Elevation	0.56	ft.



Key
1. Upstream uncontracted cross section (XS output)
2. Internal bridge cross section (BR U or BR D in HEC-RAS output)
3. Upstream bounding cross section (XS output)

Determine Clear-Water or Live-Bed Flow Conditions

Ku coefficient (Enter 6.19 for SI units or 11.17 for English Units):	11.17	
Channel Hydraulic Depth Variable (from XS1), **y**:	3.88	ft.
Channel Velocity (from XS1), V:	**4.250**	**ft./s**

V_c is the critical velocity. Speeds at or above this level will transport bed material of D50 and smaller.
Use Equation 6.1 (HEC-18):

$$V_c = K_u \, y^{1/6} \, (D_{50})^{1/3}$$

V_c = 3.558 ft./s

If $V_c < V$ Live-Bed Scour Occurs
If Vc > V Clear-Water Scour Occurs

Live bed contraction scour will exist. Use the live bed analysis.

K_u Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077	
W, W_1, W_2 values are taken at:	at top of channel	
For Vertical Contraction Scour:		
Does overtopping of the bridge or approach roadway occur?	No	
T Superstructure Depth (including girders, deck and parapet):	2.00	ft.

Contraction Scour 100-yr

Clear-Water Scour (NOT APPLICABLE)

K_u	Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077		
y_0	Hydraulic Depth Variable (from XS2):	3.66	ft	
W	Estimated bottom or top channel width, less pier widths (XS2):	89.59	ft	at top of channel
Q	Flow through the bridge opening, or on the set-back over bank area at the bridge associated with the width, W (from XS2):	1468.21	cfs	
D_m	Diameter of the smallest nontransportable particle in the bed material, 1.25 * D_{50}:	0.02051	ft	
y_2	Average depth in the contracted section: Equation 6.4 (HEC-18) $y_2 = \left[\frac{0.0077Q^2}{D_m^{2/3}W^2}\right]^{3/7}$	4.15	ft	

y_s Average contraction scour depth: $y_s = y_2 - y_0$ **0.49 ft**

Equation 6.5 (HEC-18)

Contraction Scour 100-yr

Live Bed Scour (GOVERNS)

y_1	Channel Hydraulic Depth Variable (from XS1):	3.88	ft
y_0	Hydraulic Depth Variable (from XS2):	3.66	ft

HEC-18, Section 6.3 Note #7 - "In sand channel streams where the contraction scour hole is filled in on the falling stage, the y_0 depth may be approximated by y_1. Sketches or surveys through the bridge can help in determining the existing bed elevation."

W_1	Estimated bottom or top channel width (XS1):	89.16	ft	at top of channel
W_2	Estimated bottom or top channel width, less pier widths (XS2):	89.59	ft	at top of channel

HEC-RAS internal bridge cross section accounts for deduction of pier and sloping abutment. Minimum of upstream and downstream.

Q_1	Channel Flow (XS1):	1468.21	cfs
Q_2	Flow in the contracted channel (XS2):	1468.21	cfs

HEC-18, Section 6.3 Note # - "Q2 may be the total flow going through the bridge opening as in cases 1a and 1b. It is not the total flow for Case 1c. For Case 1c contraction scour must be computed separately for the main channel and the left and/or right overbank areas."

y_2 Average depth in the contracted section: 3.87 ft
Equation 6.2 (HEC-18)

$$y_2 = y_1 \left(\frac{Q_2}{Q_1}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1}$$

y_s Average contraction scour depth: 0.21 ft
Equation 6.3 (HEC-18)

$$y_s = y_2 - y_0$$

Contraction Scour 100-yr

Live Bed Scour, Continued (GOVERNS)

g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
S	Slope of the energy grade line (from XS1):	0.00086	
T_{SI}	Fall velocity of particles (from Fig. 6.8, HEC-18):	0.025	m/s
		0.082	*ft/s*
T	Temperature of water:	20.0	C
V*	Shear velocity (XS1): $V^* = (g \times y_1 \times S)^{1/2}$	0.33	ft/s

V*/T	k1	Mode of Bed Material Transport (Fig. 6.8, HEC-18, pg. 6.11)
< 0.50	0.59	Mostly contact bed material discharge
0.50 to 2.00	0.64	Some suspended bed material discharge
> 2.00	0.69	Mostly suspended bed material discharge

V* / T = 3.99   Where T = w

k_1 = 0.69

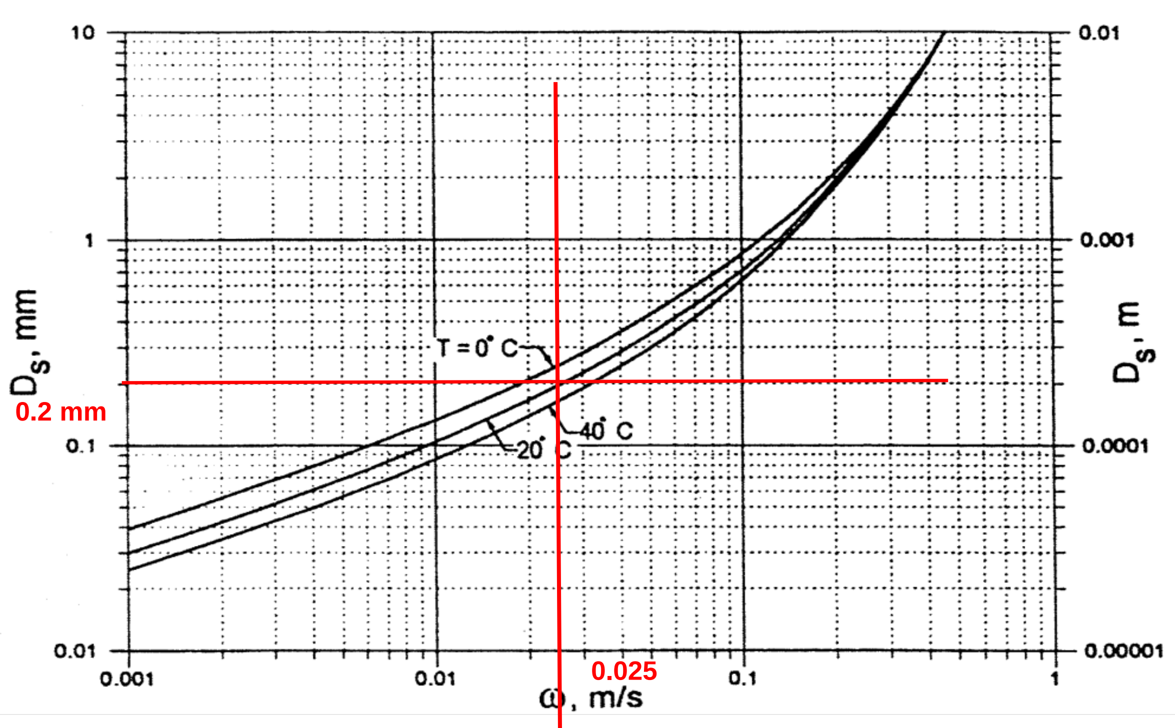


Figure 6.8 from HEC 18

Riprap Sizing 100-yr

Type of Abutment: **Vertical**

In accordance with DM4, Chapter 7, 7.2.5

V (fps)	Rock Size	D50 (feet)
up to 12	R-6 or larger	1
13 to 15	R-7 or larger	1.5
16 to 17.5	R-8	2

Table from DM4, Chapter 7

Vertical Abutment Riprap Size:

Velocity (BR Open Vel from XS2) = 4.48 ft/s

Factored Velocity for Riprap Sizing = 1.8 * BR Open Vel = 8.06 ft/s

Riprap Size at Vertical Abutments: R-6

HEC-23 Rip Rap Sizing for Vertical or Spill Through Abutments

fr $V/(gy)^{1/2}$ ≤ 0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)$

K spill through abutment = 0.89
vertical wall abutment = 1.02

fr $V/(gy)^{1/2}$ >0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)^{0.14}$

K spill through abutment = 0.61
vertical wall abutment = 0.69

Where:

fr (froude number at XS2) 0.41

Abutment type (spill through or vertical wall) Vertical

K 0.89

y Depth of flow in the contracted bridge opening (depth from XS2) 6.90 ft

V As described above for Abutments or Piers: 4.48 ft/s

S Specific Gravity: 2.65

g Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English): 32.2 ft/s²

D_{50} 0.34 ft

Riprap Abutment Size per HEC-23: R-6

Upon discussion and concurrence from PennDOT at OTS if velocities indicate a larger D50 than R-8 and there is no evidence of scour at the existing bridge then use R-8 otherwise use R-8 partially grouted.

Presence of Existing Scour in Inspection Reports: **N/A**

Final Recommended Riprap Size at Abutments: R-6

Scour Calculation Results

Design Year: 100

Reference HEC 18, 5th Edition

Live bed contraction scour will exist. Use the live bed analysis.

Do Coarse Bed Conditions Exist? NO ("YES" or "NO")

Contractions Scour Results:

If Clear-Water Governs 7.95 ft

If Live-Bed Governs, Minimum of ysLB and ysCW 0.29 ft

100-yr Contraction Scour: 0.29 feet

Does Vertical Contractions Scour Occur? NO ("YES" or "NO")

--

-- -- --

-- -- --

-- -- --

Are there piers within the 500-year floodplain? YES ("YES" or "NO")

100-yr Local Pier Scour: 4.78 feet

Riprap Size at Abutments: R-6

Riprap Size at Piers: R-6

Note: If the super flood (500-year) scour depth is below the bottom of the footing elevation then the rock size should be as determined by the 500-year calculations.

100-yr Scour Results (ft)

Scour Type	Abutment 1	Abutment 2	Pier
Contraction Scour	1.00	1.00	1.00
Vertical Contraction Scour	--	--	--
Local Scour	--	--	5.00
Total Scour	1.00	1.00	6.00

Notes: (1) Local abutment scour calculations are not required when the substructure is protected with multi-layered riprap protection. (2) If multi-layered riprap protection is proposed at the piers the local pier scour depth may be reduced by 50%.

XS1

HEC-RAS, 100 Year Design

Plan: COC-300		RS:2915	Profile: 100-Yr		
E.G. Elev (ft)	7.45	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.31	Wt. n-Val.		0.025	
W.S. Elev (ft)	7.14	Reach Len. (ft)	16.25	14.84	14.71
Crit W.S. (ft)		Flow Area (sq ft)		328.3	
E.G. Slope (ft/ft)	0.001093	Area (sq ft)		328.3	
Q Total (cfs)	1468.21	Flow (cfs)		1468.21	
Top Width (ft)	93.94	Top Width (ft)		93.94	
Vel Total (ft/s)	4.47	Avg. Vel. (ft/s)		4.47	
Max Chl Dpth (ft)	6.69	Hydr. Depth (ft)		3.49	
Conv. Total (cfs)	44401.6	Conv. (cfs)		44401.6	
Length Wtd. (ft)	14.84	Wetted Per. (ft)		95.64	
Min Ch El (ft)	0.45	Shear (lb/sq ft)		0.23	
Alpha	1	Stream Power (lb/ft s)	143.17	8.6	137.38
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	12.63	14.11	0.12
C & E Loss (ft)		Cum SA (acres)	11.39	4.86	0.16

XS2

HEC-RAS, 100 Year Design

Plan: COC-300		RS:2871	Profile: 100-Yr	
E.G. US. (ft)	7.42	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	7.13	E.G. Elev (ft)	7.33	7.13
Q Total (cfs)	1468.2	W.S. Elev (ft)	6.98	6.73
Q Bridge (cfs)	1468.2	Crit W.S. (ft)	5.12	4.83
Q Weir (cfs)		Max Chl Dpth (ft)	6.57	6.46
Weir Sta Lft (ft)		Vel Total (ft/s)	4.79	5.11
Weir Sta Rgt (ft)		Flow Area (sq ft)	306.44	287.12
Weir Submerg		Froude # Chl	0.44	0.47
Weir Max Depth (ft)		Specif Force (cu ft)	922.82	903.72
Min El Weir Flow (ft)	14.47	Hydr Depth (ft)	3.70	3.67
Min El Prs (ft)	14.06	W.P. Total (ft)	119.06	112.12
Delta EG (ft)	0.25	Conv. Total (cfs)	34206.2	31942.7
Delta WS (ft)	0.29	Top Width (ft)	82.73	78.31
BR Open Area (sq ft)	704.61	Frctn Loss (ft)		
BR Open Vel (ft/s)	5.11	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.3	0.34
Br Sel Method	Momentum	Power Total (lb/ft s)	0	0

XS3

HEC-RAS, 100 Year Design

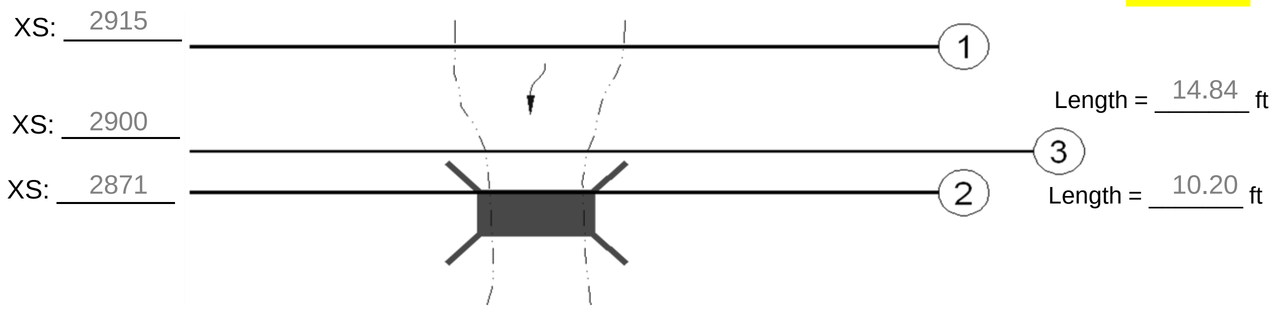
Plan: COC-300		RS:2900	Profile: 100-Yr		
E.G. Elev (ft)	7.42	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.29	Wt. n-Val.		0.025	
W.S. Elev (ft)	7.13	Reach Len. (ft)	10.2	10.2	10.2
Crit W.S. (ft)	4.96	Flow Area (sq ft)		342.31	
E.G. Slope (ft/ft)	0.000898	Area (sq ft)		342.31	
Q Total (cfs)	1468.2	Flow (cfs)		1468.2	
Top Width (ft)	88.99	Top Width (ft)		88.99	
Vel Total (ft/s)	4.29	Avg. Vel. (ft/s)		4.29	
Max Chl Dpth (ft)	6.72	Hydr. Depth (ft)		3.85	
Conv. Total (cfs)	48992.6	Conv. (cfs)		48992.6	
Length Wtd. (ft)	10.2	Wetted Per. (ft)		91.61	
Min Ch El (ft)	0.41	Shear (lb/sq ft)		0.21	
Alpha	1	Stream Power (lb/ft s)	128.26	0	128.26
Frctn Loss (ft)		Cum Volume (acre-ft)	12.63	14	0.12
C & E Loss (ft)		Cum SA (acres)	11.39	4.83	0.16

Scour 100-yr

Streambed Particle Size (D_{50}): 0.008 in.
0.2 mm
0.0007 ft.

Determined by: Set to minimum
Note: *Set minimum D_{50} to 0.2mm (0.008-inch) for lower limit per HEC-18 6.2*

Upstream Uncontracted Cross Section (XS1):	2915		Length to XS1:	14.84	ft.
Internal Upstream Cross Section (XS2):	2871		Length to XS3:	10.20	ft.
Upstream Bounding Cross Section (XS3):	2900		Low Chord Elevation:	11.325	ft.
Long-term aggradation / degradation:	0.0	ft.	Water Surface Elevation:	7.13	ft.
			Streambed Elevation	0.41	ft.



Key
1. Upstream uncontracted cross section (XS output)
2. Internal bridge cross section (BR U or BR D in HEC-RAS output)
3. Upstream bounding cross section (XS output)

Determine Clear-Water or Live-Bed Flow Conditions

Ku coefficient (Enter 6.19 for SI units or 11.17 for English Units):	11.17	
Channel Hydraulic Depth Variable (from XS1), **y**:	3.49	ft.
Channel Velocity (from XS1), V:	**4.470**	**ft./s**

V_c is the critical velocity. Speeds at or above this level will transport bed material of D50 and smaller.
Use Equation 6.1 (HEC-18):

$$V_c = K_u \, y^{1/6} \, (D_{50})^{1/3}$$

V_c = 1.202 ft./s

If $V_c < V$ Live-Bed Scour Occurs
If Vc > V Clear-Water Scour Occurs

Live bed contraction scour will exist. Use the live bed analysis.

K_u Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077	
W, W_1, W_2 values are taken at:	at top of channel	
For Vertical Contraction Scour:		
Does overtopping of the bridge or approach roadway occur?	No	
T Superstructure Depth (including girders, deck and parapet):	1.16	ft.

Contraction Scour 100-yr

Clear-Water Scour (NOT APPLICABLE)

K_u	Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077	
y_0	Hydraulic Depth Variable (from XS2):	3.67	ft
W	Estimated bottom or top channel width, less pier widths (XS2):	78.31	ft at top of channel
Q	Flow through the bridge opening, or on the set-back over bank area at the bridge associated with the width, W (from XS2):	1468.2	cfs
D_m	Diameter of the smallest nontransportable particle in the bed material, 1.25 * D_{50}:	0.00083	ft
y_2	Average depth in the contracted section: Equation 6.4 (HEC-18) $y_2 = \left[\frac{0.0077Q^2}{D_m^{2/3}W^2}\right]^{3/7}$	11.62	ft

y_s Average contraction scour depth: $y_s = y_2 - y_0$ **7.95 ft**

Equation 6.5 (HEC-18)

Contraction Scour 100-yr

Live Bed Scour (GOVERNS)

y_1	Channel Hydraulic Depth Variable (from XS1):	3.49	ft
y_0	Hydraulic Depth Variable (from XS2):	3.67	ft

HEC-18, Section 6.3 Note #7 - "In sand channel streams where the contraction scour hole is filled in on the falling stage, the y_0 depth may be approximated by y_1. Sketches or surveys through the bridge can help in determining the existing bed elevation."

W_1	Estimated bottom or top channel width (XS1):	93.94	ft	at top of channel
W_2	Estimated bottom or top channel width, less pier widths (XS2):	78.31	ft	at top of channel

HEC-RAS internal bridge cross section accounts for deduction of pier and sloping abutment. Minimum of upstream and downstream.

Q_1	Channel Flow (XS1):	1468.21	cfs
Q_2	Flow in the contracted channel (XS2):	1468.20	cfs

HEC-18, Section 6.3 Note # - "Q2 may be the total flow going through the bridge opening as in cases 1a and 1b. It is not the total flow for Case 1c. For Case 1c contraction scour must be computed separately for the main channel and the left and/or right overbank areas."

y_2 Average depth in the contracted section: Equation 6.2 (HEC-18)

$$y_2 = y_1\left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{k_1}$$

3.96 ft

y_s Average contraction scour depth: Equation 6.3 (HEC-18)

$$y_s = y_2 - y_0$$

0.29 ft

Contraction Scour 100-yr

Live Bed Scour, Continued (GOVERNS)

g	Gravity Constant (Enter 9.81 m/s^2 for SI or 32.2 ft/s^2 for English):	32.2	ft/s^2
S	Slope of the energy grade line (from XS1):	0.00109	
T_{SI}	Fall velocity of particles (from Fig. 6.8, HEC-18):	0.025	m/s
		0.082	*ft/s*
T	Temperature of water:	20.0	C
V*	Shear velocity (XS1): $V^* = (g \times y_1 \times S)^{1/2}$	0.35	ft/s

V*/T	k1	Mode of Bed Material Transport (Fig. 6.8, HEC-18, pg. 6.11)
< 0.50	0.59	Mostly contact bed material discharge
0.50 to 2.00	0.64	Some suspended bed material discharge
> 2.00	0.69	Mostly suspended bed material discharge

V* / T = 4.27   Where I = w

k_1 = 0.69

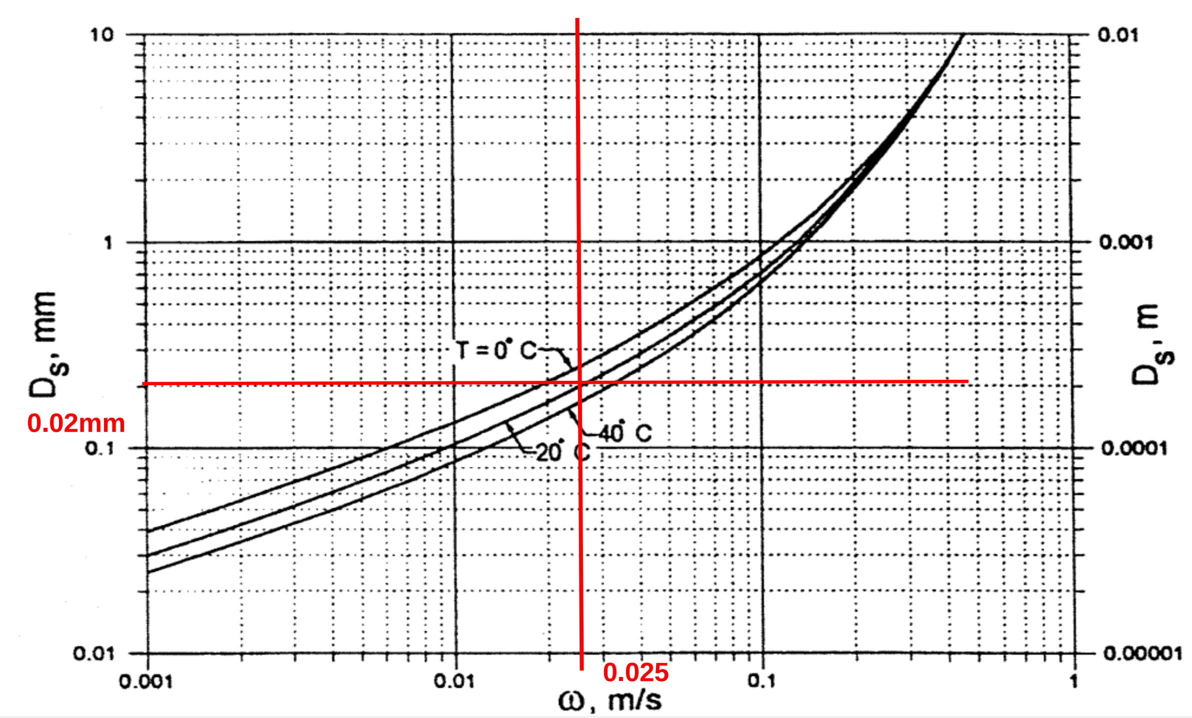


Figure 6.8 from HEC 18

Local Pier Scour 100-yr

$$y_s/y_1 = 2.0\ K_1 K_2 K_3 (a/y_1)^{0.65}\ Fr_1^{0.43}$$

y_s Scour depth, feet
y_1 Flow depth directly upstream of the pier, feet
K_1 Correction factor for the pier nose shape (Figure 7.3 and Table 7.1, HEC-18)
K_2 Correction factor for the angle of attack of flow (Table 7.2 or Equation 7.4, HEC-18)
K_3 Correction factor for bed condition (Table 7.3, HEC-18)

a Pier width, feet
L Length of pier, feet
Fr_1 Froude number directly upstream of the pier = $V_1/(gy_1)^{0.5}$
$V_{1.}$ Mean velocity of flow directly upstream of the pier, feet/second (from Velocity Distribution)
g Acceleration of gravity (32.2 ft/s^2)

Table 7.1

Correction Factor for Pier shape	K_1
(a) Square nose	1.1
(b) Round nose	1
(c) Circular cylinder	1
(d) Group of cylinders	1
(e) Sharp nose	0.9

Table 7.3

Correction factor for bed condition		K_3
Bed Condition	Dune Height	K_3
Clear-water Scour	N/A	1.1
Planne bed/Antidune	N/A	1.1
Small dune	3>H≥0.6	1.1
Medium Dumes	9>H≥3	1.2 to 1.1
Large Dunes	H≥9	1.3

Table 7.2

Correction factor angle of attack K_2			
Angle	L/a=4	L/a=8	L/a=12
0	1	1	1
15	1.5	2	2.5
30	2	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5

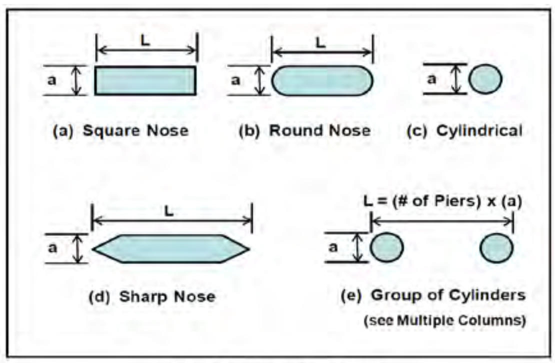


Figure 7.3 Common pier shapes

Angle of Flow: 0 Degrees

Pier Number	y_1	K_1	K_2	K_3	a	L	Fr_1	V_1	g
1 thru 2	6.57	1	1	1.1	2.5	10	0.329	4.79	32.2

Scour Depth
4.8

Local Pier Scour Velocity Distribution Tables 100-yr

Plan: Scour_100Y Dis Coyote Creek Middle Lower RS: 2871 BR U Profile: Max WS											
	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	Chan	0	128.26	1468.2	306.44	119.06	100	3.7	4.79	0.3	0

HEC-RAS Station for Pier Centerline 32.08

Riprap Sizing 100-yr

Type of Abutment: **Vertical**

In accordance with DM4, Chapter 7, 7.2.5

V (fps)	Rock Size	D50 (feet)
up to 12	R-6 or larger	1
13 to 15	R-7 or larger	1.5
16 to 17.5	R-8	2

Table from DM4, Chapter 7

Vertical Abutment Riprap Size:

Velocity (BR Open Vel from XS2) = 5.11 ft/s

Factored Velocity for Riprap Sizing = 1.8 * BR Open Vel = 9.20 ft/s

Riprap Size at Vertical Abutments: R-6

HEC-23 Rip Rap Sizing for Vertical or Spill Through Abutments

fr $V/(gy)^{1/2}$ ≤ 0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)$

K spill through abutment = 0.89
vertical wall abutment = 1.02

fr $V/(gy)^{1/2}$ >0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)^{0.14}$

K spill through abutment = 0.61
vertical wall abutment = 0.69

Where:

fr (froude number at XS2) 0.47

Abutment type (spill through or vertical wall) Vertical

K 0.89

y Depth of flow in the contracted bridge opening (depth from XS2) 6.57 ft

V As described above for Abutments or Piers: 5.11 ft/s

S Specific Gravity: 2.65

g Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English): 32.2 ft/s²

D_{50} 0.44 ft

Riprap Abutment Size per HEC-23: R-6

Upon discussion and concurrence from PennDOT at OTS if velocities indicate a larger D50 than R-8 and there is no evidence of scour at the existing bridge then use R-8 otherwise use R-8 partially grouted.
Presence of Existing Scour in Inspection Reports: **N/A**

Final Recommended Riprap Size at Abutments: R-6

Pier Riprap Size:

Velocity (Average Upstream Velocity from XS 3) = 4.29 ft/s

Factored Velocity for Riprap Sizing = 1.5 * Avg US Vel = 6.44 ft/s

Riprap Size at Piers: R-6

If velocities are greater than 17.5 ft/s, use the FHWA formula:

$D_{50} = 0.692*V^2 / ((S-1)(2g))$

Where:

V	As described above for or Piers (with a 1.5 factor):	6.44	ft/s
S	Specific Gravity:	2.65	
g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
D_{50}		0.27	ft

V (fps)	Rock Size
0.0 to 11.99	R-6 or larger
12.0 to 15.99	R-7 or larger
16.0 to 17.5	R-8

Table from DM4, Chapter 7

Scour Calculation Results

Design Year: 100

Reference HEC 18, 5th Edition

Live bed contraction scour will exist. Use the live bed analysis.

Do Coarse Bed Conditions Exist? NO ("YES" or "NO")

Contractions Scour Results:

If Clear-Water Governs 8.06 ft

If Live-Bed Governs, Minimum of ysLB and ysCW 0.23 ft

100-yr Contraction Scour: 0.23 feet

Does Vertical Contractions Scour Occur? NO ("YES" or "NO")

--

-- -- --

-- -- --

-- -- --

Are there piers within the 500-year floodplain? YES ("YES" or "NO")

100-yr Local Pier Scour: 2.72 feet

Riprap Size at Abutments: R-6

Riprap Size at Piers: R-6

Note: If the super flood (500-year) scour depth is below the bottom of the footing elevation then the rock size should be as determined by the 500-year calculations.

100-yr Scour Results (ft)			
Scour Type	Abutment 1	Abutment 2	Pier
Contraction Scour	1.00	1.00	1.00
Vertical Contraction Scour	--	--	--
Local Scour	--	--	3.00
Total Scour	1.00	1.00	4.00

Notes: (1) Local abutment scour calculations are not required when the substructure is protected with multi-layered riprap protection. (2) If multi-layered riprap protection is proposed at the piers the local pier scour depth may be reduced by 50%.

XS1

HEC-RAS, 100 Year Design

Plan: COC-200		RS:2849	Profile: 100-Yr		
E.G. Elev (ft)	7.13	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.35	Wt. n-Val.		0.025	
W.S. Elev (ft)	6.78	Reach Len. (ft)	1.49	4.06	3.57
Crit W.S. (ft)		Flow Area (sq ft)		309	
E.G. Slope (ft/ft)	0.001121	Area (sq ft)		309	
Q Total (cfs)	1468.02	Flow (cfs)		1468.02	
Top Width (ft)	82.2	Top Width (ft)		82.2	
Vel Total (ft/s)	4.75	Avg. Vel. (ft/s)		4.75	
Max Chl Dpth (ft)	6.53	Hydr. Depth (ft)		3.76	
Conv. Total (cfs)	43851.1	Conv. (cfs)		43851.1	
Length Wtd. (ft)	4.06	Wetted Per. (ft)		83.76	
Min Ch El (ft)	0.25	Shear (lb/sq ft)		0.26	
Alpha	1	Stream Power (lb/ft s)	115.76	0.2	115.76
Frctn Loss (ft)	0	Cum Volume (acre-ft)	12.63	13.64	0.12
C & E Loss (ft)		Cum SA (acres)	11.39	4.73	0.16

XS2

HEC-RAS, 100 Year Design

Plan: COC-200		RS:2837	Profile: 100-Yr	
E.G. US. (ft)	7.12	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	6.77	E.G. Elev (ft)	7.11	6.96
Q Total (cfs)	1468.02	W.S. Elev (ft)	6.7	6.57
Q Bridge (cfs)	1468.02	Crit W.S. (ft)	4.77	4.66
Q Weir (cfs)		Max Chl Dpth (ft)	6.46	6.37
Weir Sta Lft (ft)		Vel Total (ft/s)	5.16	4.99
Weir Sta Rgt (ft)		Flow Area (sq ft)	284.77	294.25
Weir Submerg		Froude # Chl	0.47	0.45
Weir Max Depth (ft)		Specif Force (cu ft)	906.95	903.32
Min El Weir Flow (ft)	12.11	Hydr Depth (ft)	3.69	3.9
Min El Prs (ft)	14.43	W.P. Total (ft)	116.49	113.18
Delta EG (ft)	0.18	Conv. Total (cfs)	30714.1	33067
Delta WS (ft)	0.17	Top Width (ft)	77.25	75.43
BR Open Area (sq ft)	852.38	Frctn Loss (ft)		
BR Open Vel (ft/s)	5.16	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.35	0.32
Br Sel Method	Momentum	Power Total (lb/ft s)	0	0

XS3

HEC-RAS, 100 Year Design

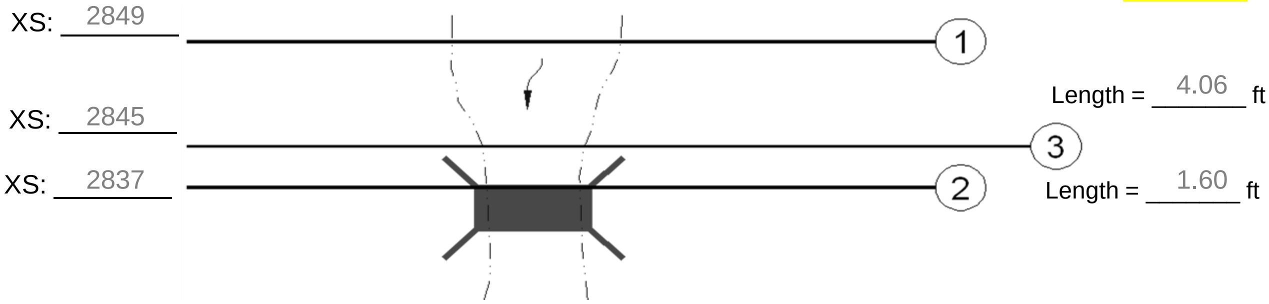
Plan: COC-200		RS:2845	Profile: 100-Yr		
E.G. Elev (ft)	7.12	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.35	Wt. n-Val.		0.025	
W.S. Elev (ft)	6.77	Reach Len. (ft)	1.6	1.6	1.6
Crit W.S. (ft)	4.64	Flow Area (sq ft)		309.97	
E.G. Slope (ft/ft)	0.001115	Area (sq ft)		309.97	
Q Total (cfs)	1468.02	Flow (cfs)		1468.02	
Top Width (ft)	82.53	Top Width (ft)		82.53	
Vel Total (ft/s)	4.74	Avg. Vel. (ft/s)		4.74	
Max Chl Dpth (ft)	6.53	Hydr. Depth (ft)		3.76	
Conv. Total (cfs)	43958.7	Conv. (cfs)		43958.7	
Length Wtd. (ft)	1.6	Wetted Per. (ft)		84.1	
Min Ch El (ft)	0.24	Shear (lb/sq ft)		0.26	
Alpha	1	Stream Power (lb/ft s)	113.2	10.78	113.2
Frctn Loss (ft)		Cum Volume (acre-ft)	12.63	13.62	0.12
C & E Loss (ft)		Cum SA (acres)	11.39	4.72	0.16

Scour 100-yr

Streambed Particle Size (D_{50}): 0.008 in.
0.2 mm
0.0007 ft.

Determined by: Set to minimum
Note: *Set minimum D_{50} to 0.2mm (0.008-inch) for lower limit per HEC-18 6.2*

Upstream Uncontracted Cross Section (XS1):	2849		Length to XS1:	4.06	ft.
Internal Upstream Cross Section (XS2):	2837		Length to XS3:	1.60	ft.
Upstream Bounding Cross Section (XS3):	2845		Low Chord Elevation:	9.10	ft.
Long-term aggradation / degradation:	0.0	ft.	Water Surface Elevation:	6.77	ft.
			Streambed Elevation	0.24	ft.



Key
1. Upstream uncontracted cross section (XS output)
2. Internal bridge cross section (BR U or BR D in HEC-RAS output)
3. Upstream bounding cross section (XS output)

Determine Clear-Water or Live-Bed Flow Conditions

Ku coefficient (Enter 6.19 for SI units or 11.17 for English Units):	11.17	
Channel Hydraulic Depth Variable (from XS1), **y**:	3.76	ft.
Channel Velocity (from XS1), V:	**4.750**	**ft./s**

V_c is the critical velocity. Speeds at or above this level will transport bed material of D50 and smaller.
Use Equation 6.1 (HEC-18):

$$V_c = K_u\, y^{1/6} (D_{50})^{1/3}$$

V_c = 1.217 ft./s

If $V_c < V$ Live-Bed Scour Occurs
If Vc > V Clear-Water Scour Occurs

Live bed contraction scour will exist. Use the live bed analysis.

K_u Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077	
W, W_1, W_2 values are taken at:	at top of channel	
For Vertical Contraction Scour:		
Does overtopping of the bridge or approach roadway occur?	No	
T Superstructure Depth (including girders, deck and parapet):	1.55	ft.

Contraction Scour 100-yr

Clear-Water Scour (NOT APPLICABLE)

K_u	Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077	
y_0	Hydraulic Depth Variable (from XS2):	3.69	ft
W	Estimated bottom or top channel width, less pier widths (XS2):	77.25	ft at top of channel
Q	Flow through the bridge opening, or on the set-back over bank area at the bridge associated with the width, W (from XS2):	1468.02	cfs
D_m	Diameter of the smallest nontransportable particle in the bed material, 1.25 * D_{50}:	0.00083	ft
y_2	Average depth in the contracted section: Equation 6.4 (HEC-18) $y_2 = \left[\frac{0.0077Q^2}{D_m^{2/3}W^2}\right]^{3/7}$	11.75	ft

y_s Average contraction scour depth: $y_s = y_2 - y_0$ **8.06 ft**

Equation 6.5 (HEC-18)

Contraction Scour 100-yr

Live Bed Scour (GOVERNS)

y_1	Channel Hydraulic Depth Variable (from XS1):	3.76	ft	
y_0	Hydraulic Depth Variable (from XS2):	3.69	ft	

HEC-18, Section 6.3 Note #7 - "In sand channel streams where the contraction scour hole is filled in on the falling stage, the y_0 depth may be approximated by y_1. Sketches or surveys through the bridge can help in determining the existing bed elevation."

W_1	Estimated bottom or top channel width (XS1):	82.2	ft	at top of channel
W_2	Estimated bottom or top channel width, less pier widths (XS2):	77.25	ft	at top of channel

HEC-RAS internal bridge cross section accounts for deduction of pier and sloping abutment. Minimum of upstream and downstream.

Q_1	Channel Flow (XS1):	1468.02	cfs
Q_2	Flow in the contracted channel (XS2):	1468.02	cfs

HEC-18, Section 6.3 Note # - "Q2 may be the total flow going through the bridge opening as in cases 1a and 1b. It is not the total flow for Case 1c. For Case 1c contraction scour must be computed separately for the main channel and the left and/or right overbank areas."

y_2 Average depth in the contracted section: **3.92** ft

Equation 6.2 (HEC-18)

$$y_2 = y_1\left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{k_1}$$

y_s **Average contraction scour depth:** **0.23 ft**

Equation 6.3 (HEC-18)

$$y_s = y_2 - y_0$$

Contraction Scour 100-yr

Live Bed Scour, Continued (GOVERNS)

g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
S	Slope of the energy grade line (from XS1):	0.00112	
T_{SI}	Fall velocity of particles (from Fig. 6.8, HEC-18):	0.025	m/s
		0.082	ft/s
T	Temperature of water:	20.0	C
V*	Shear velocity (XS1): $V^* = (g \times y_1 \times S)^{1/2}$	0.37	ft/s

V*/T	k1	Mode of Bed Material Transport (Fig. 6.8, HEC-18, pg. 6.11)
< 0.50	0.59	Mostly contact bed material discharge
0.50 to 2.00	0.64	Some suspended bed material discharge
> 2.00	0.69	Mostly suspended bed material discharge

V* / T = 4.49 Where T = w

k_1 = 0.69

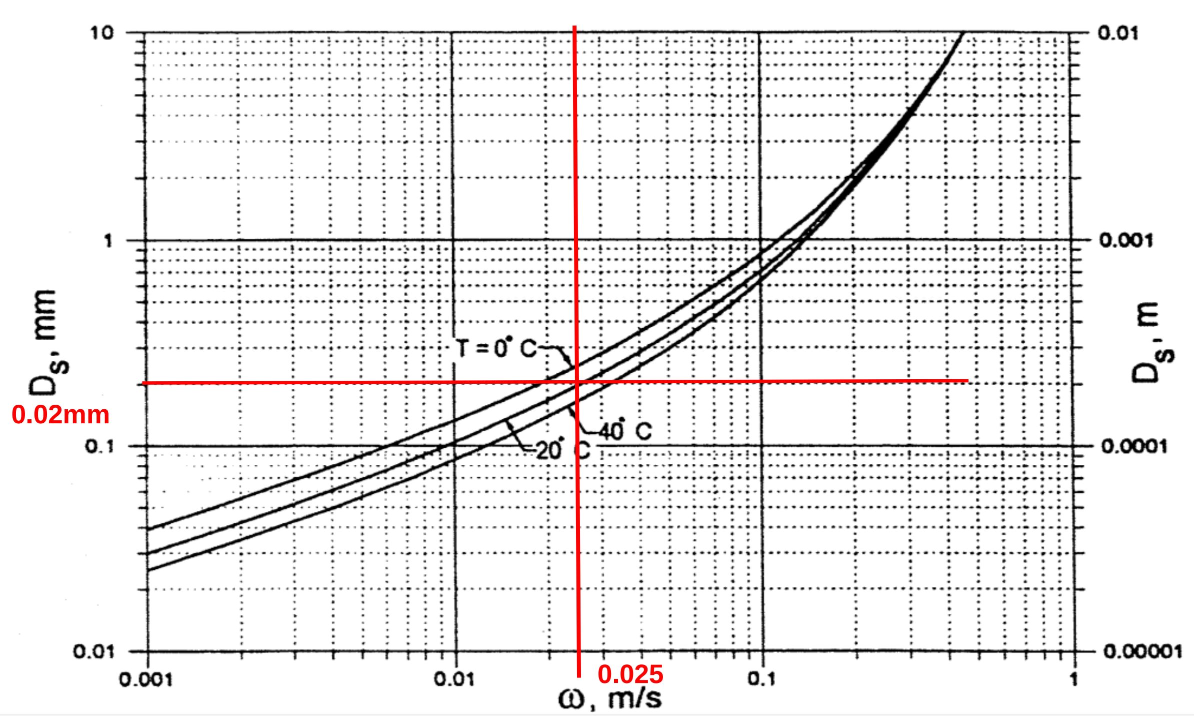


Figure 6.8 from HEC 18

Local Pier Scour 100-yr

$$y_s/y_1 = 2.0\ K_1 K_2 K_3 (a/y_1)^{0.65}\ Fr_1^{0.43}$$

y_s Scour depth, feet
y_1 Flow depth directly upstream of the pier, feet
K_1 Correction factor for the pier nose shape (Figure 7.3 and Table 7.1, HEC-18)
K_2 Correction factor for the angle of attack of flow (Table 7.2 or Equation 7.4, HEC-18)
K_3 Correction factor for bed condition (Table 7.3, HEC-18)

a Pier width, feet
L Length of pier, feet
Fr_1 Froude number directly upstream of the pier = $V_1/(gy_1)^{0.5}$
V_1. Mean velocity of flow directly upstream of the pier, feet/second (from Velocity Distribution)
g Acceleration of gravity (32.2 ft/s^2)

Table 7.1

Correction Factor for Pier shape	K_1
(a) Square nose	1.1
(b) Round nose	1
(c) Circular cylinder	1
(d) Group of cylinders	1
(e) Sharp nose	0.9

Table 7.3

Correction factor for bed condition		K_3
Bed Condition	Dune Height	K_3
Clear-water Scour	N/A	1.1
Planne bed/Antidune	N/A	1.1
Small dune	3>H≥0.6	1.1
Medium Dumes	9>H≥3	1.2 to 1.1
Large Dunes	H≥9	1.3

Table 7.2

Correction factor angle of attack K_2			
Angle	L/a=4	L/a=8	L/a=12
0	1	1	1
15	1.5	2	2.5
30	2	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5

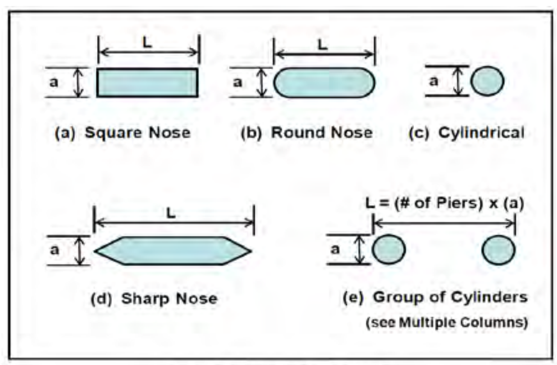


Figure 7.3. Common pier shapes

Angle of Flow: 0 Degrees

Pier Number	y_1	K_1	K_2	K_3	a	L	Fr_1	V_1	g
1 thru 2	6.46	1	1	1.1	1	2	0.358	5.16	32.2

Scour Depth
2.7

Local Pier Scour Velocity Distribution Tables 100-yr

Plan: Scour_100Y Dis	Coyote Creek	Middle Lower	RS: 2837	BR U				Profile: Max WS			
	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	Chan	10.78	113.2	1468	284.77	116.49	100	3.69	5.16	0.35	10.78

HEC-RAS Station for Pier Centerline 21.15

Riprap Sizing 100-yr

Type of Abutment: Vertical

In accordance with DM4, Chapter 7, 7.2.5

V (fps)	Rock Size	D50 (feet)
up to 12	R-6 or larger	1
13 to 15	R-7 or larger	1.5
16 to 17.5	R-8	2

Table from DM4, Chapter 7

Vertical Abutment Riprap Size:

Velocity (BR Open Vel from XS2) = 5.16 ft/s

Factored Velocity for Riprap Sizing = 1.8 * BR Open Vel = 9.29 ft/s

Riprap Size at Vertical Abutments: R-6

HEC-23 Rip Rap Sizing for Vertical or Spill Through Abutments

fr $V/(gy)^{1/2}$ ≤ 0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)$

K spill through abutment = 0.89
vertical wall abutment = 1.02

fr $V/(gy)^{1/2}$ >0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)^{0.14}$

K spill through abutment = 0.61
vertical wall abutment = 0.69

Where:

fr	(froude number at XS2)	0.47	
Abutment type (spill through or vertical wall)		Vertical	
K		0.89	
y	Depth of flow in the contracted bridge opening (depth from XS2)	6.46	ft
V	As described above for Abutments or Piers:	5.16	ft/s
S	Specific Gravity:	2.65	
g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
D_{50}		0.45	ft

Riprap Abutment Size per HEC-23: R-6

Upon discussion and concurrence from PennDOT at OTS if velocities indicate a larger D50 than R-8 and there is no evidence of scour at the existing bridge then use R-8 otherwise use R-8 partially grouted.

Presence of Existing Scour in Inspection Reports: N/A

Final Recommended Riprap Size at Abutments: R-6

Pier Riprap Size:

Velocity (Average Upstream Velocity from XS 3) = 4.74 ft/s

Factored Velocity for Riprap Sizing = 1.5 * Avg US Vel = 7.11 ft/s

Riprap Size at Piers: R-6

If velocities are greater than 17.5 ft/s, use the FHWA formula:

$D_{50} = 0.692 * V^2 / ((S-1)(2g))$

Where:

V	As described above for or Piers (with a 1.5 factor):	7.11	ft/s
S	Specific Gravity:	2.65	
g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
D_{50}		0.33	ft

V (fps)	Rock Size
0.0 to 11.99	R-6 or larger
12.0 to 15.99	R-7 or larger
16.0 to 17.5	R-8

Table from DM4, Chapter 7

Scour Calculation Results

Reference HEC 18, 5th Edition

Design Year: 100

Live bed contraction scour will exist. Use the live bed analysis.

Do Coarse Bed Conditions Exist? NO ("YES" or "NO")

Contractions Scour Results:

If Clear-Water Governs 5.31 ft

If Live-Bed Governs, Minimum of ysLB and ysCW 1.82 ft

100-yr Contraction Scour: 1.82 feet

Does Vertical Contractions Scour Occur? NO ("YES" or "NO")

--

-- -- --

-- -- --

-- -- --

Are there piers within the 500-year floodplain? YES ("YES" or "NO")

100-yr Local Pier Scour: 2.95 feet

Riprap Size at Abutments: R-6

Riprap Size at Piers: R-6

Note: If the super flood (500-year) scour depth is below the bottom of the footing elevation then the rock size should be as determined by the 500-year calculations.

100-yr Scour Results (ft)			
Scour Type	Abutment 1	Abutment 2	Pier
Contraction Scour	2.00	2.00	2.00
Vertical Contraction Scour	--	--	--
Local Scour	--	--	3.00
Total Scour	2.00	2.00	5.00

Notes: (1) Local abutment scour calculations are not required when the substructure is protected with multi-layered riprap protection. (2) If multi-layered riprap protection is proposed at the piers the local pier scour depth may be reduced by 50%.

XS1

HEC-RAS, 100 Year Design

Plan: COC-100		RS:1300	Profile:	100	
E.G. Elev (ft)	4.82	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.11	Wt. n-Val.	0.025	0.025	
W.S. Elev (ft)	4.71	Reach Len. (ft)	51.21	49.99	55.69
Crit W.S. (ft)		Flow Area (sq ft)	242.92	311.64	
E.G. Slope (ft/ft)	0.000456	Area (sq ft)	1153.55	311.64	
Q Total (cfs)	1463.5	Flow (cfs)	671.97	791.53	
Top Width (ft)	1051.77	Top Width (ft)	942.49	109.28	
Vel Total (ft/s)	2.64	Avg. Vel. (ft/s)	2.77	2.54	
Max Chl Dpth (ft)	4.13	Hydr. Depth (ft)	3.22	2.85	
Conv. Total (cfs)	68507.9	Conv. (cfs)	31455.4	37052.5	
Length Wtd. (ft)	50.42	Wetted Per. (ft)	75.55	110.15	
Min Ch El (ft)	0.58	Shear (lb/sq ft)	0.09	0.08	
Alpha	1.01	Stream Power (lb/ft s)	1860.21	0	1860.2
Frctn Loss (ft)	0.03	Cum Volume (acre-ft)	6.61	1.75	0.11
C & E Loss (ft)		Cum SA (acres)	3.94	0.72	0.12

XS2

HEC-RAS, 100 Year Design

Plan: COC-100		RS:1211	Profile:	100
E.G. US. (ft)	4.87	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	4.65	E.G. Elev (ft)	4.72	4.7
Q Total (cfs)	1433.67	W.S. Elev (ft)	4.42	4.38
Q Bridge (cfs)	1433.67	Crit W.S. (ft)	3.27	3.34
Q Weir (cfs)		Max Chl Dpth (ft)	3.6	3.74
Weir Sta Lft (ft)		Vel Total (ft/s)	4.41	4.54
Weir Sta Rgt (ft)		Flow Area (sq ft)	325.17	315.95
Weir Submerg		Froude # Chl	0.41	0.41
Weir Max Depth (ft)		Specif Force (cu ft)	679.37	653.06
Min El Weir Flow (ft)	7.16	Hydr Depth (ft)	2.74	2.66
Min El Prs (ft)	7.06	W.P. Total (ft)	168.01	168.44
Delta EG (ft)	0.18	Conv. Total (cfs)	30045.9	28571.7
Delta WS (ft)	0.22	Top Width (ft)	118.73	118.63
BR Open Area (sq ft)	617.07	Frctn Loss (ft)	0.02	0.08
BR Open Vel (ft/s)	4.54	C & E Loss (ft)	0	0.01
Coef of Q		Shear Total (lb/sq ft)	0.28	0.29
Br Sel Method	Energy only	Power Total (lb/ft s)	0	0

XS3

HEC-RAS, 100 Year Design

Plan: COC-100		RS:1250	Profile: 100-Yr		
E.G. Elev (ft)	4.87	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.21	Wt. n-Val.	0.025	0.025	
W.S. Elev (ft)	4.65	Reach Len. (ft)	35.01	35.01	35.01
Crit W.S. (ft)	3.16	Flow Area (sq ft)	84.61	303.27	
E.G. Slope (ft/ft)	0.000919	Area (sq ft)	1902.91	304.23	
Q Total (cfs)	1433.67	Flow (cfs)	339.1	1094.56	
Top Width (ft)	1272.77	Top Width (ft)	1162.01	110.76	
Vel Total (ft/s)	3.7	Avg. Vel. (ft/s)	4.01	3.61	
Max Chl Dpth (ft)	3.83	Hydr. Depth (ft)	3.32	2.85	
Conv. Total (cfs)	47282.7	Conv. (cfs)	11183.6	36099.1	
Length Wtd. (ft)	35.01	Wetted Per. (ft)	25.51	107.01	
Min Ch El (ft)	0.82	Shear (lb/sq ft)	0.19	0.16	
Alpha	1.01	Stream Power (lb/ft s)	1954.54	0	1954.53
Frctn Loss (ft)	0.05	Cum Volume (acre-ft)	4.82	1.4	0.11
C & E Loss (ft)	0.01	Cum SA (acres)	2.7	0.59	0.12

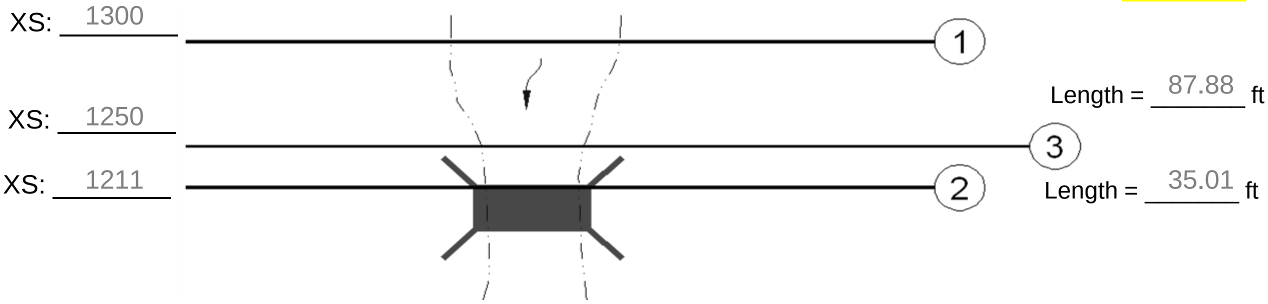
Scour 100-yr

Streambed Particle Size (D_{50}): 0.008 in.
0.2 mm
0.0007 ft.

Determined by: Set to minimum
Note: *Set minimum D_{50} to 0.2mm (0.008-inch) for lower limit per HEC-18 6.2*

Upstream Uncontracted Cross Section (XS1):	1300	
Internal Upstream Cross Section (XS2):	1211	
Upstream Bounding Cross Section (XS3):	1250	
Long-term aggradation / degradation:	0.0	ft.

Length to XS1:	87.88	ft.
Length to XS3:	35.01	ft.
Low Chord Elevation:	7.01	ft.
Water Surface Elevation:	4.65	ft.
Streambed Elevation	0.82	ft.



Key
1. Upstream uncontracted cross section (XS output)
2. Internal bridge cross section (BR U or BR D in HEC-RAS output)
3. Upstream bounding cross section (XS output)

Determine Clear-Water or Live-Bed Flow Conditions

Ku coefficient (Enter 6.19 for SI units or 11.17 for English Units):	11.17	
Channel Hydraulic Depth Variable (from XS1), **y**:	2.85	ft.
Channel Velocity (from XS1), V:	**2.540**	**ft./s**

V_c is the critical velocity. Speeds at or above this level will transport bed material of D50 and smaller.
Use Equation 6.1 (HEC-18):

$$V_c = K_u \, y^{1/6} (D_{50})^{1/3}$$

V_c = 1.162 ft./s

If $V_c < V$ Live-Bed Scour Occurs
If Vc > V Clear-Water Scour Occurs

Live bed contraction scour will exist. Use the live bed analysis.

K_u Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077	
W, W_1, W_2 values are taken at:	at top of channel	
For Vertical Contraction Scour:		
Does overtopping of the bridge or approach roadway occur?	No	
T Superstructure Depth (including girders, deck and parapet):	1.55	ft.

Contraction Scour 100-yr

Clear-Water Scour (NOT APPLICABLE)

K_u	Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077		
y_0	Hydraulic Depth Variable (from XS2):	2.66	ft	
W	Estimated bottom or top channel width, less pier widths (XS2):	118.63	ft	at top of channel
Q	Flow through the bridge opening, or on the set-back over bank area at the bridge associated with the width, W (from XS2):	1433.67	cfs	
D_m	Diameter of the smallest nontransportable particle in the bed material, 1.25 * D_{50}:	0.00083	ft	
y_2	Average depth in the contracted section: Equation 6.4 (HEC-18) $y_2 = \left[\frac{0.0077Q^2}{D_m^{2/3}W^2}\right]^{3/7}$	7.97	ft	

y_s Average contraction scour depth: $y_s = y_2 - y_0$ **5.31 ft**

Equation 6.5 (HEC-18)

Contraction Scour 100-yr

Live Bed Scour (GOVERNS)

y_1	Channel Hydraulic Depth Variable (from XS1):	2.85	ft
y_0	Hydraulic Depth Variable (from XS2):	2.66	ft

HEC-18, Section 6.3 Note #7 - "In sand channel streams where the contraction scour hole is filled in on the falling stage, the y_0 depth may be approximated by y_1. Sketches or surveys through the bridge can help in determining the existing bed elevation."

W_1	Estimated bottom or top channel width (XS1):	109.28	ft	at top of channel
W_2	Estimated bottom or top channel width, less pier widths (XS2):	118.63	ft	at top of channel

HEC-RAS internal bridge cross section accounts for deduction of pier and sloping abutment. Minimum of upstream and downstream.

Q_1	Channel Flow (XS1):	791.53	cfs
Q_2	Flow in the contracted channel (XS2):	1433.67	cfs

HEC-18, Section 6.3 Note # - "Q2 may be the total flow going through the bridge opening as in cases 1a and 1b. It is not the total flow for Case 1c. For Case 1c contraction scour must be computed separately for the main channel and the left and/or right overbank areas."

y_2 Average depth in the contracted section: **4.48** ft

Equation 6.2 (HEC-18)

$$y_2 = y_1\left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{k_1}$$

y_s **Average contraction scour depth: 1.82 ft**

Equation 6.3 (HEC-18)

$$y_s = y_2 - y_0$$

Contraction Scour 100-yr

Live Bed Scour, Continued (GOVERNS)

g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
S	Slope of the energy grade line (from XS1):	0.00046	
T_{SI}	Fall velocity of particles (from Fig. 6.8, HEC-18):	0.025	m/s
		0.082	ft/s
T	Temperature of water:	20.0	C
V*	Shear velocity (XS1): $V^* = (g \times y_1 \times S)^{1/2}$	0.20	ft/s

V*/T	k1	Mode of Bed Material Transport (Fig. 6.8, HEC-18, pg. 6.11)
< 0.50	0.59	Mostly contact bed material discharge
0.50 to 2.00	0.64	Some suspended bed material discharge
> 2.00	0.69	Mostly suspended bed material discharge

V* / T = 2.49 Where T = w

k_1 = 0.69

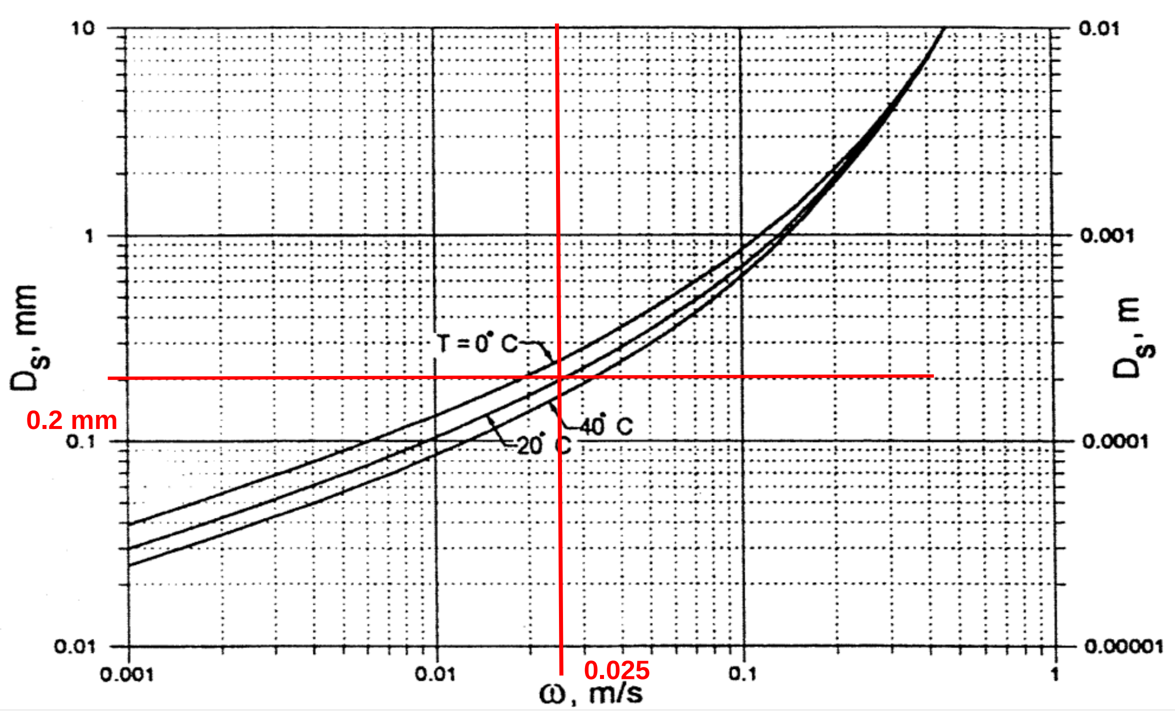


Figure 6.8 from HEC 18

Local Pier Scour 100-yr

$$y_s/y_1 = 2.0\, K_1 K_2 K_3 (a/y_1)^{0.65}\, Fr_1^{0.43}$$

y_s Scour depth, feet
y_1 Flow depth directly upstream of the pier, feet
K_1 Correction factor for the pier nose shape (Figure 7.3 and Table 7.1, HEC-18)
K_2 Correction factor for the angle of attack of flow (Table 7.2 or Equation 7.4, HEC-18)
K_3 Correction factor for bed condition (Table 7.3, HEC-18)

a Pier width, feet
L Length of pier, feet
Fr_1 Froude number directly upstream of the pier = $V_1/(gy_1)^{0.5}$
V_1 Mean velocity of flow directly upstream of the pier, feet/second (from Velocity Distribution)
g Acceleration of gravity (32.2 ft/s^2)

Table 7.1

Correction Factor for Pier shape	K_1
(a) Square nose	1.1
(b) Round nose	1
(c) Circular cylinder	1
(d) Group of cylinders	1
(e) Sharp nose	0.9

Table 7.3

Correction factor for bed condition		K_3
Bed Condition	Dune Height	K_3
Clear-water Scour	N/A	1.1
Planne bed/Antidune	N/A	1.1
Small dune	3>H≥0.6	1.1
Medium Dumes	9>H≥3	1.2 to 1.1
Large Dunes	H≥9	1.3

Table 7.2

Correction factor angle of attack K_2			
Angle	L/a=4	L/a=8	L/a=12
0	1	1	1
15	1.5	2	2.5
30	2	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5

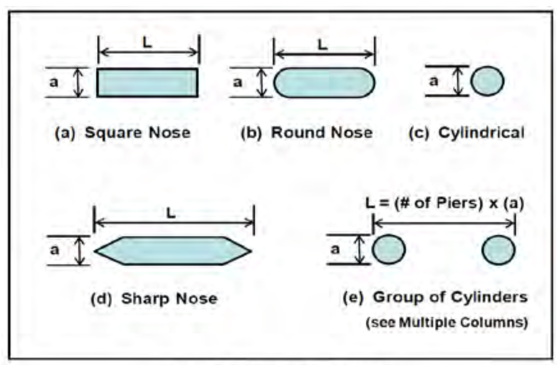


Figure 7.3. Common pier shapes

Angle of Flow: 0 Degrees

Pier Number	y_1	K_1	K_2	K_3	a	L	Fr_1	V_1	g
1 thru 2	3.74	1	1	1.1	1.42	7.1	0.397	4.36	32.2

Scour Depth
2.9

Local Pier Scour Velocity Distribution Tables 100-yr

Plan: Scour_100Y Dis Coyote Creek Middle Lower RS: 1211 BR U Profile: Max WS											
	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB		1752.4	334.72	73.13	35.79	23.35	3.09	4.58	0.29	1954.5
2	Chan	1752.4	1912.4	1098.9	252.04	132.21	76.65	2.65	4.36	0.27	0

HEC-RAS Station for Pier Centerline 1120.3

Riprap Sizing 100-yr

Type of Abutment: **Vertical**

In accordance with DM4, Chapter 7, 7.2.5

V (fps)	Rock Size	D50 (feet)
up to 12	R-6 or larger	1
13 to 15	R-7 or larger	1.5
16 to 17.5	R-8	2

Table from DM4, Chapter 7

Vertical Abutment Riprap Size:

Velocity (BR Open Vel from XS2) = 4.54 ft/s

Factored Velocity for Riprap Sizing = 1.8 * BR Open Vel = 8.17 ft/s

Riprap Size at Vertical Abutments: R-6

HEC-23 Rip Rap Sizing for Vertical or Spill Through Abutments

fr $V/(gy)^{1/2}$ ≤ 0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)$

K spill through abutment = 0.89
vertical wall abutment = 1.02

fr $V/(gy)^{1/2}$ >0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)^{0.14}$

K spill through abutment = 0.61
vertical wall abutment = 0.69

Where:

fr	(froude number at XS2)	0.41	
Abutment type (spill through or vertical wall)		Vertical	
K		0.89	
y	Depth of flow in the contracted bridge opening (depth from XS2)	3.74	ft
V	As described above for Abutments or Piers:	4.54	ft/s
S	Specific Gravity:	2.65	
g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
D_{50}		0.35	ft

Riprap Abutment Size per HEC-23: R-6

Upon discussion and concurrence from PennDOT at OTS if velocities indicate a larger D50 than R-8 and there is no evidence of scour at the existing bridge then use R-8 otherwise use R-8 partially grouted.
Presence of Existing Scour in Inspection Reports: **N/A**

Final Recommended Riprap Size at Abutments: R-6

Pier Riprap Size:

Velocity (Average Upstream Velocity from XS 3) = 3.61 ft/s

Factored Velocity for Riprap Sizing = 1.5 * Avg US Vel = 5.42 ft/s

Riprap Size at Piers: R-6

If velocities are greater than 17.5 ft/s, use the FHWA formula:

$D_{50} = 0.692*V^2 / ((S-1)(2g))$

Where:

V	As described above for or Piers (with a 1.5 factor):	5.42	ft/s
S	Specific Gravity:	2.65	
g	Gravity Constant (Enter 9.81 m/s^2 for SI or 32.2 ft/s^2 for English):	32.2	ft/s^2
D_{50}		0.19	ft

V (fps)	Rock Size
0.0 to 11.99	R-6 or larger
12.0 to 15.99	R-7 or larger
16.0 to 17.5	R-8

Table from DM4, Chapter 7

Scour Calculation Results

Design Year: **100**

Reference HEC 18, 5th Edition

Live bed contraction scour will exist. Use the live bed analysis.

Do Coarse Bed Conditions Exist? NO ("YES" or "NO")

--

-- -- --

-- -- --

-- **--** **--**

Does Vertical Contractions Scour Occur? YES ("YES" or "NO")

Vertical Contractions Scour Results:

If Clear-Water Governs 7.84 ft

If Live-Bed Governs, Minimum of ysLB and ysCW 3.21 ft

100-yr Vertical Contraction Scour: 3.21 feet

Are there piers within the 500-year floodplain? YES ("YES" or "NO")

100-yr Local Pier Scour: 2.49 feet

Riprap Size at Abutments: R-6

Riprap Size at Piers: R-6

Note: If the super flood (500-year) scour depth is below the bottom of the footing elevation then the rock size should be as determined by the 500-year calculations.

100-yr Scour Results (ft)

Scour Type	Abutment 1	Abutment 2	Pier
Contraction Scour	--	--	--
Vertical Contraction Scour	4.00	4.00	--
Local Scour	--	--	--
Total Scour	4.00	4.00	0.00

Notes: (1) Local abutment scour calculations are not required when the substructure is protected with multi-layered riprap protection. (2) If multi-layered riprap protection is proposed at the piers the local pier scour depth may be reduced by 50%.

XS1

HEC-RAS, 100 Year Design

Plan: NYC_200		RS:969	Profile: 100-Yr		
E.G. Elev (ft)	11.01	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.09	Wt. n-Val.	0.025	0.025	0.025
W.S. Elev (ft)	10.92	Reach Len. (ft)	30.12	31.13	31.47
Crit W.S. (ft)		Flow Area (sq ft)	32.89	128.06	71.13
E.G. Slope (ft/ft)	0.000333	Area (sq ft)	32.89	128.06	71.8
Q Total (cfs)	489.16	Flow (cfs)	54.17	352.64	82.34
Top Width (ft)	109.7	Top Width (ft)	15.62	29.89	64.19
Vel Total (ft/s)	2.11	Avg. Vel. (ft/s)	1.65	2.75	1.16
Max Chl Dpth (ft)	5.77	Hydr. Depth (ft)	2.11	4.28	1.11
Conv. Total (cfs)	26810.5	Conv. (cfs)	2969.2	19328.3	4513
Length Wtd. (ft)	31.11	Wetted Per. (ft)	17.57	31.64	64.49
Min Ch El (ft)	5.15	Shear (lb/sq ft)	0.04	0.08	0.02
Alpha	1.35	Stream Power (lb/ft s)	143.84	0.36	0
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.06	4.21	0.4
C & E Loss (ft)		Cum SA (acres)	0.08	0.73	0.46

XS2

HEC-RAS, 100 Year Design

Plan: NYC_200		RS:913	Profile: 100-Yr	
E.G. US. (ft)	11.12	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	10.9	E.G. Elev (ft)	11.17	10.94
Q Total (cfs)	489.19	W.S. Elev (ft)	10.96	10.75
Q Bridge (cfs)	319.91	Crit W.S. (ft)	10.91	8.03
Q Weir (cfs)	169.28	Max Chl Dpth (ft)	6.21	6.11
Weir Sta Lft (ft)	0.1	Vel Total (ft/s)	3.98	3.12
Weir Sta Rgt (ft)	105.16	Flow Area (sq ft)	122.9	156.84
Weir Submerg	0	Froude # Chl	0.35	0.35
Weir Max Depth (ft)	0.84	Specif Force (cu ft)	294.26	303.63
Min El Weir Flow (ft)	10.34	Hydr Depth (ft)	1.22	1.23
Min El Prs (ft)	8.13	W.P. Total (ft)	151.11	178.54
Delta EG (ft)	0.9	Conv. Total (cfs)		
Delta WS (ft)	0.83	Top Width (ft)	100.77	127.14
BR Open Area (sq ft)	48.81	Frctn Loss (ft)		
BR Open Vel (ft/s)	6.55	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)		
Br Sel Method	Press/Weir	Power Total (lb/ft s)	0	0

XS3

HEC-RAS, 100 Year Design

Plan: NYC_200		RS:938	Profile: 100-Yr		
E.G. Elev (ft)	11.12	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.22	Wt. n-Val.	0.025	0.025	0.025
W.S. Elev (ft)	10.9	Reach Len. (ft)	4.9	4.9	4.9
Crit W.S. (ft)	8.21	Flow Area (sq ft)	4.12	118.18	24.27
E.G. Slope (ft/ft)	0.000969	Area (sq ft)	14.57	149.71	42.53
Q Total (cfs)	489.19	Flow (cfs)	3.97	459.15	26.07
Top Width (ft)	99.97	Top Width (ft)	9.46	35.86	54.65
Vel Total (ft/s)	3.34	Avg. Vel. (ft/s)	0.96	3.89	1.07
Max Chl Dpth (ft)	6.15	Hydr. Depth (ft)	0.44	3.3	0.44
Conv. Total (cfs)	15714.4	Conv. (cfs)	127.5	14749.4	837.6
Length Wtd. (ft)	4.9	Wetted Per. (ft)	10.95	38.84	54.85
Min Ch El (ft)	4.75	Shear (lb/sq ft)	0.02	0.18	0.03
Alpha	1.28	Stream Power (lb/ft s)	134.11	0.1	0
Frctn Loss (ft)		Cum Volume (acre-ft)	0.05	4.11	0.36
C & E Loss (ft)		Cum SA (acres)	0.07	0.7	0.42

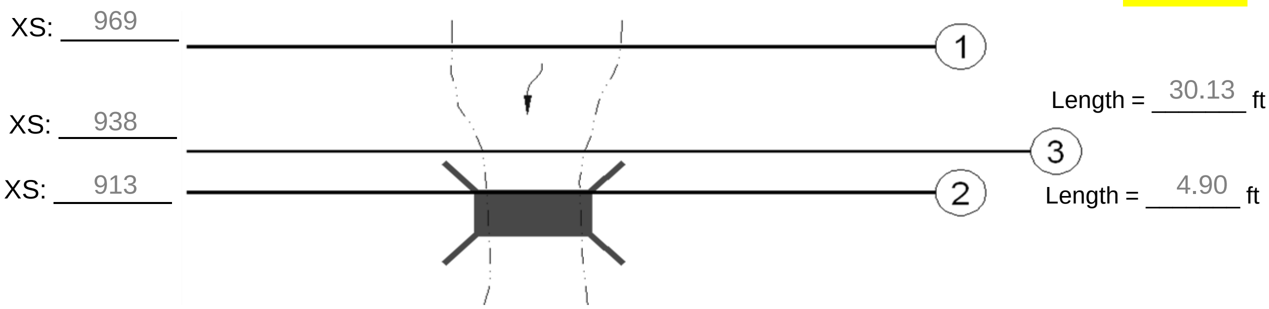
Scour 100-yr

Streambed Particle Size (D_{50}): 0.008 in.
0.2 mm
0.0007 ft.

Determined by: Set to minimum
Note: *Set minimum D_{50} to 0.2mm (0.008-inch) for lower limit per HEC-18 6.2*

Upstream Uncontracted Cross Section (XS1):	969	
Internal Upstream Cross Section (XS2):	913	
Upstream Bounding Cross Section (XS3):	938	
Long-term aggradation / degradation:	0.0	ft.

Length to XS1:	30.13	ft.
Length to XS3:	4.90	ft.
Low Chord Elevation:	8.02	ft.
Water Surface Elevation:	10.90	ft.
Streambed Elevation	4.75	ft.



Key
1. Upstream uncontracted cross section (XS output)
2. Internal bridge cross section (BR U or BR D in HEC-RAS output)
3. Upstream bounding cross section (XS output)

Determine Clear-Water or Live-Bed Flow Conditions

Ku coefficient (Enter 6.19 for SI units or 11.17 for English Units):	11.17	
Channel Hydraulic Depth Variable (from XS1), **y**:	4.28	ft.
Channel Velocity (from XS1), V:	**2.750**	**ft./s**

V_c is the critical velocity. Speeds at or above this level will transport bed material of D50 and smaller.
Use Equation 6.1 (HEC-18):

$$V_c = K_u \; y^{1/6} \; (D_{50})^{1/3}$$

V_c = 1.243 ft./s

If V_c < V Live-Bed Scour Occurs
If Vc > V Clear-Water Scour Occurs

Live bed contraction scour will exist. Use the live bed analysis.

K_u Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077	
W, W_1, W_2 values are taken at:	at top of channel	
For Vertical Contraction Scour:		
Does overtopping of the bridge or approach roadway occur?	Yes	
T Superstructure Depth (including girders, deck and parapet):	2.31	ft.

Contraction Scour 100-yr

Live Bed Scour, Continued (GOVERNS)

g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
S	Slope of the energy grade line (from XS1):	0.00033	
T_{SI}	Fall velocity of particles (from Fig. 6.8, HEC-18):	0.025	m/s
		0.082	*ft/s*
T	Temperature of water:	20.0	C
V*	Shear velocity (XS1): $V^* = (g \times y_1 \times S)^{1/2}$	0.21	ft/s

V*/T	k1	Mode of Bed Material Transport (Fig. 6.8, HEC-18, pg. 6.11)
< 0.50	0.59	Mostly contact bed material discharge
0.50 to 2.00	0.64	Some suspended bed material discharge
> 2.00	0.69	Mostly suspended bed material discharge

V* / T = 2.61 Where T = w

k_1 = 0.69

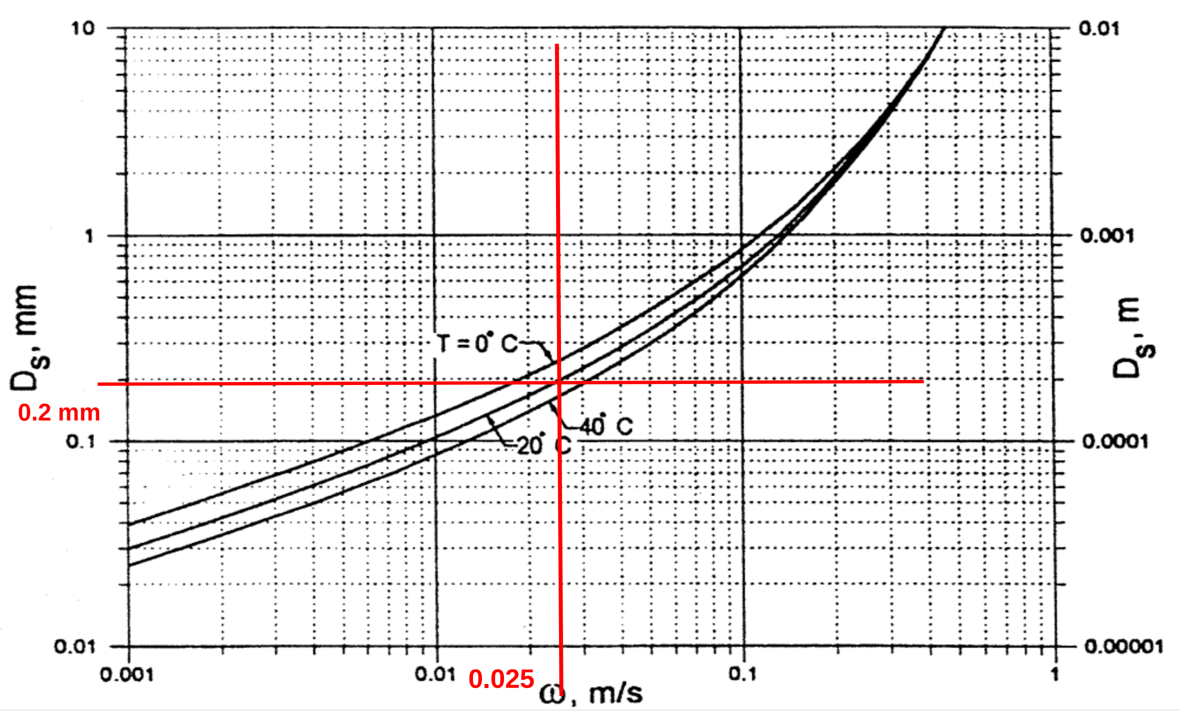


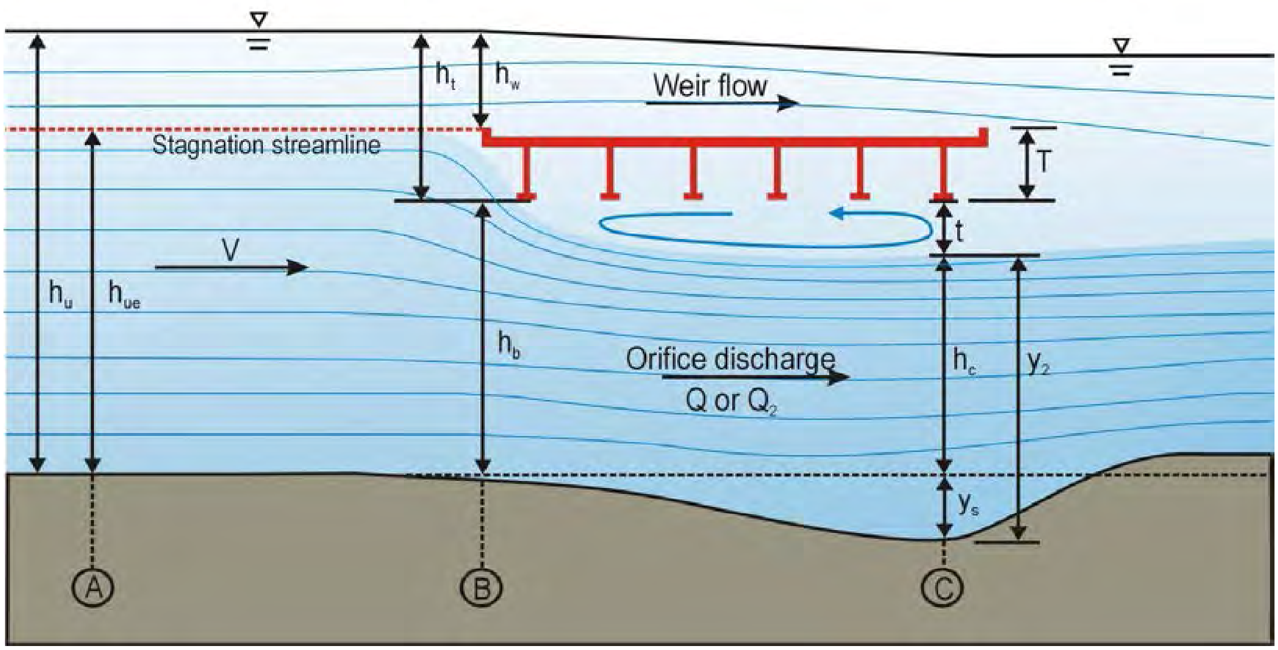
Figure 6.8 from HEC 18

Vertical Contraction Scour 100-yr

Determine Flow Conditions (Critical Velocity For Movement of the D_{50} Particle)

Streambed Particle Size (D_{50}): 0.008 in.; 0.203 mm; 0.0007 ft.

Determined by: Set to minimum



Vertical Contraction Scour 100-yr

Clear-Water Scour (NOT APPLICABLE)

K_u	Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077		
y_0	Hydraulic Depth Variable (from XS2):	2.30	ft	BR Area/BR Sp
W	Estimated bottom or top channel width, less pier widths (XS2):	21.19	ft	BR Clear Span
Q	Flow through the bridge opening, or on the set-back over bank area at the bridge associated with the width, W (from XS2):	319.91	cfs	
D_m	Diameter of the smallest nontransportable particle in the bed material, 1.25 * D_{50}:	0.00083	ft	
y_{2cw}	Average depth in the contracted section: Equation 6.4 (HEC-18) $y_{2CW} = \left[\frac{K_u Q_2^{\,2}}{(1.25 D_{50})^{2/3} W_2^{\,2}}\right]^{3/7}$	9.65	ft	
t	$\frac{t}{h_b} = 0.5\left(\frac{h_b \cdot h_t}{h_u^2}\right)^{0.2}\left(1-\frac{h_w}{h_t}\right)^{-0.1}$	1.46	ft	

y_{sCW} Vertical Clear-Water contraction scour depth: 7.84 ft

$y_s = y_2 + t - h_b$

Vertical Contraction Scour 100-yr

Live Bed Scour (GOVERNS)

Does overtopping of the bridge or approach roadway occur? Yes

$h_u = y_1$	Channel Hydraulic Depth Variable (from XS1):	4.28	ft
y_0	Hydraulic Depth Variable (from XS2):	2.30	ft BR Area/BR Sp

HEC-18, Section 5.3 Note #7 - In sand channel streams where the contraction scour hole is filled in on the falling stage, the y_0 depth may be approximated by y_1. Sketches or surveys through the bridge can help in determining the existing bed elevation.

W_1	Estimated bottom or top channel width (XS1):	29.89	ft at top of channel
W_2	Estimated bottom or top channel width, less pier widths (XS2):	21.19	ft BR Clear Span

HEC-RAS internal bridge cross section accounts for deduction of pier and sloping abutment. Minimum of upstream and downstream.

Q_1	Channel Flow (XS1):	352.64	cfs
Q_2	Flow in the contracted channel (XS2):	319.91	cfs

If the proposed bridge abutments are located in the channel (HEC-18, Case 1a) or at the channel banks (HEC-18, Case 1b), Q_2 should be the flow through the bridge opening.

S_1			0.00033	ft. / ft.
h_b	Bridge Underclearance:		3.27	ft.
T	Superstructure Depth (including girders, deck and parapet):		2.31	ft.
h_t	Distance from Water Surface to Low Chord:	= WSE-Low Chord	2.88	ft.
h_w	Weir Flow Height (If applicable):	$= h_t - T$	0.57	ft.

Adjustments when Overtopping occurs (if required):

$y_1 = h_{ue}$	Effective Upstream Flow Depth:	$=h_b + T$	5.58	ft.
$Q_1 = Q_{ue}$	Effective Upstream Discharge:	$=Q_1 (h_{ue}/h_u)^{8/7}$	478	cfs
k_1	Reference HEC 18, Page 6.10, Table for k_1 selection.		0.69	
y_{2LB}		$y_{2LB} = \left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{k_1} y_1$	5.02	ft.
t	$\frac{t}{h_b} = 0.5\left(\frac{h_b . h_t}{h_u^2}\right)^{0.2}\left(1-\frac{h_w}{h_t}\right)^{-0.1}$		1.46	ft.

y_{sLB} Vertical contraction scour depth: 3.21 ft

$y_s = y_2 + t - h_b$

Local Pier Scour 100-yr

$$y_s/y_1 = 2.0\ K_1 K_2 K_3 (a/y_1)^{0.65}\ Fr_1^{0.43}$$

y_s Scour depth, feet
y_1 Flow depth directly upstream of the pier, feet
K_1 Correction factor for the pier nose shape (Figure 7.3 and Table 7.1, HEC-18)
K_2 Correction factor for the angle of attack of flow (Table 7.2 or Equation 7.4, HEC-18)
K_3 Correction factor for bed condition (Table 7.3, HEC-18)

a Pier width, feet
L Length of pier, feet
Fr_1 Froude number directly upstream of the pier = $V_1/(gy_1)^{0.5}$
V_1. Mean velocity of flow directly upstream of the pier, feet/second (from Velocity Distribution)
g Acceleration of gravity (32.2 ft/s^2)

Table 7.1

Correction Factor for Pier shape	K_1
(a) Square nose	1.1
(b) Round nose	1
(c) Circular cylinder	1
(d) Group of cylinders	1
(e) Sharp nose	0.9

Table 7.3

Correction factor for bed condition		K_3
Bed Condition	Dune Height	K_3
Clear-water Scour	N/A	1.1
Planne bed/Antidune	N/A	1.1
Small dune	3>H≥0.6	1.1
Medium Dumes	9>H≥3	1.2 to 1.1
Large Dunes	H≥9	1.3

Table 7.2

Correction factor angle of attack K_2			
Angle	L/a=4	L/a=8	L/a=12
0	1	1	1
15	1.5	2	2.5
30	2	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5

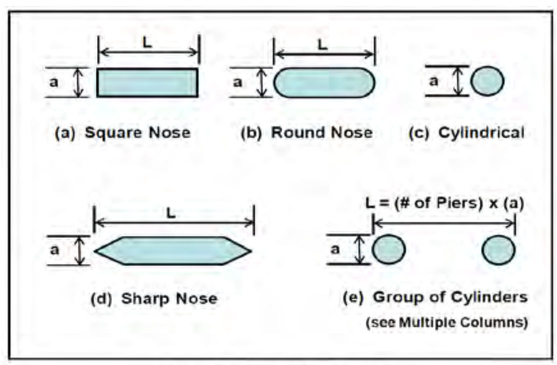


Figure 7.3. Common pier shapes

Angle of Flow: 0 Degrees

Pier Number	y_1	K_1	K_2	K_3	a	L	Fr_1	V_1	g
1 thru 2	4.68	1	1	1.1	1	1	0.381	4.68	32.2

Scour Depth
2.5

Local Pier Scour Velocity Distribution Tables 100-yr

Plan: Scour_100Y Dis		Nyhan Creek		Lower RS: 913		BR U		Profile: Max WS			
	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB		9.56	27.77	6.69	9.96	100	0.71	4.15		134.11
2	Chan	9.56	45.42	357.32	76.37	85.64	100	2.13	4.68		0.1
3	ROB	45.42		101.35	39.84	55.51	100	0.72	2.54		0

HEC-RAS Station for Pier Centerline 28.65

Riprap Sizing 100-yr

Type of Abutment: **Vertical**

In accordance with DM4, Chapter 7, 7.2.5

V (fps)	Rock Size	D50 (feet)
up to 12	R-6 or larger	1
13 to 15	R-7 or larger	1.5
16 to 17.5	R-8	2

Table from DM4, Chapter 7

Vertical Abutment Riprap Size:

Velocity (BR Open Vel from XS2) = 6.55 ft/s

Factored Velocity for Riprap Sizing = 1.8 * BR Open Vel = 11.79 ft/s

Riprap Size at Vertical Abutments: R-6

HEC-23 Rip Rap Sizing for Vertical or Spill Through Abutments

fr $V/(gy)^{1/2}$ ≤ 0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)$

K spill through abutment = 0.89
vertical wall abutment = 1.02

fr $V/(gy)^{1/2}$ >0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)^{0.14}$

K spill through abutment = 0.61
vertical wall abutment = 0.69

Where:

fr	(froude number at XS2)	0.35	
Abutment type (spill through or vertical wall)		Vertical	
K		0.89	
y	Depth of flow in the contracted bridge opening (depth from XS2)	6.21	ft
V	As described above for Abutments or Piers:	6.55	ft/s
S	Specific Gravity:	2.65	
g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
D_{50}		0.72	ft

Riprap Abutment Size per HEC-23: R-6

Upon discussion and concurrence from PennDOT at OTS if velocities indicate a larger D50 than R-8 and there is no evidence of scour at the existing bridge then use R-8 otherwise use R-8 partially grouted.

Presence of Existing Scour in Inspection Reports: **N/A**

Final Recommended Riprap Size at Abutments: R-6

Pier Riprap Size:

Velocity (Average Upstream Velocity from XS 3) = 3.89 ft/s

Factored Velocity for Riprap Sizing = 1.5 * Avg US Vel = 5.84 ft/s

Riprap Size at Piers: R-6

If velocities are greater than 17.5 ft/s, use the FHWA formula:

$D_{50} = 0.692 * V^2 / ((S-1)(2g))$

Where:

V	As described above for or Piers (with a 1.5 factor):	5.84	ft/s
S	Specific Gravity:	2.65	
g	Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English):	32.2	ft/s²
D_{50}		0.22	ft

V (fps)	Rock Size
0.0 to 11.99	R-6 or larger
12.0 to 15.99	R-7 or larger
16.0 to 17.5	R-8

Table from DM4, Chapter 7

Scour Calculation Results

Reference HEC 18, 5th Edition

Design Year: 100

Live bed contraction scour will exist. Use the live bed analysis.

Do Coarse Bed Conditions Exist? NO ("YES" or "NO")

--

-- -- --

-- -- --

-- **--** **--**

Does Vertical Contractions Scour Occur? YES ("YES" or "NO")

Vertical Contractions Scour Results:

If Clear-Water Governs 7.62 ft

If Live-Bed Governs, Minimum of ysLB and ysCW 4.98 ft

100-yr Vertical Contraction Scour: 4.98 feet

Are there piers within the 500-year floodplain? NO ("YES" or "NO")

-- **--** **--**

Riprap Size at Abutments: R-7

-- **--**

Note: If the super flood (500-year) scour depth is below the bottom of the footing elevation then the rock size should be as determined by the 500-year calculations.

100-yr Scour Results (ft)			
Scour Type	Abutment 1	Abutment 2	Pier
Contraction Scour	--	--	--
Vertical Contraction Scour	5.00	5.00	--
Local Scour	--	--	--
Total Scour	5.00	5.00	0.00

Notes: (1) Local abutment scour calculations are not required when the substructure is protected with multi-layered riprap protection. (2) If multi-layered riprap protection is proposed at the piers the local pier scour depth may be reduced by 50%.

XS1

HEC-RAS, 100 Year Design

Plan: NYC_100		RS:607	Profile: 100-Yr		
E.G. Elev (ft)	10.14	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.23	Wt. n-Val.	0.025	0.025	0.025
W.S. Elev (ft)	9.91	Reach Len. (ft)	23.1	26.68	29.4
Crit W.S. (ft)		Flow Area (sq ft)	1.42	118.53	26.76
E.G. Slope (ft/ft)	0.00071	Area (sq ft)	1.42	118.53	32.84
Q Total (cfs)	512.6	Flow (cfs)	1.05	474.89	36.66
Top Width (ft)	62.32	Top Width (ft)	4.37	25.45	32.5
Vel Total (ft/s)	3.49	Avg. Vel. (ft/s)	0.74	4.01	1.37
Max Chl Dpth (ft)	7.22	Hydr. Depth (ft)	0.32	4.66	0.82
Conv. Total (cfs)	19240.7	Conv. (cfs)	39.4	17825.2	1376.1
Length Wtd. (ft)	26.69	Wetted Per. (ft)	4.42	29.45	33.26
Min Ch El (ft)	2.69	Shear (lb/sq ft)	0.01	0.18	0.04
Alpha	1.23	Stream Power (lb/ft s)	67.07	0.1	0
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.02	3.16	0.04
C & E Loss (ft)		Cum SA (acres)	0.02	0.42	0.07

XS2

HEC-RAS, 100 Year Design

Plan: NYC_100		RS:556	Profile: 100-Yr	
E.G. US. (ft)	10.23	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	9.88	E.G. Elev (ft)	10.16	10.16
Q Total (cfs)	512.59	W.S. Elev (ft)	9.78	9.75
Q Bridge (cfs)	335.75	Crit W.S. (ft)	7.53	7.32
Q Weir (cfs)	176.84	Max Chl Dpth (ft)	7.09	7.66
Weir Sta Lft (ft)	0.18	Vel Total (ft/s)	4.83	4.91
Weir Sta Rgt (ft)	65.32	Flow Area (sq ft)	106.04	104.5
Weir Submerg	0	Froude # Chl	0.45	0.44
Weir Max Depth (ft)	1.41	Specif Force (cu ft)	304.09	319.7
Min El Weir Flow (ft)	8.76	Hydr Depth (ft)	1.63	2.07
Min El Prs (ft)	7.79	W.P. Total (ft)	92.41	79.38
Delta EG (ft)	1.22	Conv. Total (cfs)		
Delta WS (ft)	1.29	Top Width (ft)	64.87	63.59
BR Open Area (sq ft)	40.44	Frctn Loss (ft)		
BR Open Vel (ft/s)	8.3	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)		
Br Sel Method	Press/Weir	Power Total (lb/ft s)	0	0

XS3

HEC-RAS, 100 Year Design

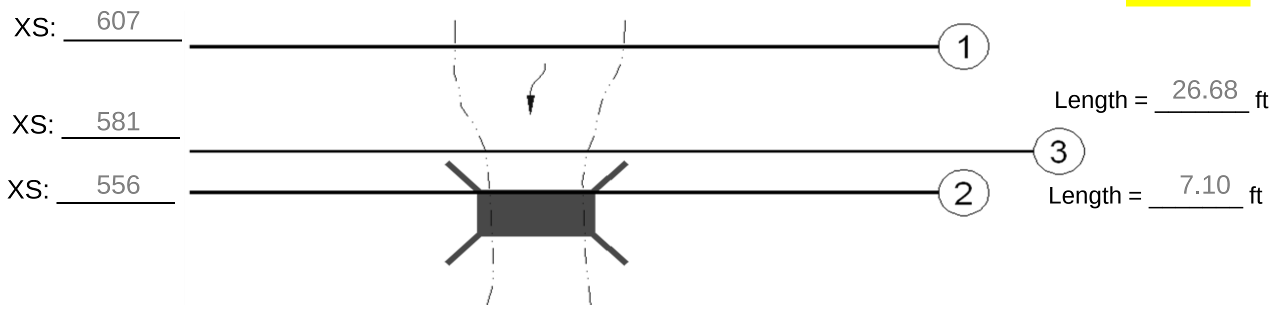
Plan: NYC_100		RS:581	Profile: 100-Yr		
E.G. Elev (ft)	10.23	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.35	Wt. n-Val.	0.025	0.025	0.025
W.S. Elev (ft)	9.88	Reach Len. (ft)	7.1	7.1	7.1
Crit W.S. (ft)	7.26	Flow Area (sq ft)	21.38	81.36	25.89
E.G. Slope (ft/ft)	0.001177	Area (sq ft)	21.38	81.36	30.9
Q Total (cfs)	512.59	Flow (cfs)	54.08	417.17	41.35
Top Width (ft)	64.95	Top Width (ft)	14.79	13.37	36.79
Vel Total (ft/s)	3.98	Avg. Vel. (ft/s)	2.53	5.13	1.6
Max Chl Dpth (ft)	7.19	Hydr. Depth (ft)	1.45	6.09	0.7
Conv. Total (cfs)	14938.1	Conv. (cfs)	1575.9	12157.3	1204.9
Length Wtd. (ft)	7.1	Wetted Per. (ft)	15.49	20.41	37.36
Min Ch El (ft)	2.69	Shear (lb/sq ft)	0.1	0.29	0.05
Alpha	1.4	Stream Power (lb/ft s)	78.53	0.18	0
Frctn Loss (ft)		Cum Volume (acre-ft)	0.01	3.1	0.02
C & E Loss (ft)		Cum SA (acres)	0.01	0.4	0.04

Scour 100-yr

Streambed Particle Size (D_{50}): 0.008 in.
0.2032 mm
0.0007 ft.

Determined by: Set to minimum
Note: *Set minimum D_{50} to 0.2mm (0.008-inch) for lower limit per HEC-18 6.2*

Upstream Uncontracted Cross Section (XS1):	607		Length to XS1:	26.68	ft.
Internal Upstream Cross Section (XS2):	556		Length to XS3:	7.10	ft.
Upstream Bounding Cross Section (XS3):	581		Low Chord Elevation:	7.31	ft.
Long-term aggradation / degradation:	0.0	ft.	Water Surface Elevation:	9.88	ft.
			Streambed Elevation	2.69	ft.



Key
1. Upstream uncontracted cross section (XS output)
2. Internal bridge cross section (BR U or BR D in HEC-RAS output)
3. Upstream bounding cross section (XS output)

Determine Clear-Water or Live-Bed Flow Conditions

Ku coefficient (Enter 6.19 for SI units or 11.17 for English Units):	11.17	
Channel Hydraulic Depth Variable (from XS1), **y**:	4.66	ft.
Channel Velocity (from XS1), V:	**4.010**	**ft./s**

V_c is the critical velocity. Speeds at or above this level will transport bed material of D50 and smaller.
Use Equation 6.1 (HEC-18):

$$V_c = K_u \, y^{1/6} \, (D_{50})^{1/3}$$

V_c = 1.261 ft./s

If $V_c < V$ Live-Bed Scour Occurs
If Vc > V Clear-Water Scour Occurs

Live bed contraction scour will exist. Use the live bed analysis.

K_u Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077	
W, W_1, W_2 values are taken at:	at top of channel	
For Vertical Contraction Scour:		
Does overtopping of the bridge or approach roadway occur?	Yes	
T Superstructure Depth (including girders, deck and parapet):	1.36	ft.

Contraction Scour 100-yr

Live Bed Scour, Continued (GOVERNS)

g	Gravity Constant (Enter 9.81 m/s^2 for SI or 32.2 ft/s^2 for English):	32.2	ft/s^2
S	Slope of the energy grade line (from XS1):	0.00071	
T_{SI}	Fall velocity of particles (from Fig. 6.8, HEC-18):	0.025	m/s
		0.082	*ft/s*
T	Temperature of water:	20.0	C
V*	Shear velocity (XS1): V* = (g x y_1 X S)$^{1/2}$	0.33	ft/s

V*/T	k1	Mode of Bed Material Transport (Fig. 6.8, HEC-18, pg. 6.11)
< 0.50	0.59	Mostly contact bed material discharge
0.50 to 2.00	0.64	Some suspended bed material discharge
> 2.00	0.69	Mostly suspended bed material discharge

V* / T = 3.98 Where I = w

k_1 = 0.69

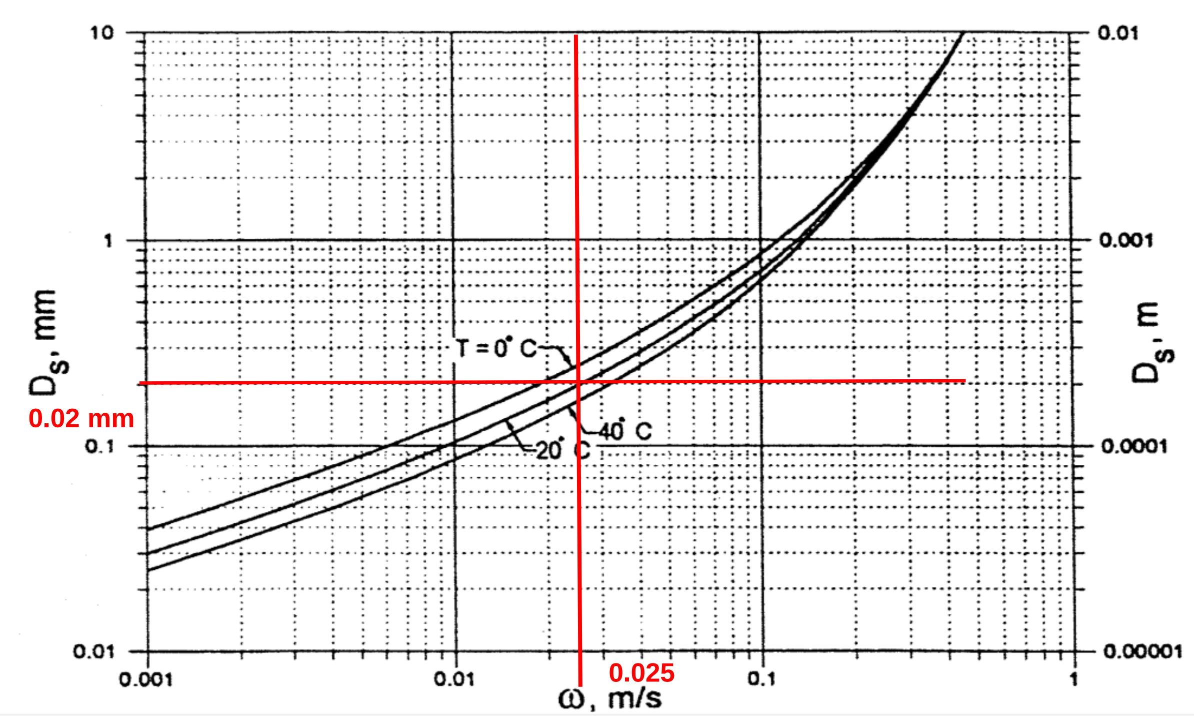


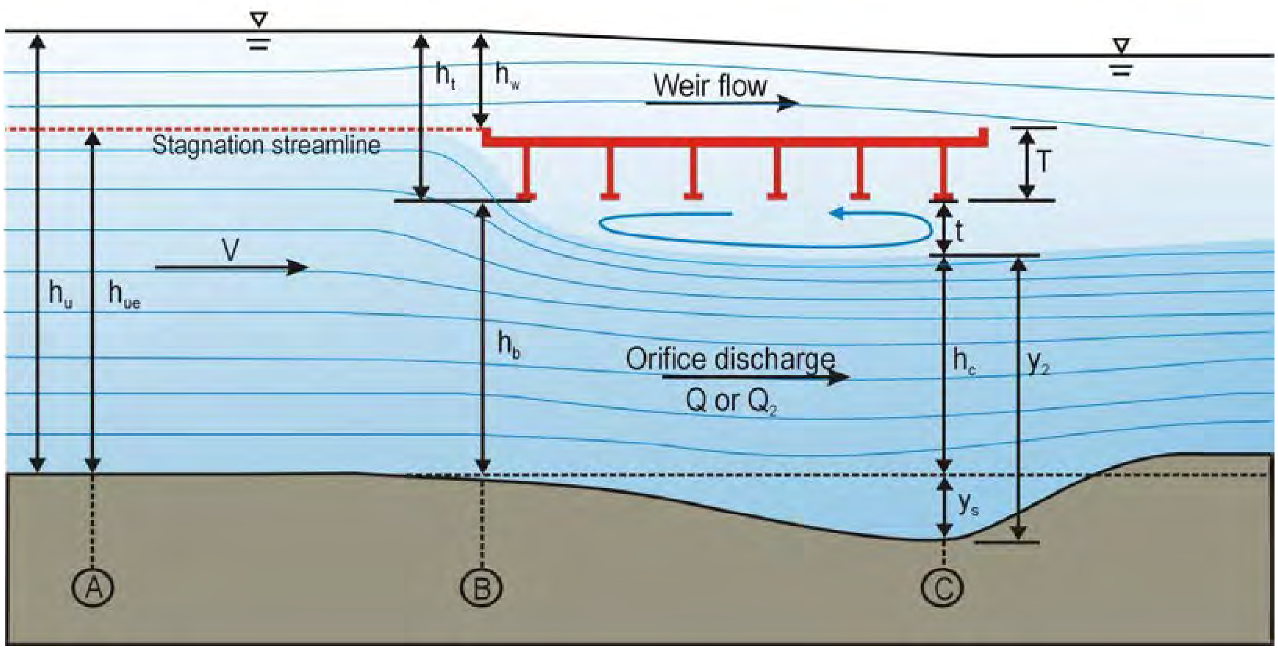
Figure 6.8 from HEC 18

Vertical Contraction Scour 100-yr

Determine Flow Conditions (Critical Velocity For Movement of the D_{50} Particle)

Streambed Particle Size (D_{50}): 0.008 in. / 0.203 mm / 0.0007 ft.

Determined by: Set to minimum



Vertical Contraction Scour 100-yr

Clear-Water Scour (NOT APPLICABLE)

K_u	Coefficient (Enter 0.25 for SI units or 0.0077 for English Units):	0.0077		
y_0	Hydraulic Depth Variable (from XS2):	1.91	ft	BR Area/BR Sp
W	Estimated bottom or top channel width, less pier widths (XS2):	21.19	ft	BR Clear Span
Q	Flow through the bridge opening, or on the set-back over bank area at the bridge associated with the width, W (from XS2):	335.75	cfs	
D_m	Diameter of the smallest nontransportable particle in the bed material, 1.25 * D_{50}:	0.00083	ft	
y_{2cw}	Average depth in the contracted section: Equation 6.4 (HEC-18) $y_{2CW} = \left[\frac{K_u Q_2^{\,2}}{(1.25 D_{50})^{2/3} W_2^{\,2}}\right]^{3/7}$	10.06	ft	
t	$\frac{t}{h_b} = 0.5\left(\frac{h_b \cdot h_t}{h_u^2}\right)^{0.2}\left(1-\frac{h_w}{h_t}\right)^{-0.1}$	2.18	ft	

y_{sCW} Vertical Clear-Water contraction scour depth: 7.62 ft

$y_s = y_2 + t - h_b$

Vertical Contraction Scour 100-yr

Live Bed Scour (GOVERNS)

Does overtopping of the bridge or approach roadway occur? Yes

$h_u = y_1$	Channel Hydraulic Depth Variable (from XS1):		4.66	ft	
y_0	Hydraulic Depth Variable (from XS2):		4.76	ft	BR Area/ BR Span

HEC-18, Section 5.3 Note #7 - In sand channel streams where the contraction scour hole is filled in on the falling stage, the y_0 depth may be approximated by y_1. Sketches or surveys through the bridge can help in determining the existing bed elevation.

W_1	Estimated bottom or top channel width (XS1):		25.45	ft	at top of channel
W_2	Estimated bottom or top channel width, less pier widths (XS2):		8.5	ft	BR Clear Span

HEC-RAS internal bridge cross section accounts for deduction of pier and sloping abutment. Minimum of upstream and downstream.

Q_1	Channel Flow (XS1):		474.89	cfs
Q_2	Flow in the contracted channel (XS2):		335.75	cfs

If the proposed bridge abutments are located in the channel (HEC-18, Case 1a) or at the channel banks (HEC-18, Case 1b), Q_2 should be the flow through the bridge opening.

S_1			0.00071	ft. / ft.
h_b	Bridge Underclearance:		4.62	ft.
T	Superstructure Depth (including girders, deck and parapet):		1.36	ft.
h_t	Distance from Water Surface to Low Chord:	= WSE-Low Chord	2.57	ft.
h_w	Weir Flow Height (If applicable):	$= h_t - T$	1.21	ft.

Adjustments when Overtopping occurs (if required):

$y_1 = h_{ue}$	Effective Upstream Flow Depth:	$=h_b + T$	5.98	ft.
$Q_1 = Q_{ue}$	Effective Upstream Discharge:	$=Q_1 (h_{ue}/h_u)^{8/7}$	632	cfs
k_1	Reference HEC 18, Page 6.10, Table for k_1 selection.		0.69	
y_{2LB}		$y_{2LB} = \left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{k_1} y_1$	7.42	ft.
t	$\frac{t}{h_b} = 0.5\left(\frac{h_b \cdot h_t}{h_u^2}\right)^{0.2}\left(1-\frac{h_w}{h_t}\right)^{-0.1}$		2.18	ft.

y_{sLB} Vertical contraction scour depth: 4.98 ft

$y_s = y_2 + t - h_b$

Riprap Sizing 100-yr

Type of Abutment: **Vertical**

In accordance with DM4, Chapter 7, 7.2.5

V (fps)	Rock Size	D50 (feet)
up to 12	R-6 or larger	1
13 to 15	R-7 or larger	1.5
16 to 17.5	R-8	2

Table from DM4, Chapter 7

Vertical Abutment Riprap Size:

Velocity (BR Open Vel from XS2) = 8.3 ft/s

Factored Velocity for Riprap Sizing = 1.8 * BR Open Vel = 14.94 ft/s

Riprap Size at Vertical Abutments: R-7

HEC-23 Rip Rap Sizing for Vertical or Spill Through Abutments

fr $V/(gy)^{1/2}$ ≤ 0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)$

K spill through abutment = 0.89
vertical wall abutment = 1.02

fr $V/(gy)^{1/2}$ >0.80 $D_{50} = y*(K/(S_s-1))*(V^2/gy)^{0.14}$

K spill through abutment = 0.61
vertical wall abutment = 0.69

Where:

fr (froude number at XS2) 0.45

Abutment type (spill through or vertical wall) Vertical

K 0.89

y Depth of flow in the contracted bridge opening (depth from XS2) 7.66 ft

V As described above for Abutments or Piers: 8.30 ft/s

S Specific Gravity: 2.65

g Gravity Constant (Enter 9.81 m/s² for SI or 32.2 ft/s² for English): 32.2 ft/s²

D_{50} 1.15 ft

Riprap Abutment Size per HEC-23: R-7

Upon discussion and concurrence from PennDOT at OTS if velocities indicate a larger D50 than R-8 and there is no evidence of scour at the existing bridge then use R-8 otherwise use R-8 partially grouted.

Presence of Existing Scour in Inspection Reports: **N/A**

Final Recommended Riprap Size at Abutments: R-7

Appendix F

Noble Consultants, Inc. Sediment Analysis

NOBLE CONSULTANTS, INC.

MEMORANDUM 7

359 Bel Marin Keys Blvd, #9, Novato, CA 94949 (415) 884-0727
FACSIMILE (415) 884-0735

Project: Coyote Creek Sediment Stabilization Project
Job No: 552-12
Client: Marin County Flood Control and Water Conservation District

By: W. Qin & S. Noble

Date: 6/5/13

RE: Sedimentation Analysis

We performed the following analyses to evaluate sedimentation in Coyote Creek. Recommendations on the timing (schedule) for the next maintenance event follow the discussion on the analyses.

1. Analyzed historic topographic/bathymetric surveys to determine sedimentation quantities.
2. Estimated annual shoaling rates using sedimentation quantities and typical cross sections.
3. Calculated time series of available freeboard using shoaling rates and 2013 available freeboard.
4. Evaluated threshold shoaling along the creek.

Sedimentation Quantities

Three historical surveys were used to compute sedimentation quantities. These included the 2013 condition survey, the 2003 post excavation survey, and the 1999 condition survey. The project design geometry (template) and the 2003 post excavation survey were used as the base condition for computing the quantities. The quantity computed based on the design template has two short comings: 1) the computation assumes that the post-excavation condition is the same as the design (contractor excavated exactly to design template), and 2) the calculation does not account for any shoaling outside of the design template. If the actual post – excavation condition is below the design template then the calculated sedimentation quantity will be low, while if the actual condition is above the design the calculated quantity will be high. The three sedimentation quantities that were calculated included:

1. 1999 to Design. Shoaling between the design template and the 1999 condition survey.

2. 2013 to Design. Shoaling between the design template and the 2013 condition survey.
3. 2013 to 2003. Shoaling between the 2003 post-excavation survey and the 2013 condition survey.

The "2013 to 2003" is the best scenario for evaluating sedimentation quantities because it is the difference between two specific surveys.

Figure 1 shows the calculated quantity of sediment that has accumulated by 50-foot station for the three calculation scenarios. The sedimentation quantity between 2003 and 2013 ranges typically between 50 and 200 cubic yards (cy) for a 50-foot length of channel. The calculation for 1999 suggests, subject to the qualifications mentioned above, much higher accumulated sediment in the creek area between Stations 36+50 and 37+50.

Figure 2 shows the calculated cumulative quantity of sediment in the earthen channel for the three scenarios. The curves are relatively similar in shape. The analysis shows that approximately 4,000 cy of sediment has accumulated in the earthen channel since the channel maintenance in 2003.

Shoaling Rates

The annual shoaling rate was calculated using the 2003 to 2013 sedimentation results. The shoaling rate was estimated by dividing the shoaled-in cross sectional area (2003 to 2013 cut area) by the width of the channel as determined at the 20-year flood level, and ultimately averaging the sedimentation over the length of time (10 years) between the surveys. It is noted that sediment shoaling typically occurs in the center (deep) part of the channel, so the average shoaling depth used in this analysis is typically less than the actual shoaling depth in the center of the channel. The results indicate a range in annual shoaling of 0.4 to 1.8 inches, with an average calculated shoaling rate of 0.8 inches per year.

Available Freeboard

The annual shoaling rate by station and the 2013 available freeboard determined from the Meridian survey (March, 2013) were used to develop a time series of available freeboard along the earthen channel. Figures 3 and 4 show the projected freeboard by Station (River Station Feet) from 2013 to 2023 for the left and right banks of the creek (looking downstream), respectively. It is assumed that the water level will rise at the same rate as sediment shoaling. Therefore, the annual reduction of the freeboard is equal to the annual shoaling depth. The Corps of Engineers project authorization requires a minimum 1-foot of freeboard when the 20-year return water level is higher than 0.5 feet above 5.5 feet Mean Sea Level, which it is.

The freeboard results along the left bank (Figure 3) are summarized below.

1. The 2013 condition survey shows 1-foot of freeboard at and adjacent to Station 40+00 (River Station RS 4,000). This location is just below the confluence with Nyhan Creek. This occurs along a 50-foot length. In 2015 that length extends to 100 feet and the freeboard is 0.9 feet. In 2017 about 200 feet has a freeboard between 0.8 and 0.9 feet.
2. Between Station 44+00 and 45+00 (RS 4,400 and 4,500) the freeboard is currently at or below 1.0 feet, with a value of 0.7 feet at Station 44+50. This location is at Flamingo Road. The HEC-RAS calculated 20-year water surface elevation at this location is about 8.5 ft, NAVD88. The bridge on the left side of the creek is at about elevation 10 ft, NAVD88. The low spots generating the low freeboards are on either side of the bridge. In 2015 the length with a freeboard below 1-foot is about 150 feet, with the lowest freeboard being 0.6 feet at Station 44+57 on the west side of the bridge.

The freeboard results along the right bank (Figure 4) are summarized below.

1. About a 350-foot long section of the creek, between Station 31+00 and 34+50, has a current freeboard ranging between 0.8 to 1.2 feet. In 2015 the projected freeboard in this area ranges between 0.6 to 1.1 feet, but the length of the levee with less than 1-foot of freeboard remains the same. The levee elevations used to calculate the freeboard are on the creek side of the bike path. On the landside of the bike path the ground typically extends up a short hill before the road is encountered. Therefore, the road is not in danger of being flooded. While the Community Center (about Station 34+00 to 35+50) is lower than the road, the ground elevation on the landside of the bike path appears to provide at least 1-foot of freeboard in 2015.
2. At Station 40+00 the existing freeboard is calculated to be 0.8 feet. This occurs on the creek side of the bike path where the County staging area is located. The staging area and the confluence with Nyhan Creek extends between approximately Station 40+00 and 42+00.
3. Similar to the left bank, there is a low isolated area adjacent to the Flamingo Road bridge at about Station 44+00. The freeboard on the upstream and downstream sides of the bridge is approximately 0.8 and 0.9 feet, respectively. More specifically, based on detailed spot elevations contained in the Meridian survey file, the freeboard within 5, 6, and 35 feet of the west side of the bridge is approximately 0.8, 1.1, and 1.5 feet, respectively. The freeboard within 6 and 29 feet of the east side of the bridge is 0.9 and 1.4 feet respectively. The freeboard is reduced by 0.1 feet in 2015.

Threshold Shoaling

Threshold shoaling area is another way to evaluate the need for maintenance work. The threshold area is the excess cross sectional area available prior to the minimum 1-foot of freeboard being violated. The threshold area was estimated by multiplying the excess freeboard (above the required 1-foot) with the top channel width at the 20-year water level. Figures 5 and 6 show the threshold area in square footage and as a percentage of the 2013 cross sectional area. The threshold value is 0 if the existing freeboard is less than or equal to the required freeboard of 1-foot. Also shown on Figure 6 are average relative threshold values calculated by PWA (2012) for four sections of the earthen channel.

Maintenance Recommendations

Based on the sedimentation analysis we have the following recommendations.

1. Excavation in the concrete channel should occur as soon as authorization can be obtained. This recommendation is based on the HEC-RAS analysis that shows that the lower part of the concrete channel will be overtopped if the project design flows occur.
2. Obtain additional spot elevations in three locations to improve the accuracy of the boundary where a freeboard less than 1-foot occurs. The three locations are: 1) on both sides of the Flamingo Bridge near Station 44+00; 2) in the area around Station 40+00 on the left side of the creek; and 3) in the area of the Community Center on the right side of the creek.
3. Develop a levee improvement plan based on additional spot elevations (see Recommendation 2), or on the existing topography, that will increase the freeboard to at least 1.2 feet in the two critical areas (Station 44+00 and 40+00).
4. If a freeboard of 0.8 feet is acceptable then delay excavation in the earthen channel until 2015.
5. If a suitable levee improvement plan is developed and implemented and a freeboard of 0.8 feet is acceptable then delay excavation in the earthen channel until 2016 or 2017.

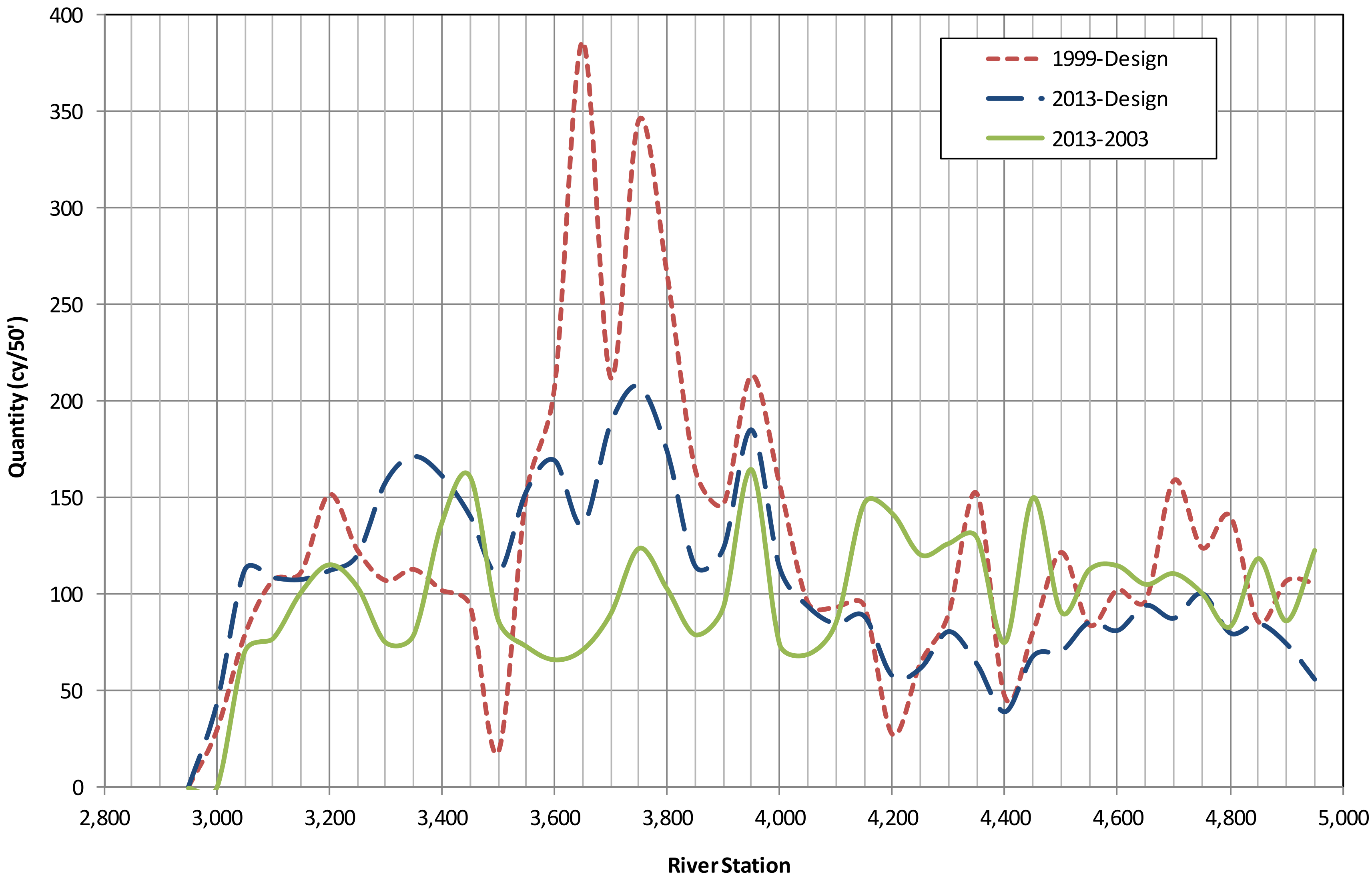


Figure 1. Earthen Channel Station (50') Quantities

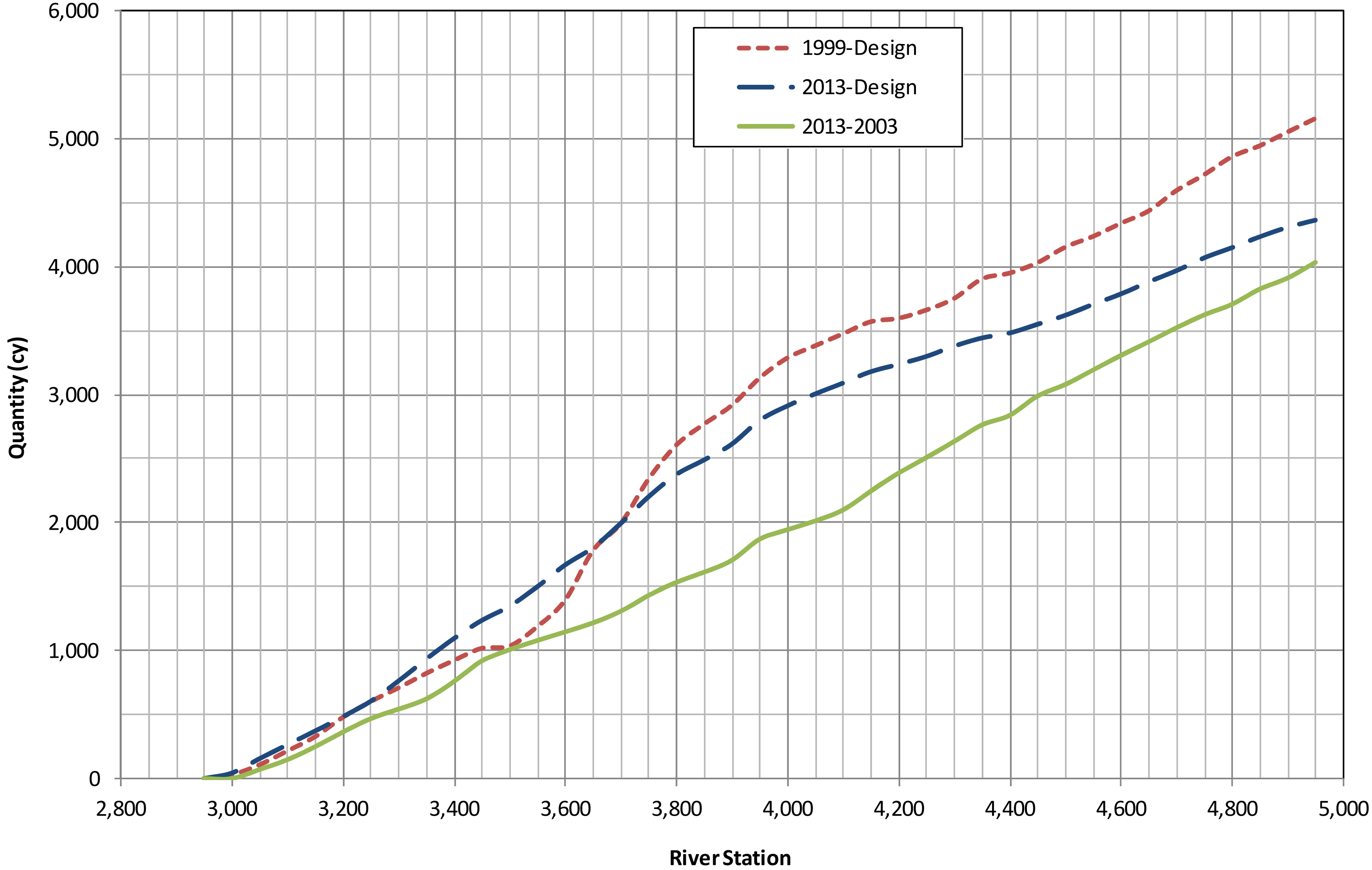


Figure 2. Earthen Channel Cumulative Quantities

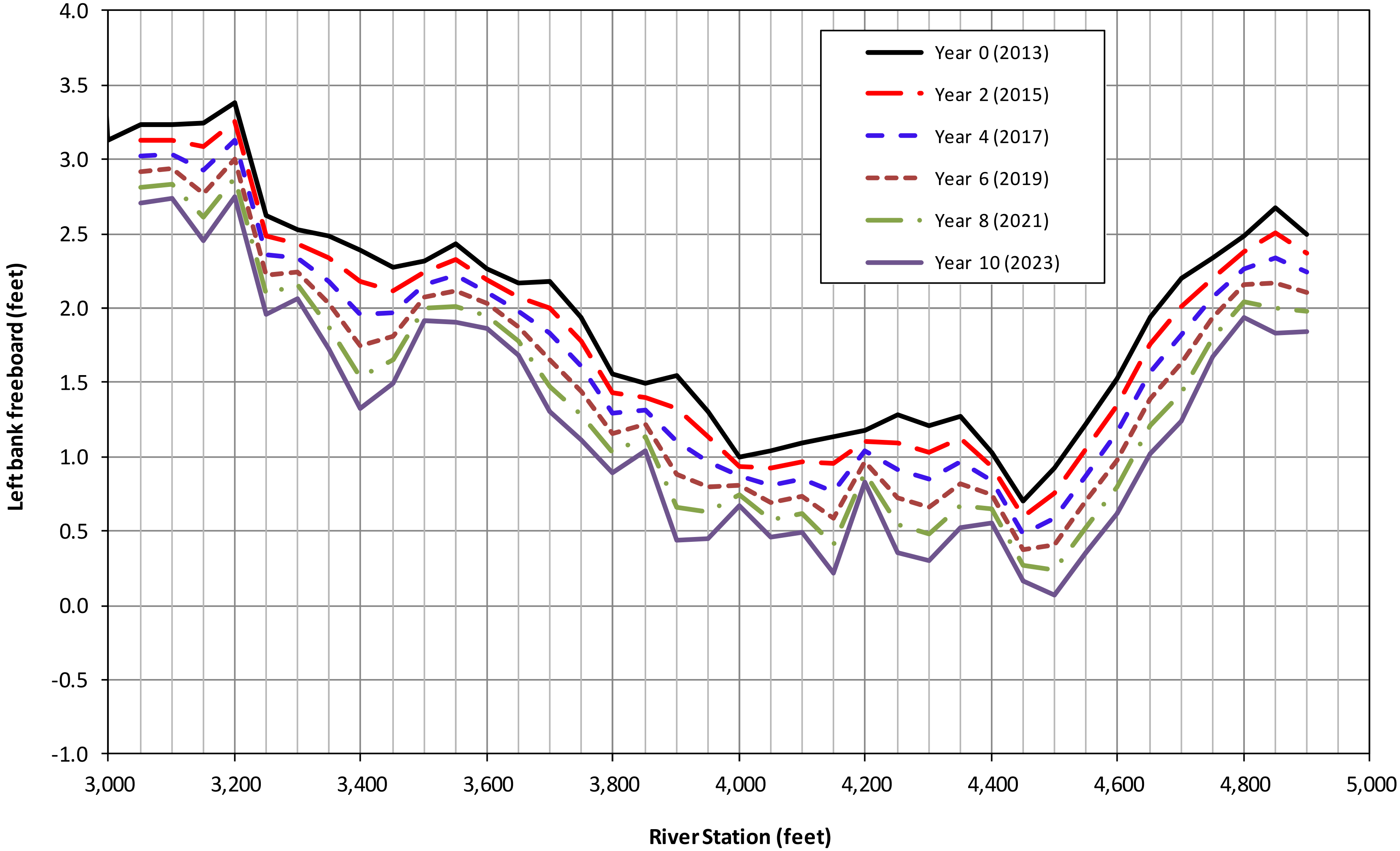


Figure 3. Projected Left Bank Freeboard

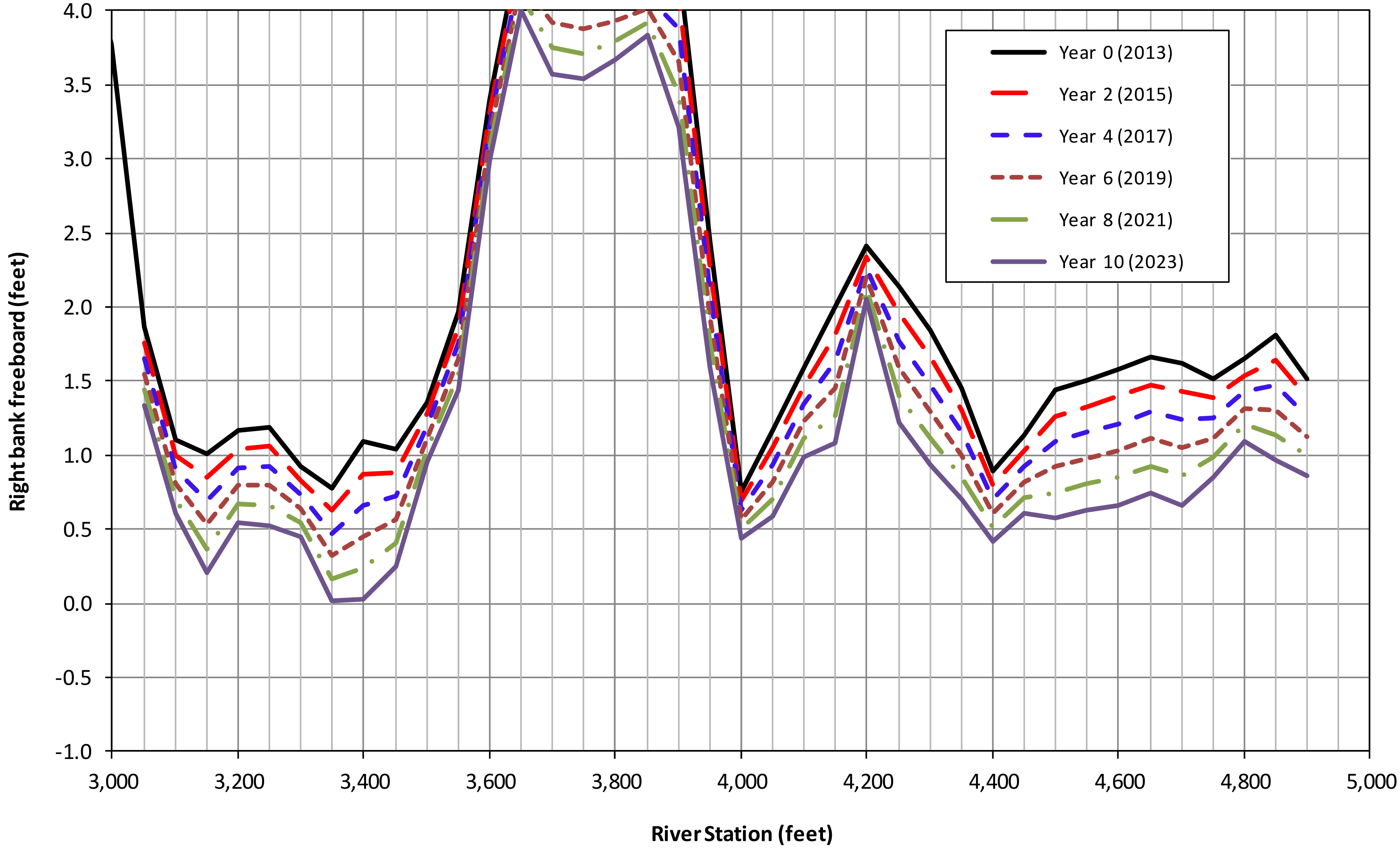


Figure 4. Projected Right Bank Freeboard

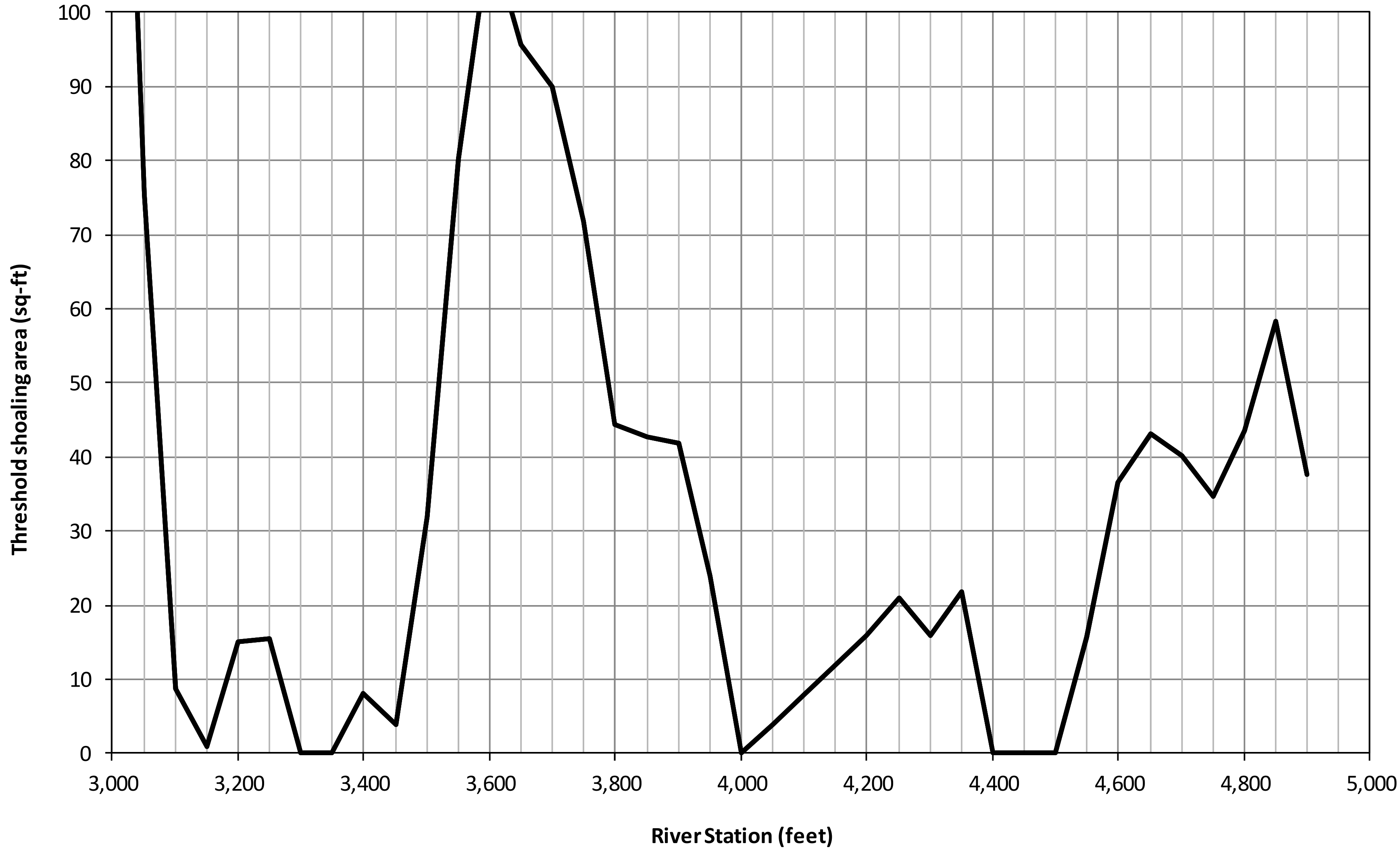


Figure 5. Threshold Sectional Shoaling Area in Square Footage

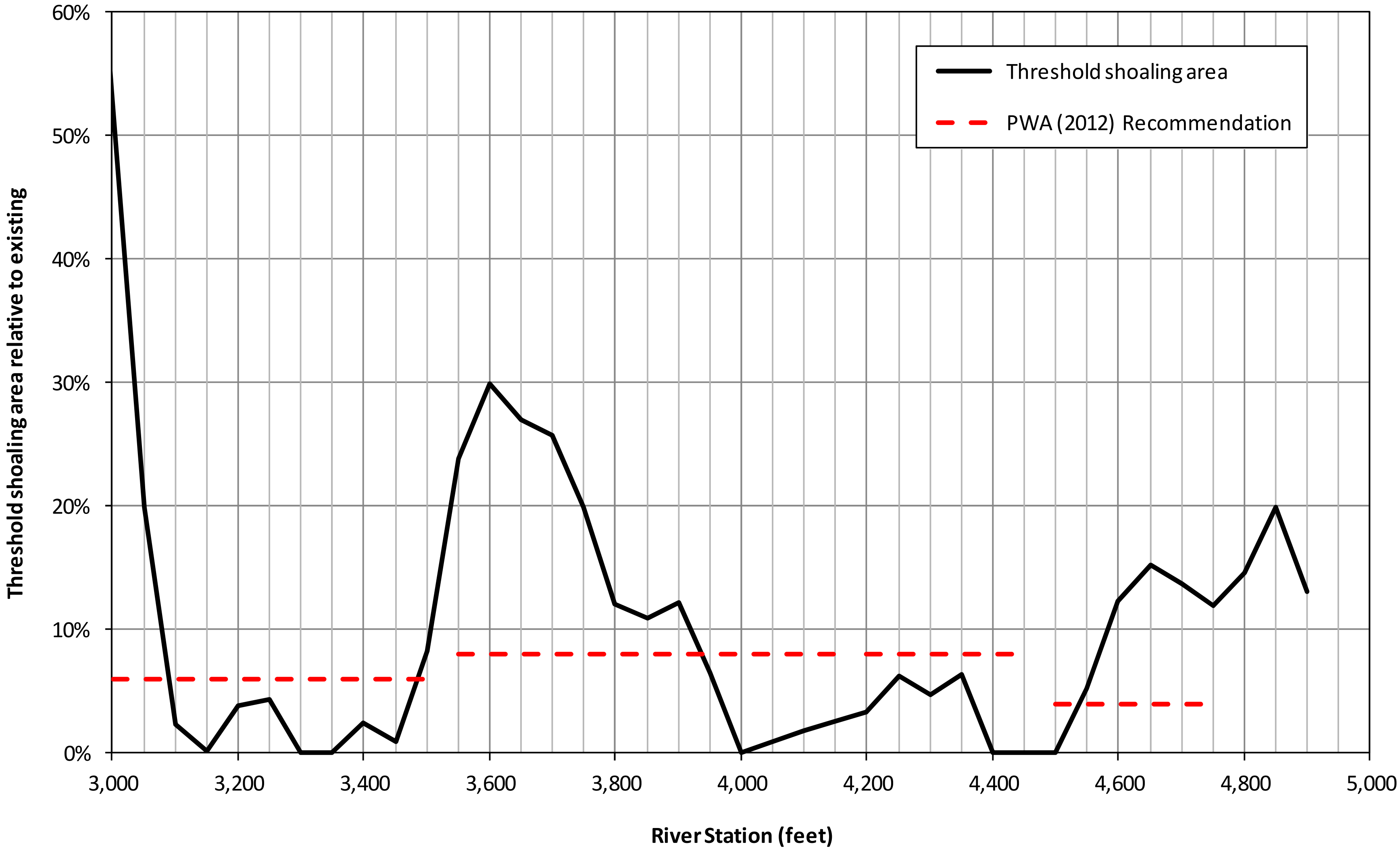


Figure 6. Threshold Sectional Shoaling Area as a Percentage of the 2013 Cross Sectional Area

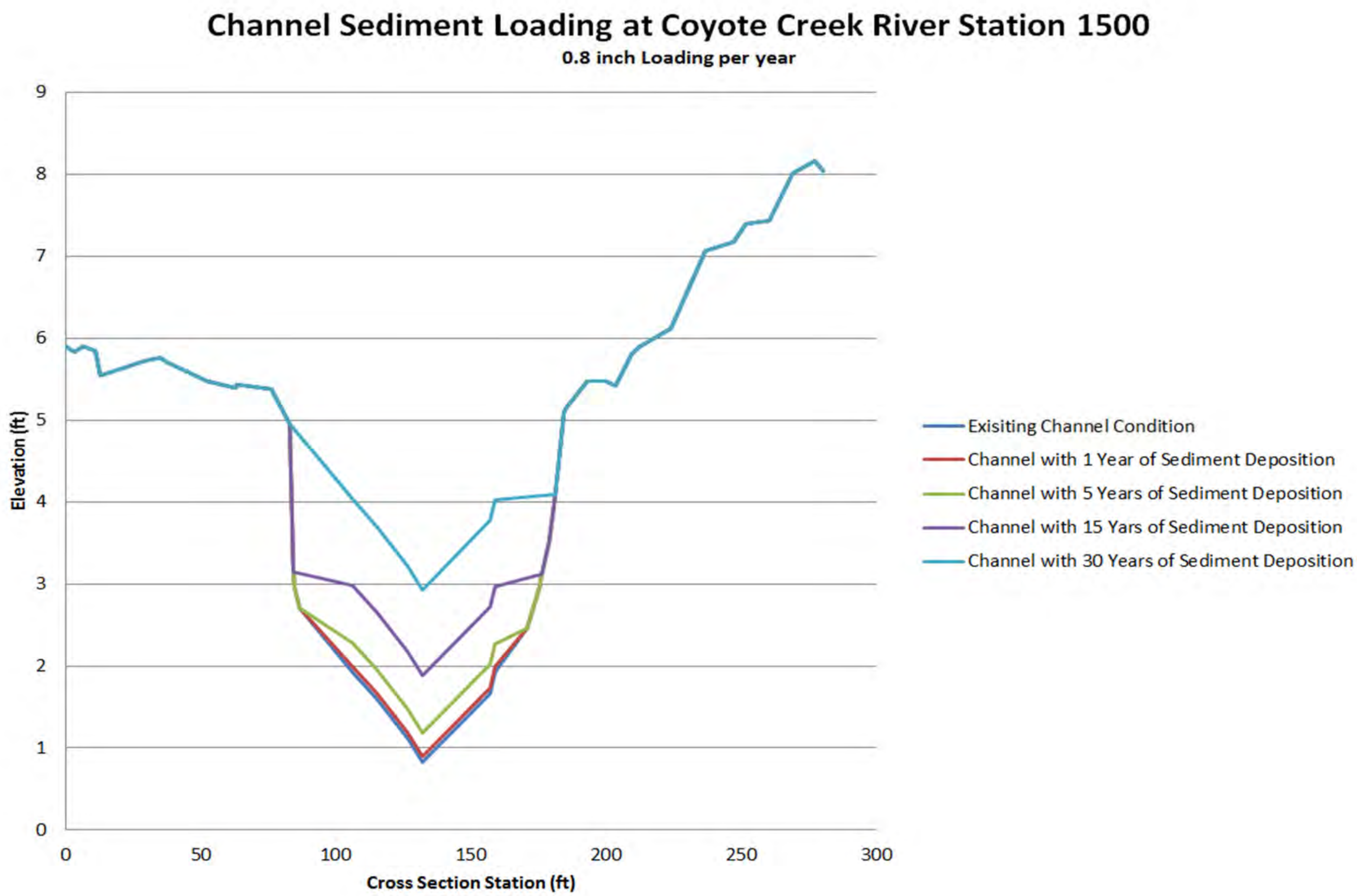
Appendix G

Channel Sediment Loading

Channel Sediment Loading Analysis at Coyote Creek River Station 1500

Label	Sediment Load (in)	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Discharge (ft^3/s)	Flow Area (ft^2)	Normal Depth (ft)	Velocity (ft/s)	Flow Type
Coyote Creek RS 1500 Base	0	Normal Depth	Manning Formula	0.025	0.00113	6.03	1518.46	463.35	5.2	3.28	Subcritical
Coyote Creek RS 1500 +1Y	0.8	Normal Depth	Manning Formula	0.025	0.00113	6.06	1518.46	464.59	5.16	3.27	Subcritical
Coyote Creek RS 1500 +5Y	4	Normal Depth	Manning Formula	0.025	0.00113	6.16	1518.46	467.79	4.98	3.25	Subcritical
Coyote Creek RS 1500 +15Y	12	Normal Depth	Manning Formula	0.025	0.00113	6.43	1518.46	470.95	4.55	3.22	Subcritical
Coyote Creek RS 1500 +30Y	24	Normal Depth	Manning Formula	0.025	0.00113	6.91	1518.46	475.96	3.98	3.19	Subcritical

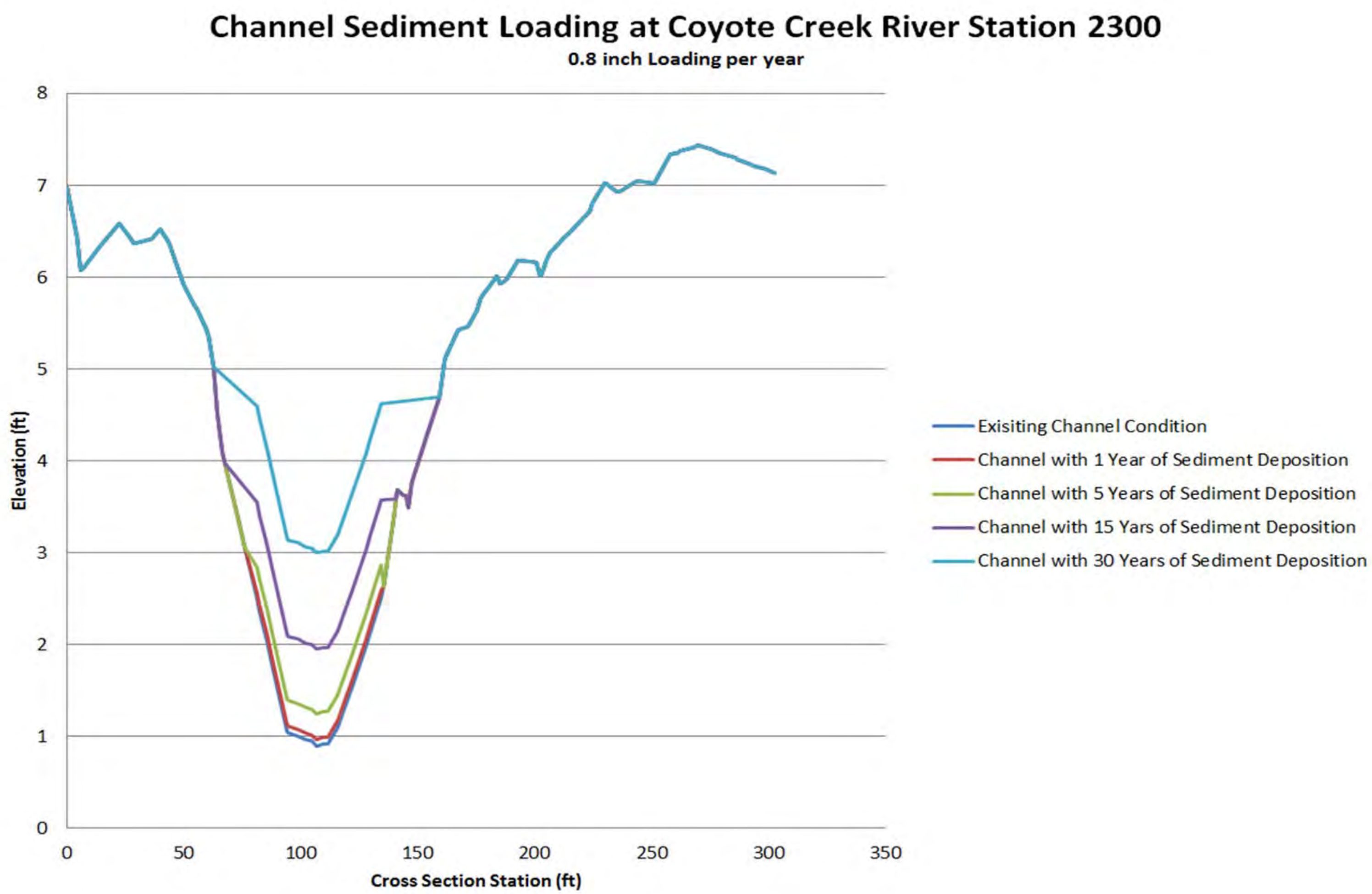
Note: Analysis was performed with existing condition scenario 3b Enhanced B (District 1-percent annual exceedance probability event)



Channel Sediment Loading Analysis at Coyote Creek River Station 2300

Label	Sediment Load (in)	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Discharge (ft³/s)	Flow Area (ft²)	Normal Depth (ft)	Velocity (ft/s)	Flow Type
Coyote Creek RS 2300 Base	0	Normal Depth	Manning Formula	0.025	0.00045	7.47	1468	680.66	6.57	2.16	Subcritical
Coyote Creek RS 2300 +1Y	0.8	Normal Depth	Manning Formula	0.025	0.00045	7.48	1468	680.65	6.51	2.16	Subcritical
Coyote Creek RS 2300 +5Y	4	Normal Depth	Manning Formula	0.025	0.00045	7.53	1468	680.74	6.28	2.16	Subcritical
Coyote Creek RS 2300 +15Y	12	Normal Depth	Manning Formula	0.025	0.00045	7.69	1468	680.9	5.74	2.16	Subcritical
Coyote Creek RS 2300 +30Y	24	Normal Depth	Manning Formula	0.025	0.00045	7.99	1468	681.22	4.99	2.15	Subcritical

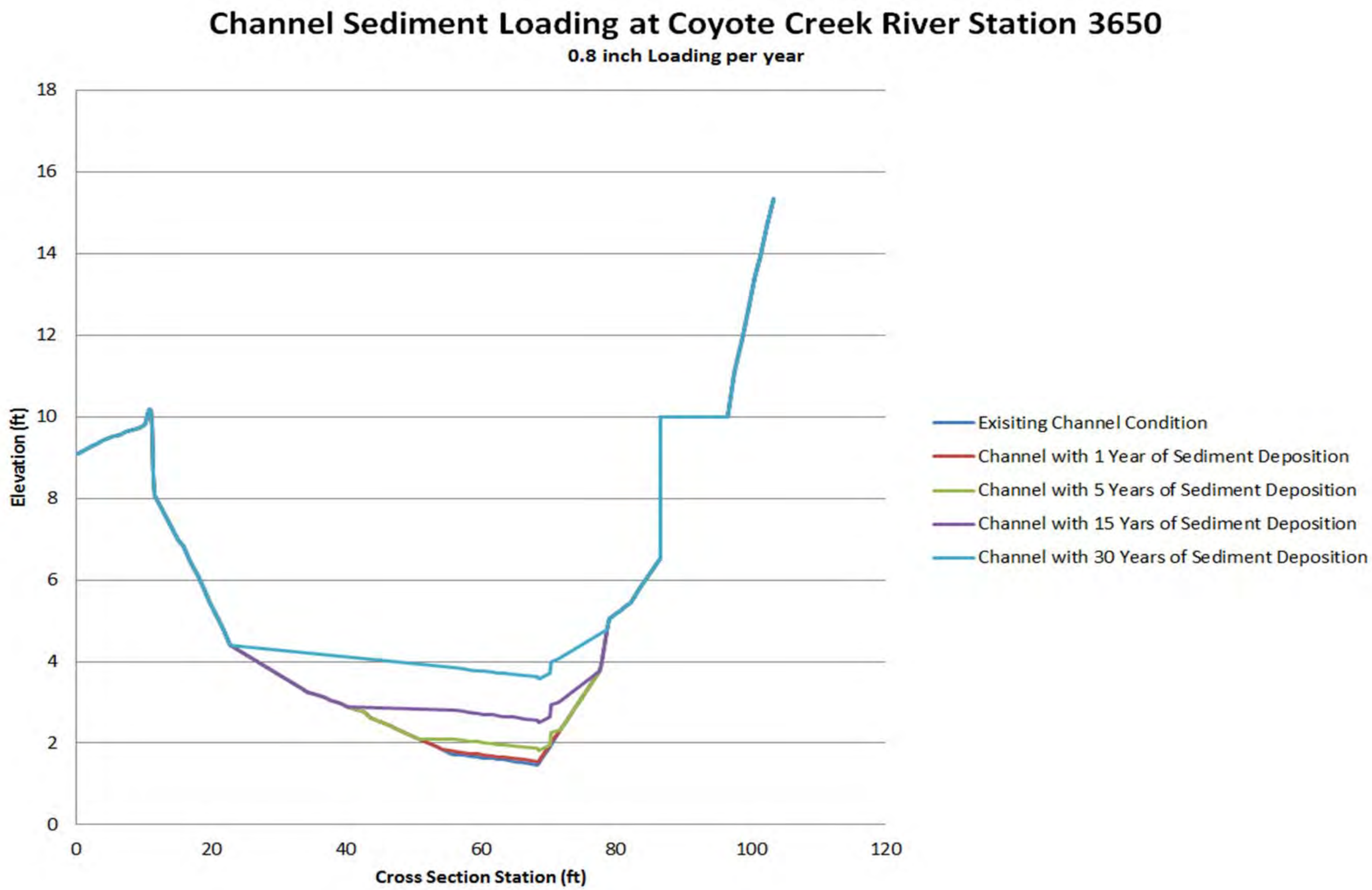
Note: Analysis was performed with existing condition scenario 3b Enhanced B (District 1-percent annual exceedance probability event)



Channel Sediment Loading Analysis at Coyote Creek River Sation 3650

Label	Sediment Load (in)	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Discharge (ft³/s)	Flow Area (ft²)	Normal Depth (ft)	Velocity (ft/s)	Flow Type
Coyote Creek RS 3650 Base	0	Normal Depth	Manning Formula	0.025	0.00069	8.01	1401.56	336.94	6.54	4.16	Subcritical
Coyote Creek RS 3650 +1Y	0.8	Normal Depth	Manning Formula	0.025	0.00069	8.03	1401.56	337.03	6.49	4.16	Subcritical
Coyote Creek RS 3650 +5Y	4	Normal Depth	Manning Formula	0.025	0.00069	8.1	1401.56	337.42	6.28	4.15	Subcritical
Coyote Creek RS 3650 +15Y	12	Normal Depth	Manning Formula	0.025	0.00069	8.39	1401.56	338.17	5.87	4.14	Subcritical
Coyote Creek RS 3650 +30Y	24	Normal Depth	Manning Formula	0.025	0.00069	9.13	1401.56	340.84	5.56	4.11	Subcritical

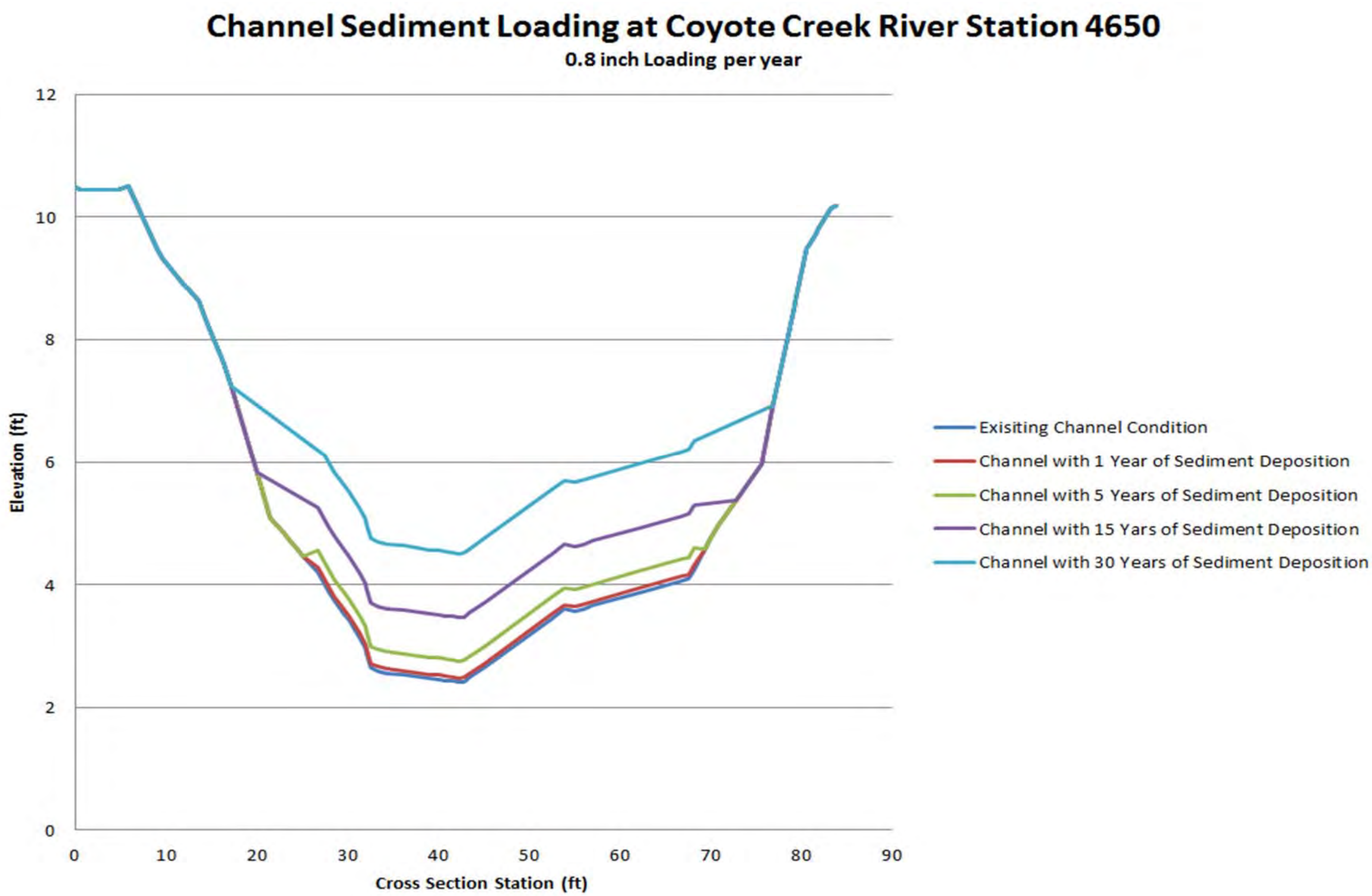
Note: Analysis was performed with existing condition scenario 3b Enhanced B (District 1-percent annual exceedance probability event)



Channel Sediment Loading Analysis at Coyote Creek River Station 4650

Label	Sediment Load (in)	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Discharge (ft³/s)	Flow Area (ft²)	Normal Depth (ft)	Velocity (ft/s)	Flow Type
Coyote Creek RS 4650 Base	0	Normal Depth	Manning Formula	0.025	0.00028	8.63	752.97	288.17	6.22	2.61	Subcritical
Coyote Creek RS 4650 +1Y	0.8	Normal Depth	Manning Formula	0.025	0.00028	8.68	752.97	288.83	6.2	2.61	Subcritical
Coyote Creek RS 4650 +5Y	4	Normal Depth	Manning Formula	0.025	0.00028	8.9	752.97	291.69	6.14	2.58	Subcritical
Coyote Creek RS 4650 +15Y	12	Normal Depth	Manning Formula	0.025	0.00028	9.51	752.97	298.04	6.05	2.53	Subcritical
Coyote Creek RS 4650 +30Y	24	Normal Depth	Manning Formula	0.025	0.00028	10.55	752.97	316.58	6.04	2.38	Subcritical

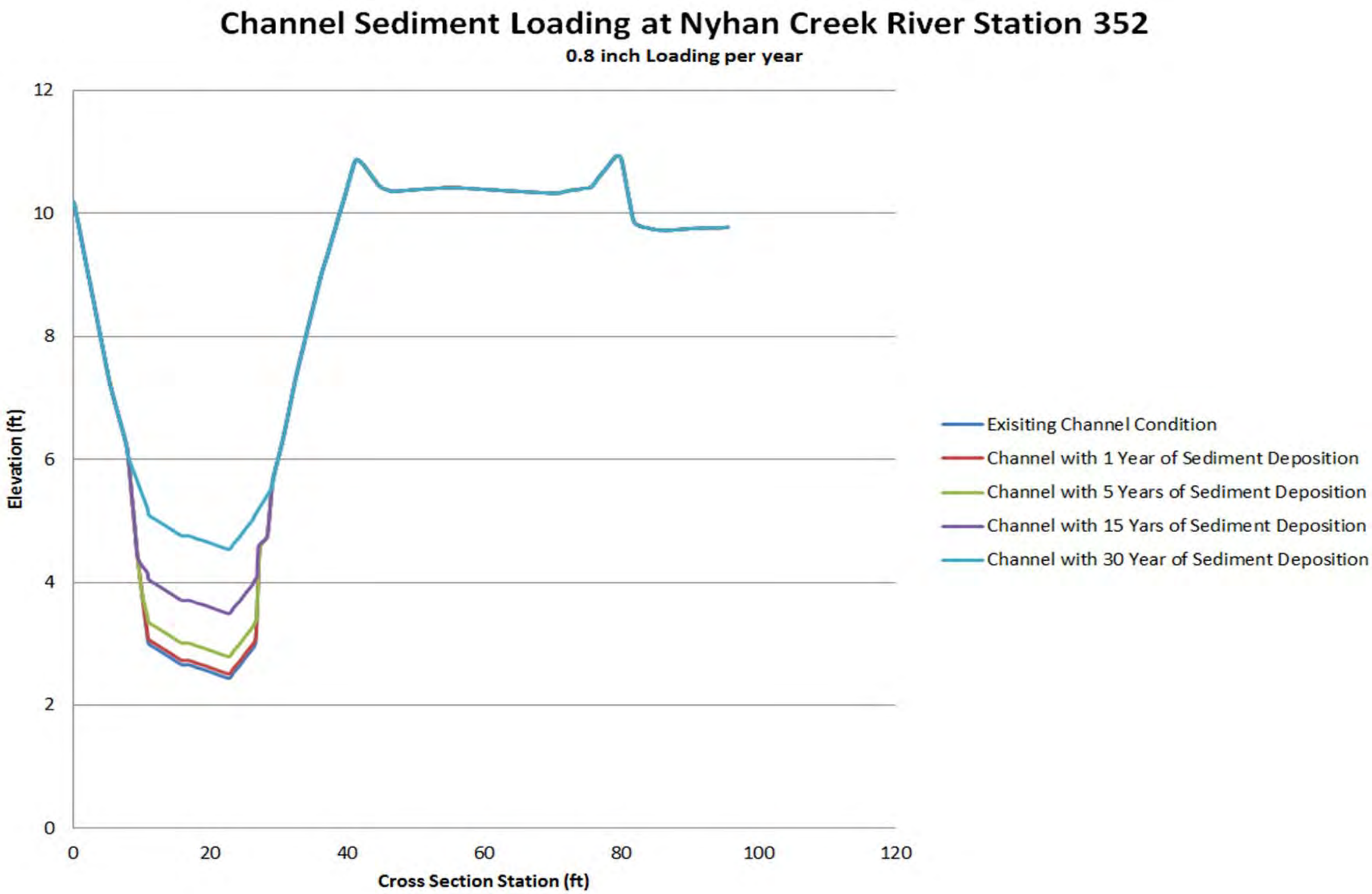
Note: Analysis was performed with existing condition scenario 3b Enhanced B (District 1-percent annual exceedance probability event)



Channel Sediment Loading Analysis at Coyote Creek River Station 4650

Label	Sediment Load (in)	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Discharge (ft^3/s)	Flow Area (ft^2)	Normal Depth (ft)	Velocity (ft/s)	Flow Type
Nyhan Creek RS 352 Base	0	Normal Depth	Manning Formula	0.025	0.00162	8.25	649.86	119.6	5.81	5.43	Subcritical
Nyhan Creek RS 352 +1Y	0.8	Normal Depth	Manning Formula	0.025	0.00162	8.29	649.86	119.7	5.78	5.43	Subcritical
Nyhan Creek RS 352 +5Y	4	Normal Depth	Manning Formula	0.025	0.00162	8.45	649.86	120.24	5.66	5.4	Subcritical
Nyhan Creek RS 352 +15Y	12	Normal Depth	Manning Formula	0.025	0.00162	8.86	649.86	121.63	5.37	5.34	Subcritical
Nyhan Creek RS 352 +30Y	24	Normal Depth	Manning Formula	0.025	0.00162	9.95	649.86	142.93	5.41	4.55	Subcritical

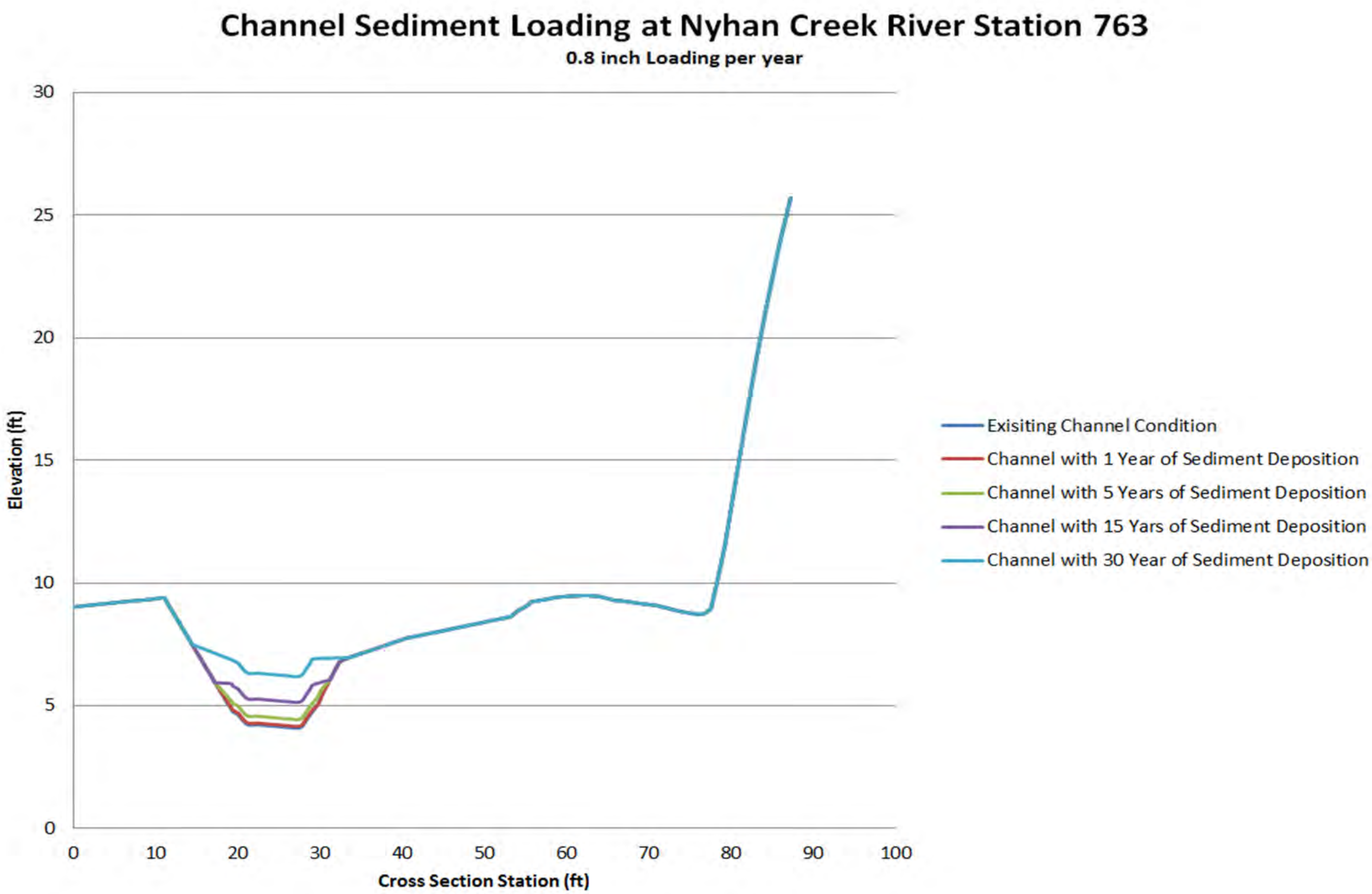
Note: Analysis was performed with existing condition scenario 3b Enhanced B (District 1-percent annual exceedance probability event)



Channel Sediment Loading Analysis at Coyote Creek River Station 4650

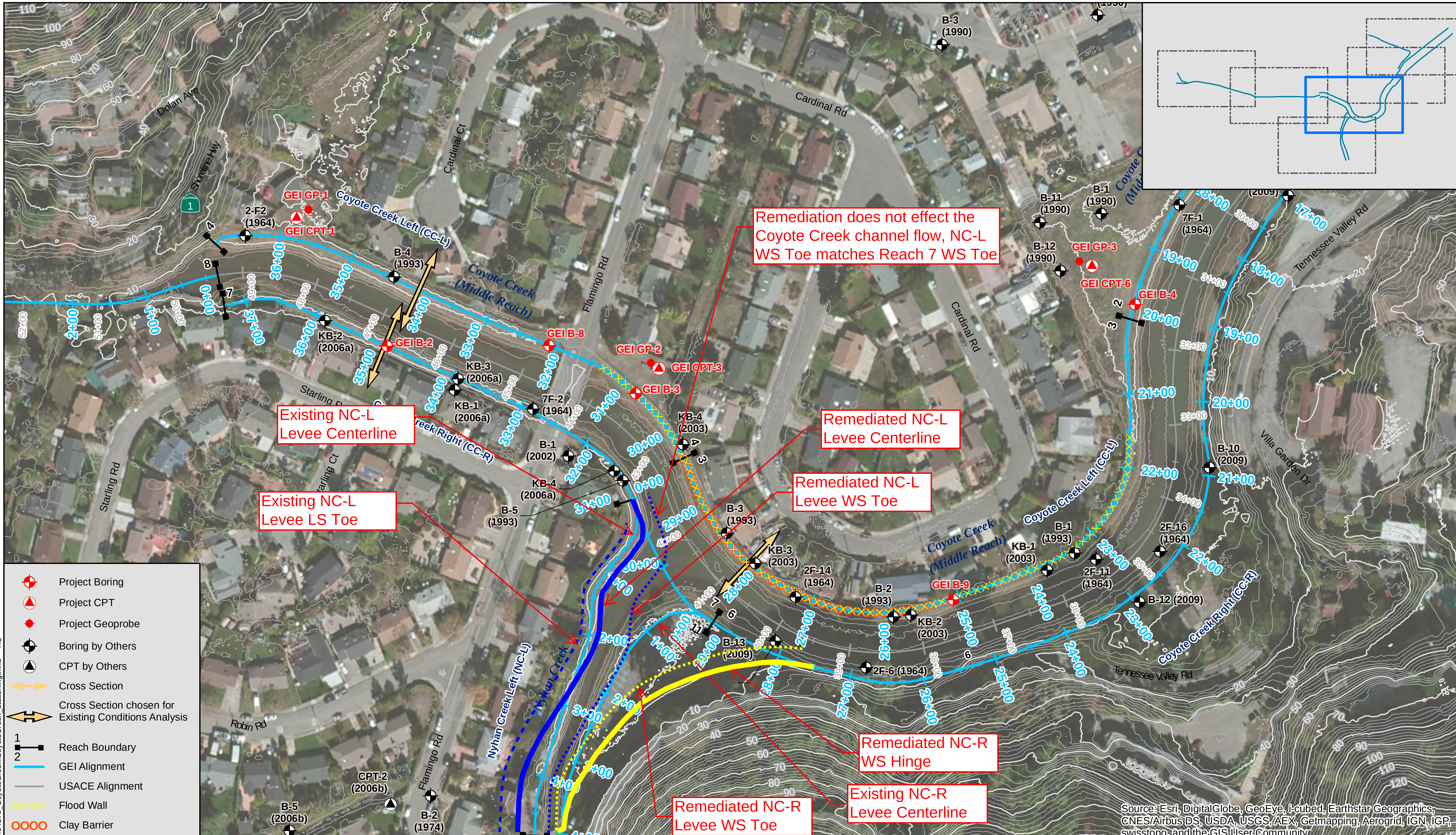
Label	Sediment Load (in)	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Discharge (ft^3/s)	Flow Area (ft^2)	Normal Depth (ft)	Velocity (ft/s)	Flow Type
Nyhan Creek RS 763 Base	0	Normal Depth	Manning Formula	0.025	0.00114	9.84	480.1	155.76	5.75	3.08	Subcritical
Nyhan Creek RS 763 +1Y	0.8	Normal Depth	Manning Formula	0.025	0.00114	9.85	480.1	155.75	5.69	3.08	Subcritical
Nyhan Creek RS 763 +5Y	4	Normal Depth	Manning Formula	0.025	0.00114	9.88	480.1	155.65	5.44	3.08	Subcritical
Nyhan Creek RS 763 +15Y	12	Normal Depth	Manning Formula	0.025	0.00114	9.99	480.1	155.53	4.85	3.09	Subcritical
Nyhan Creek RS 763 +30Y	24	Normal Depth	Manning Formula	0.025	0.00114	10.21	480.1	155.43	4.02	3.09	Subcritical

Note: Analysis was performed with existing condition scenario 3b Enhanced B (District 1-percent annual exceedance probability event)



Appendix H

Remediation Alternative Evaluation



200 100 0 200

Feet

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

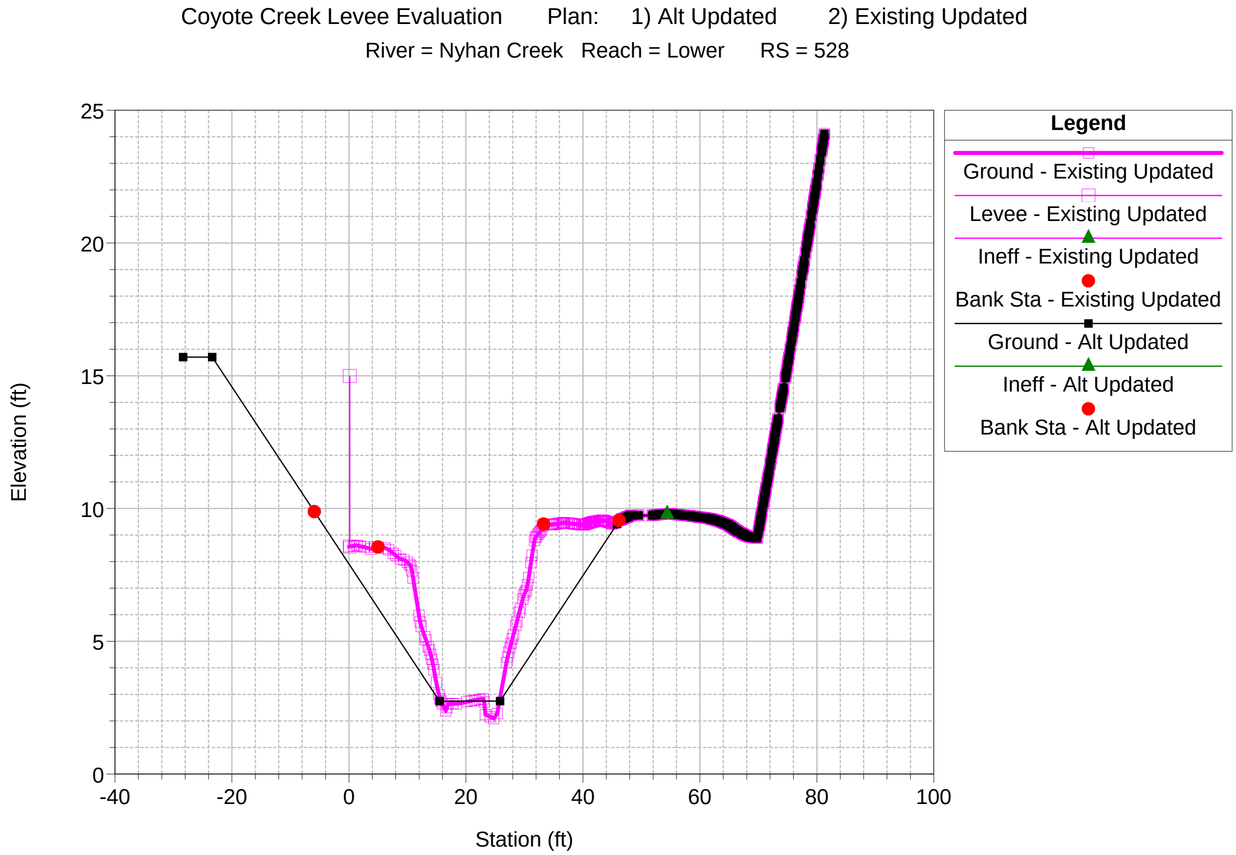
GEI Consultants

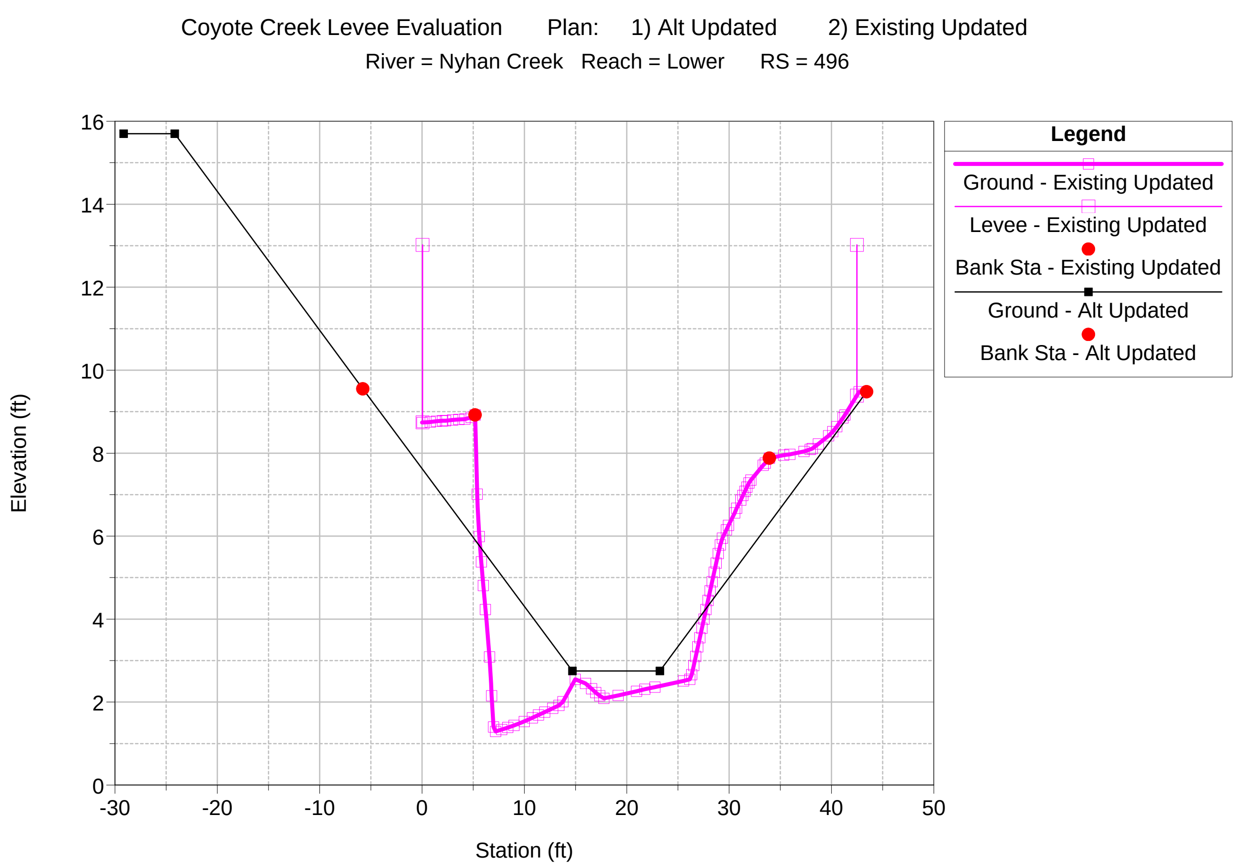
NYHAN CREEK REMEDIATION ALTERNATIVE ALIGNMENT

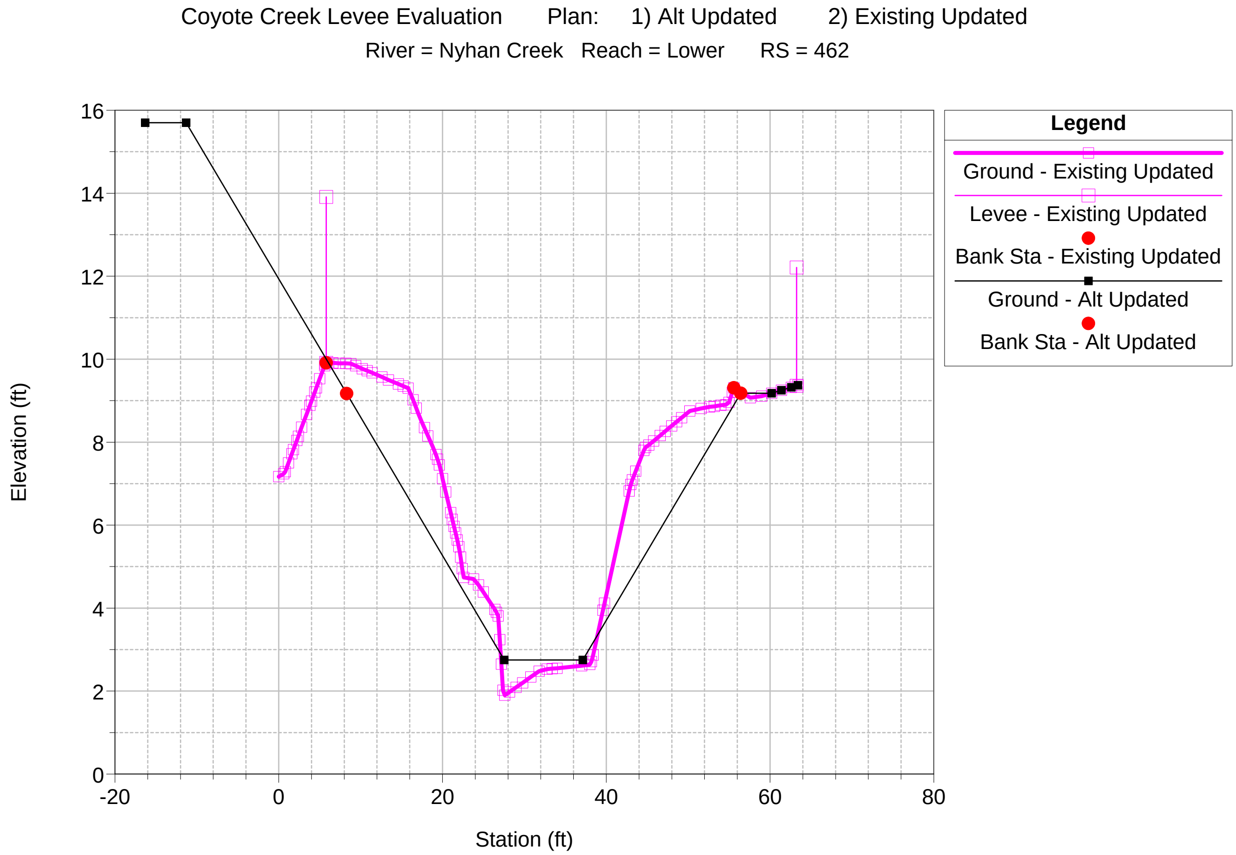
JANUARY 2016

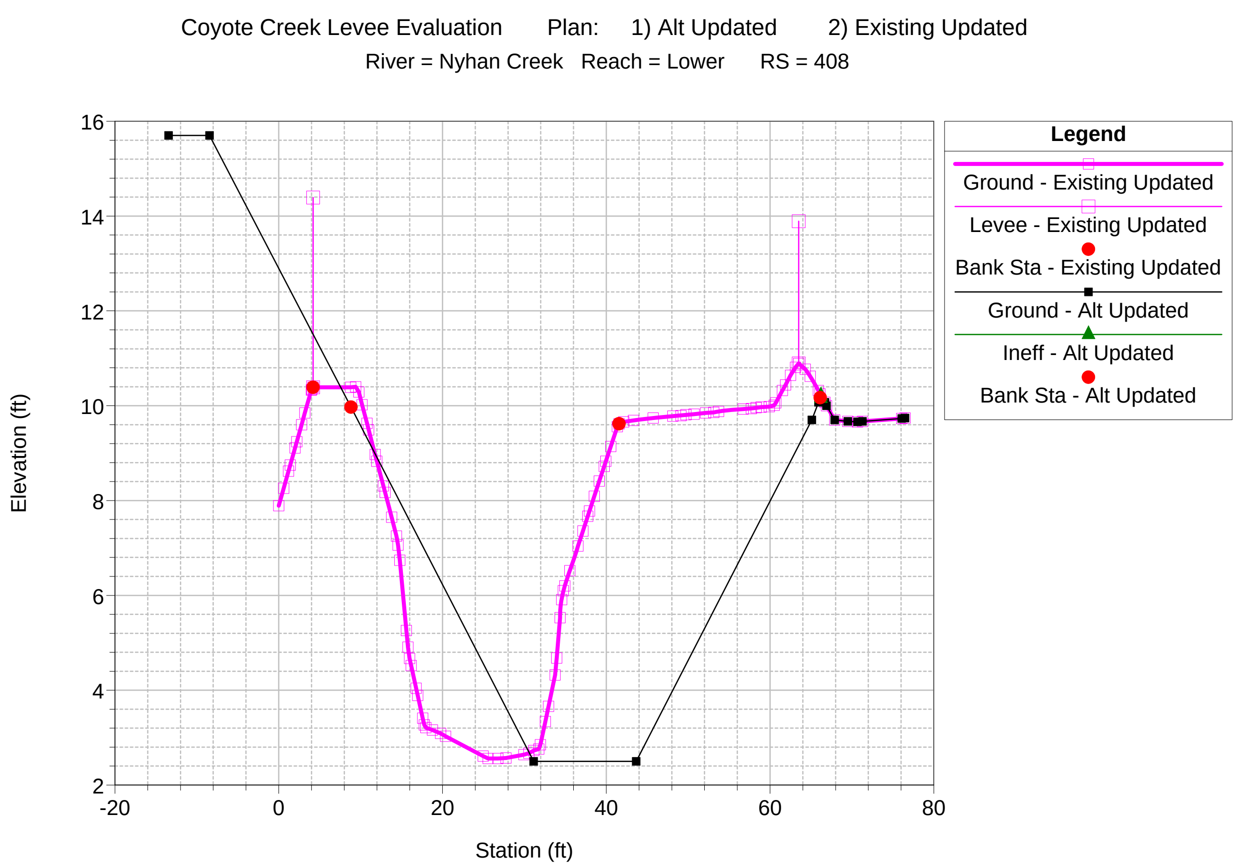
FIGURE 3-1

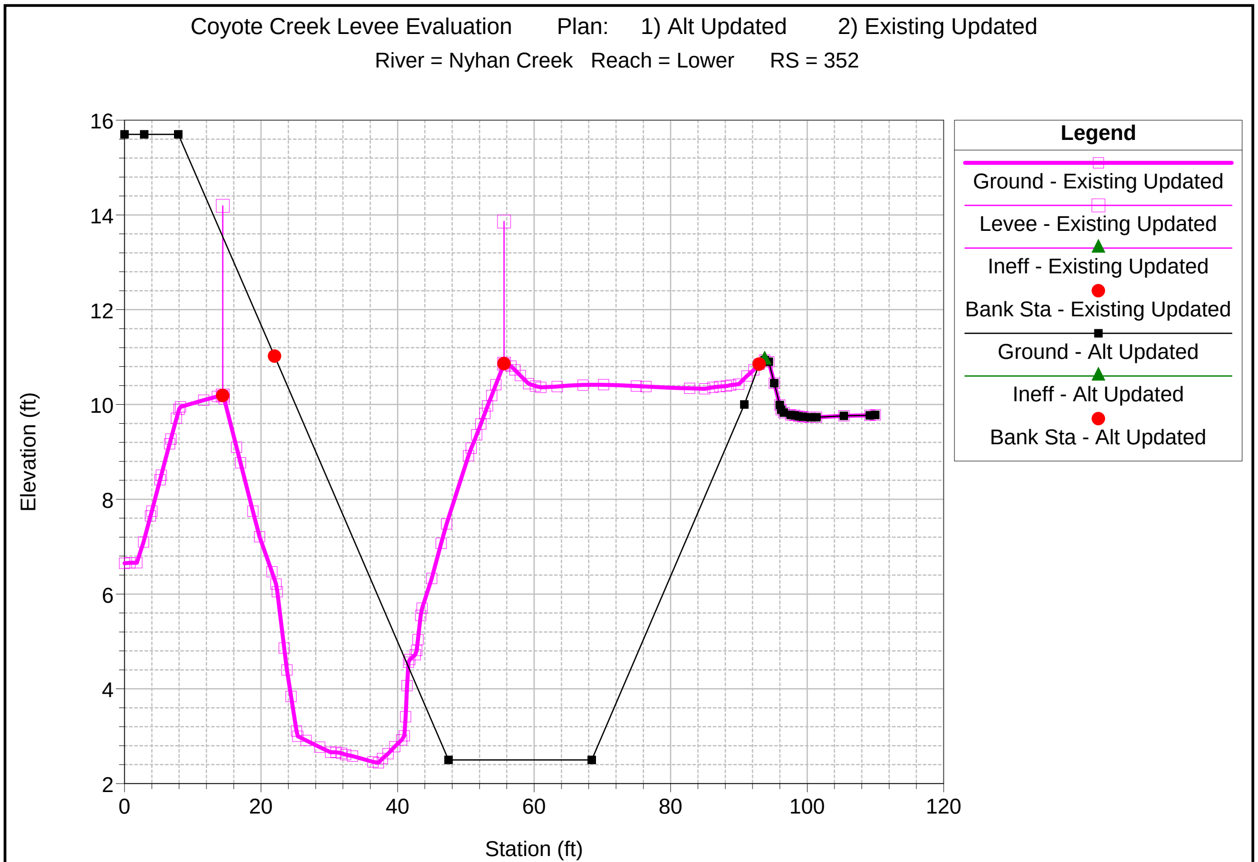
26-May-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS

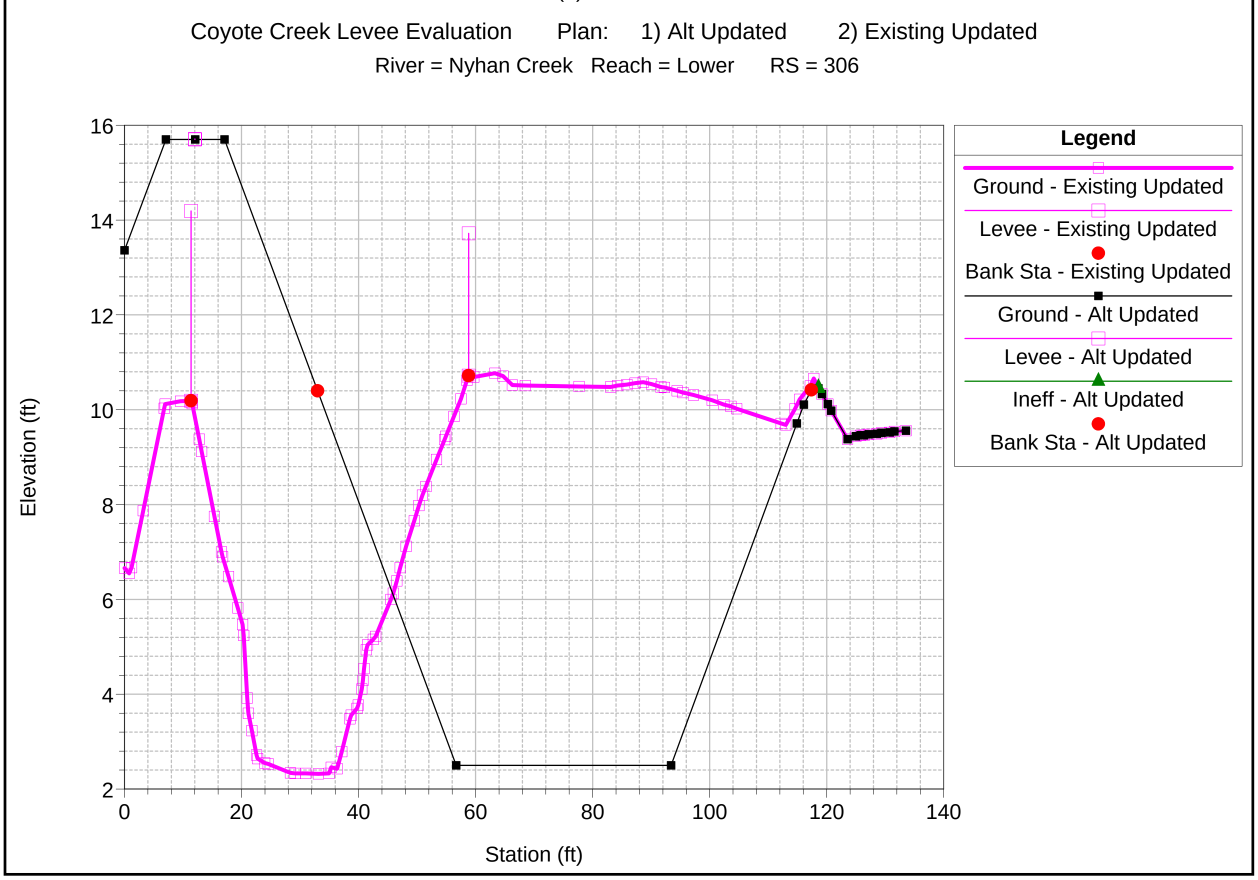

Coyote Creek Levee Evaluation Plan: 1) Alt Updated 2) Existing Updated
River = Nyhan Creek Reach = Lower RS = 528
Legend
Ground - Existing Updated
Levee - Existing Updated
Ineff - Existing Updated
Bank Sta - Existing Updated
Ground - Alt Updated
Ineff - Alt Updated
Bank Sta - Alt Updated
Elevation (ft)
Station (ft)
25
20
15
10
5
0
-40
-20
0
20
40
60
80
100

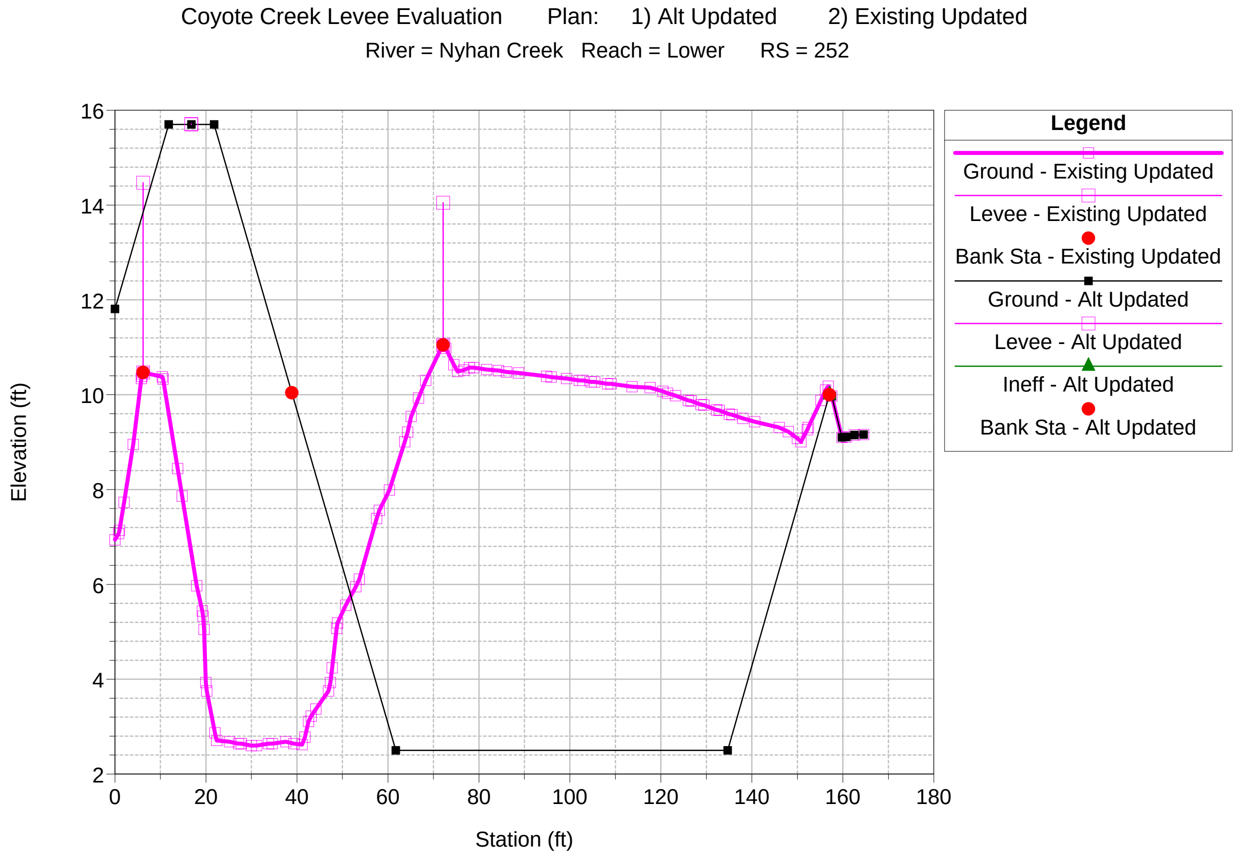

Coyote Creek Levee Evaluation Plan: 1) Alt Updated 2) Existing Updated
River = Nyhan Creek Reach = Lower RS = 496
Legend
Ground - Existing Updated
Levee - Existing Updated
Bank Sta - Existing Updated
Ground - Alt Updated
Bank Sta - Alt Updated
Elevation (ft)
Station (ft)
16
14
12
10
8
6
4
2
0
-30
-20
-10
0
10
20
30
40
50


Coyote Creek Levee Evaluation Plan: 1) Alt Updated 2) Existing Updated
River = Nyhan Creek Reach = Lower RS = 462
Legend
Ground - Existing Updated
Levee - Existing Updated
Bank Sta - Existing Updated
Ground - Alt Updated
Bank Sta - Alt Updated
Elevation (ft)
Station (ft)
16
14
12
10
8
6
4
2
0
-20
0
20
40
60
80

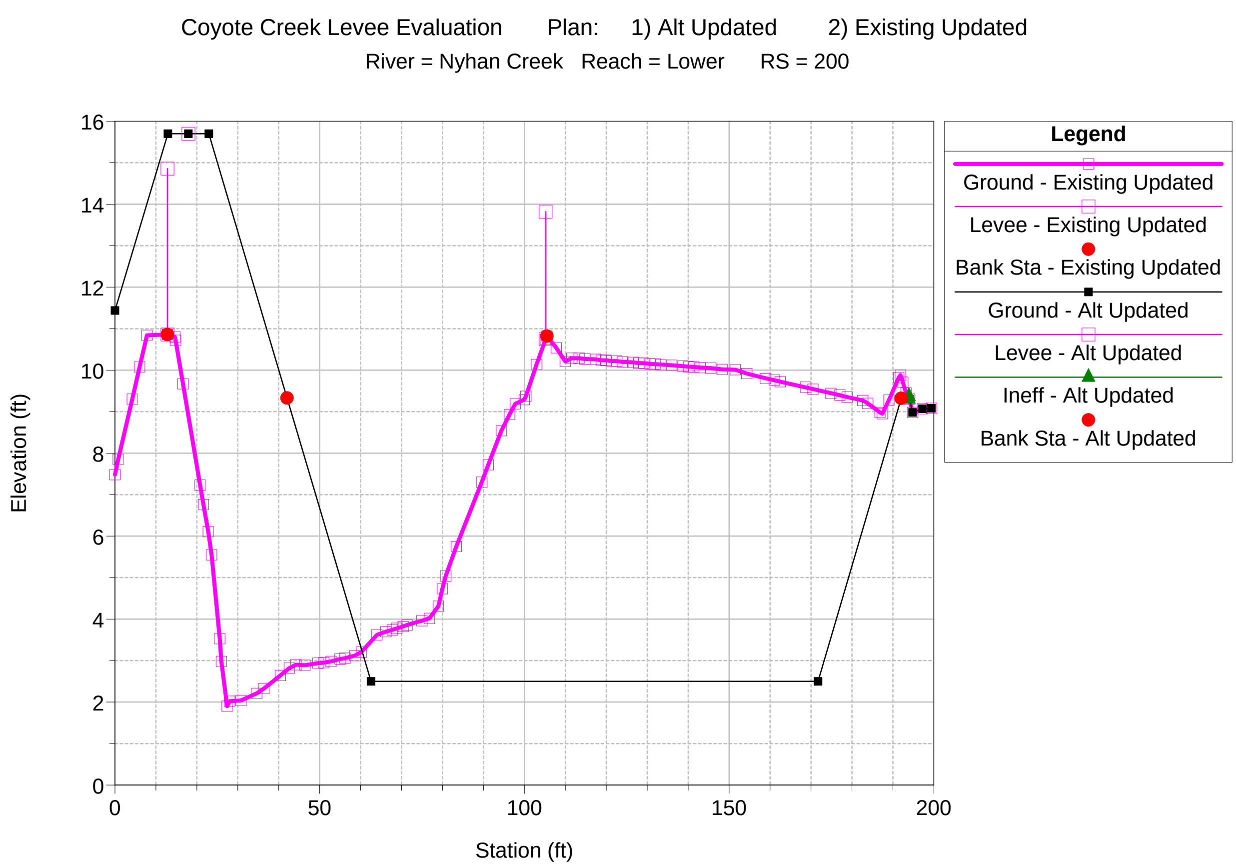

Coyote Creek Levee Evaluation Plan: 1) Alt Updated 2) Existing Updated
River = Nyhan Creek Reach = Lower RS = 408
Legend
Ground - Existing Updated
Levee - Existing Updated
Bank Sta - Existing Updated
Ground - Alt Updated
Ineff - Alt Updated
Bank Sta - Alt Updated
Elevation (ft)
Station (ft)
16
14
12
10
8
6
4
2
-20
0
20
40
60
80


Coyote Creek Levee Evaluation Plan: 1) Alt Updated 2) Existing Updated
River = Nyhan Creek Reach = Lower RS = 352
Legend
Ground - Existing Updated
Levee - Existing Updated
Ineff - Existing Updated
Bank Sta - Existing Updated
Ground - Alt Updated
Ineff - Alt Updated
Bank Sta - Alt Updated
Elevation (ft)
Station (ft)
16
14
12
10
8
6
4
2
0
20
40
60
80
100
120

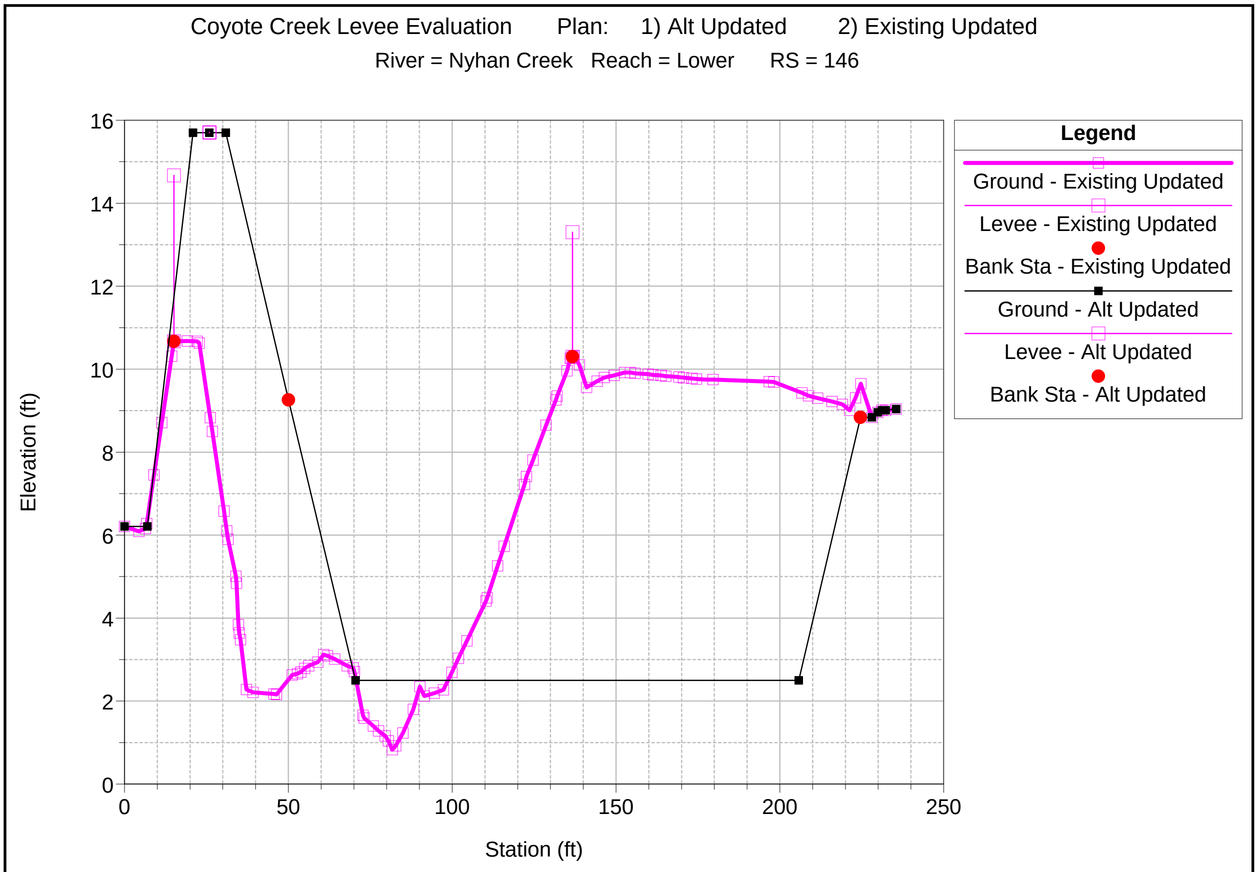

Coyote Creek Levee Evaluation Plan: 1) Alt Updated 2) Existing Updated
River = Nyhan Creek Reach = Lower RS = 306
Legend
Ground - Existing Updated
Levee - Existing Updated
Bank Sta - Existing Updated
Ground - Alt Updated
Levee - Alt Updated
Ineff - Alt Updated
Bank Sta - Alt Updated
Elevation (ft)
Station (ft)
16
14
12
10
8
6
4
2
0
20
40
60
80
100
120
140



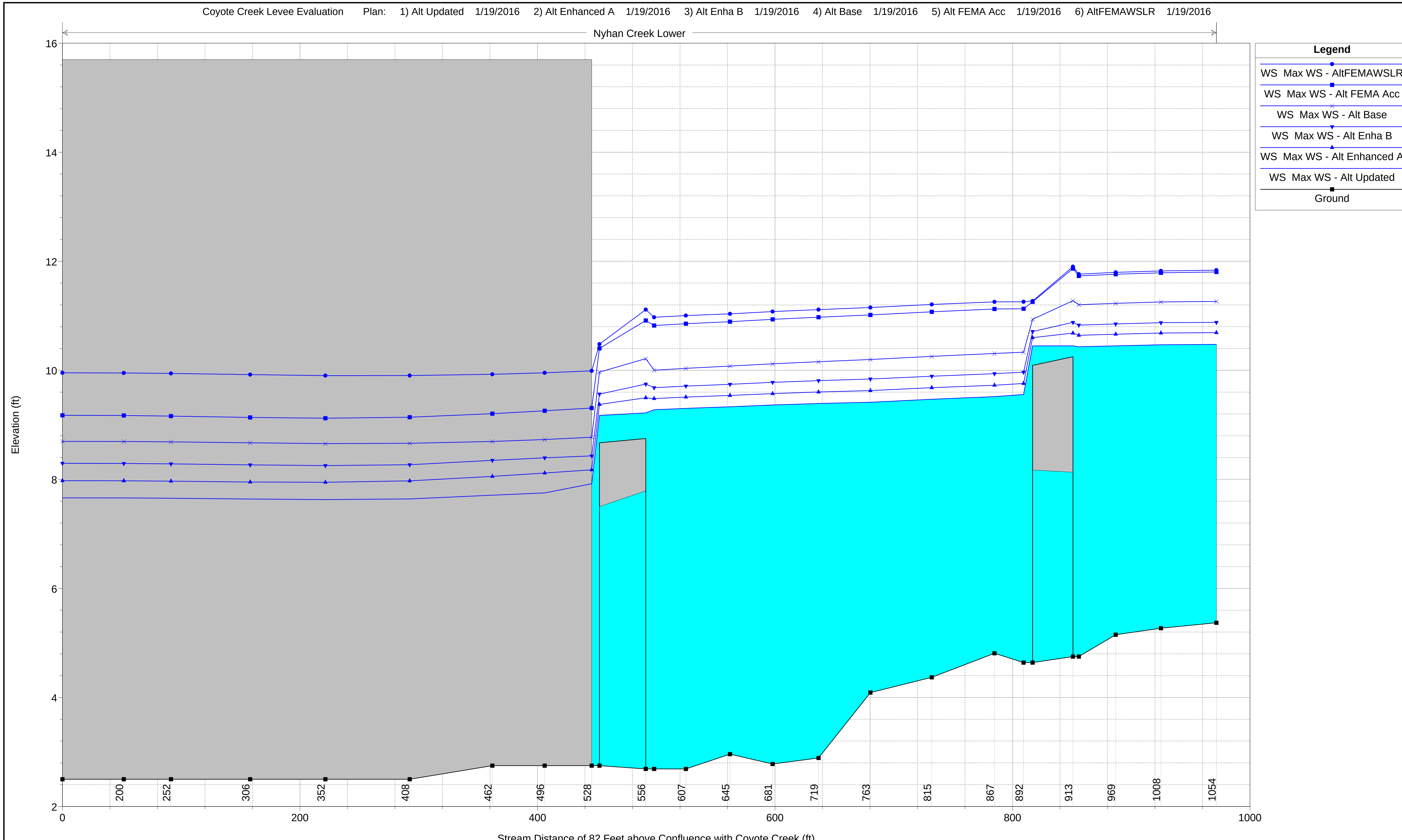
Coyote Creek Levee Evaluation Plan: 1) Alt Updated 2) Existing Updated
River = Nyhan Creek Reach = Lower RS = 252
Elevation (ft)
Station (ft)
16
14
12
10
8
6
4
2
0
20
40
60
80
100
120
140
160
180
Legend
Ground - Existing Updated
Levee - Existing Updated
Bank Sta - Existing Updated
Ground - Alt Updated
Levee - Alt Updated
Ineff - Alt Updated
Bank Sta - Alt Updated



Coyote Creek Levee Evaluation Plan: 1) Alt Updated 2) Existing Updated
River = Nyhan Creek Reach = Lower RS = 200
Elevation (ft)
Station (ft)
16
14
12
10
8
6
4
2
0
0
50
100
150
200
Legend
Ground - Existing Updated
Levee - Existing Updated
Bank Sta - Existing Updated
Ground - Alt Updated
Levee - Alt Updated
Ineff - Alt Updated
Bank Sta - Alt Updated



Coyote Creek Levee Evaluation Plan: 1) Alt Updated 2) Existing Updated
River = Nyhan Creek Reach = Lower RS = 146
Legend
Ground - Existing Updated
Levee - Existing Updated
Bank Sta - Existing Updated
Ground - Alt Updated
Levee - Alt Updated
Bank Sta - Alt Updated
Elevation (ft)
Station (ft)
0
2
4
6
8
10
12
14
16
0
50
100
150
200
250


Coyote Creek Levee Evaluation Plan: 1) Alt Updated 1/19/2016 2) Alt Enhanced A 1/19/2016 3) Alt Enha B 1/19/2016 4) Alt Base 1/19/2016 5) Alt FEMA Acc 1/19/2016 6) AltFEMAWSLR 1/19/2016
Nyhan Creek Lower
Legend
WS Max WS - AltFEMAWSLR
WS Max WS - Alt FEMA Acc
WS Max WS - Alt Base
WS Max WS - Alt Enha B
WS Max WS - Alt Enhanced A
WS Max WS - Alt Updated
Ground
Elevation (ft)
Stream Distance of 82 Feet above Confluence with Coyote Creek (ft)
2
4
6
8
10
12
14
16
0
200
400
600
800
1000
200
252
306
352
408
462
496
528
556
607
645
681
719
763
815
867
892
913
969
1008
1054

Water Surface Elevation Comparison

		Baseline Scenario WSE (ft)			Updated Scenario WSE (ft)			Enhanced A WSE (ft)			Enhanced B WSE (ft)			FEMA Accredited WSE (ft)			FEMA Accredited with Sea Level Rise WSE (ft)		
Stream Name	River Station	Existing	Alternative 1	Change in WSE	Existing	Alternative 1	Change in WSE	Existing	Alternative 1	Change in WSE	Existing	Alternative 1	Change in WSE	Existing	Alternative 1	Change in WSE	Existing	Alternative 1	Change in WSE
Nyhan Creek	1054	11.38	11.26	-0.12	10.48	10.48	0.00	10.71	10.69	-0.02	10.96	10.88	-0.08	11.96	11.80	-0.16	11.94	11.84	-0.10
Nyhan Creek	1008	11.37	11.25	-0.12	10.47	10.47	0.00	10.70	10.68	-0.02	10.95	10.87	-0.08	11.94	11.79	-0.15	11.93	11.82	-0.11
Nyhan Creek	969	11.35	11.23	-0.12	10.45	10.45	0.00	10.68	10.66	-0.02	10.93	10.85	-0.08	11.92	11.76	-0.16	11.90	11.80	-0.10
Nyhan Creek	938	11.32	11.20	-0.12	10.43	10.43	0.00	10.66	10.64	-0.02	10.91	10.83	-0.08	11.89	11.73	-0.16	11.87	11.76	-0.11
Nyhan Creek	892	10.74	10.33	-0.41	9.57	9.56	-0.01	9.78	9.76	-0.02	10.18	9.97	-0.21	11.66	11.13	-0.53	11.61	11.26	-0.35
Nyhan Creek	867	10.74	10.31	-0.43	9.51	9.52	0.01	9.74	9.73	-0.01	10.17	9.94	-0.23	11.66	11.12	-0.54	11.61	11.25	-0.36
Nyhan Creek	815	10.70	10.26	-0.44	9.46	9.47	0.01	9.69	9.68	-0.01	10.12	9.89	-0.23	11.63	11.07	-0.56	11.57	11.21	-0.36
Nyhan Creek	763	10.65	10.20	-0.45	9.40	9.41	0.01	9.64	9.63	-0.01	10.08	9.84	-0.24	11.58	11.01	-0.57	11.52	11.15	-0.37
Nyhan Creek	719	10.63	10.16	-0.47	9.38	9.39	0.01	9.62	9.60	-0.02	10.06	9.81	-0.25	11.55	10.97	-0.58	11.49	11.11	-0.38
Nyhan Creek	681	10.60	10.12	-0.48	9.35	9.36	0.01	9.59	9.57	-0.02	10.03	9.78	-0.25	11.52	10.93	-0.59	11.46	11.08	-0.38
Nyhan Creek	645	10.56	10.08	-0.48	9.32	9.33	0.01	9.56	9.54	-0.02	10.00	9.74	-0.26	11.48	10.89	-0.59	11.43	11.04	-0.39
Nyhan Creek	607	10.54	10.04	-0.50	9.29	9.30	0.01	9.53	9.51	-0.02	9.97	9.71	-0.26	11.46	10.85	-0.61	11.41	11.00	-0.41
Nyhan Creek	581	10.51	10.00	-0.51	9.26	9.28	0.02	9.51	9.48	-0.03	9.94	9.68	-0.26	11.44	10.82	-0.62	11.38	10.97	-0.41
Nyhan Creek	528	8.94	8.77	-0.17	7.90	7.92	0.02	8.24	8.17	-0.07	8.60	8.43	-0.17	9.56	9.31	-0.25	10.15	9.99	-0.16
Nyhan Creek	496	8.89	8.73	-0.16	7.91	7.75	-0.16	8.23	8.12	-0.11	8.57	8.39	-0.18	9.51	9.26	-0.25	10.12	9.95	-0.17
Nyhan Creek	462	8.85	8.69	-0.16	7.84	7.71	-0.13	8.17	8.05	-0.12	8.51	8.35	-0.16	9.45	9.21	-0.24	10.08	9.93	-0.15
Nyhan Creek	408	8.76	8.66	-0.10	7.75	7.64	-0.11	8.09	7.97	-0.12	8.43	8.27	-0.16	9.34	9.14	-0.20	10.00	9.90	-0.10
Nyhan Creek	352	8.69	8.66	-0.03	7.68	7.63	-0.05	8.00	7.95	-0.05	8.33	8.25	-0.08	9.23	9.12	-0.11	9.93	9.90	-0.03
Nyhan Creek	306	8.66	8.67	0.01	7.64	7.64	0.00	7.96	7.95	-0.01	8.28	8.27	-0.01	9.16	9.14	-0.02	9.90	9.92	0.02
Nyhan Creek	252	8.65	8.69	0.04	7.63	7.65	0.02	7.94	7.97	0.03	8.25	8.28	0.03	9.13	9.16	0.03	9.90	9.94	0.04
Nyhan Creek	200	8.68	8.70	0.02	7.65	7.66	0.01	7.96	7.97	0.01	8.28	8.29	0.01	9.15	9.17	0.02	9.94	9.95	0.01
Nyhan Creek	146	8.70	8.70	0.00	7.66	7.66	0.00	7.98	7.98	0.00	8.29	8.29	0.00	9.17	9.17	0.00	9.95	9.95	0.00

Note : Nyhan Creek is the only stream affected by the Alternative 1 channel configuration.

Appendix I

Electronic Files (DVD only)