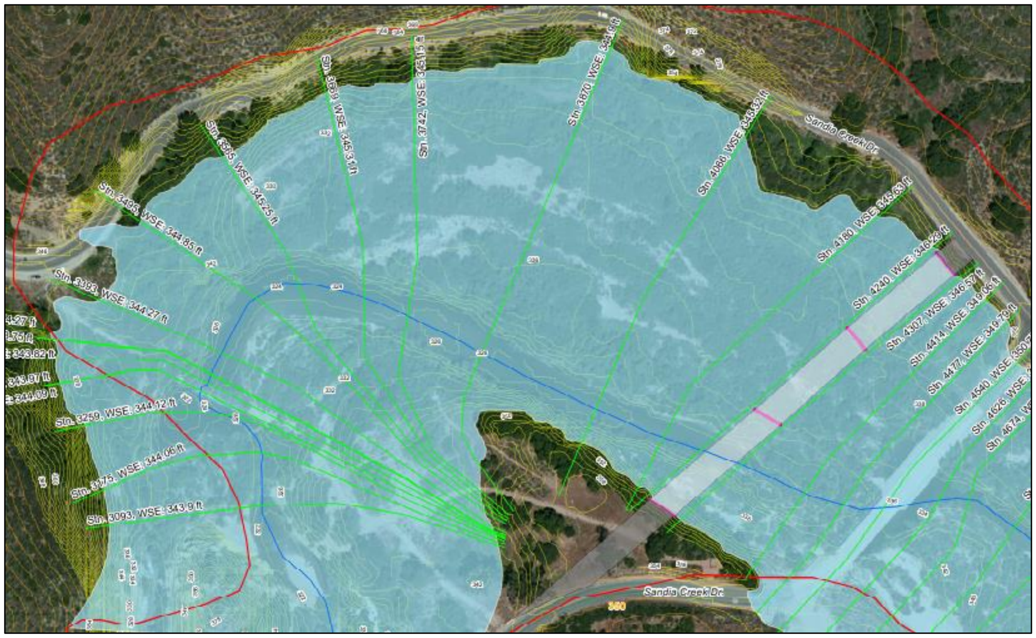
Sandia Creek Drive Bridge Replacement Project
Fallbrook, San Diego County, CA

Hydraulic/Scour Report



May
2021

Final Report

Prepared for:

CALIFORNIA TROUT
FISH · WATER · PEOPLE

Prepared by:

RIVER FOCUS
WATER RESOURCE CONSULTANTS

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Table of Contents

List of Tables

List of Figures

List of Appendices

1 INTRODUCTION

The purpose of this hydraulic/scour report is to provide computed flood elevations, flow velocities, estimated scour depths, and riprap sizing for the Sandia Creek Drive Bridge replacement project. The proposed bridge will replace the aging, flood-prone Sandia Creek Drive Bridge, which crosses the Santa Margarita River north of the community of Fallbrook in San Diego County.

1.1 Project Overview

The benefits of the bridge replacement project are numerous and include (1) improving reliable and safe access for residents during high flows that flood the current crossing; (2) enhancing trail user experience through better safety controls for pedestrians, cyclists, equestrian users, disadvantaged communities, and vehicles; (3) improving traffic congestion; (4) providing back-country access to emergency response personnel during large storm events; and (5) increasing quality of riparian and river habitat for multiple species.

A project location map is provided in Figure 1-1.

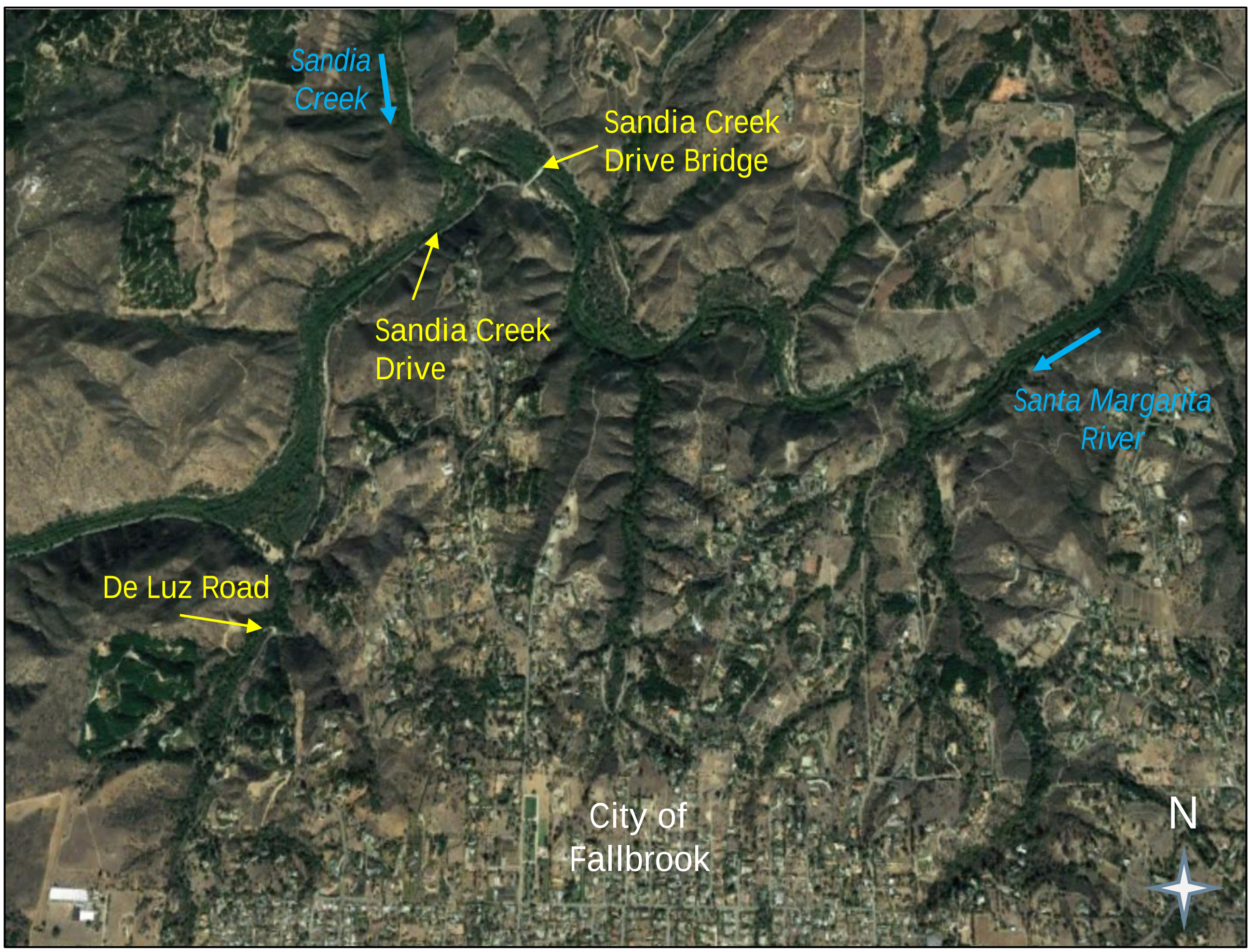

Figure 1-1. Study Area Location Map

1.2 Existing Bridge

The existing Sandia Creek Drive Bridge consists of a concrete road base on top of 10 – 10' wide by 4' high concrete box culverts. The river flows through the culverts and cascades over riprap into several pools at the outlets. The crossing is 300 feet long and 30 feet wide. Figure 1-2 shows the existing bridge and riparian area at a typical flow of approximately 6 cfs (upper left) and 100 cfs (upper right).

Figure 1-2. Existing Sandia Creek Drive Bridge

Downstream of Sandia Creek Drive Bridge near the confluence of Sandia Creek and Santa Margarita River is an old concrete ford crossing, which is now partially removed. The location of the two structures relative to each other is shown in Figure 1-3.

Figure 1-3. Aerial View of Existing Structures – Santa Margarita River

1.3 Floodplain/Floodway Designation

FEMA Mapping

The study area is within a FEMA Zone A floodplain (Figure 1-4), signifying that this reach of the Santa Margarita River was studied and mapped by FEMA using approximate methods (i.e., no detailed modeling was performed by FEMA). FEMA does not have reported peak flows for the study reach, nor do they have base (100-year) flood elevations.

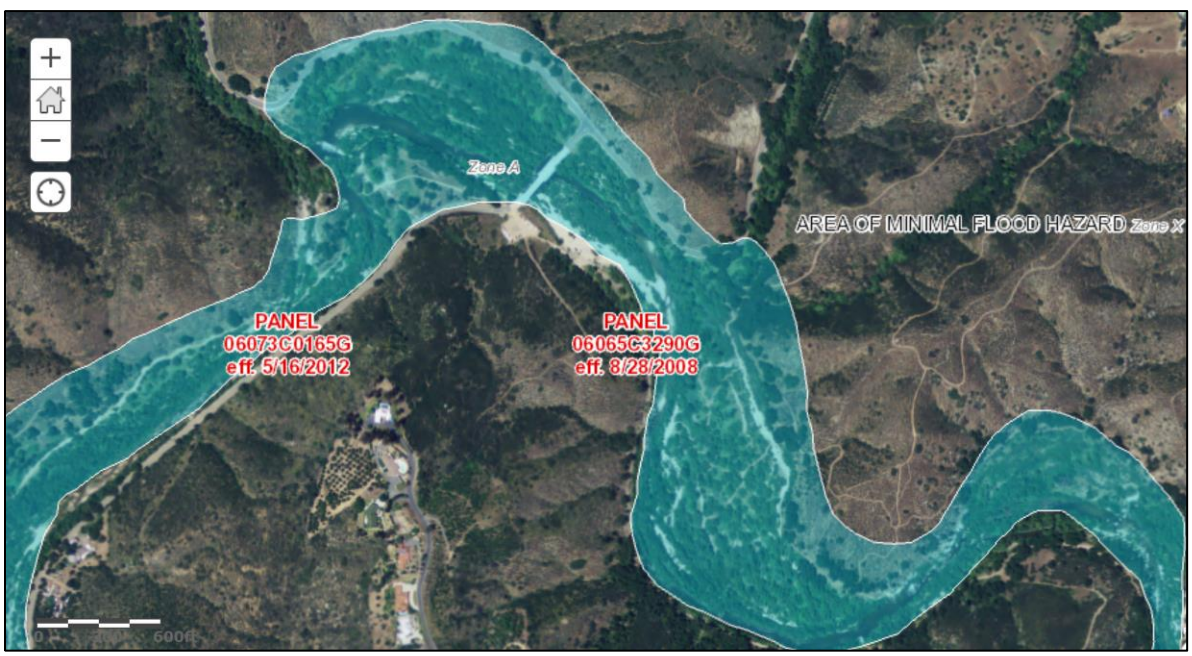

Figure 1-4. FEMA Zone A (Approximate) Floodplain – Santa Margarita River

Given the Zone A (approximate) floodplain, a FEMA regulatory floodway has not been established for the study area. In addition, the following conditions apply in this case:

- There are no habitable structures within or in the vicinity of the study reach; therefore, any localized increase in flood elevations due to the project would have no impact on any habitable structures.
- The project reach is part of an approximately 1,390-acre property along the Santa Margarita River owned by the Wildlands Conservancy, who are supportive of the current project.

As pertinent to FEMA: the proposed project does not adversely affect the hydraulic carrying capacity of the river. The cumulative effect of the proposed project when combined with all other existing and anticipated development (not applicable in this case) will not increase the water surface elevation of the base flood more than one foot at any point.

County of San Diego Mapping

The County of San Diego has not designated their own floodplain or floodway for the Santa Margarita River.

1.4 Field Reconnaissance

Team personnel have participated in multiple field reconnaissance visits and field meetings. Selected field photos are provided in Figure 1-5 to Figure 1-10.

Figure 1-5. Santa Margarita River Upstream of Sandia Creek Drive Bridge

Figure 1-6. Sandia Creek Drive Bridge (Upstream Face)

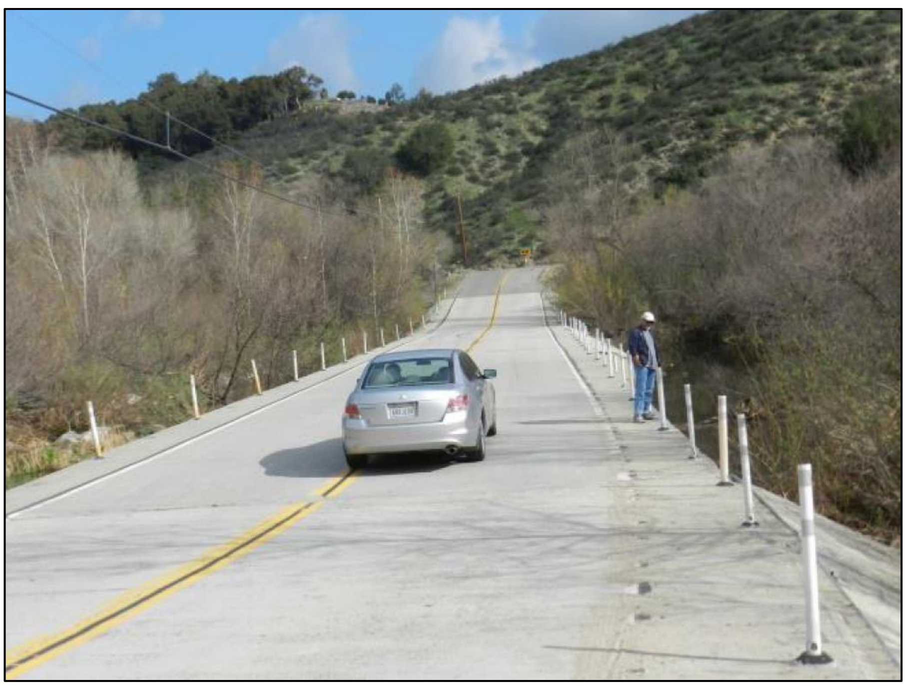

Figure 1-7. Sandia Creek Drive, Facing North

Figure 1-8. Sandia Creek Drive, Facing South toward Parking Lot

Figure 1-9. Santa Margarita River Upstream of Old Concrete Ford Crossing

Figure 1-10. Old Concrete Ford Crossing (North Side, Partially Removed)

1.5 Project Reach

Major features of the project reach—from upstream of the existing crossing to the downstream confluence of Santa Margarita River and Sandia Creek—are presented in Figure 1-11.

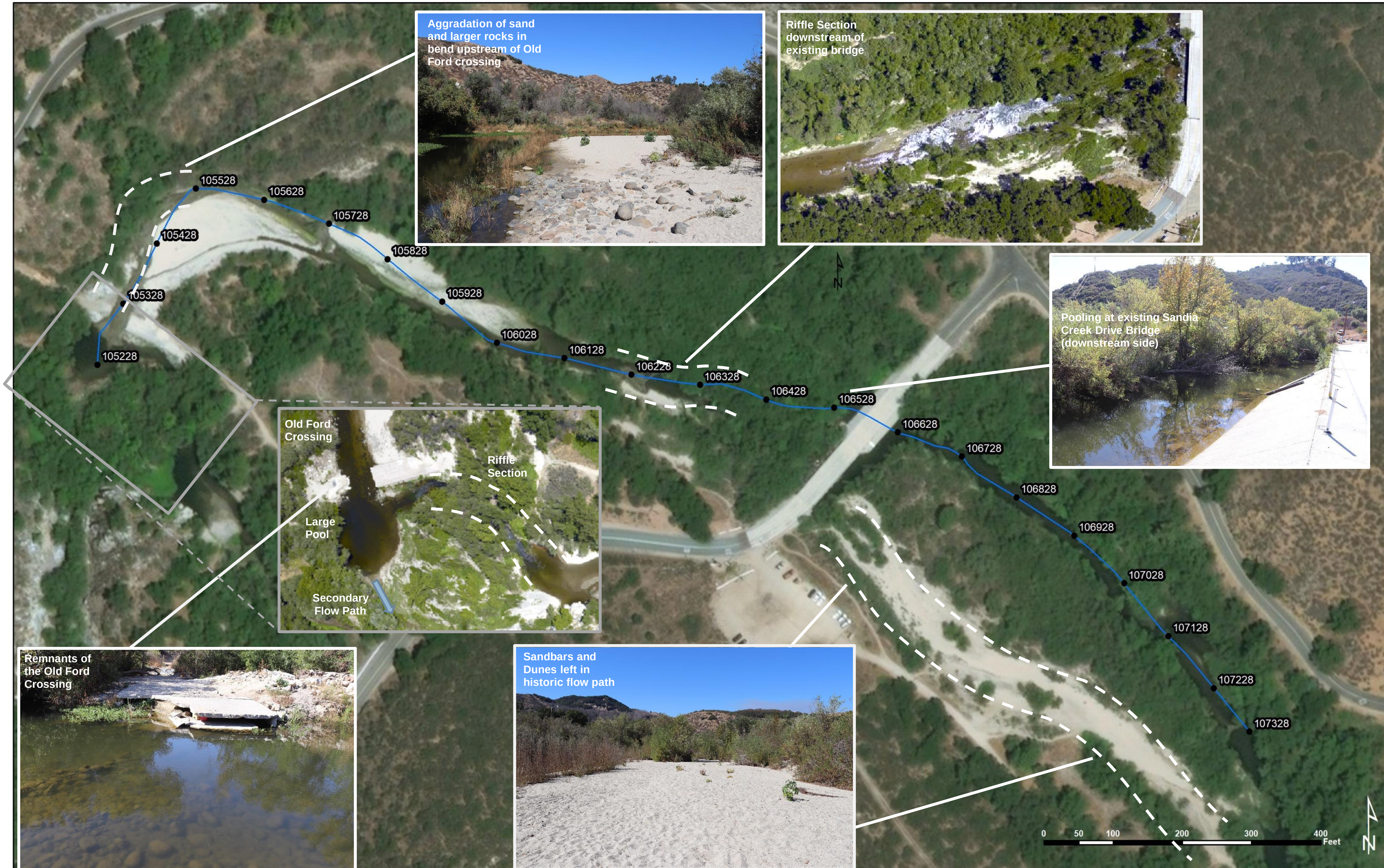

Figure 1-11. Project Reach – Channel and Overbank Features

2 HYDRAULIC MODELING

Hydraulic modeling was performed using the U.S. Army Corps of Engineers' HEC-RAS (River Analysis System), version 5.0.7 (HEC, 2019). River Focus created a 1-D steady flow hydraulic model to compute flood elevations for the 2% and 1% annual chance exceedance (50-year and 100-year) events.

This chapter describes the hydraulic model development and presents the model results. Floodplain workmaps for existing and proposed conditions are provided in Appendix A. Hydraulic model results are provided in Appendix B.

2.1 Bridge Hydraulic Design Criteria

County of San Diego Design Criteria

Based on the San Diego County Hydraulic Design Manual (HDM), new bridges should be designed to pass the 100-year peak discharge with 1 foot of freeboard (County of San Diego, 2014).

Caltrans Design Criteria

According to the Caltrans Highway Design Manual (Section 800), which describes the hydraulic design criteria for all bridges new bridges should be designed to pass the 50-year peak discharge with sufficient freeboard (typically 2 feet) and convey the 100-year peak discharge without freeboard (Caltrans, 2020). If the bridge designer can provide sufficient evidence that less freeboard is needed, exceptions may be granted. While 2 feet of freeboard is often appropriate for preliminary bridge designs, the Caltrans manual leaves the recommendation for freeboard to the judgment of the hydraulic engineer based primarily upon the debris anticipated at the bridge.

For the Sandia Creek Drive Bridge, the County of San Diego design criteria take precedence (i.e., 1 foot of freeboard for the 100-year event); however, the 50-year event was also checked to confirm that there is 2 feet of freeboard.

Pier Debris (Drift) Potential

Neither the County nor Caltrans has a specific design standard for pier debris. Pier debris should be applied on a case-by-case basis for locations where large woody debris has been observed or expected from the watershed. For watersheds where chaparral or coastal sage scrub is predominant, woody debris would originate from the riparian corridor along the stream. Based on field reconnaissance and the experience of locals, some woody debris can and does occur within the study reach (see Figure 2-1).

Figure 2-1. Sandia Creek Drive Bridge (Upstream Face)

2.2 Hydraulic Model Development

Model Cross-Sections

The Santa Margarita River hydraulic study area is shown in Figure 2-2. The hydraulic model was extended far enough upstream and downstream to provide a reasonable tie-in to the effective FEMA floodplain limits.

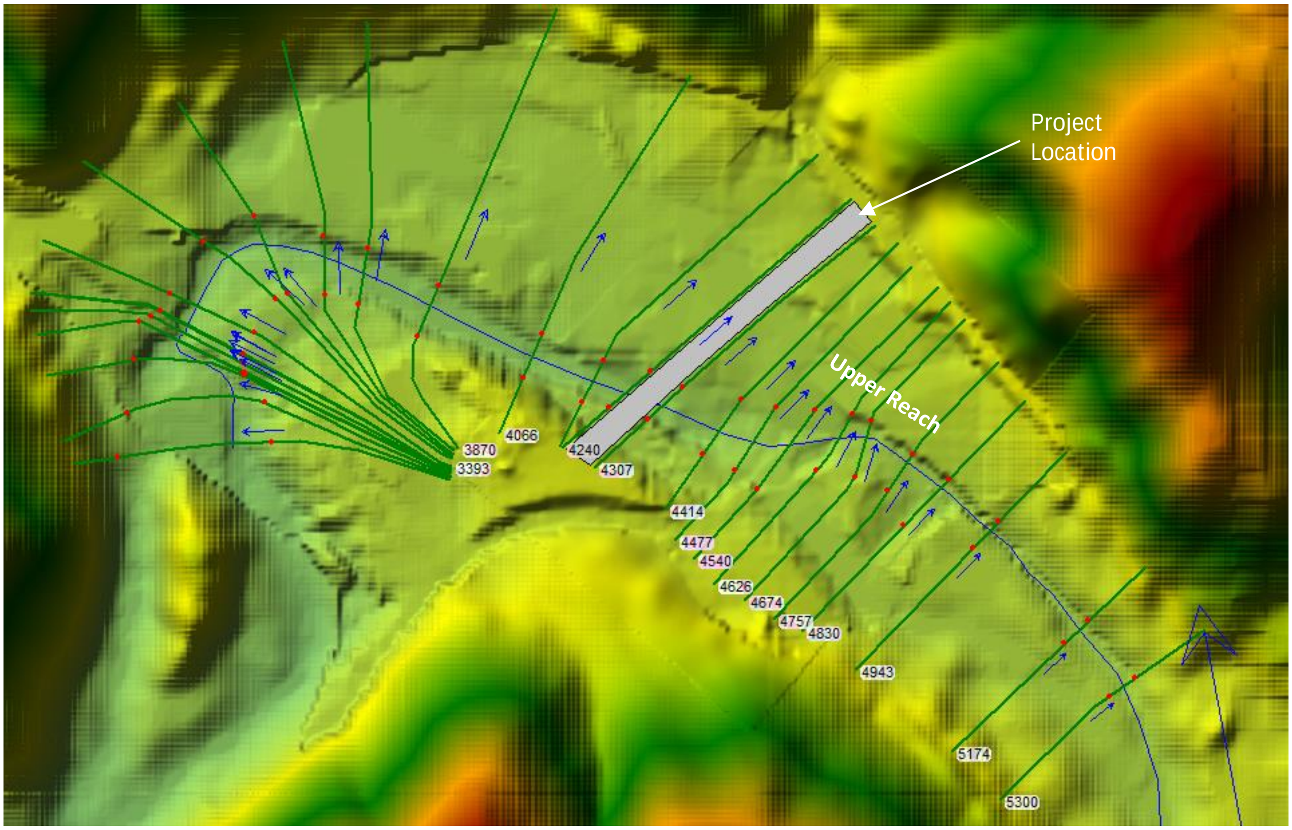

Figure 2-2. HEC-RAS 1-D Model Study Area and Cross-Sections (Proposed Conditions)

Modeled River Crossings

There are two modeled crossings in the study area: Sandia Creek Drive Bridge and the old ford crossing.

The Sandia Creek Drive Bridge is modeled as a bridge structure within the HEC-RAS model geometry. The existing bridge structure is modeled in the Corrected Effective and Existing Conditions model runs. The proposed bridge is modeled in the Proposed Conditions model runs (with the existing bridge removed). Bridge dimensions with profile/plans are discussed below in the Existing and Proposed Conditions sections.

Given its low-profile and the fact that it is partially removed, the old ford crossing is modeled within the HEC-RAS model geometry in the cross-section data rather than as a bridge or inline weir structure. It was modeled as fully in place in the Corrected Effective model run and was modeled with an opening of approximately 25 feet in the Existing and Proposed Conditions model runs.

The old ford crossing and the Sandia Creek Drive Bridge locations (both existing and proposed bridge) on Santa Margarita River, are shown in Figure 2-3.

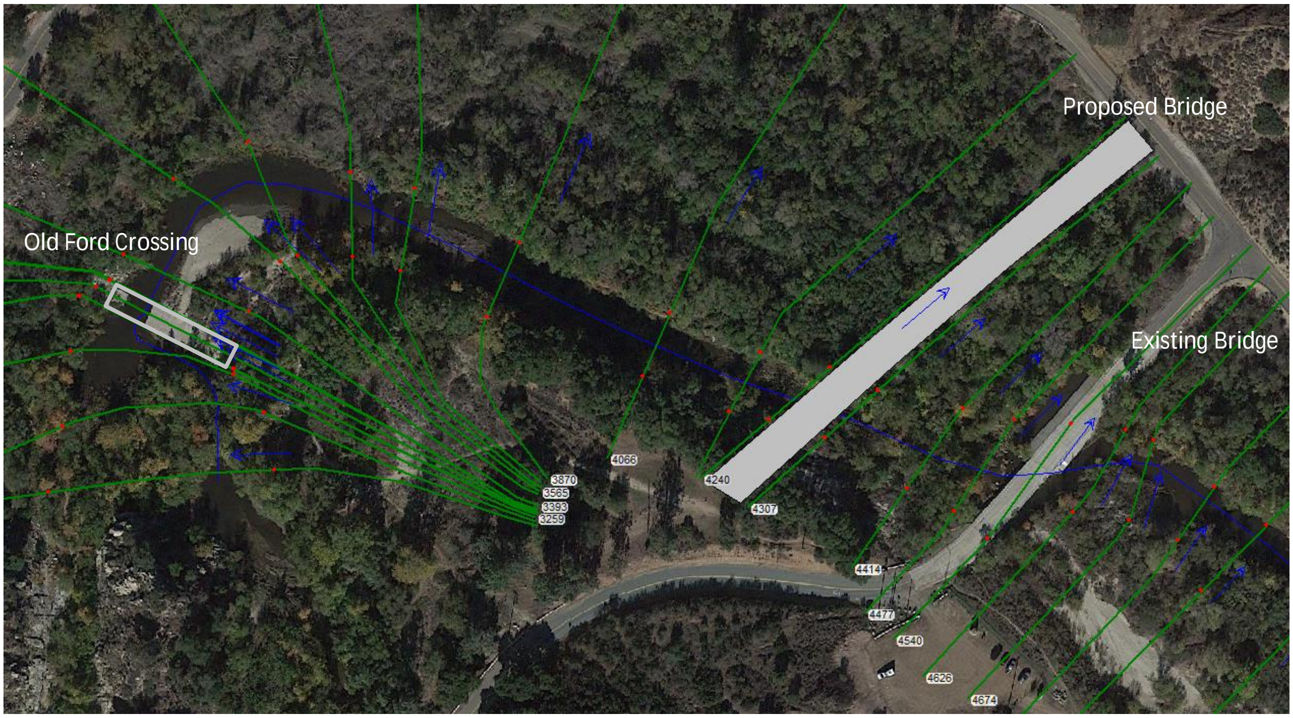

Figure 2-3. Old Ford Crossing and Sandia Creek Drive Bridge (Existing and Proposed) Locations

Boundary Conditions

HEC-HMS modeled 50-year and 100-year flow hydrographs at the upstream and downstream locations of Sandia Creek confluence were used to set the inflow boundary conditions and flow change location for the Santa Margarita River, as described in Table 2-1 (River Focus, 2021). The downstream boundary condition was set as normal depth and assigned a friction slope value of 0.0015 ft/ft.

Table 2-1. Santa Margarita River Design Discharges

Santa Margarita River Location	Peak Discharge (cfs)	
	50-Year	100-Year
Upstream of Sandia Creek Confluence	31,100	38,600
Downstream of Sandia Creek Confluence	34,500	42,600

Topographic Data

Detailed ground survey data for the project reach was developed by Rosell Surveying in March 2018 in the NAVD88 vertical datum. The area covered by the ground survey is shown in light blue in Figure 2-4.

For the limited areas without ground survey data, NOAA IfSAR (Interferometric Synthetic Aperture Radar) data was used; this data set is circa 2002 from the NOAA Office for Coastal Management and the California Coastal Conservancy (also in the NAVD88 vertical datum;

reported RSME of plus/minus 1.04 m). Upstream of the existing crossing, low-flow channel cross-section survey data was also used, which was obtained by WEST Consultants in 2017 (NAVD88 vertical datum).

All of the data sources were available in digital format. In terms of order of use, ground survey data (newest, most accurate) > cross section survey > IfSAR data (oldest, less accurate).

Figure 2-4. Topographic Data Sources

The existing conditions terrain data was supplemented with the proposed grading contours in the vicinity of the existing Sandia Creek Drive Bridge crossing (provided by KPFF Consulting Engineers) for the proposed conditions DEM.

Vertical Datum and Horizontal Projection

All elevations in this report and the HEC-RAS hydraulic model are referenced to the NAVD88 vertical datum. The projection/horizontal coordinate system used for this study is NAD 1983 State Plane California III (FIPS 0403 feet).

Manning's Roughness

The main channel roughness and overbank roughness values (Manning's *n*) used in the hydraulic model are described in Table 2-2. The *n* values were selected based on field observations, aerial imagery, the San Diego County HDM, and engineering judgment. Based on the San Diego County HDM, a channel *n* value of 0.15 was used for areas impacted by grading under proposed conditions, and vegetated overbank/floodplain areas were assigned a value of 0.10.

Table 2-2. Manning's Roughness Values

Manning's *n* Value	Description / Notes
Main Channel	
0.035 – 0.042	Santa Margarita River – Open Areas
0.050 – 0.100	Santa Margarita River – Dense Vegetation
0.150	Disturbed Channel (Proposed Conditions)
Overbank Area & Secondary Channels	
0.015	Concrete Crossing
0.020	Asphalt Roadway
0.025	Dirt Parking Lot and Trail
0.028	Overbank Flow Path (Upstream)
0.045	Concrete Rubble
0.050	Secondary Channel
0.100	Vegetated Floodplain

2.3 Hydraulic Models

FEMA Effective Model

Santa Margarita Creek was mapped by FEMA using approximate conditions; therefore, a FEMA effective model is not available. In the absence of an Effective Model, the Corrected Effective Model (described below) also serves as the Effective Model for the project.

Corrected Effective

The Corrected Effective model represents conditions that were in place when the original FEMA mapping was created; however, more detailed data has been incorporated. As described previously, the old ford crossing is modeled as fully in place in the Corrected Effective model, whereas a 25-feet opening (Figure 2-5) was modeled in the Existing and Proposed Conditions plans. Figure 2-6 shows the HEC-RAS cross-section schematic differences between the two conditions.

The existing Sandia Creek Drive Bridge was modeled in both the Corrected Effective Conditions and Existing Conditions models. See the following section for more information on modeling of the existing Sandia Creek Drive Bridge.

Figure 2-5. Partially Removed Ford Crossing

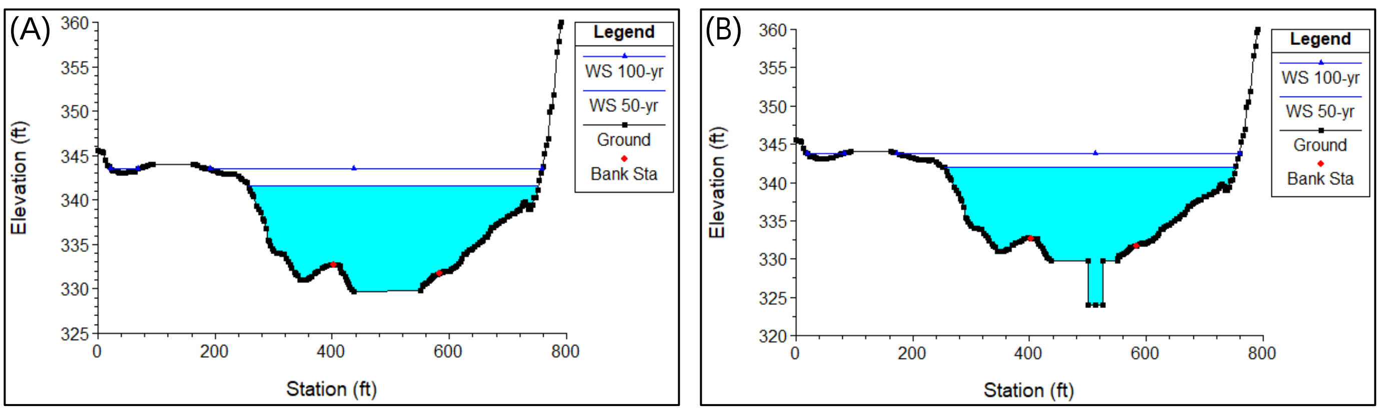

Figure 2-6. Old Ford Crossing: (A) Corrected Effective, (B) Existing and Proposed Conditions

Existing Conditions

The existing Sandia Creek Drive Bridge was modeled based on plans provided by County of San Diego, Department of Public Works (Appendix C). The existing and proposed bridge locations are shown in Figure 2-7. As described previously, the existing Sandia Creek Drive Bridge consists of a concrete road base on top of 10 – 10-ft wide by 4-ft high concrete box culverts, and is 300 feet long and 30 feet wide. The HEC-RAS existing bridge cross-section profile (upstream section) is provided in Figure 2-8.

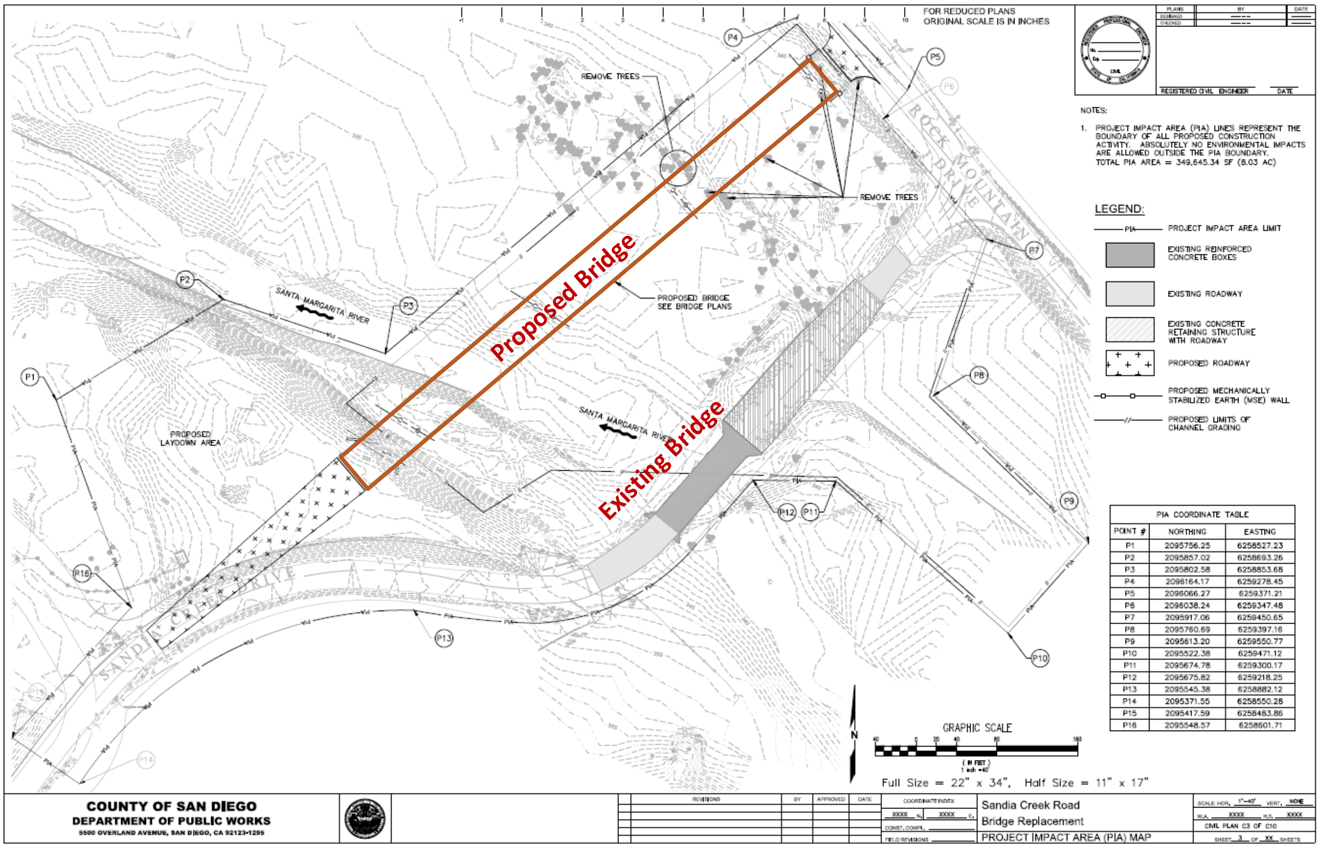

Figure 2-7. Existing and Proposed Bridges – Sandia Creek Drive Crossing over Santa Margarita River

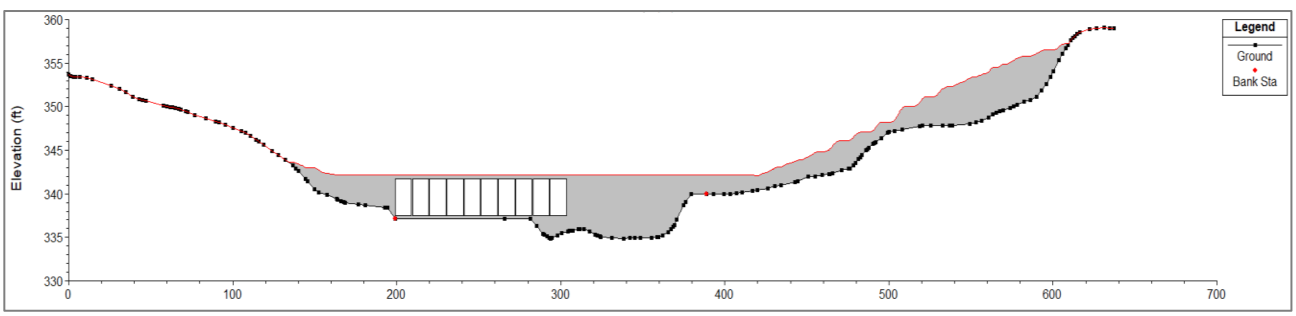

Figure 2-8. Existing Sandia Creek Drive Bridge Cross-Section (HEC-RAS)

Proposed Conditions

The proposed bridge will be a 574-ft long, 40-ft wide three-span bridge, including 2 – 4-ft wide pier sections and 2 abutments. Given the skew of the channel, the bridge width in the direction of flow is approximately 51 ft. The design plan/profile for the proposed bridge, provided by KPFF Consulting Engineers, is provided in Appendix D. In the HEC-RAS model, floating pier debris (10-ft wide by 6-ft tall) was added to each of the two bridge piers.

Because there is no significant contraction/expansion at the proposed bridge, the County of San Diego requested that contraction/expansion coefficients remain at 0.1/0.3 (the values used for a typical channel cross section rather than increasing them to 0.3/0.5, as is typically done at cross sections bounding a bridge.

The existing conditions terrain data was supplemented with the proposed grading contours in the vicinity of the existing Sandia Creek Drive Bridge crossing (provided by KPFF Consulting Engineers) for the proposed conditions DEM. Overall, there will be minimal grading following the removal of the existing crossing. As directed by the California Department of Fish and Wildlife (CDFW), the river will be allowed to create its preferred channel over time.

2.4 Hydraulic Model Results

The computed 50-year and 100-year water surface profiles are shown in Figure 2-10 and Figure 2-9, respectively. Floodplain workmaps are provided in Appendix A.

Existing vs. Proposed Flood Elevations

Flood elevations increased slightly in the area upstream of the proposed bridge near the removal of the existing crossing. The maximum increase in water surface elevation is 0.58 feet for the 100-year flood event (see Table 2-3), which is caused by the San Diego County HDM mandated higher *n* value (0.15) under proposed conditions. There are no habitable structures in this area that could be impacted by the localized increase.

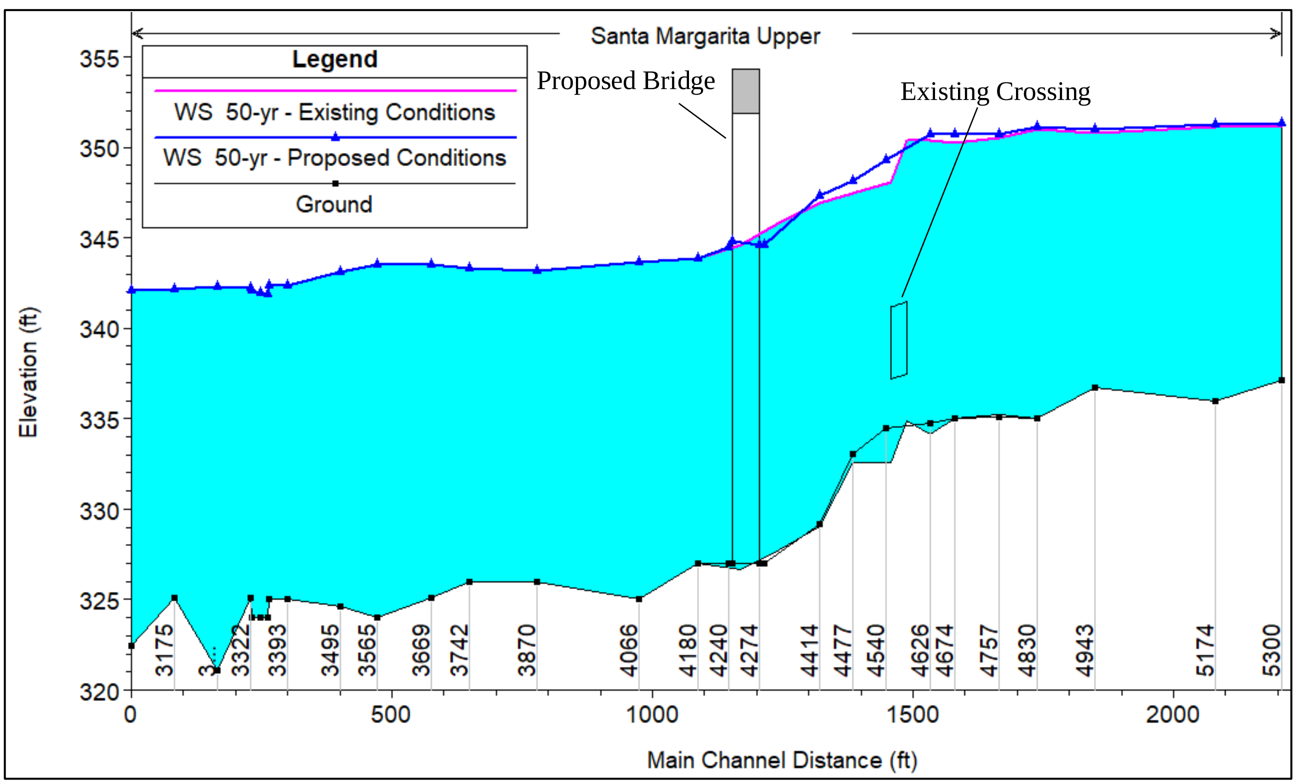

Figure 2-9. Existing vs. Proposed 50-year Water Surface Profile Plot

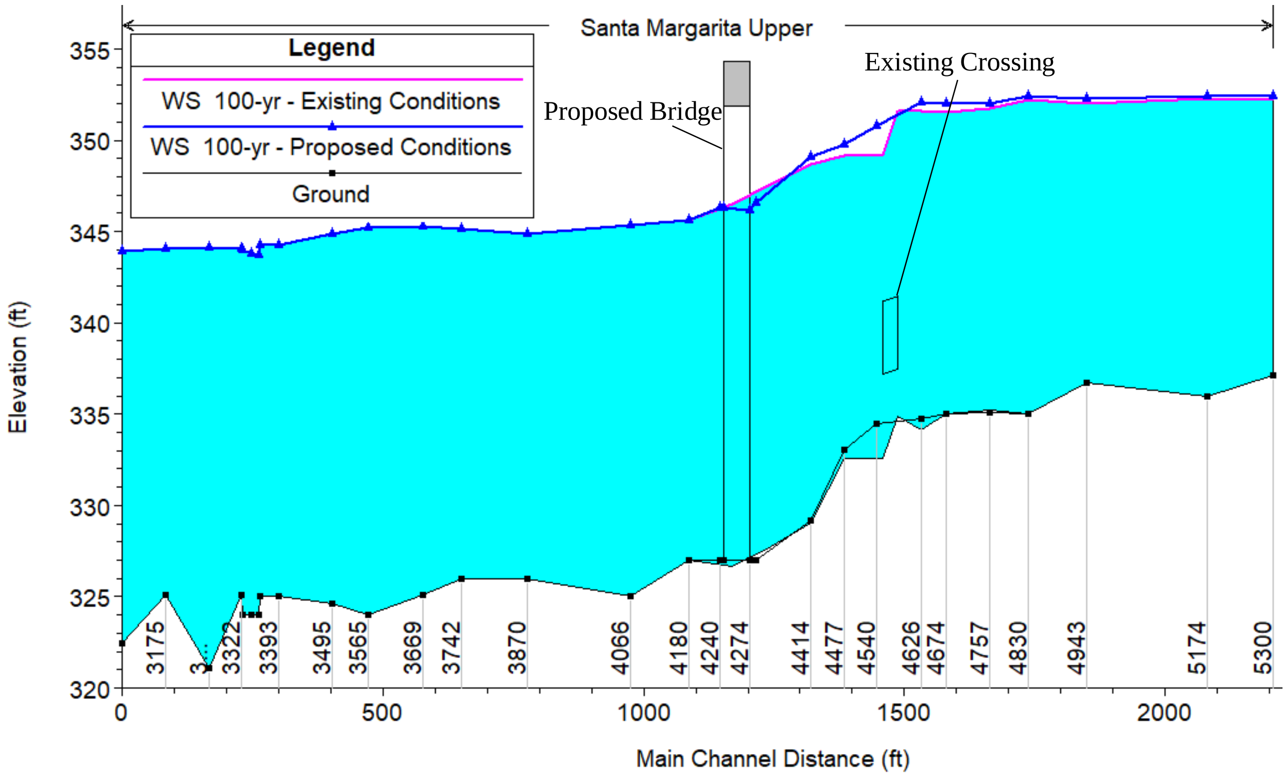

Figure 2-10. Existing vs. Proposed 100-year Water Surface Profile Plot

Table 2-3. Proposed vs. Existing 100-yr Water Surface Elevation Comparison

Existing Model		Proposed Model		Difference (ft)
Cross Section	100-yr WSEL (ft)	Cross Section	100-yr WSEL (ft)	*(Proposed – Existing)*
5300	352.29	5300	352.40	0.11
5174	352.34	5174	352.45	0.11
4943	352.12	4943	352.26	0.14
4830	352.30	4830	352.42	0.12
4757	351.84	4757	352.04	0.20
4674	351.63	4674	352.02	0.39
4626	351.68	4626	352.07	0.39
4532	Existing Crossing	4540	350.77	n/a*
4477	349.22	4477	349.80	0.58
4414	348.69	4414	349.06	0.37
4336	347.58	4307	346.58	n/a*
		4274	Proposed Bridge	
4263	346.51	4240	346.31	n/a*
4180	345.66	4180	345.66	0
4066	345.35	4066	345.35	0
3870	344.94	3870	344.94	0
3742	345.19	3742	345.19	0
3669	345.35	3669	345.35	0
3565	345.28	3565	345.28	0
3495	344.89	3495	344.89	0
3393	344.33	3393	344.33	0
3356	344.32	3356	344.32	0
3355	343.81	3355	343.81	0
3341	343.88	3341	343.88	0
3323	343.97	3323	343.97	0
3322	344.09	3322	344.09	0
3259	344.12	3259	344.12	0
3175	344.06	3175	344.06	0
3093	343.90	3093	343.90	0

*Cross-section stations do not match due to differences between existing and proposed conditions models.

Freeboard

The bridge minimum low-chord elevation meets the County requirement of at least 1 foot of freeboard for the 100-year discharge. It also meets the Caltrans freeboard requirement of at least 2 feet of freeboard for the 50-year discharge.

Figure 2-11 shows that the low chord of the bridge (minimum elevation: 347.58 ft, NAVD88) has 1 ft of available freeboard based on the 100-year flood elevation (346.58 ft) and 2.75 ft of available freeboard based on the 50-year flood elevation (344.83 ft).

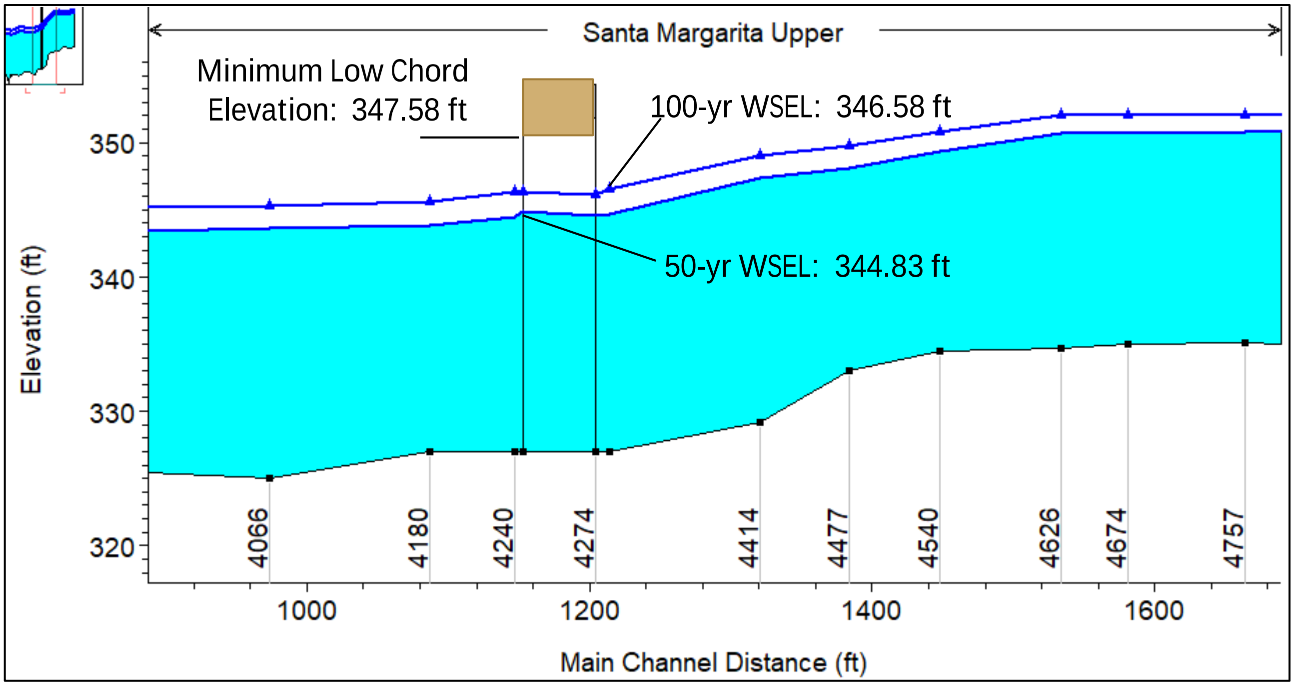

Figure 2-11. Proposed Water Surface Profile Plot with Minimum Low Chord Elevation

2.5 Hydrologic Summary Table

A Caltrans hydrologic summary table is provided in Table 2-4.

Table 2-4. Hydrologic Summary Table

Hydrologic Summary Table for Sandia Creek Drive Bridge (County of San Diego)			
Drainage Area: 620 mi^2 (regulated watershed)			
	Q50	Design Flood	Overtopping Flow
Frequency	50-year	100-year	> 500-year
Discharge	31,100 cfs	38,600 cfs	74,000 cfs
Velocity	8.8 ft/s	8.9 ft/s	12.2 ft/s
Water Surface Elevation (NAVD88)	344.83 ft	346.58 ft	354.31 ft
Floodplain data are based upon information available when the plans were prepared and are shown to meet federal requirements. The accuracy of said information is not warranted by the State and interested or affected parties should make their own investigation.			

3 SCOUR ANALYSIS

Scour calculations are provided in Appendix E. Scour was computed for the proposed bridge during the 100-year return period flood event based upon guidance from the Federal Highway Administration (FHWA) HEC-18 (*Evaluation of Scour at Bridges, Fifth Edition, 2012*) and Caltrans Memo to Designers 16-1 (December 2017).

Total scour at a bridge crossing is determined by adding three scour components: (1) long-term degradation of the streambed, (2) general scour at the bridge, and (3) local scour at the piers or abutments. These three components are outlined in the following sections. The proposed bridge is a 3-span bridge with two abutments ("Abutment 1" and "Abutment 4") and two piers ("Pier 2" and "Pier 3").

Foundation piles will be socketed directly into bedrock for both the pier and abutment foundations. In addition, soil improvements will be used around Pier 2 to address potentially liquifiable soils (Leighton Consulting, 2019).

3.1 Historic Channel Alignments

Historic Aerial Imagery

To better understand the channel migration patterns of the Santa Margarita River over time near the proposed project site, River Focus analyzed the available historic aerial and satellite imagery and obtained high-resolution imagery for 7 different years: 1938, 1946, 1964, 1980, 1994, 2003, and 2012, as shown in Figure 3-1. The existing Sandia Creek Drive Bridge was constructed between the 1964 and 1980 imagery.

The selected years were chosen based upon image clarity and to show the different channel alignments and the various crossings and in-stream structures that have existed over time at the project location. Using the aerial imagery, the historic channel centerlines were digitized in GIS. More recent imagery (from 2016-2017) was also analyzed and the stream centerlines are essentially unchanged in comparison to 2012.

As shown in Figure 3-1, the channel alignment through the proposed bridge openings has stayed relatively constant over time going back over 80 years, except for the 1946 aerial image. This alignment, which occurred prior to the existing bridge construction, may be related to the sand/gravel mining that used to occur in the river at this location.

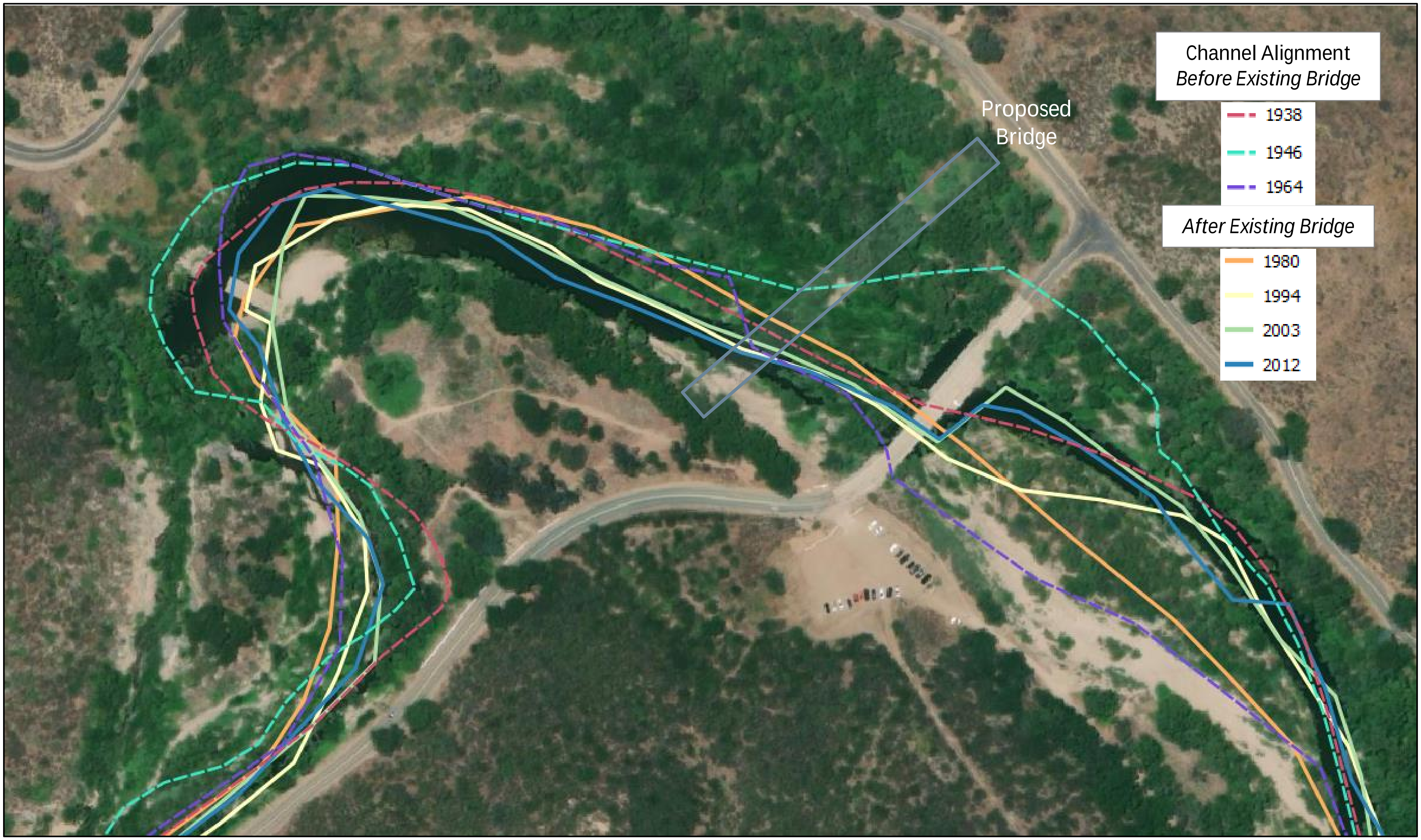

Figure 3-1. Historic Flow Paths – Santa Margarita River near Sandia Creek Drive Bridge

3.2 Sediment Gradation Data

Sediment gradation data was obtained from WEST (2000). At the "SMR nr New Sandia Road" location, the median sediment diameter (D_{50}) is approximately 0.4 mm, which is classified as medium sand. Gravel, cobbles, and boulders are also present in the study reach, particularly in the steeper sections. Overall, the channel bed can be considered a mixture of various sizes of sands and gravels.

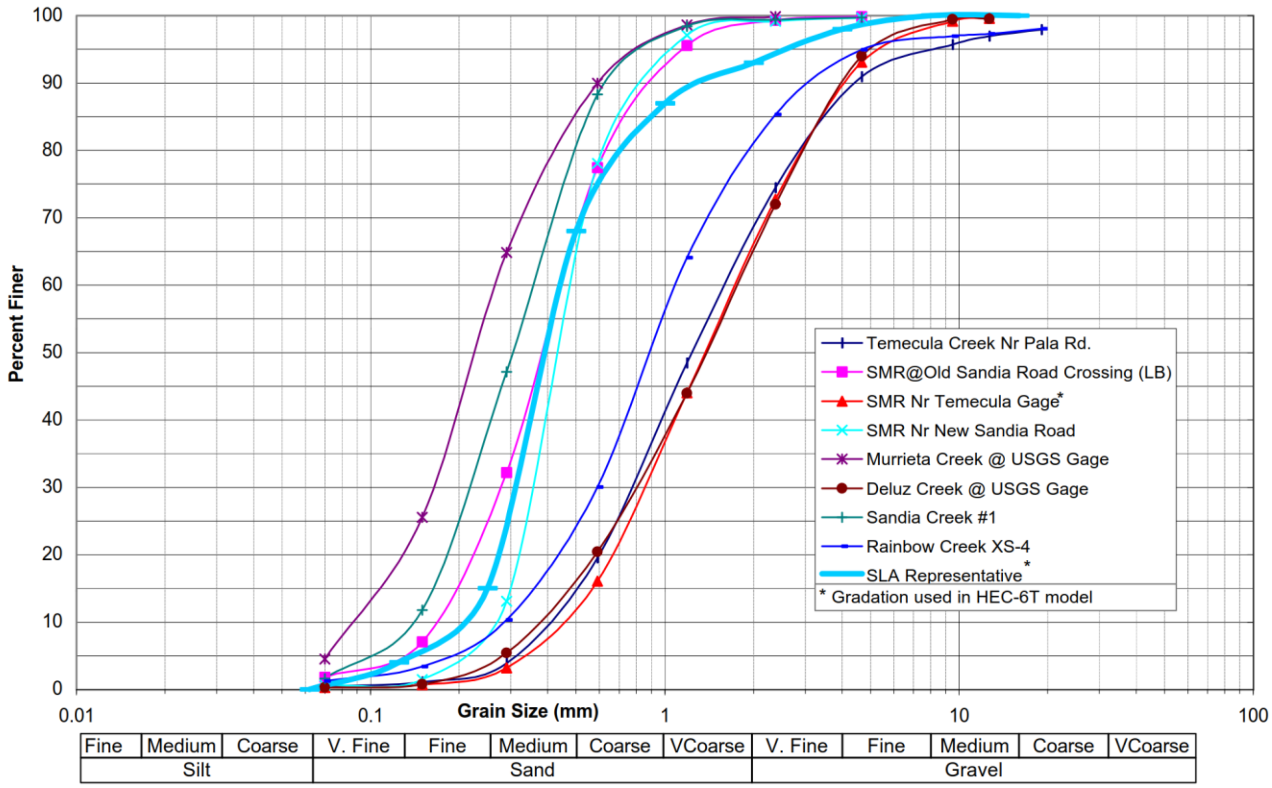

Figure 3-2. Sediment Gradation Data (WEST, 2000)

3.3 Long-Term Degradation

Long-term degradation is associated with streambed lowering over an extended period. The timescale is usually on the order of the life of the structure, up to 50 years or more.

There is no evidence of significant long-term channel degradation within the study reach. There *is* evidence to suggest that there has been some short-term degradation in the immediate vicinity of the old ford crossing. The channel bed near the old crossing was lowered by flood flows following the partial removal of the crossing, which is to be expected. However, on the scale of the larger reach, there is no evidence of long-term aggradation or degradation, meaning that it has largely remained in dynamic equilibrium.

3.4 General Scour

General scour involves lowering of the streambed across the stream at a bridge or culvert, and it is typically associated with contraction of the flow, but it may also result from the presence of a bend in the stream channel. General scour is typically cyclic, i.e., during a runoff event the bed scours/degrades during the rise in stage (increasing discharge) and fills/aggrades on the falling stage (deposition).

Contraction Scour

Contraction scour is a form of general scour that occurs when the flow area of a stream at flood stage is reduced, either by a natural contraction or bridge. It can also occur as overbank flow is forced back into the channel by roadway embankments. Contraction scour typically results in a decrease in the elevation of the bed across the bridge opening. It does not include local scour at piers and abutments or long-term changes in the streambed elevation by aggradation or degradation. Unlike long-term aggradation or degradation, contraction scour can be reversible.

Contraction scour is separated into two basic conditions: live-bed contraction scour and clear-water contraction scour. Live-bed contraction scour occurs at a bridge or natural contraction of the stream when there is a transport of bed material in the upstream reach into the contracted section. Clear-water contraction scour occurs when there is no bed material to transport from the upstream reach to the downstream reach or the material being transported in the upstream reach is transported in suspension and at less than the capacity of the flow.

For the 100-year flood event, the proposed bridge falls under live-bed contraction scour. The velocities in the channel are much higher than the critical velocity of the median particle size (D_{50}). Live-bed scour was estimated using the Modified Laursen's Equation in HEC-18, resulting in a 100-year contraction scour depth of 0 ft. The channel flow does not contract at the proposed bridge location; hence, there is no contraction scour.

Bend Scour

In a natural channel, when there is flow around a bend, the scour may be concentrated near the outside of the bend where the depth of flow is the largest. There may also be deposition on the inner portion of the bend at a point bar. If a bridge is located on or close to a bend, scour will generally be concentrated on the outer portion of the bend. Bend scour is not a concern for the proposed bridge.

3.5 Local Scour

Local scour involves scour around bridge piers, abutments, and embankments. It is also usually cyclical in nature and is caused by the acceleration of flow and cross currents induced by obstructions such as bridge piers and abutments.

Pier Scour

Local scour at the piers is a function of the flow characteristics and the obstruction caused by the geometry of the piers. Pier scour is caused by the formation of vortices at the base of the piers (known as horseshoe vortices) and vertical vortices downstream of the piers (known as wake vortices). Pier width has a direct influence on the depth of scour. Pier length in the direction of flow has no appreciable effect as long as the pier is aligned with the flow. The CSU

(Colorado State University) equation in HEC-18 was used in HEC-RAS to calculate pier scour, yielding a 100-year pier scour depth of 13 feet.

Pier debris was added to the scour calculation through the HEC-18 debris loading adjustment. Woody debris was simulated on the pier using an approximate debris dimension of 10 feet wide by 6 feet tall. The 100-year pier scour depth with debris added increased to 16 feet. This value was used for design purposes.

Abutment Scour

Abutment scour was not calculated because the abutments either do not project into the 100-year flow (Abutment 1) and/or are in areas with low flood depths and minimal flow velocities (Abutment 4).

Bedrock

The computed potential scour depths described above are based on maximum scour depth equations that do not take the presence of bedrock (including weathered bedrock) into account. Leighton Consulting provided a geotechnical report for the proposed bridge, which includes an idealized soil/bedrock profile for the cross section at the bridge.

This soil/bedrock profile has been graphed in Figure 3-3 to demonstrate the elevation of bedrock. The total scour depth at the piers is 16 ft from the channel thalweg (327 ft, NAVD88) for both Pier 2 and Pier 3. The channel thalweg is used as the basis for both piers in case of lateral channel migration. At both piers, bedrock is encountered at or before it reaches its full scour depth (Leighton Consulting, 2019). Therefore, the 100-year total scour elevation has been limited to the bedrock elevation of 311 ft (NAVD88) at Pier 2 and 315.5 ft (NAVD88) at Pier 3.

Foundation piles will be socketed directly into bedrock for both the pier and abutment foundations. Soil improvements around Pier 2 will be used to address the potentially liquifiable soils in the case of seismic event.

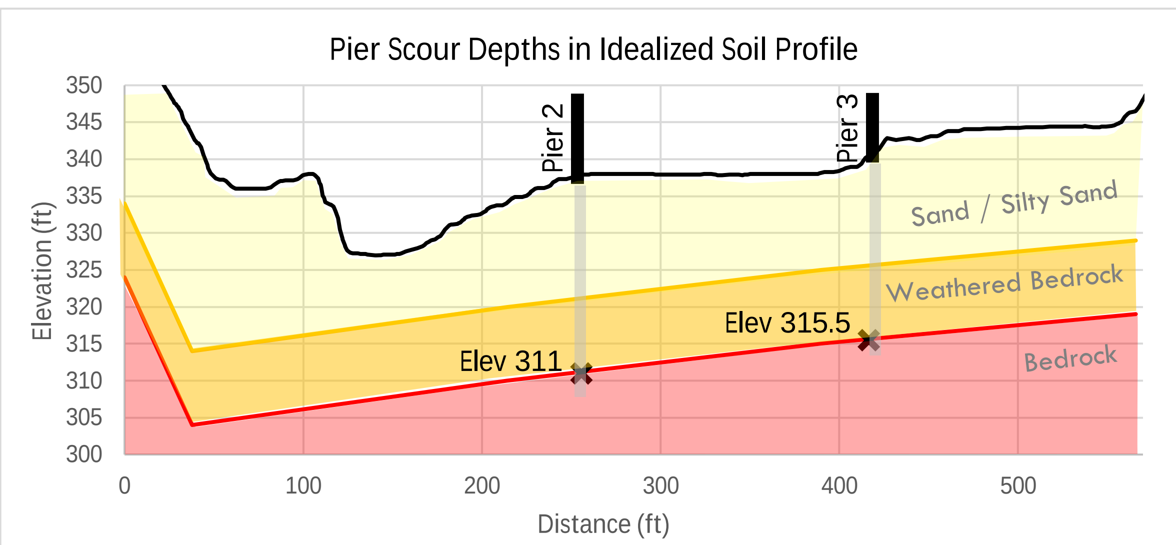

Figure 3-3. Pier Scour Depths in Idealized Soil/Bedrock Profiles

Total Scour

The total scour depth estimate for a pier is the sum of the computed long-term degradation, contraction scour, and local pier scour. The Scour Summary Table (Table 3-1) and Scour Data Table (Table 3-2) are provided below.

The Pier 2 and 3 scour elevations are based on the lowest channel elevation in the area (327 ft, NAVD88) minus the pier scour depth. This assumes that the main river channel can move toward either of the piers, based on historic channel alignments (see Figure 3-1).

Table 3-1. Scour Summary Table

Long-Term & Short-Term Scour Depths Sandia Creek Drive Bridge (County of San Diego)			
Support Location	Degradation Scour Depth (ft)	Contraction Scour Depth (ft)	Short Term (Local) Scour Depth (ft)
Abutment 1	0	0	0
Pier 2	0	0	16
Pier 3	0	0	11.5*
Abutment 4	0	0	0

*Depth is truncated at the bedrock elevation and is less than the calculated 16 ft for Pier 3.

Table 3-2. Scour Data Table

Support No.	Long Term (Degradation and Contraction) Scour Elevation (ft)	Short Term (Local) Scour Depth (ft)
Abutment 1*	336	0
Pier 2	327	16
Pier 3	327	11.5**
Abutment 4*	344	0

*Scour at support location; not at abutment embankment toe.
**Depth is truncated at the bedrock elevation and is less than the calculated 16 ft for Pier 3.

3.6 Rock Riprap Protection

Recommendations for rock riprap protection are provided below for each of the foundation components: Abutment 1, Pier 2, Pier 3, and Abutment 4.

Abutment 1

Abutment 1 will be founded on bedrock. Based on FHWA HEC-18 guidance, rock riprap protection is recommended to keep scour from developing at the base of the abutment and to protect the bank material around the abutment (see Figure 3-4). The computed 100-year flood depth is over 10 feet at the abutment toe and flow velocities reach 10 ft/sec. See Figure 3-5 through Figure 3-7.

Riprap should have a minimum D_{50} of 35 inches, which corresponds to FHWA Standard Riprap Class IX Gradation (see Table 3-3). Riprap should be installed flush with the existing slope/ground elevation to avoid creating hydraulic impacts. The riprap apron extends 25 feet from the abutment wall, with a riprap layer thickness of 6 ft per FHWA HEC-23 guidance. The riprap will extend approximately 5 feet below the contraction scour elevation (335 ft, NAVD88) at the base of the abutment.

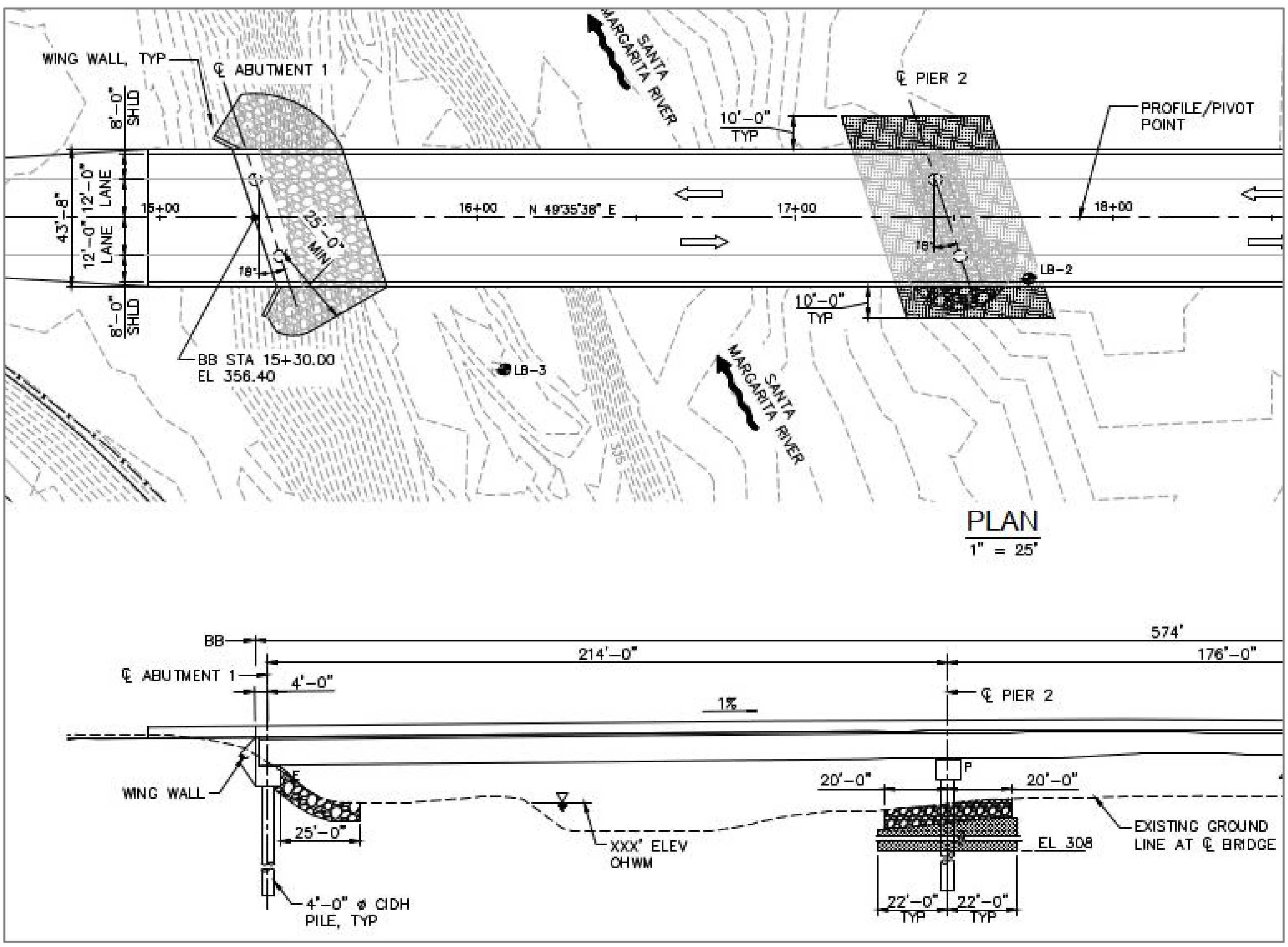

Figure 3-4. Riprap Protection at Abutment 1 Slope and Pier 2 Ground Improvements

Table 3-3. Riprap Gradation, Class IX (FHWA, 2019)

Riprap*		D_{15}		D_{50}		D_{85}		D_{100}
Class	Size	Min	Max	Min	Max	Min	Max	Max
IX	36 in	22.0	31.5	34.0	41.5	47.0	55.5	72.0

Note: Nominal riprap class by median particle diameter; size in inches

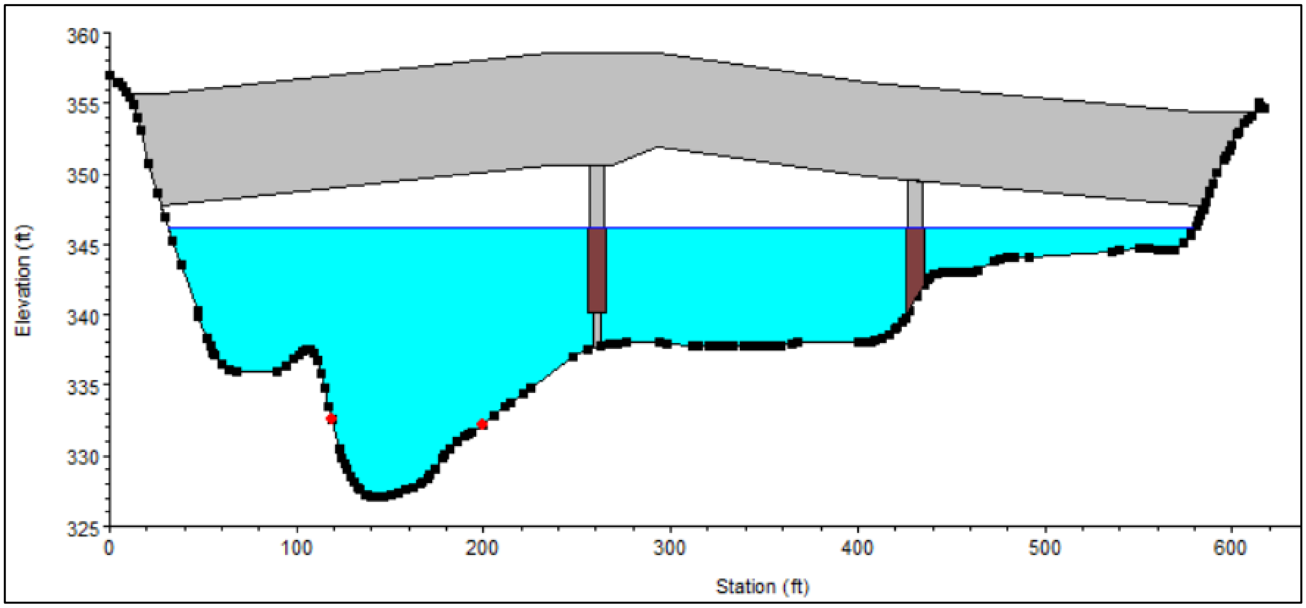

Figure 3-5. 100-year Flood Depth at Proposed Bridge

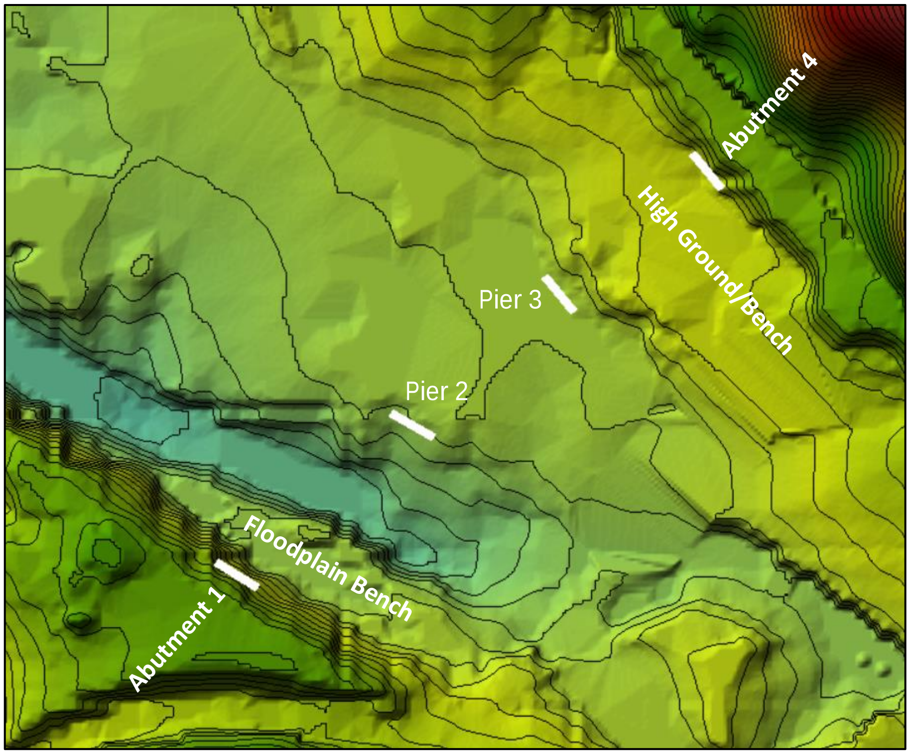

Figure 3-6. Terrain with 2-foot contour lines

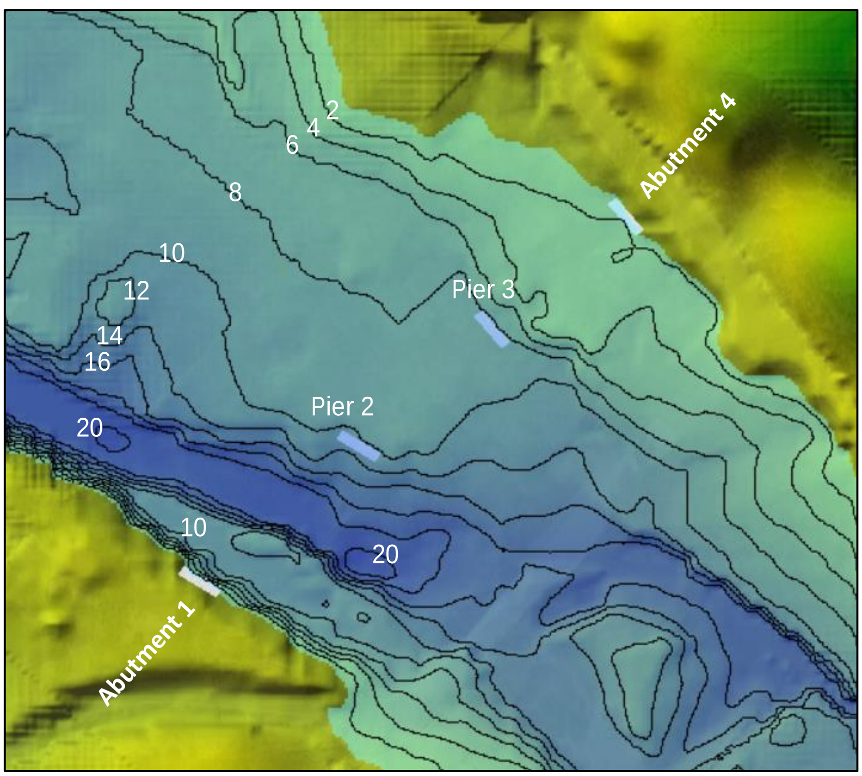

Figure 3-7. 100-year Depth with 2-ft contours labeled

Pier 2

Pier 2 will be founded on bedrock. Riprap protection with a depth of 9 feet has been specified to protect the ground improvements around Pier 2—these improvements will be installed for seismic purposes. Riprap should have a minimum D_{50} of 35 inches, which corresponds to FHWA Standard Riprap Class IX Gradation. Riprap should be installed flush with the existing ground elevation to avoid creating hydraulic impacts. Note that the riprap is intended to protect the ground improvements and per HEC-18, should not be relied upon for foundation design purposes.

Pier 3

Pier 3 will be founded on bedrock, and there are no ground improvements specified by the geotechnical engineer for Pier 3. Rock riprap protection is optional for this pier but may be specified using the same riprap size as Pier 2 as an extra precaution.

Abutment 4

Abutment 4 will be founded on bedrock. Riprap protection is not required at Abutment 4 due to the small computed 100-year flood depths (approximately 2 ft) and velocities less than 2 ft/sec. The terrain is higher along Abutment 4 than in the rest of the floodplain, there is dense vegetation that slows down the flow even further, and based on the historic channel alignments, the main channel is expected to stay far from the abutment (see Section 3.1).

Riprap Sizing and Material

Riprap sizing calculations are provided in Appendix E. Riprap should have a minimum D_{50} of 35 inches, which corresponds to FHWA Standard Riprap Class IX Gradation, which has a D_{50} of 36 inches. This riprap sizing is based on the main channel hydraulics but can be used for Abutment 1 in addition to the piers. However, the thickness of the bank protection at Abutment 1 should be 6 ft, which is equal to 2 times Class IX riprap D_{50} and D_{100} in this case.

The riprap thickness at piers should be a minimum of 9 ft, which is equal to 3 times D_{50} of the Class IX riprap. This riprap thickness is a conservative value based on designing a pier scour countermeasure; however, the purpose of the riprap is to protect the ground improvements in this case.

Rock material must meet the standards described in Section 72-2.02B of the Caltrans Standard Specifications. Geotextile should be RSP (Rock Slope Protection) fabric as described in Section 72-2.02C of the Caltrans Standard Specifications.

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5 ACKNOWLEDGMENTS

This study was performed for California Trout (CalTrout), with direction provided by Sandra Jacobson, Ph.D. The River Focus study team included Jake Gusman, P.E. (Project Manager), Darren Bertrand, CFM, Mikell Warms, EIT, Rumana Reaz Arifin, Ph.D., and Grant Brady, EIT.

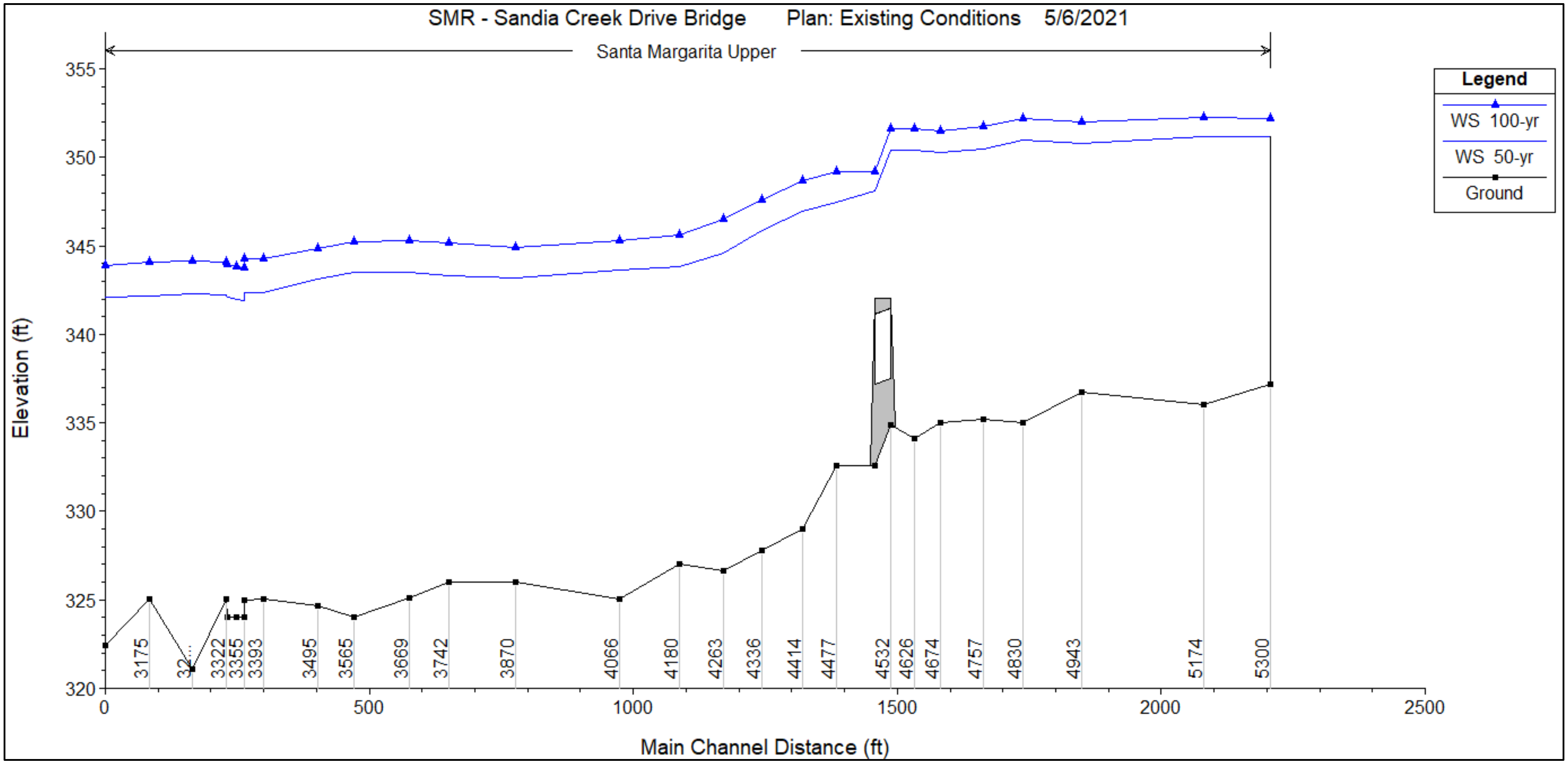
Appendix A – Floodplain Workmaps

Exhibit A-1
Santa Margarita River
Sandia Creek Drive Bridge
Existing Conditions Floodplain Workmap


Exhibit A-2
Santa Margarita River
Sandia Creek Drive Bridge
Proposed Conditions Floodplain Workmap
Feet
0 50 100 200 300 400
CALIFORNIA TROUT
FISH · WATER · PEOPLE
May 2021
N
RIVER FOCUS
WATER RESOURCE CONSULTANTS
Legend
HEC-RAS Model Cross Sections (100-yr WSE)
Stream Centerline
Effective 100-yr Floodplain (Zone A)
Proposed Bridge
Proposed Approach Roads
Proposed Abutments/Piers
Revised 100-year Floodplain
2-foot Contours
10-foot Contours
Notes:
1. Vertical Datum - NAVD88
2. Aerial Photography - ESRI Online Imagery
Floodplain Limits Certified By:
REGISTERED PROFESSIONAL ENGINEER
No. C 61032
EXP. 12/31/22
CIVIL
STATE OF CALIFORNIA
Sandia Creek Dr.
Rock Mountain Rd.
Limit of Revision
Limit of Revision
Stn. 3093, WSE: 343.9 ft
Stn. 3175, WSE: 344.06 ft
Stn. 3259, WSE: 344.12 ft
Stn. 3322, WSE: 344.09 ft
Stn. 3323, WSE: 343.97 ft
Stn. 3341, WSE: 343.82 ft
Stn. 3355, WSE: 343.75 ft
Stn. 3356, WSE: 344.27 ft
Stn. 3393, WSE: 344.27 ft
Stn. 3495, WSE: 344.85 ft
Stn. 3565, WSE: 345.25 ft
Stn. 3669, WSE: 345.31 ft
Stn. 3742, WSE: 345.15 ft
Stn. 3870, WSE: 344.9 ft
Stn. 4066, WSE: 345.32 ft
Stn. 4180, WSE: 345.63 ft
Stn. 4240, WSE: 346.29 ft
Stn. 4307, WSE: 348.57 ft
Stn. 4414, WSE: 349.06 ft
Stn. 4477, WSE: 349.79 ft
Stn. 4540, WSE: 350.77 ft
Stn. 4626, WSE: 352.07 ft
Stn. 4674, WSE: 352.02 ft
Stn. 4757, WSE: 352.04 ft
Stn. 4830, WSE: 352.42 ft
Stn. 4943, WSE: 352.28 ft
Stn. 5174, WSE: 352.25 ft
Stn. 5300, WSE: 352.4 ft
400
450
500
550

Appendix B – HEC-RAS Model Output

Existing Conditions Model
Proposed Conditions Model

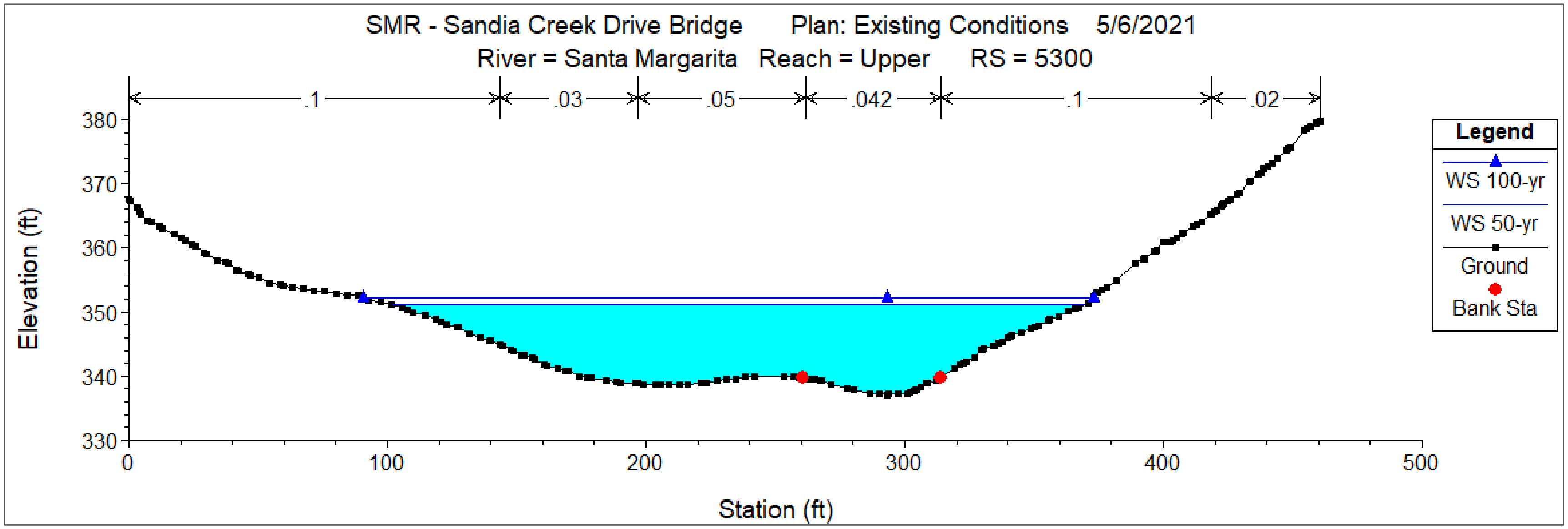


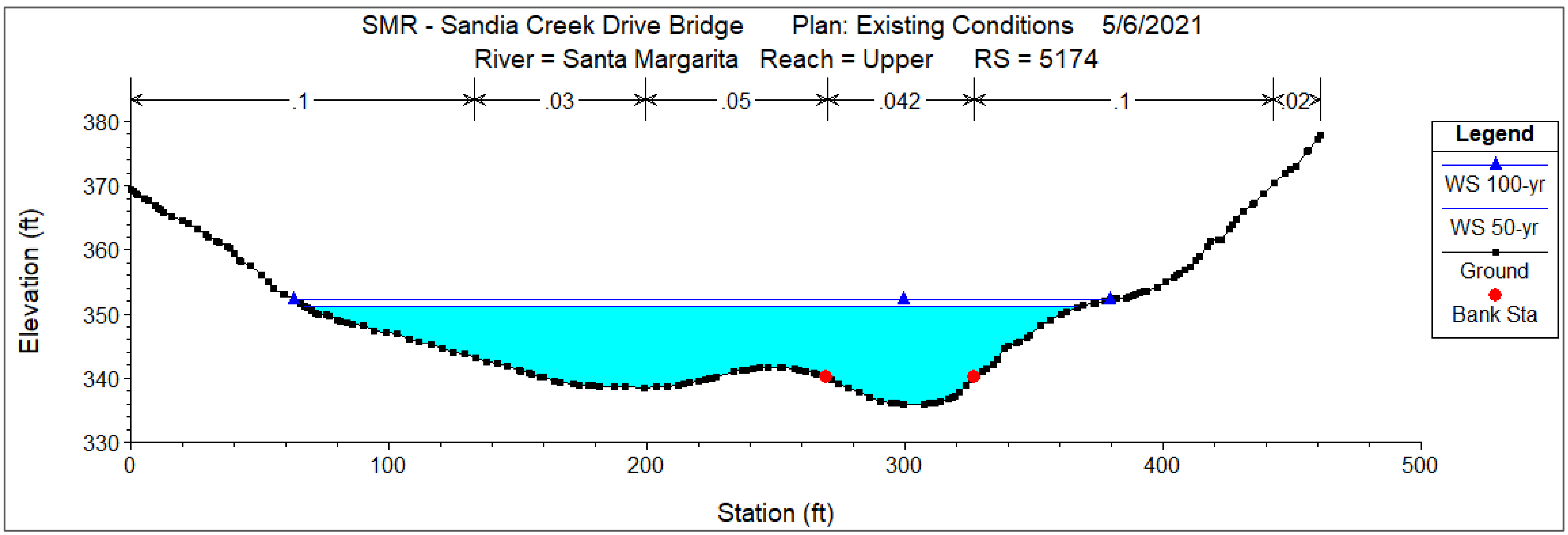
HEC-RAS Existing Conditions Water Surface Profile Plot

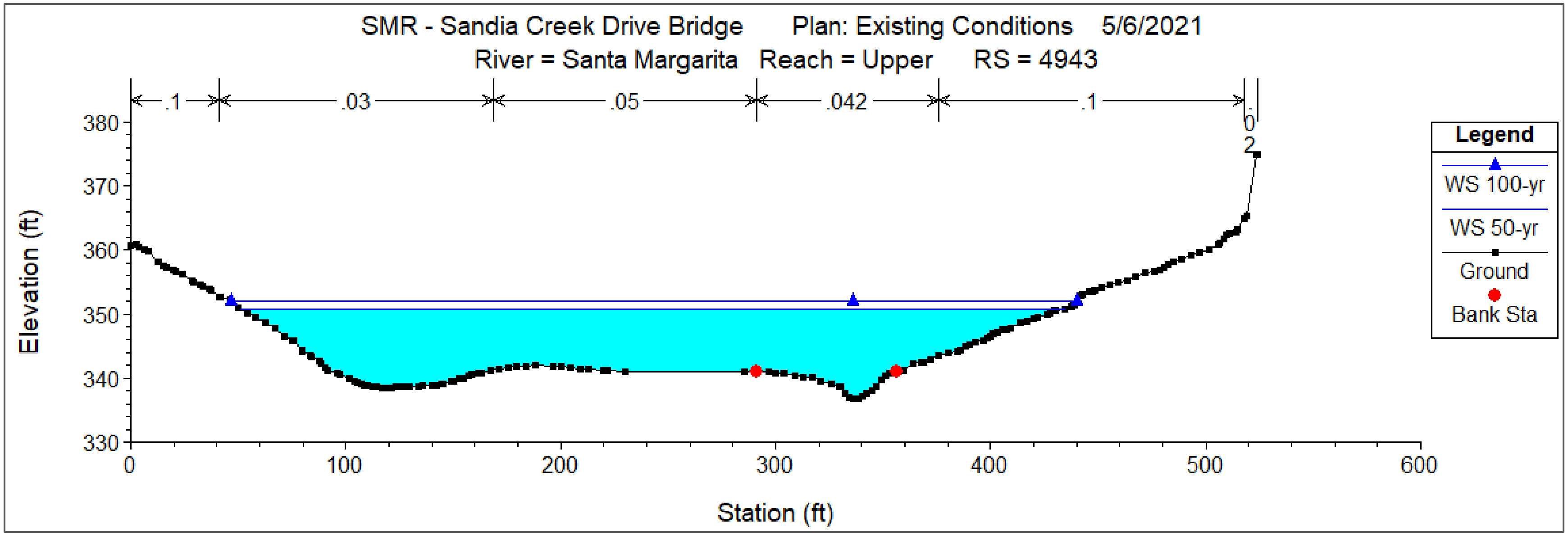
HEC-RAS Plan: Existing Conditions River: Santa Margarita Reach: Upper Profile: 100-yr

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	5300	100-yr	38600	337.15	352.29	351.17	356.06	0.007022	17.2	2713.03	283	0.81
Upper	5174	100-yr	38600	336.00	352.34	349.97	355.03	0.004830	14.8	3129.68	318	0.67
Upper	4943	100-yr	38600	336.75	352.12	348.67	353.83	0.003390	11.0	3835.57	394	0.55
Upper	4830	100-yr	38600	335.00	352.30	346.27	353.41	0.001380	9.7	5193.26	481	0.42
Upper	4757	100-yr	38600	335.22	351.84	347.90	353.28	0.002154	11.5	4556.57	525	0.52
Upper	4674	100-yr	38600	335.00	351.63	348.18	353.12	0.001788	12.5	4920.75	563	0.57
Upper	4626	100-yr	38600	334.14	351.68	346.45	352.89	0.001858	9.5	5221.34	553	0.44
Upper	4532		Culvert									
Upper	4477	100-yr	38600	332.59	349.22	343.76	350.17	0.007039	8.6	5453.01	591	0.39
Upper	4414	100-yr	38600	329.03	348.69	343.67	349.78	0.004943	10.1	5597.51	548	0.42
Upper	4336	100-yr	38600	327.76	347.58	343.73	349.46	0.002467	14.0	5233.86	563	0.59
Upper	4263	100-yr	38600	326.66	346.51	344.85	349.18	0.003317	16.0	5064.54	576	0.67
Upper	4180	100-yr	38600	327.00	345.66	344.26	348.82	0.004135	17.6	4882.84	565	0.76
Upper	4066	100-yr	38600	325.03	345.35	343.26	348.20	0.003274	16.6	5320.53	536	0.69
Upper	3870	100-yr	38600	326.00	344.94	342.43	347.42	0.003021	15.3	5770.38	699	0.65
Upper	3742	100-yr	38600	326.00	345.19	341.64	346.73	0.002120	12.7	6185.16	685	0.54
Upper	3669	100-yr	38600	325.11	345.35	340.35	346.47	0.001554	11.1	6757.18	696	0.46
Upper	3565	100-yr	38600	324.00	345.28	338.72	346.32	0.001129	9.7	6828.33	680	0.40
Upper	3495	100-yr	38600	324.63	344.89	338.98	346.21	0.001382	10.4	5618.19	697	0.44
Upper	3393	100-yr	42600	325.03	344.33	340.73	346.02	0.002161	11.9	5049.81	705	0.54
Upper	3356	100-yr	42600	325.01	344.32	340.11	345.87	0.002016	11.6	5754.99	759	0.53
Upper	3355	100-yr	42600	324.00	343.81	340.49	345.75	0.002092	12.9	5318.88	648	0.60
Upper	3341	100-yr	42600	324.00	343.88	340.10	345.63	0.001668	12.1	5455.70	656	0.56
Upper	3323	100-yr	42600	324.00	343.97	339.50	345.49	0.001426	11.1	5621.50	662	0.51
Upper	3322	100-yr	42600	325.07	344.09	338.55	345.36	0.001452	10.1	5942.25	734	0.45
Upper	3259	100-yr	42600	321.06	344.12	336.92	345.21	0.000984	9.2	6126.62	680	0.38
Upper	3175	100-yr	42600	325.08	344.06	337.24	345.10	0.001684	8.8	5701.38	643	0.38
Upper	3093	100-yr	42600	322.42	343.90	335.91	344.97	0.001501	8.6	5551.22	561	0.36

HEC-RAS Existing Conditions Model Cross Sections



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Legend
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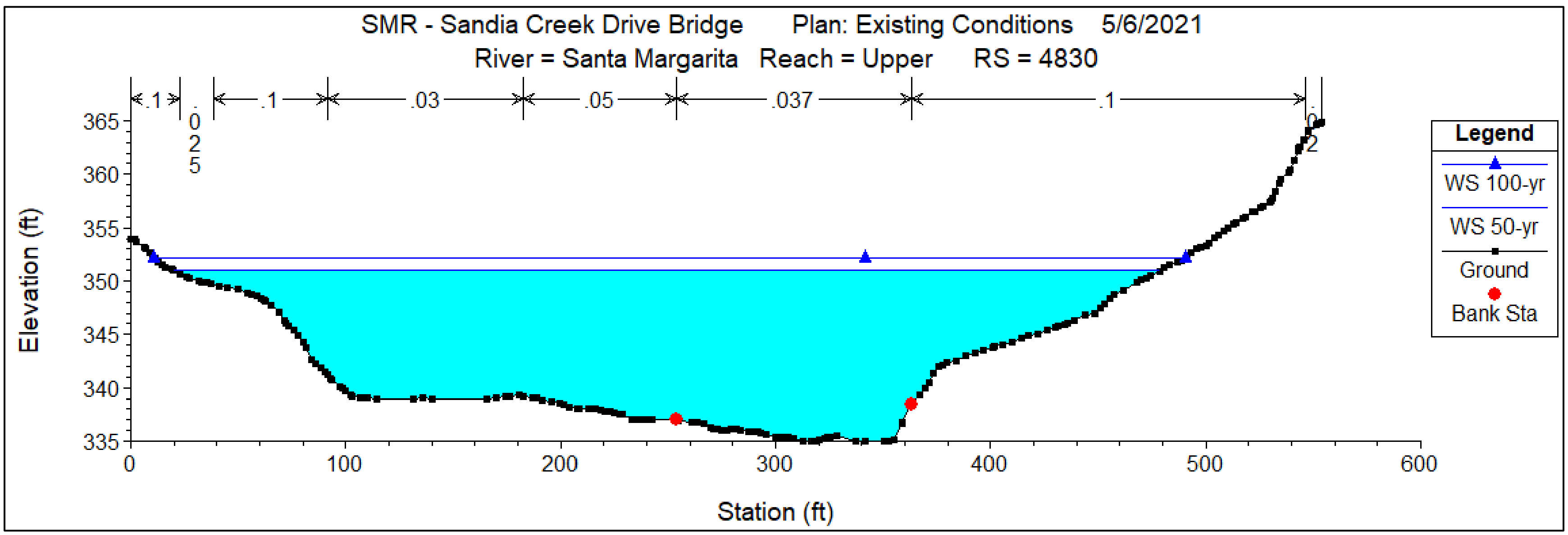
WS 50-yr
Ground
Bank Sta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Station (ft)
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WS 50-yr
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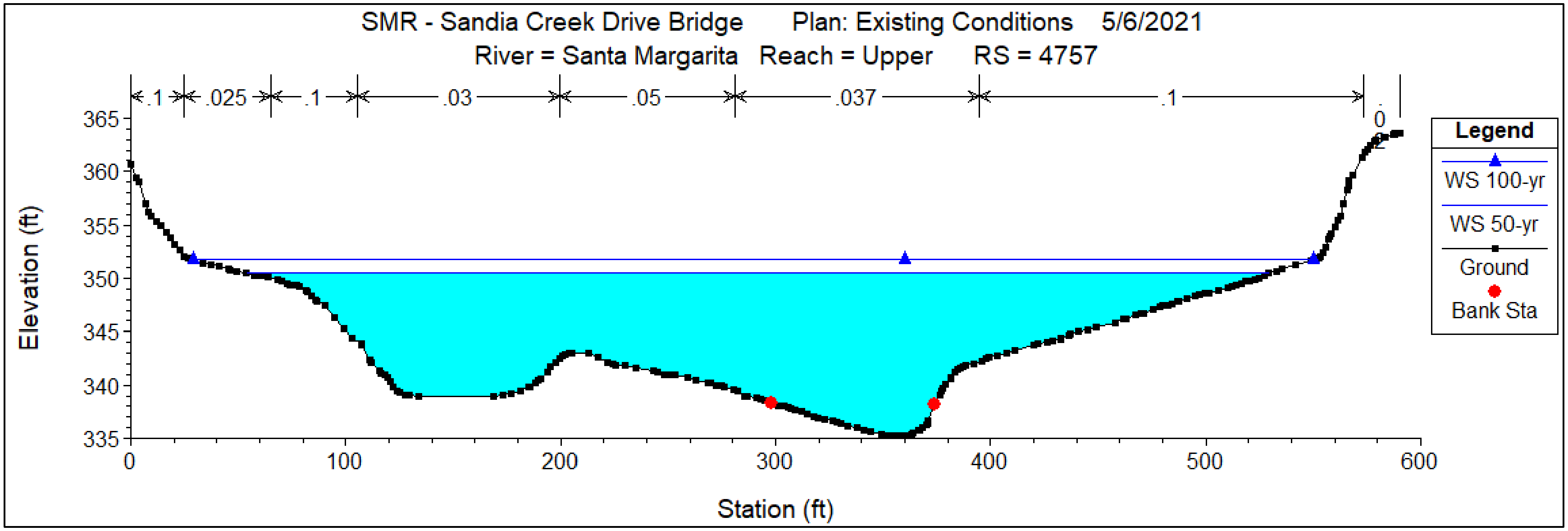
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Station (ft)
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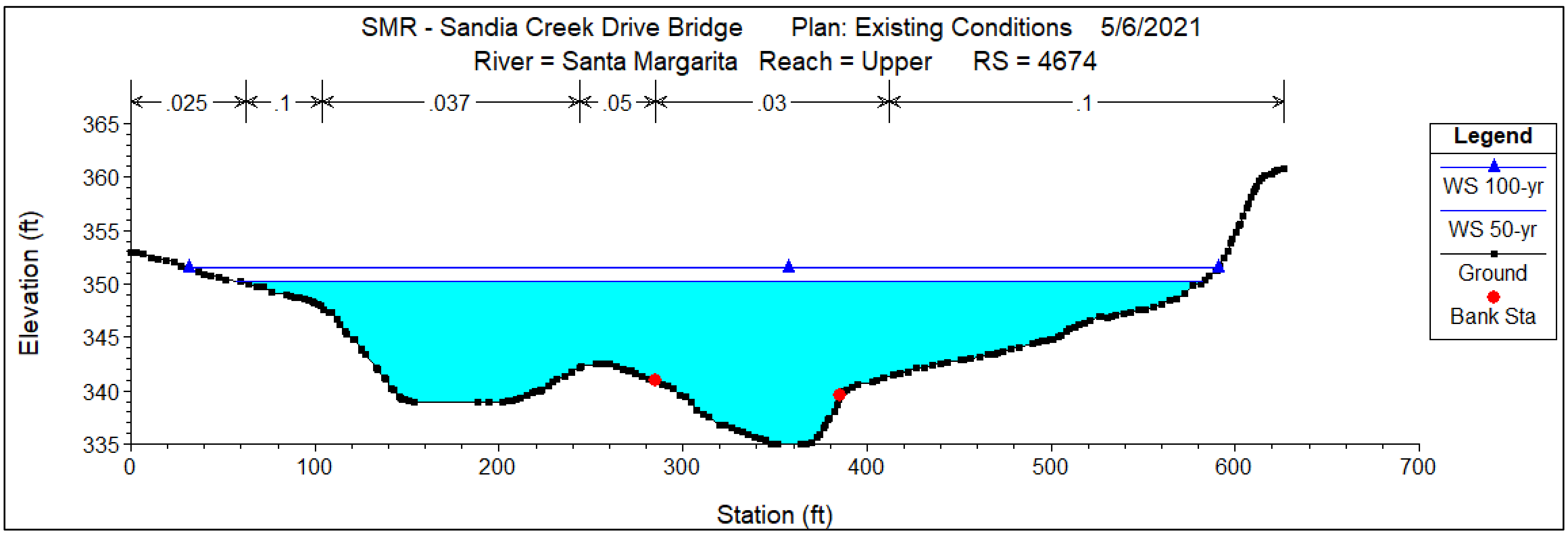
WS 50-yr
Ground
Bank Sta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Station (ft)
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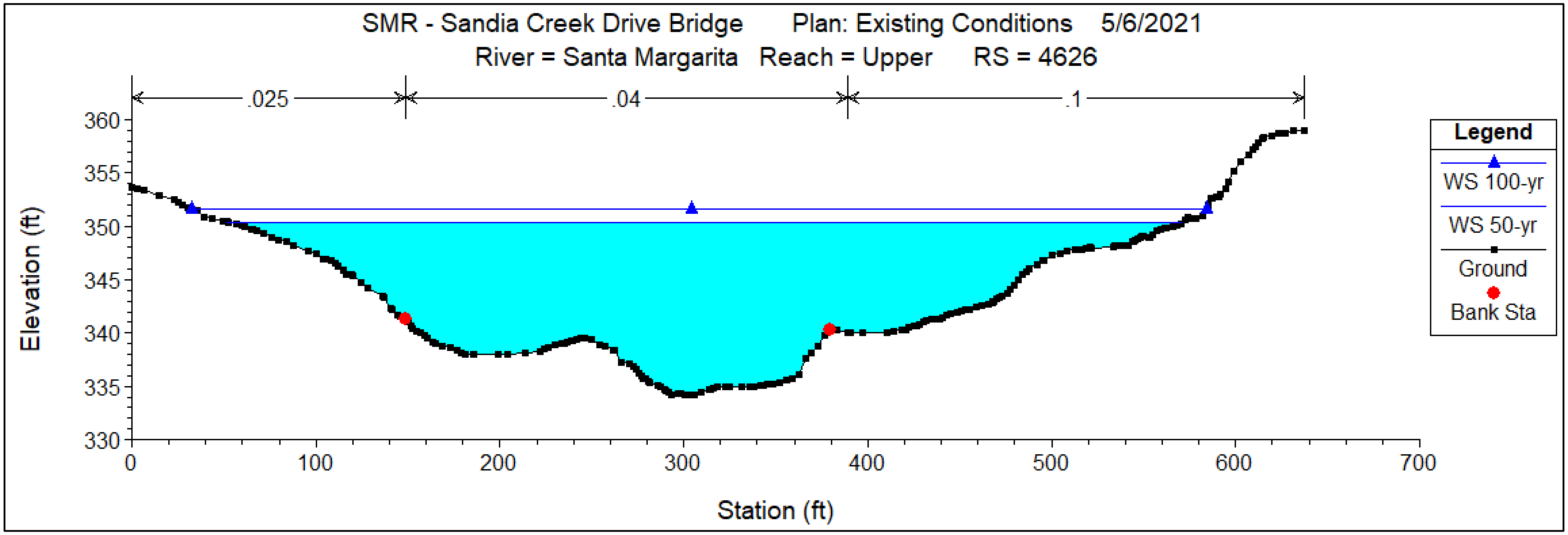
WS 50-yr
Ground
Bank Sta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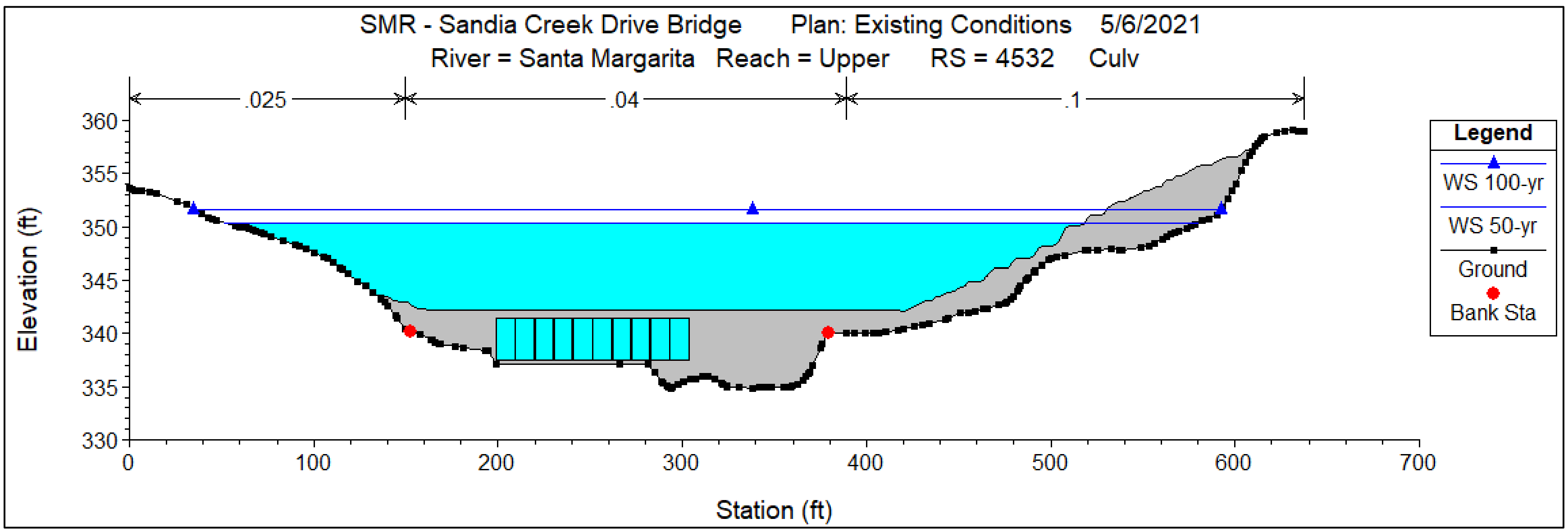
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta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Legend
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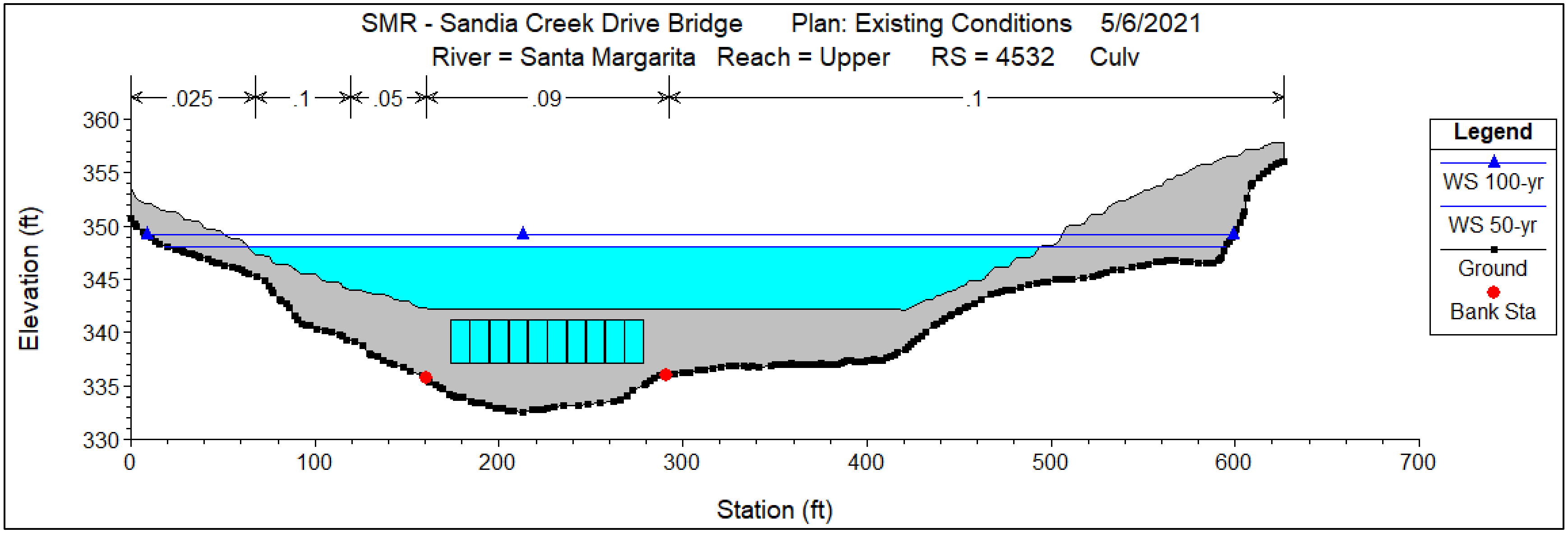
WS 50-yr
Ground
Bank Sta



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Station (ft)
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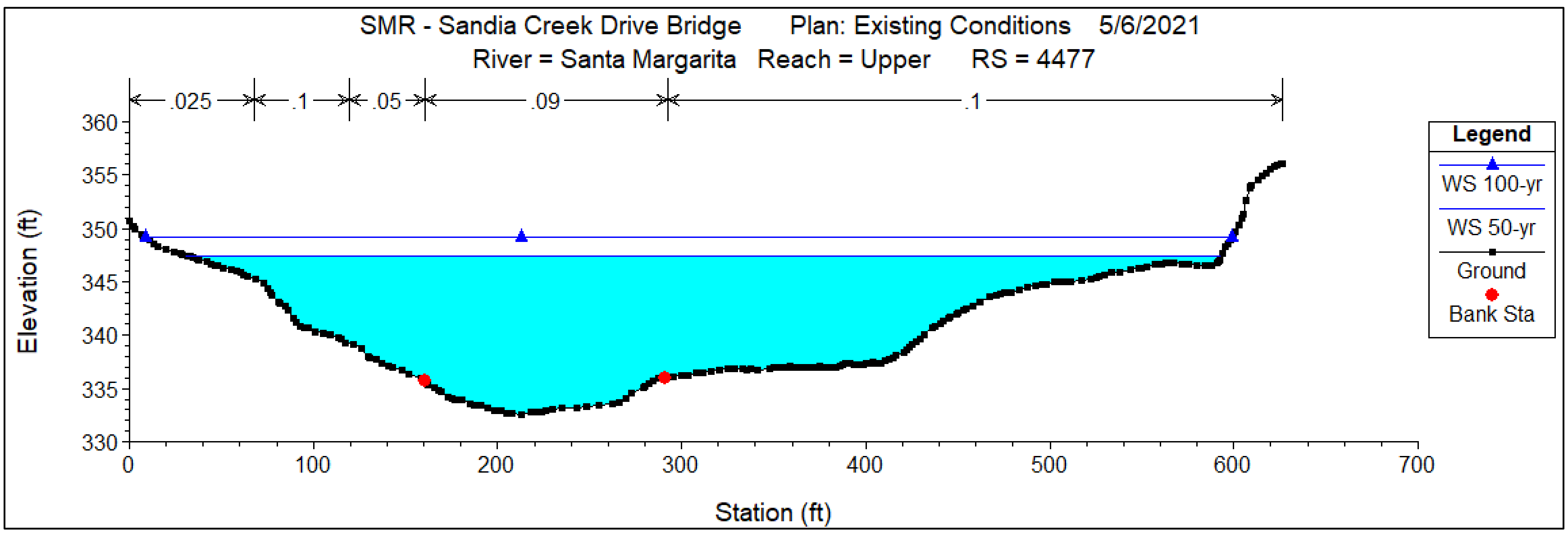
WS 50-yr
Ground
Bank Sta



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Station (ft)
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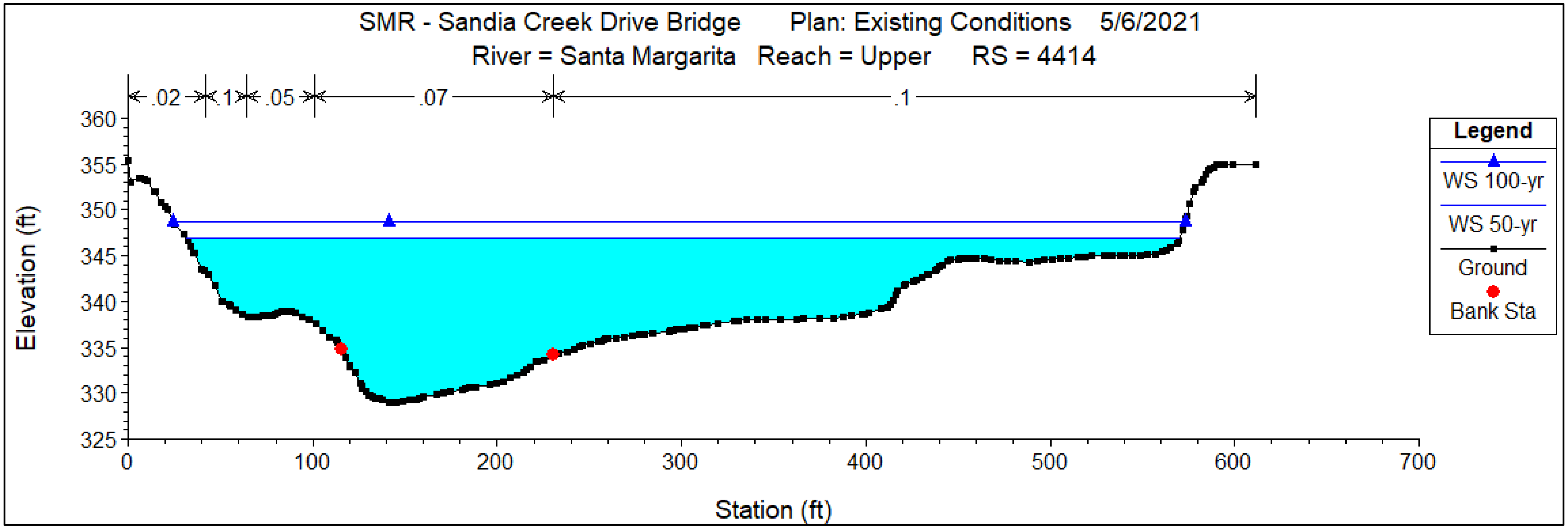
WS 50-yr
Ground
Bank Sta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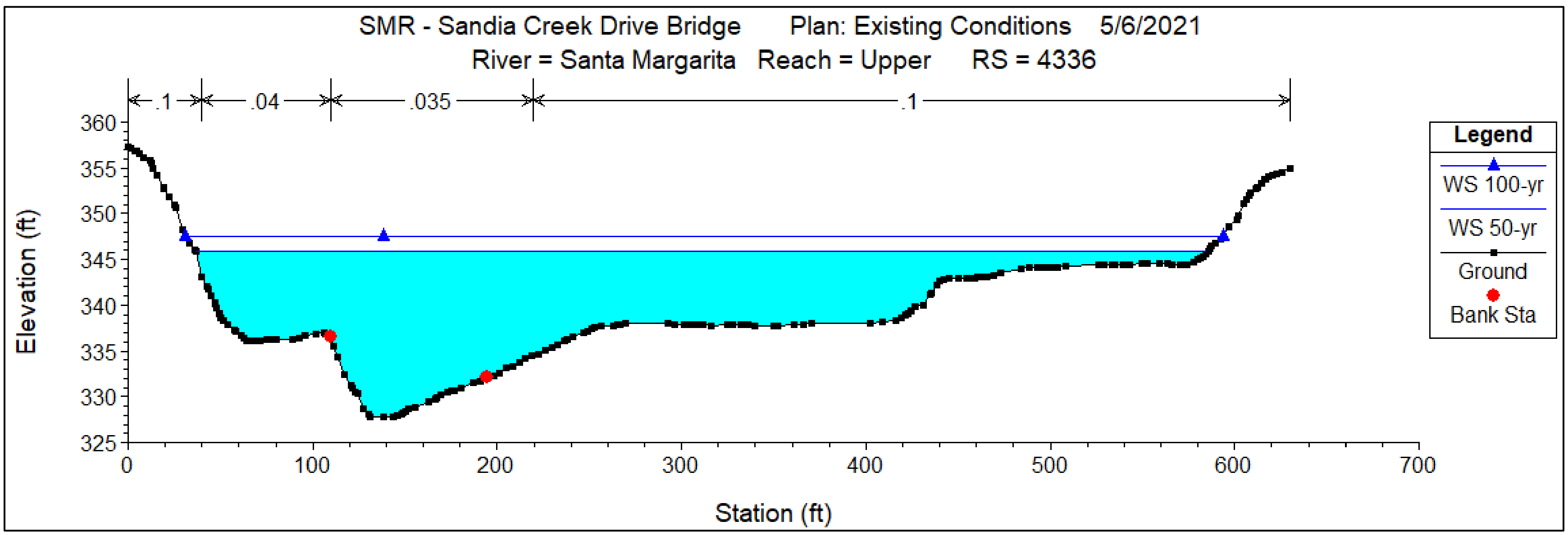
400
500
600
700
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta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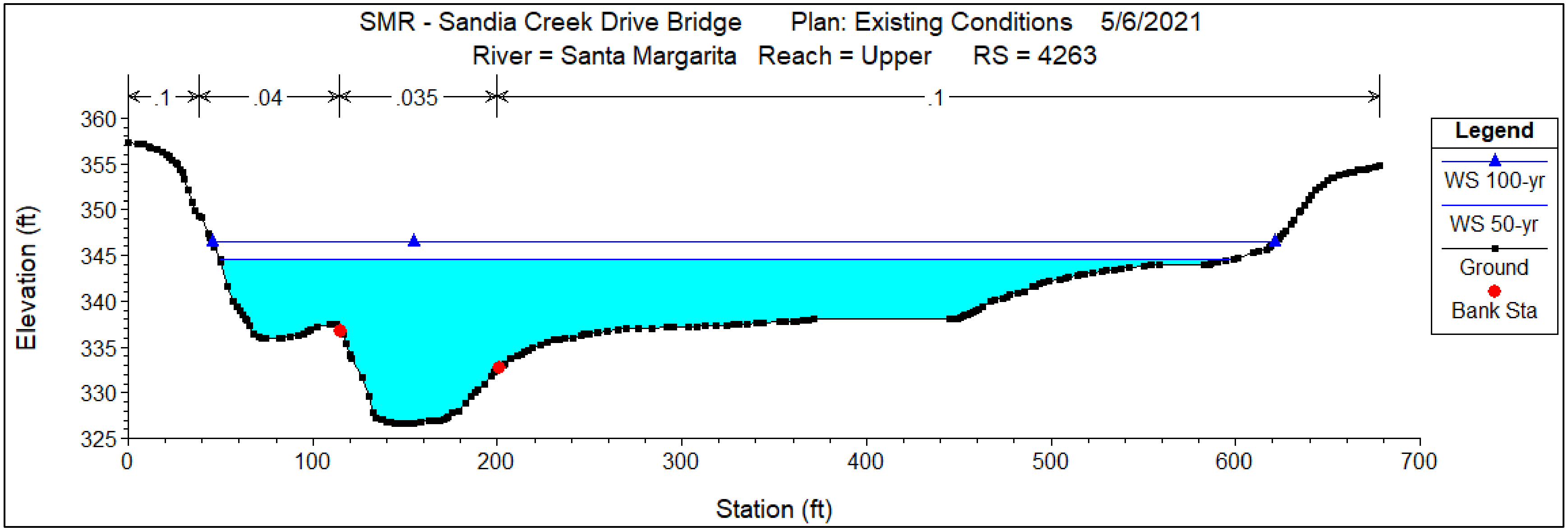
Bank Sta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Station (ft)
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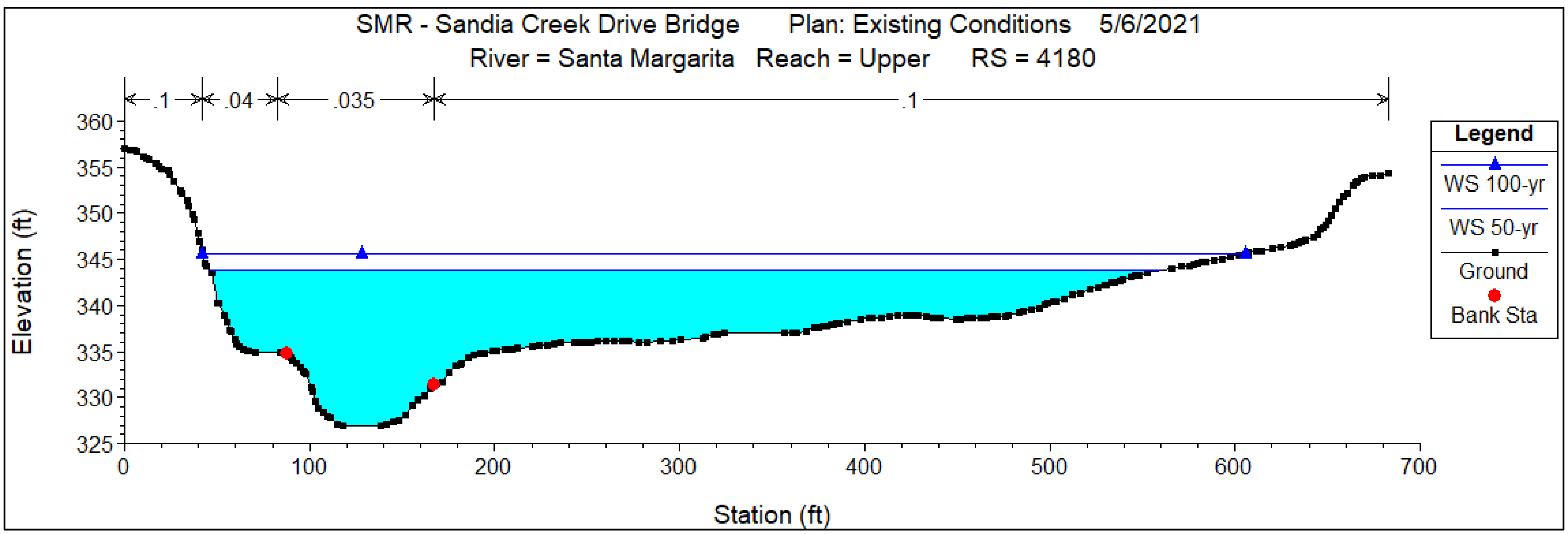
WS 50-yr
Ground
Bank Sta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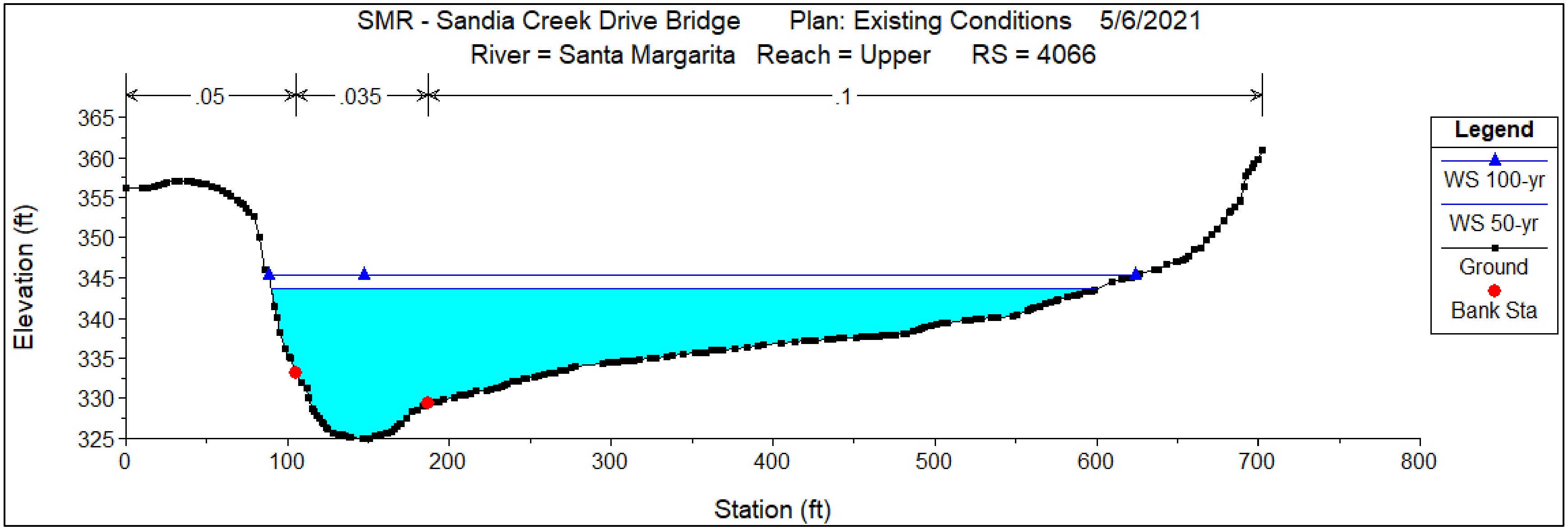
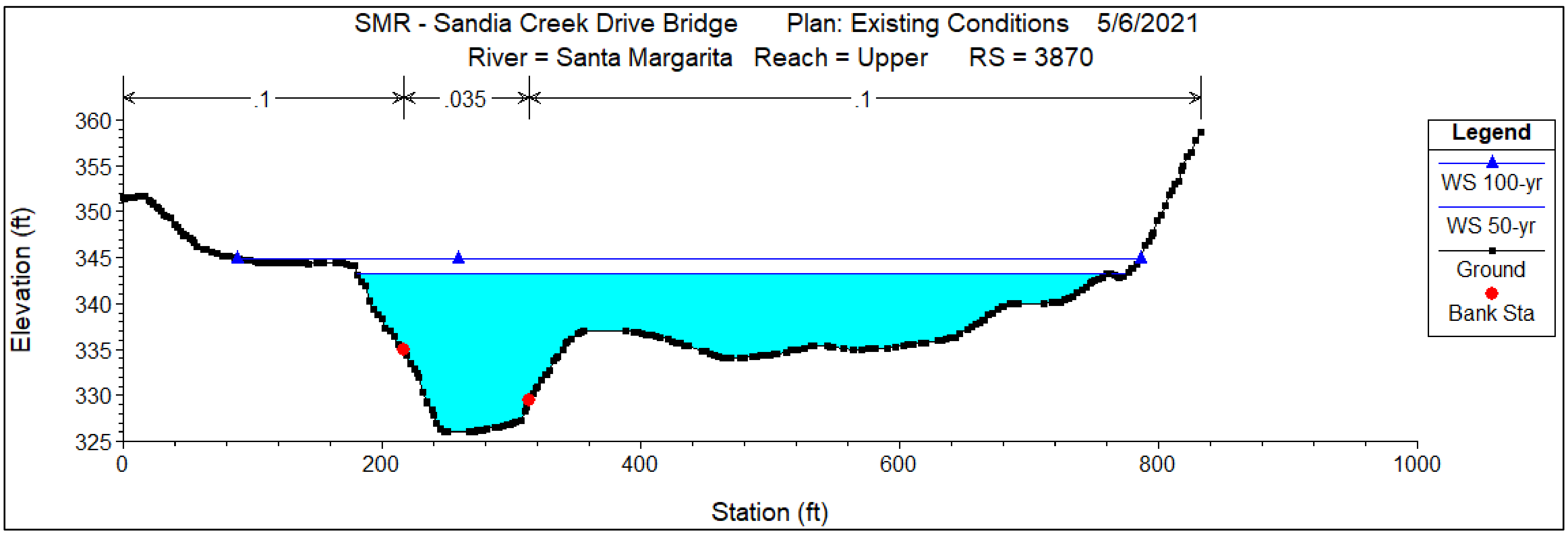
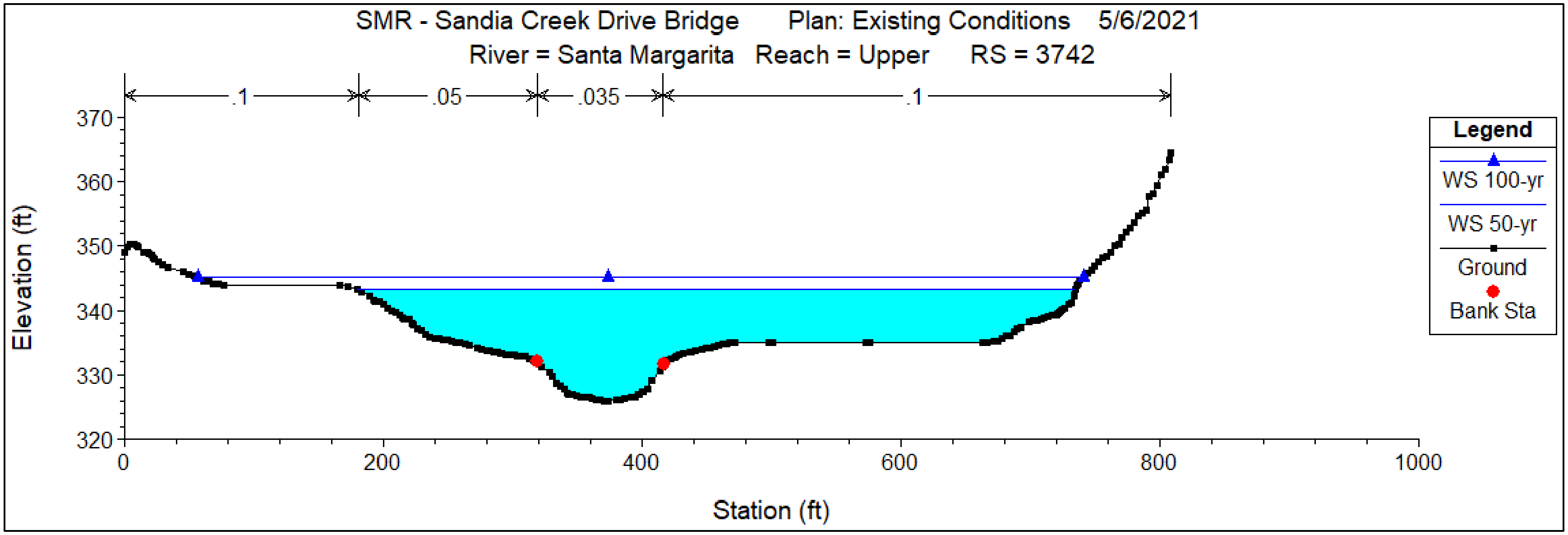
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

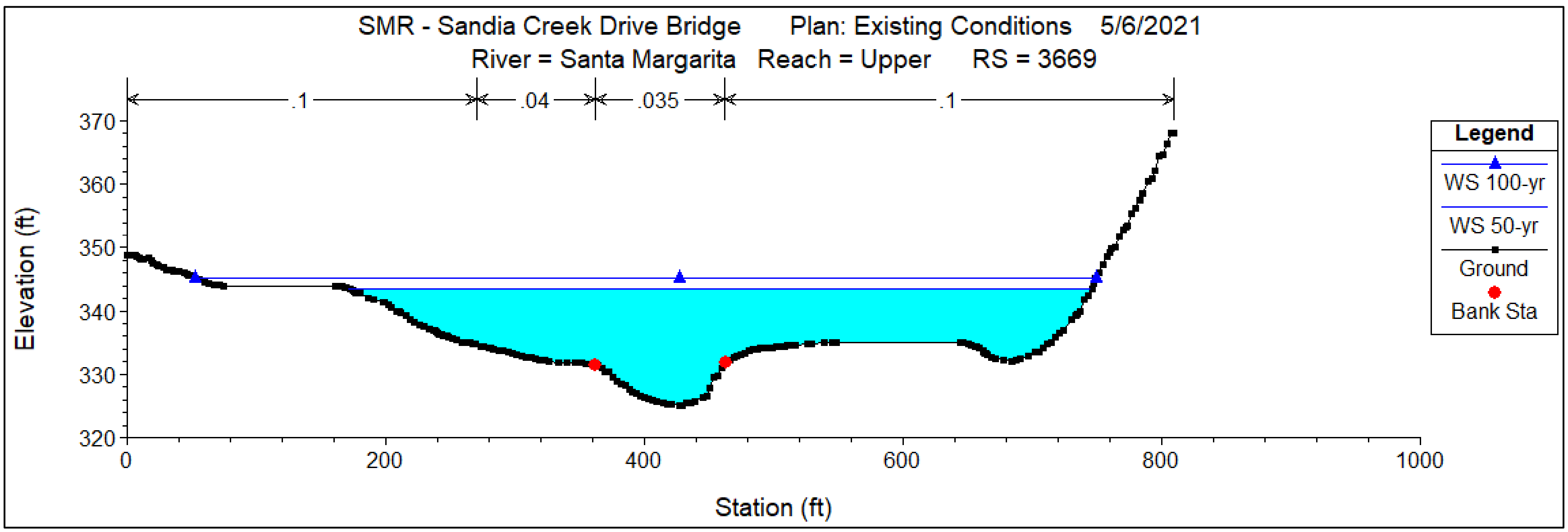


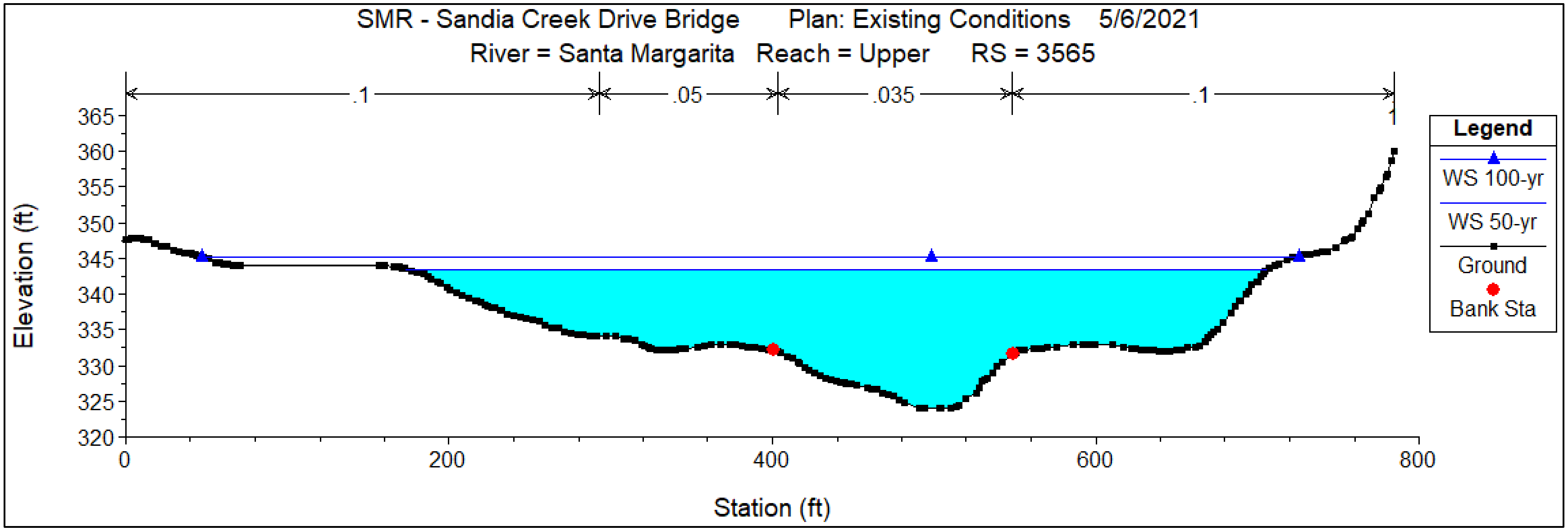
SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4066
.05
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

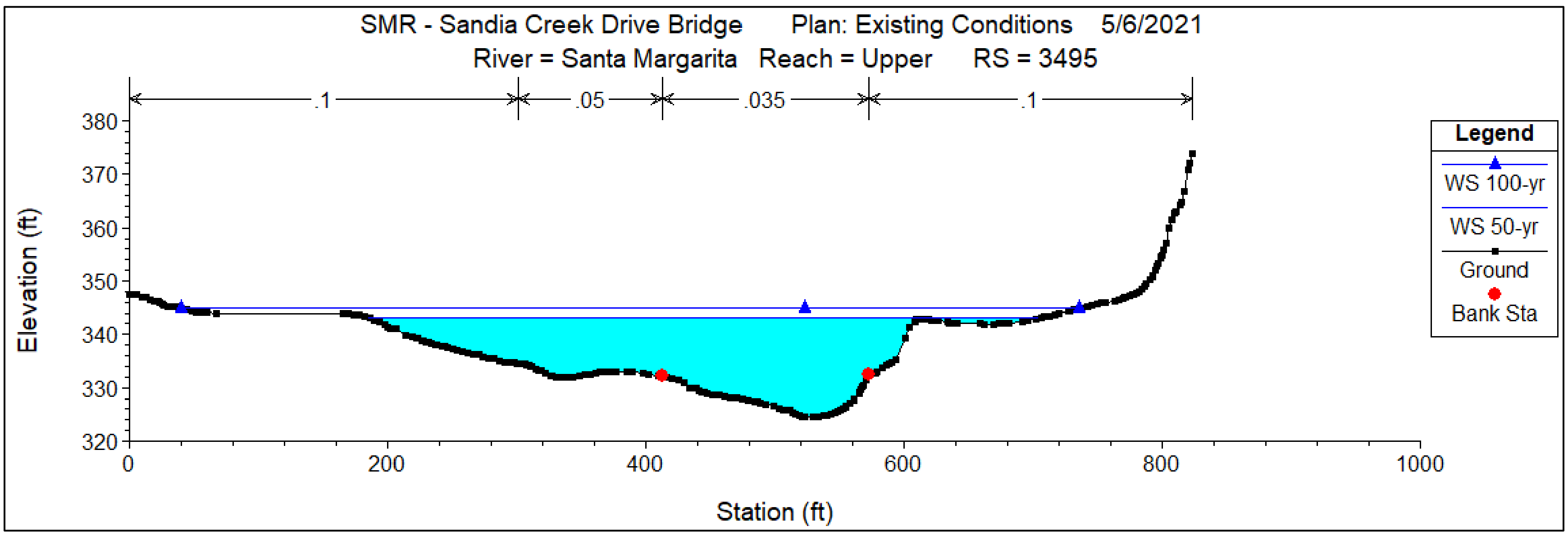


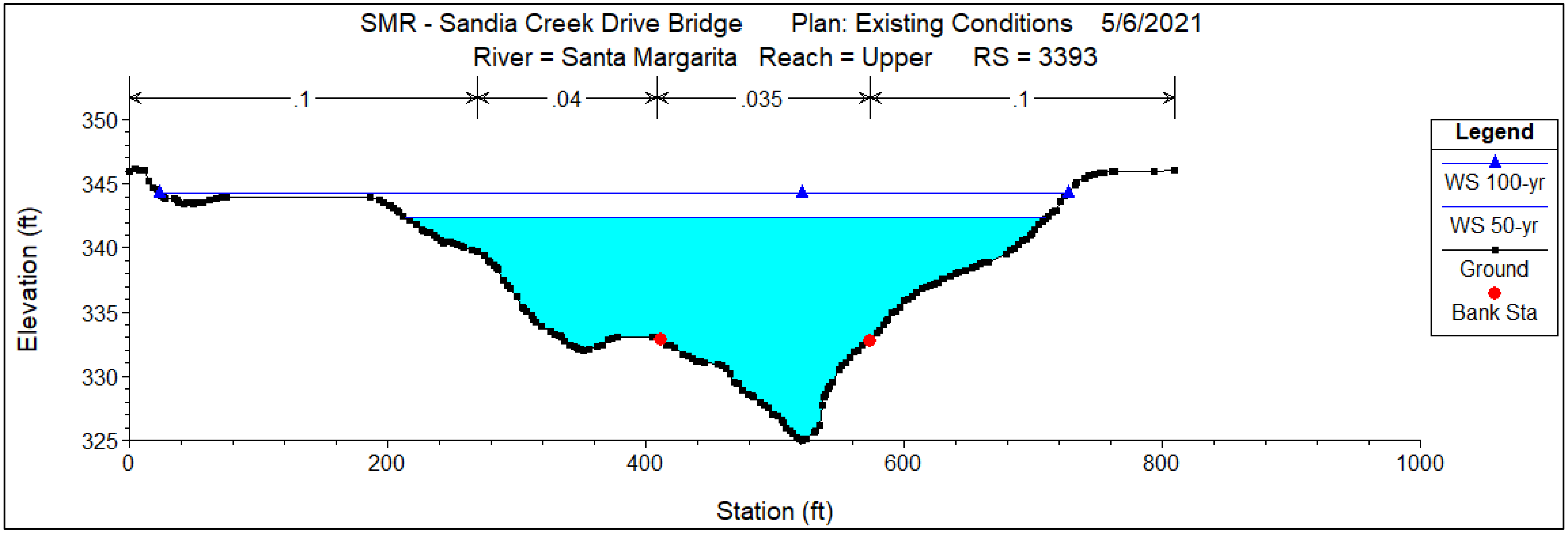
SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3870
.1
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

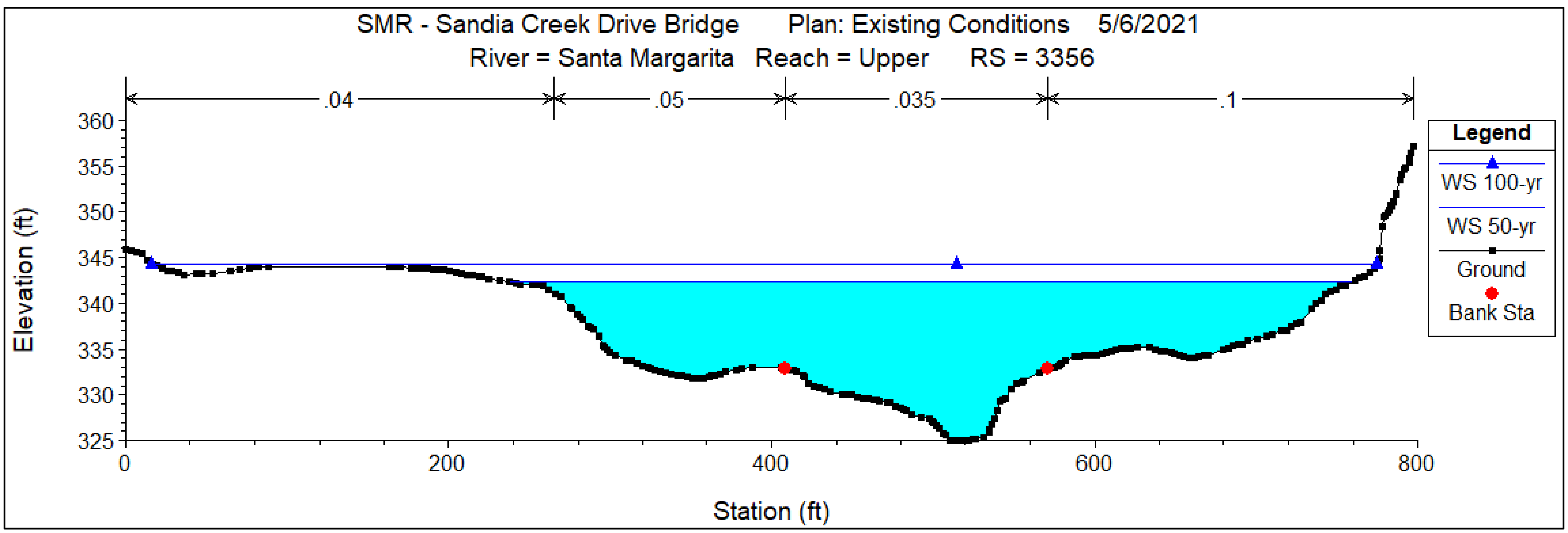

SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3742
.1
.05
.035
.1
Elevation (ft)
370
360
350
340
330
320
0
200
400
600
800
1000
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

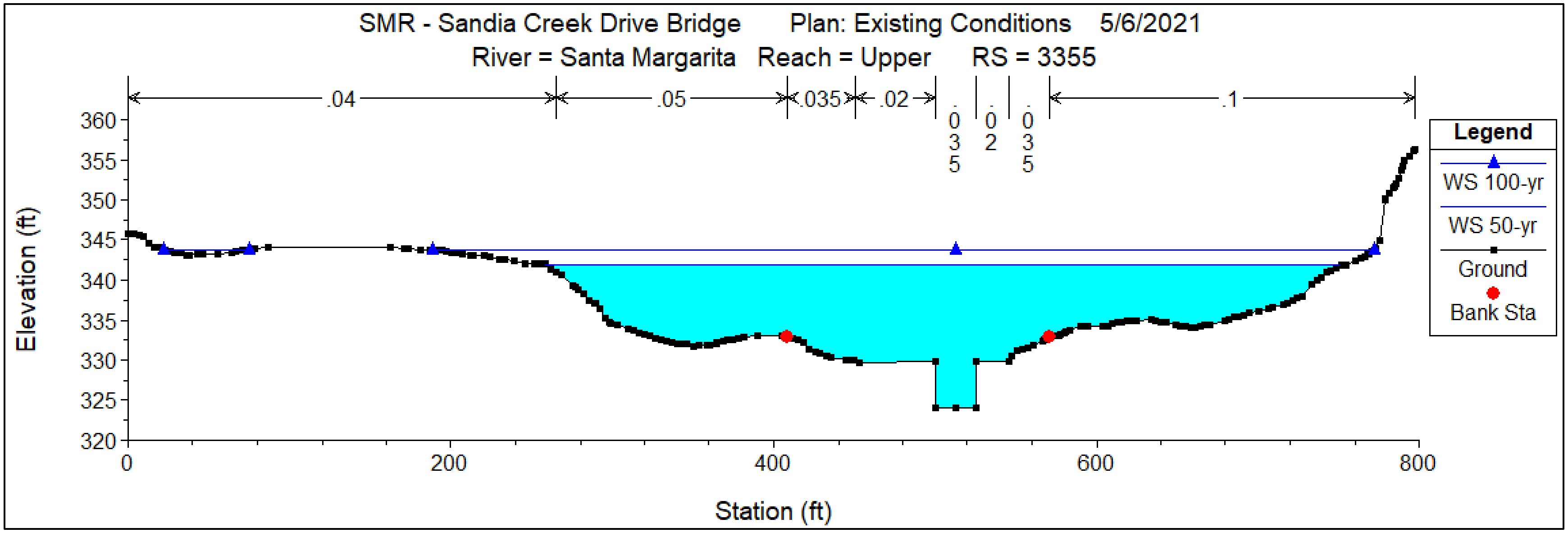

SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3669
.1
.04
.035
.1
Elevation (ft)
370
360
350
340
330
320
0
200
400
600
800
1000
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta


SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3565
.1
.05
.035
.1
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

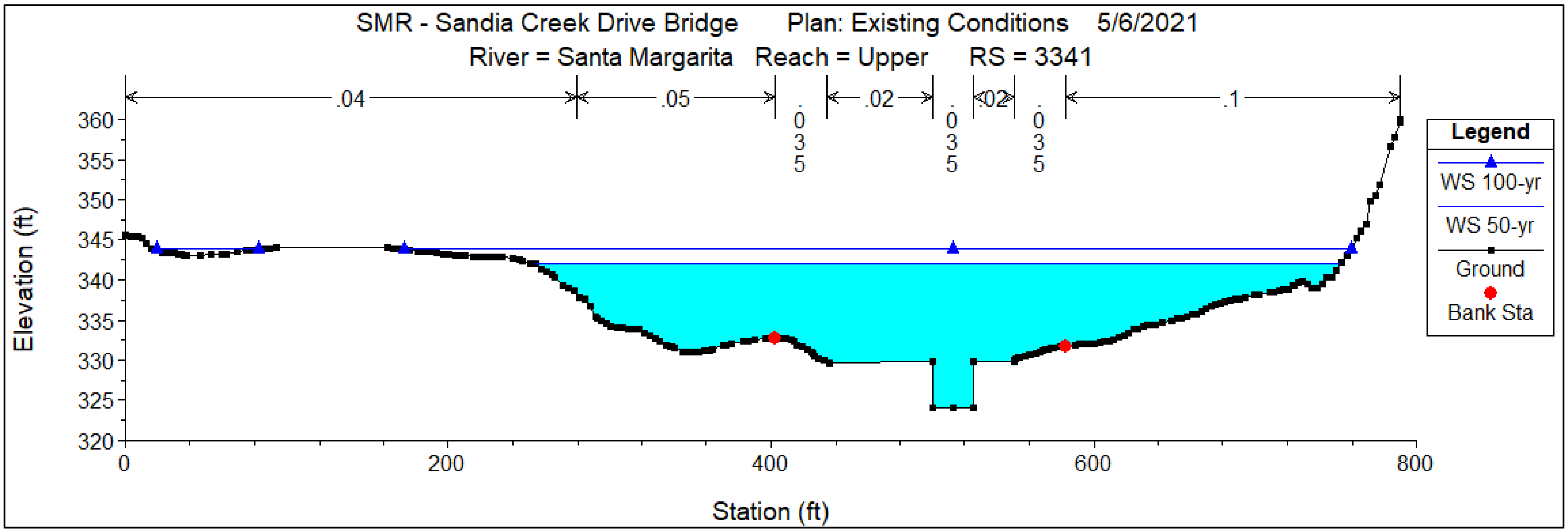

SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3495
.1
.05
.035
.1
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3393
.1
.04
.035
.1
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta
Elevation (ft)
350
345
340
335
330
325
0
200
400
600
800
1000
Station (ft)

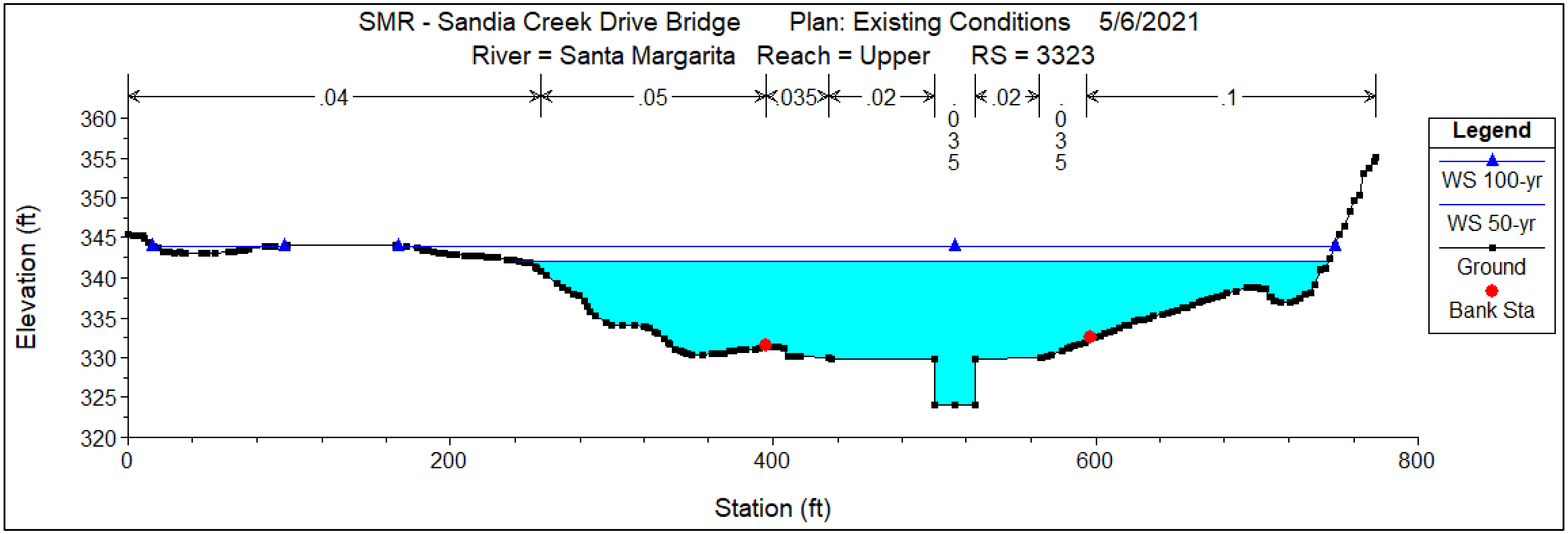

SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3356
.04
.05
.035
.1
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta
Elevation (ft)
360
355
350
345
340
335
330
325
0
200
400
600
800
Station (ft)

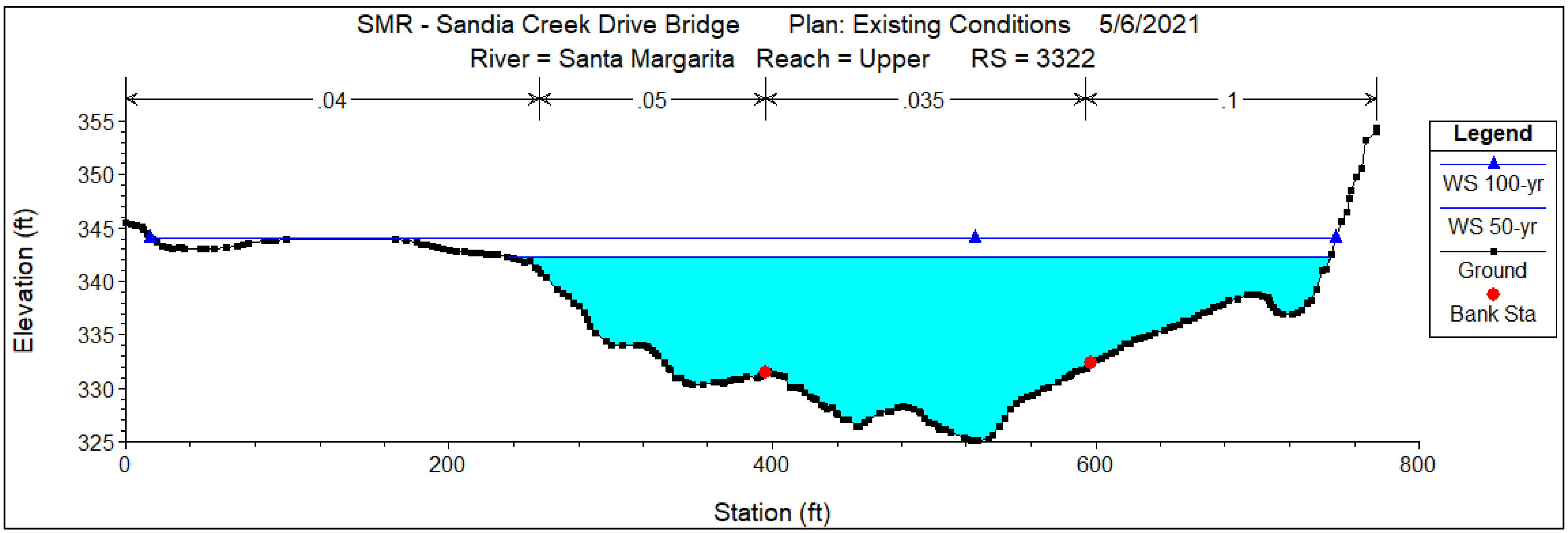


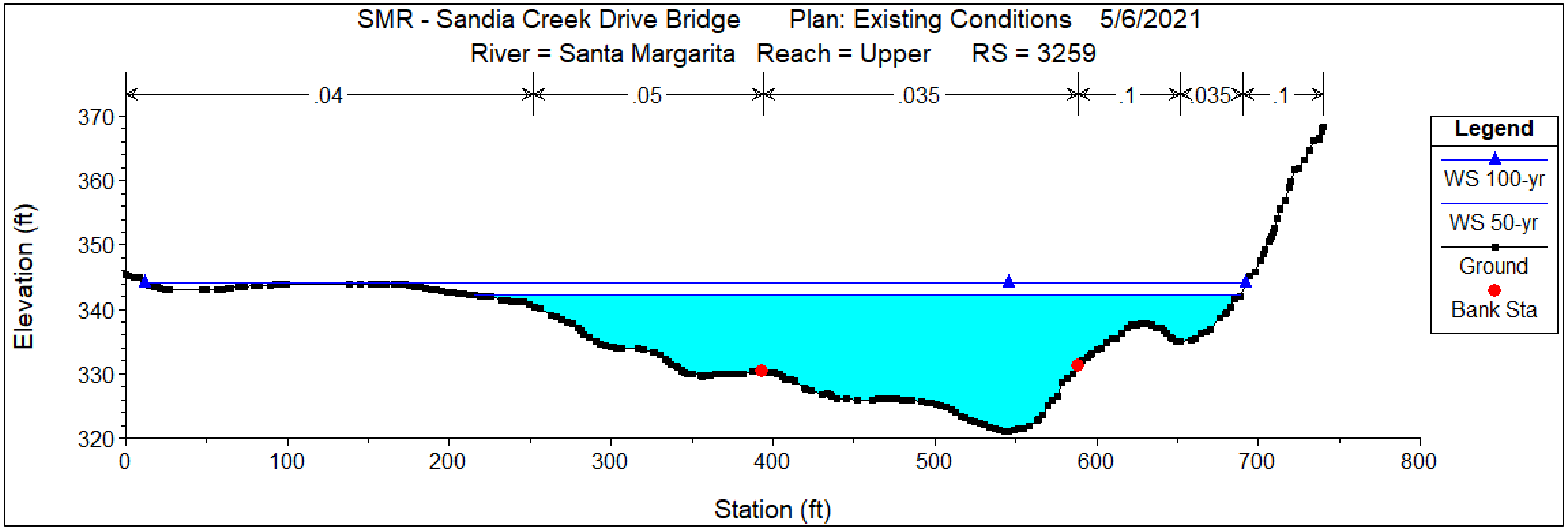
SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3355
.04
.05
.035
.02
.035
.02
.035
.1
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

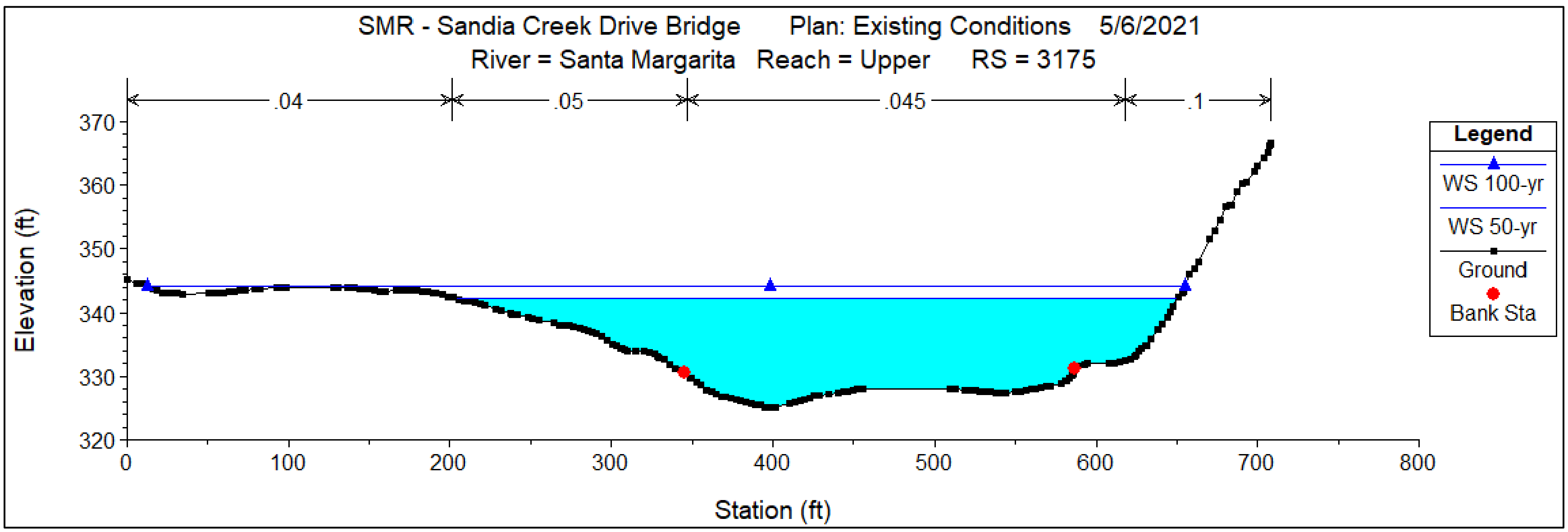


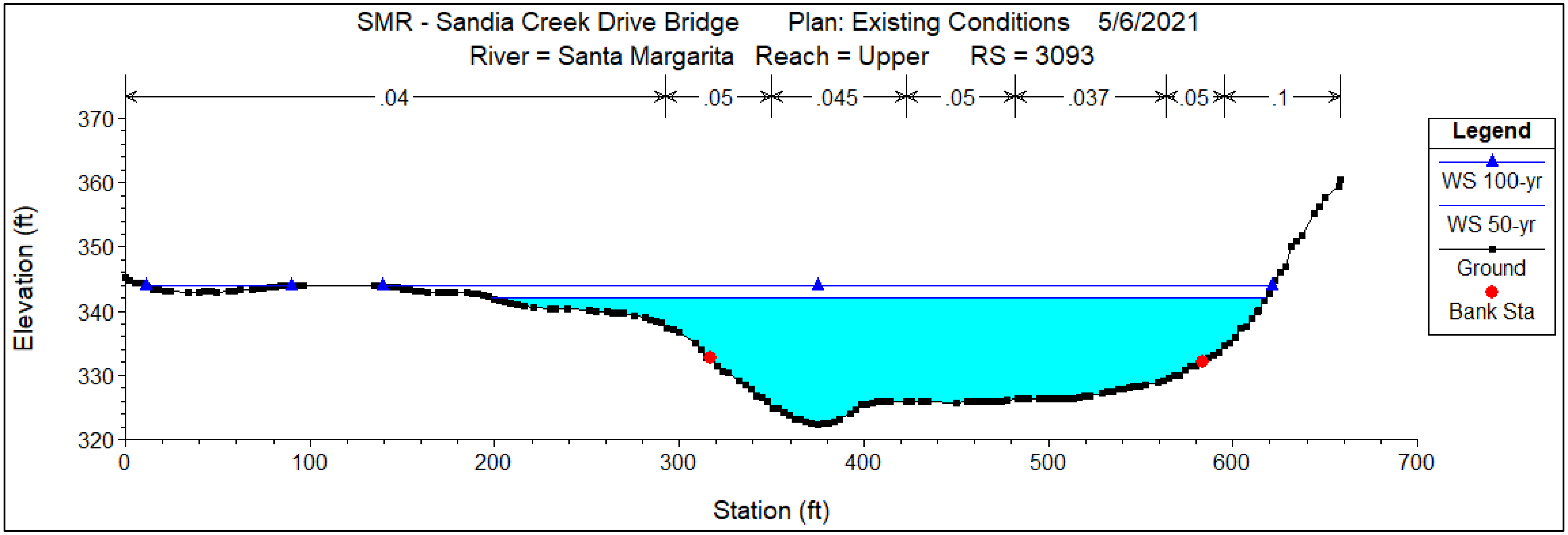
SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3341
.04
.05
.035
.02
.035
.02
.035
.1
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3323
.04
.05
.035
.02
.035
.02
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

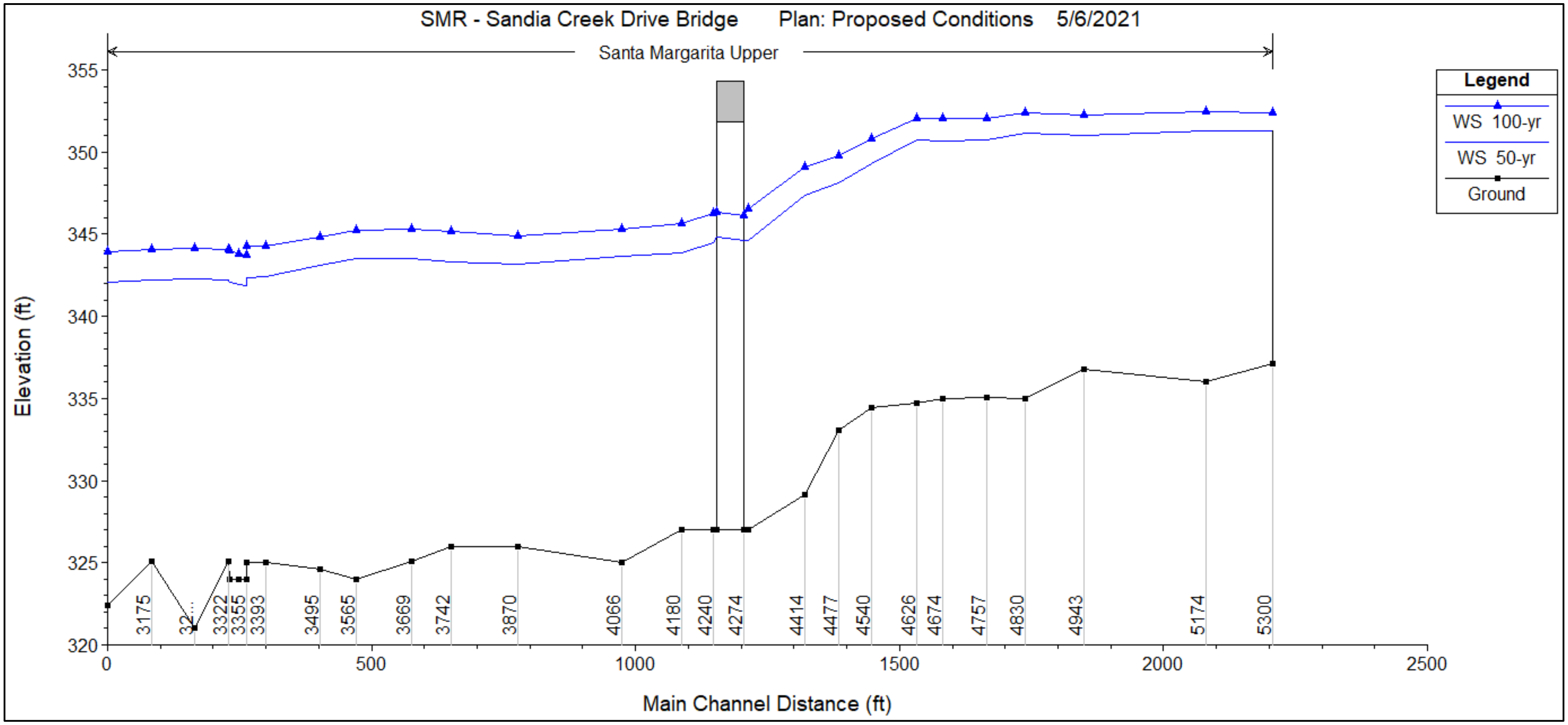

SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3322
.04
.05
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta


SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3259
.04
.05
.035
.1
.035
.1
Elevation (ft)
370
360
350
340
330
320
0
100
200
300
400
500
600
700
800
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

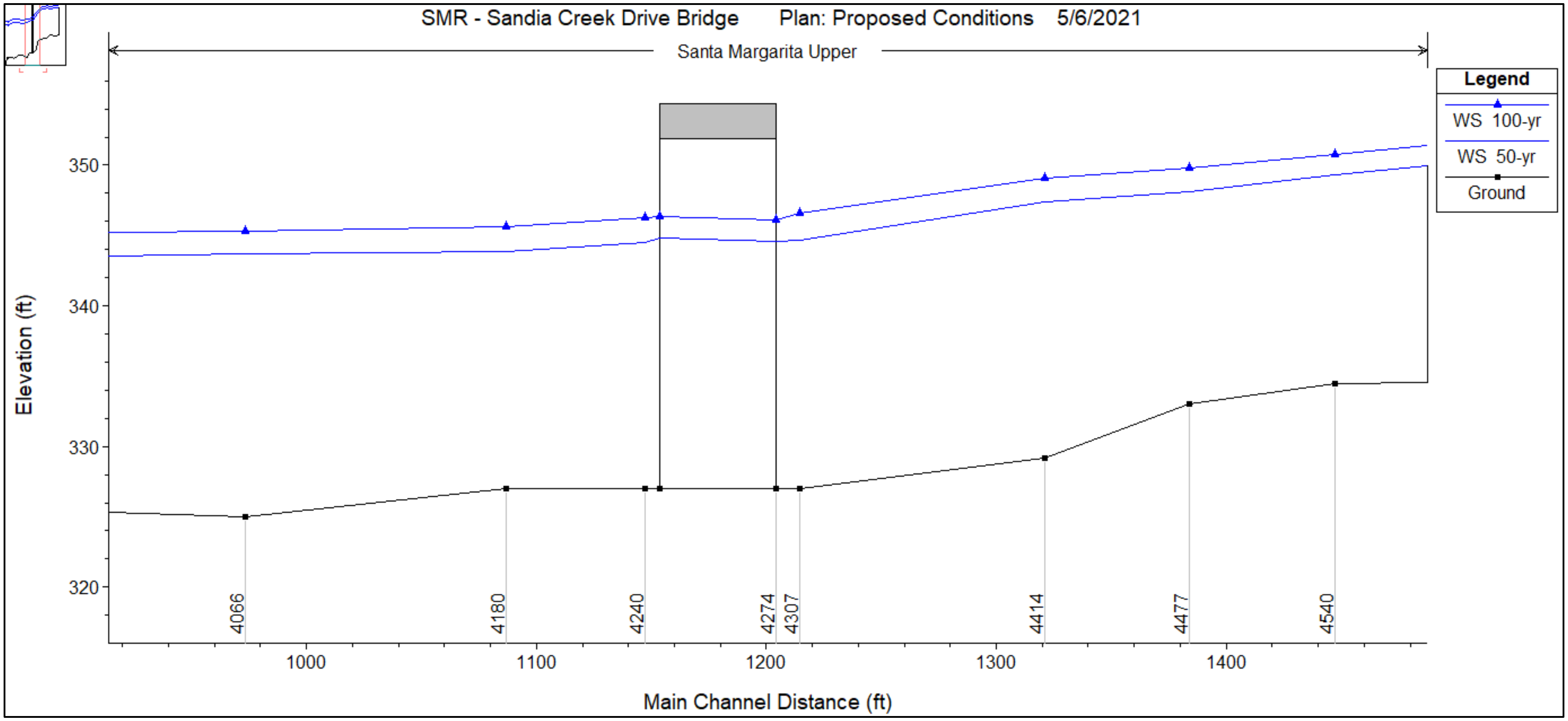

SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3175
.04
.05
.045
.1
Elevation (ft)
370
360
350
340
330
320
0
100
200
300
400
500
600
700
800
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta



SMR - Sandia Creek Drive Bridge Plan: Existing Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3093
.04
.05
.045
.05
.037
.05
.1
370
360
350
340
330
320
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta



HEC-RAS Proposed Conditions Water Surface Profile Plot

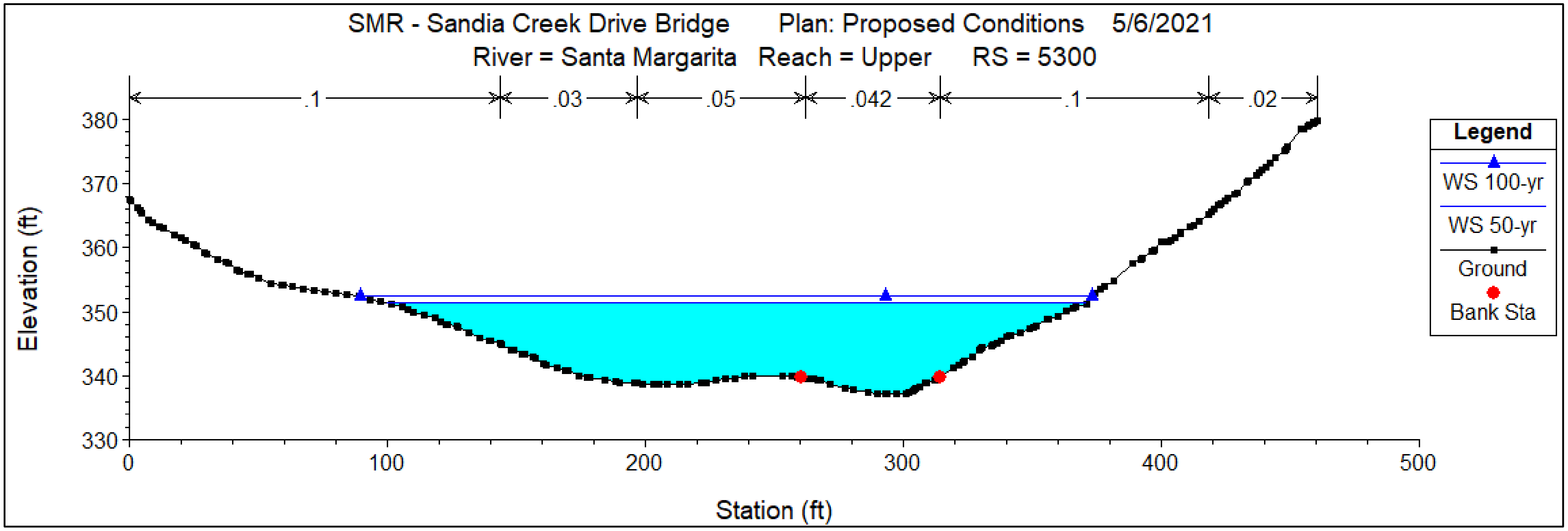


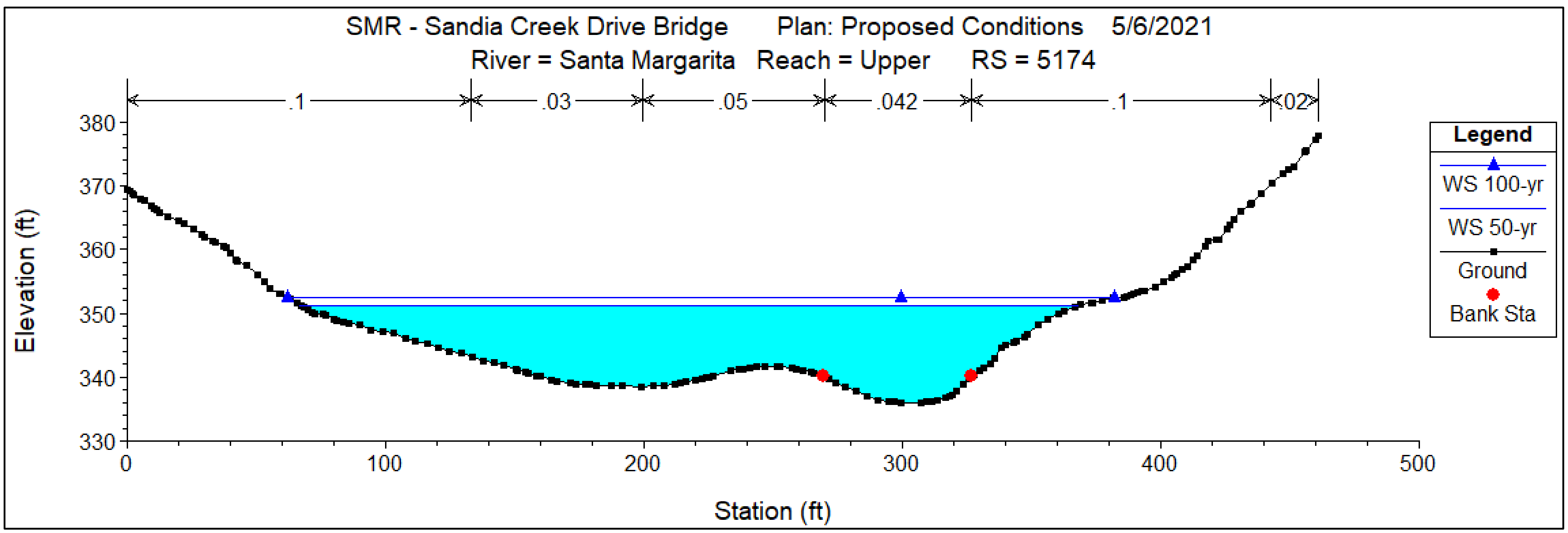
HEC-RAS Proposed Conditions Water Surface Profile Plot - ***Zoomed in to Proposed Bridge***

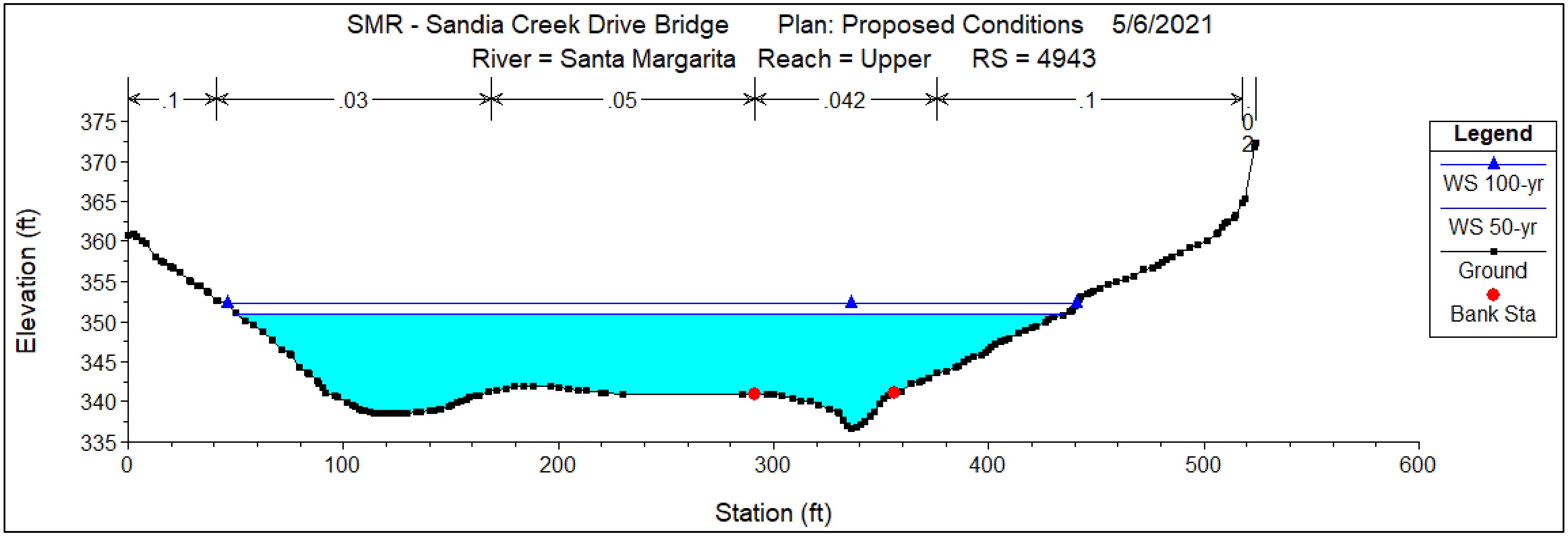
HEC-RAS Plan: Proposed Conditions River: Santa Margarita Reach: Upper Profile: 100-yr

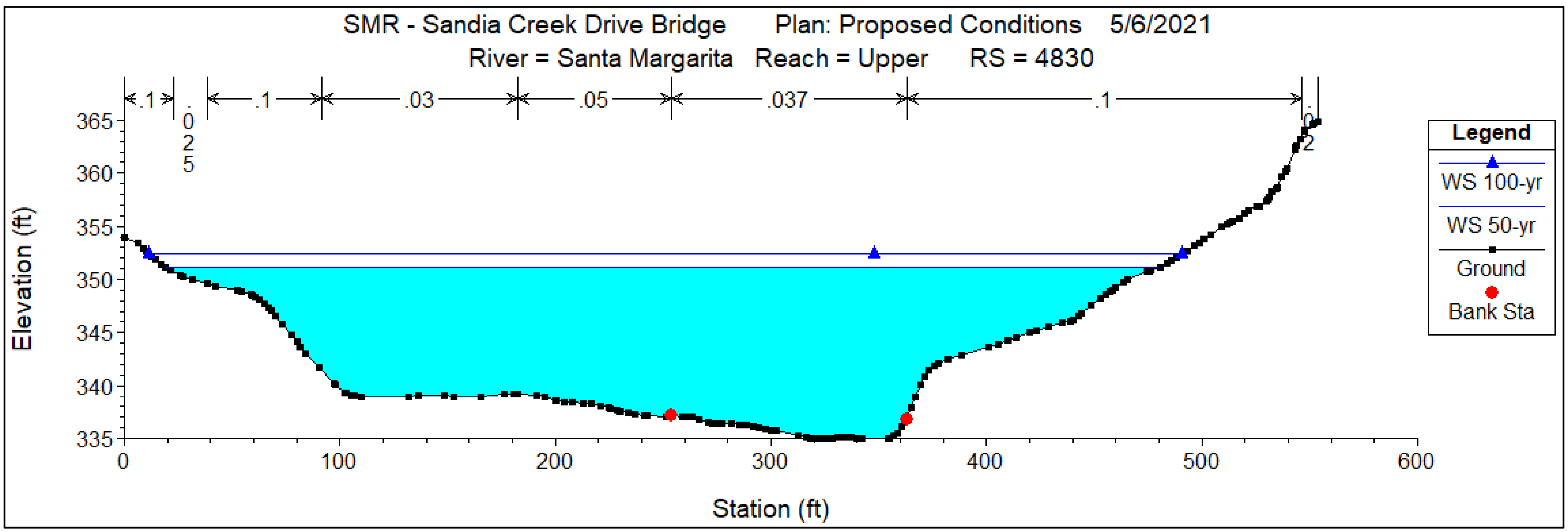
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	5300	100-yr	38600	337.15	352.40	351.17	356.09	0.006806	17.0	2744.83	284	0.79
Upper	5174	100-yr	38600	336.00	352.45	349.97	355.09	0.004686	14.7	3166.22	320	0.66
Upper	4943	100-yr	38600	336.75	352.26	348.67	353.93	0.003251	10.9	3890.89	395	0.54
Upper	4830	100-yr	38600	335.00	352.42	346.32	353.52	0.001350	9.6	5231.41	479	0.42
Upper	4757	100-yr	38600	335.06	352.04	347.80	353.40	0.001991	11.2	4686.15	524	0.50
Upper	4674	100-yr	38600	335.00	352.02	347.67	353.21	0.001731	10.1	5108.15	570	0.46
Upper	4626	100-yr	38600	334.72	352.07	346.65	352.89	0.017350	8.3	5565.76	564	0.36
Upper	4540	100-yr	38600	334.46	350.77	345.95	351.63	0.018785	8.2	5384.63	552	0.38
Upper	4477	100-yr	38600	333.05	349.80	343.90	350.58	0.017198	8.2	5717.35	594	0.36
Upper	4414	100-yr	38600	329.17	349.06	343.74	350.10	0.004587	9.9	5747.26	551	0.41
Upper	4307	100-yr	38600	327.03	346.58	343.91	349.51	0.003448	16.7	4722.70	551	0.70
Upper	4274		Bridge									
Upper	4240	100-yr	38600	327.00	346.31	343.82	349.09	0.003194	15.9	4882.36	558	0.67
Upper	4180	100-yr	38600	327.00	345.66	344.26	348.82	0.004135	17.6	4882.84	565	0.76
Upper	4066	100-yr	38600	325.03	345.35	343.26	348.20	0.003274	16.6	5320.53	536	0.69
Upper	3870	100-yr	38600	326.00	344.94	342.43	347.42	0.003021	15.3	5770.38	699	0.65
Upper	3742	100-yr	38600	326.00	345.19	341.64	346.73	0.002120	12.7	6185.16	685	0.54
Upper	3669	100-yr	38600	325.11	345.35	340.35	346.47	0.001554	11.1	6757.18	696	0.46
Upper	3565	100-yr	38600	324.00	345.28	338.72	346.32	0.001129	9.7	6828.33	680	0.40
Upper	3495	100-yr	38600	324.63	344.89	338.98	346.21	0.001382	10.4	5618.19	697	0.44
Upper	3393	100-yr	42600	325.03	344.33	340.73	346.02	0.002161	11.9	5049.81	705	0.54
Upper	3356	100-yr	42600	325.01	344.32	340.11	345.87	0.002016	11.6	5754.99	759	0.53
Upper	3355	100-yr	42600	324.00	343.81	340.49	345.75	0.002092	12.9	5318.88	648	0.60
Upper	3341	100-yr	42600	324.00	343.88	340.10	345.63	0.001668	12.1	5455.70	656	0.56
Upper	3323	100-yr	42600	324.00	343.97	339.50	345.49	0.001426	11.1	5621.50	662	0.51
Upper	3322	100-yr	42600	325.07	344.09	338.55	345.36	0.001452	10.1	5942.25	734	0.45
Upper	3259	100-yr	42600	321.06	344.12	336.92	345.21	0.000984	9.2	6126.62	680	0.38
Upper	3175	100-yr	42600	325.08	344.06	337.24	345.10	0.001684	8.8	5701.38	643	0.38
Upper	3093	100-yr	42600	322.42	343.90	335.91	344.97	0.001501	8.6	5551.22	561	0.36

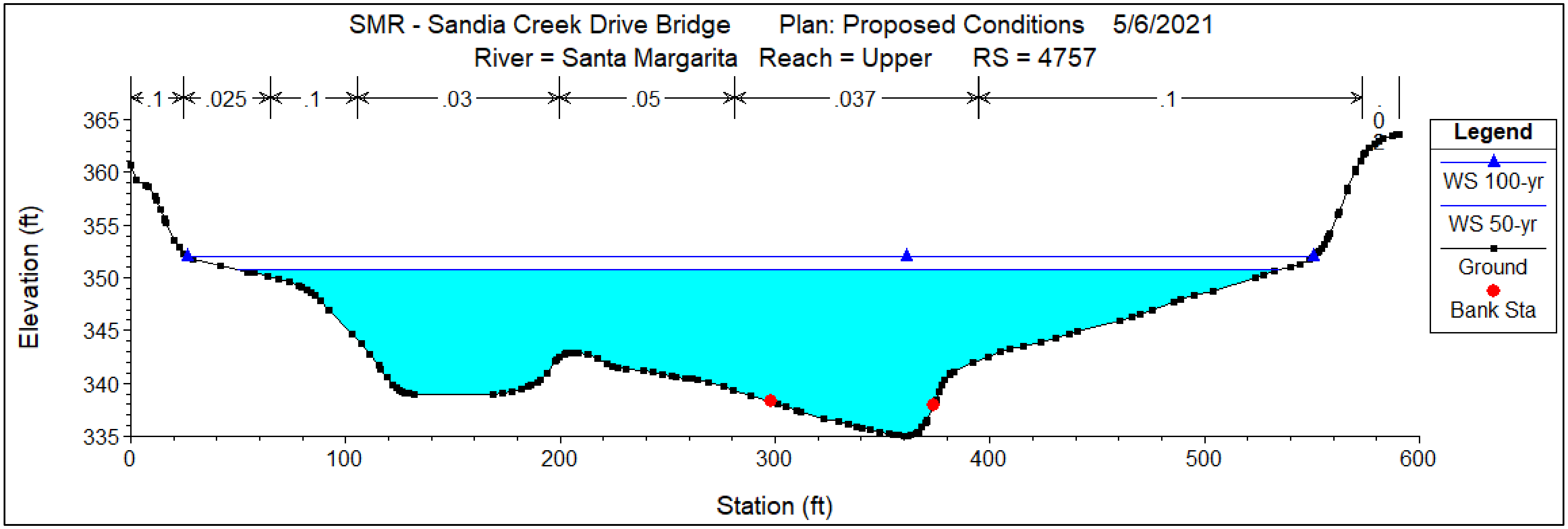
HEC-RAS Proposed Conditions Model Cross Sections

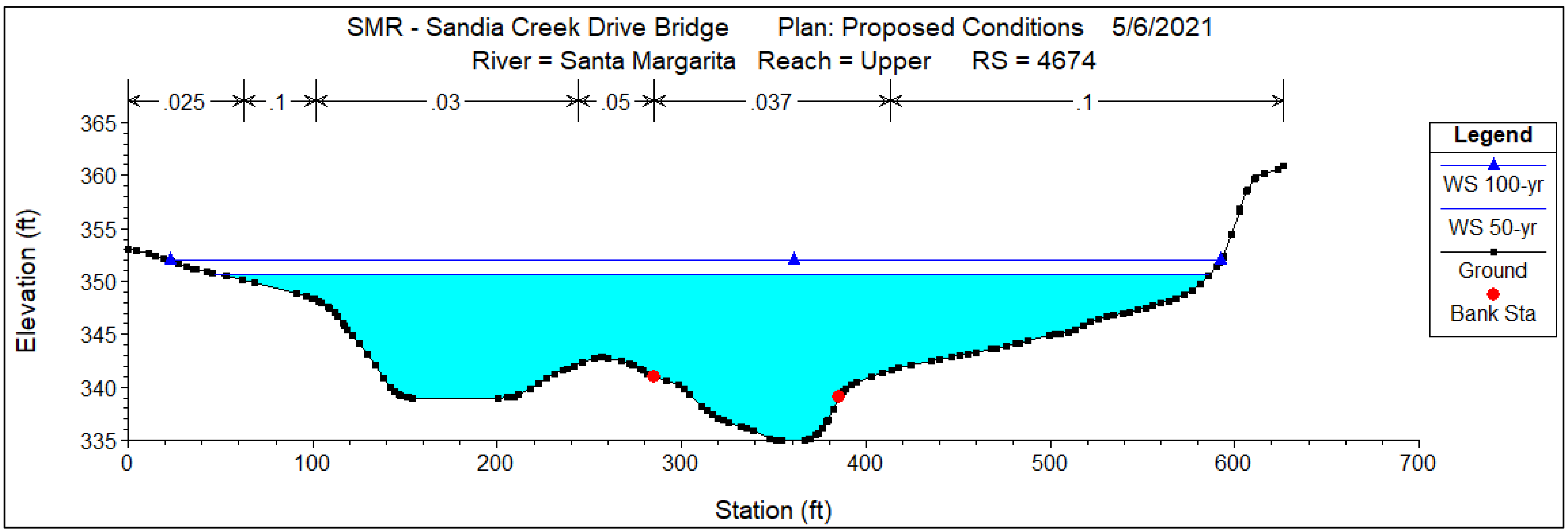


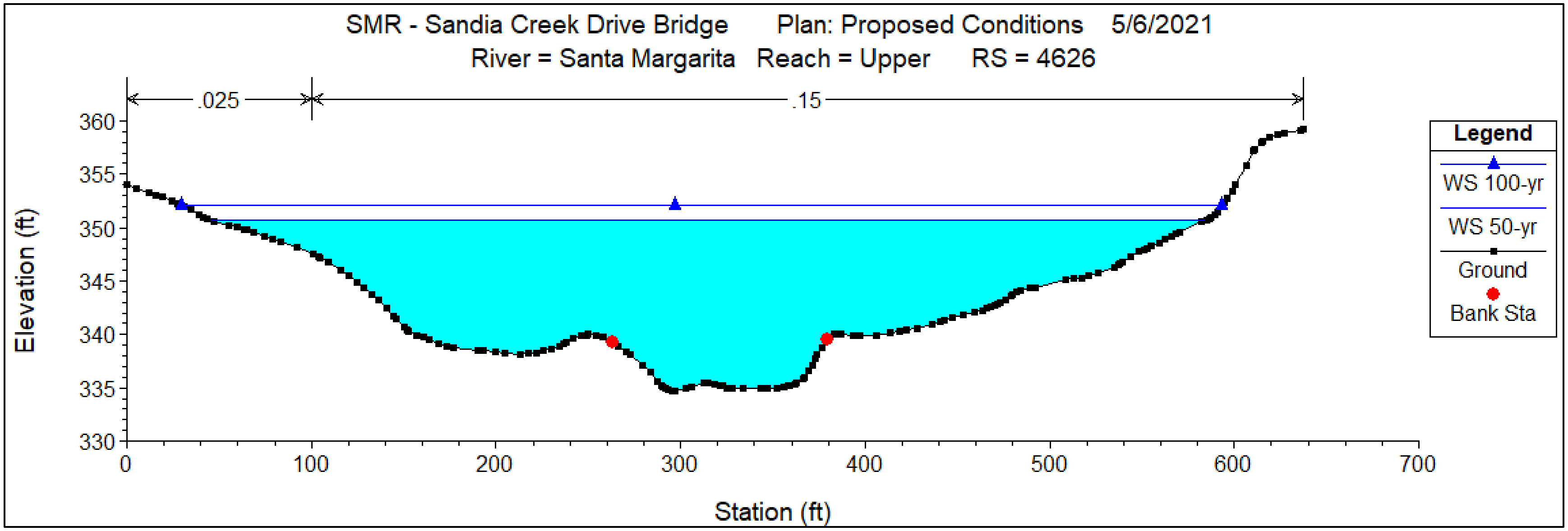


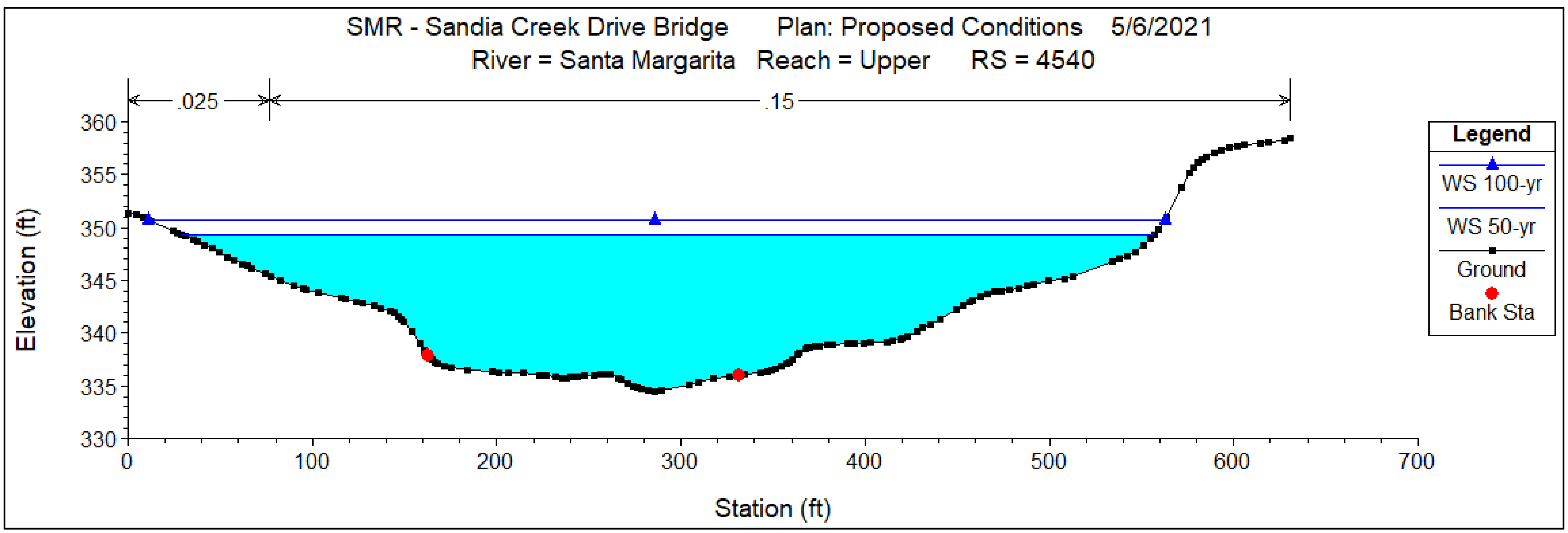

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4943
.1
.03
.05
.042
.1
.02
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

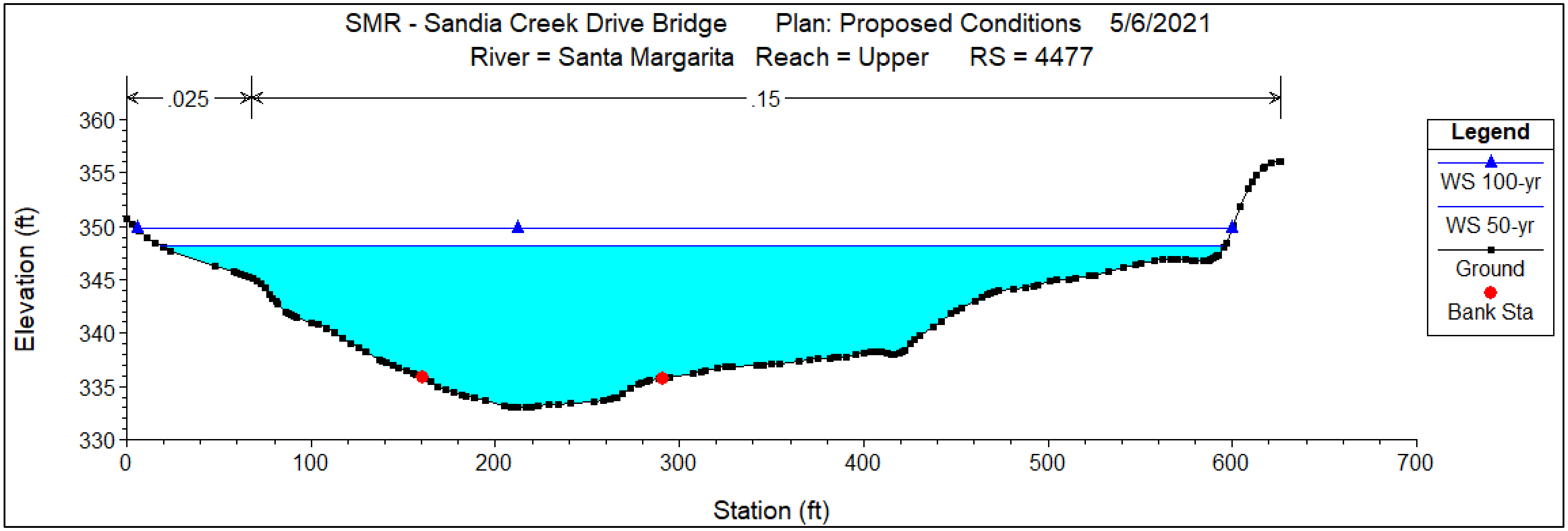

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4830
.1
.025
.1
.03
.05
.037
.1
.02
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

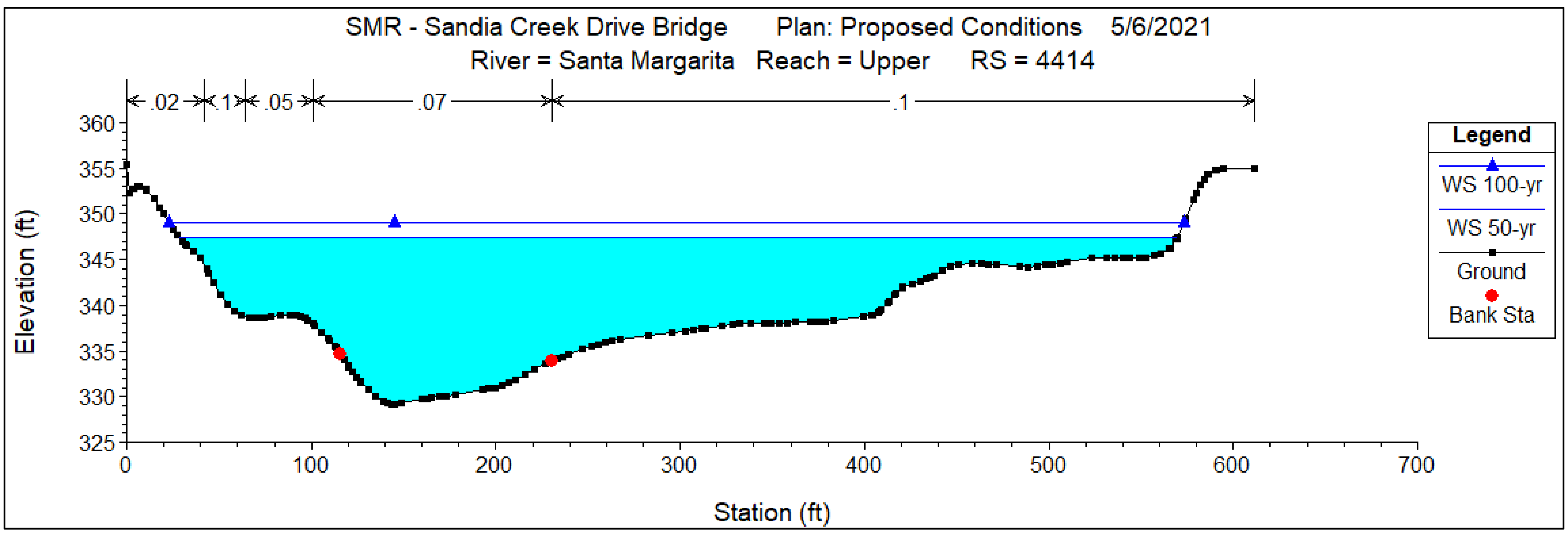

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4757
.1
.025
.1
.03
.05
.037
.1
0
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

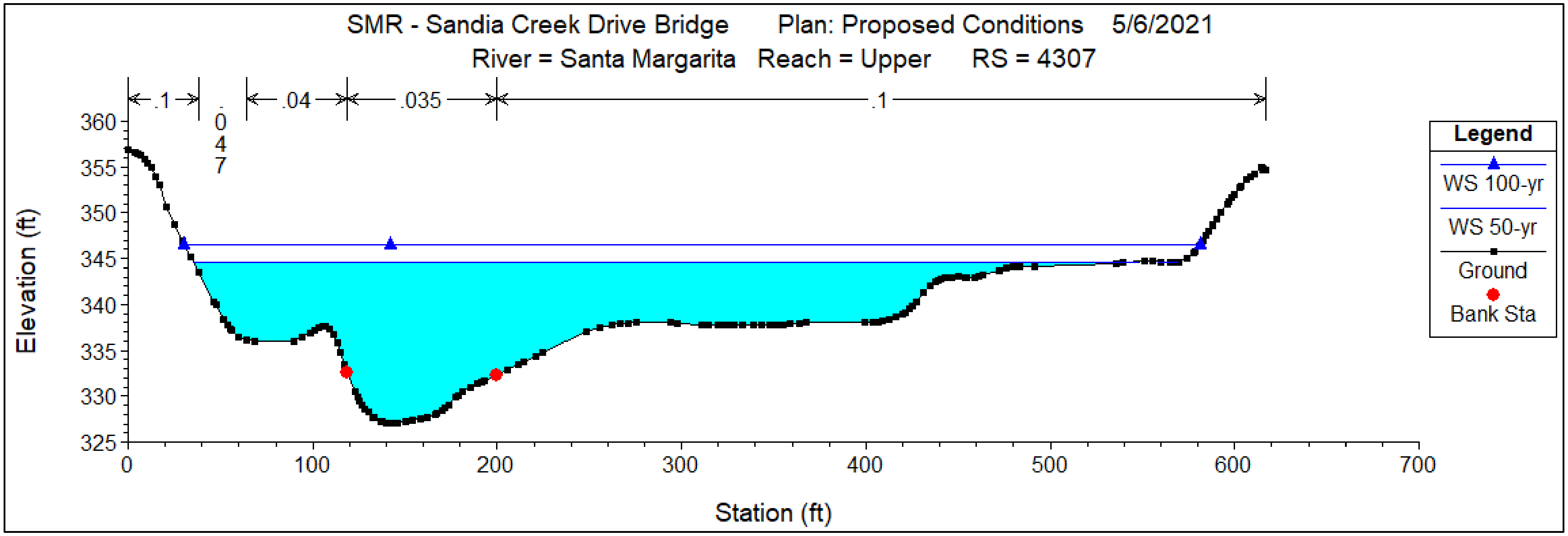

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4674
.025
.1
.03
.05
.037
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

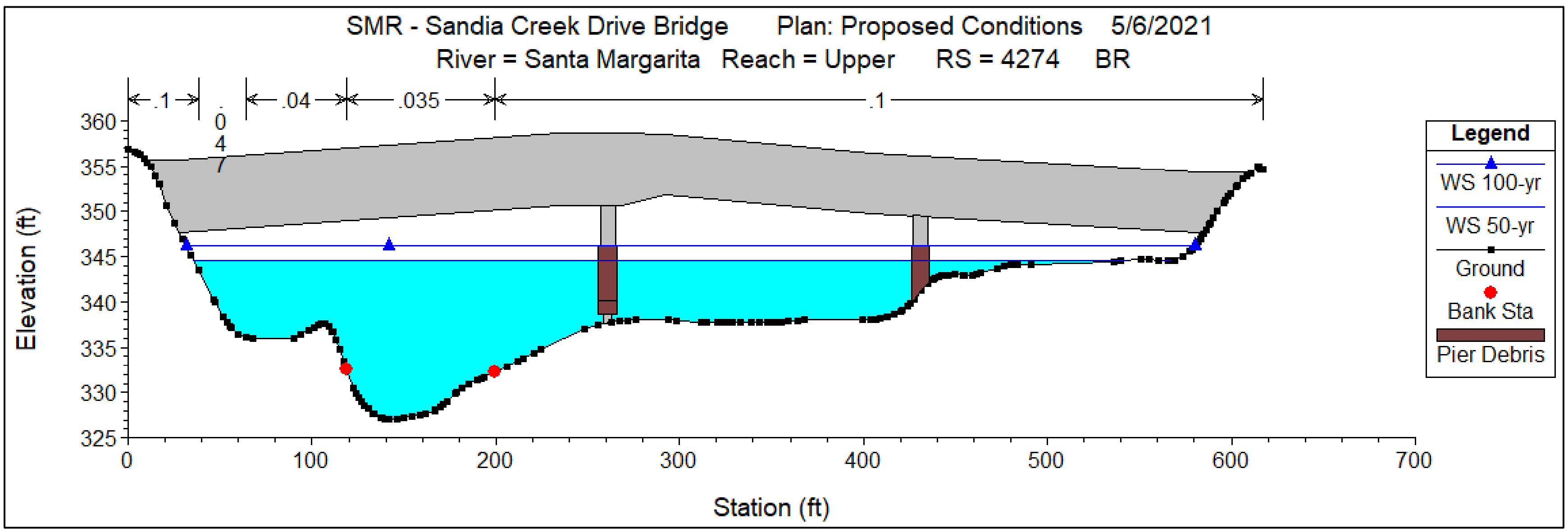

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4626
.025
.15
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

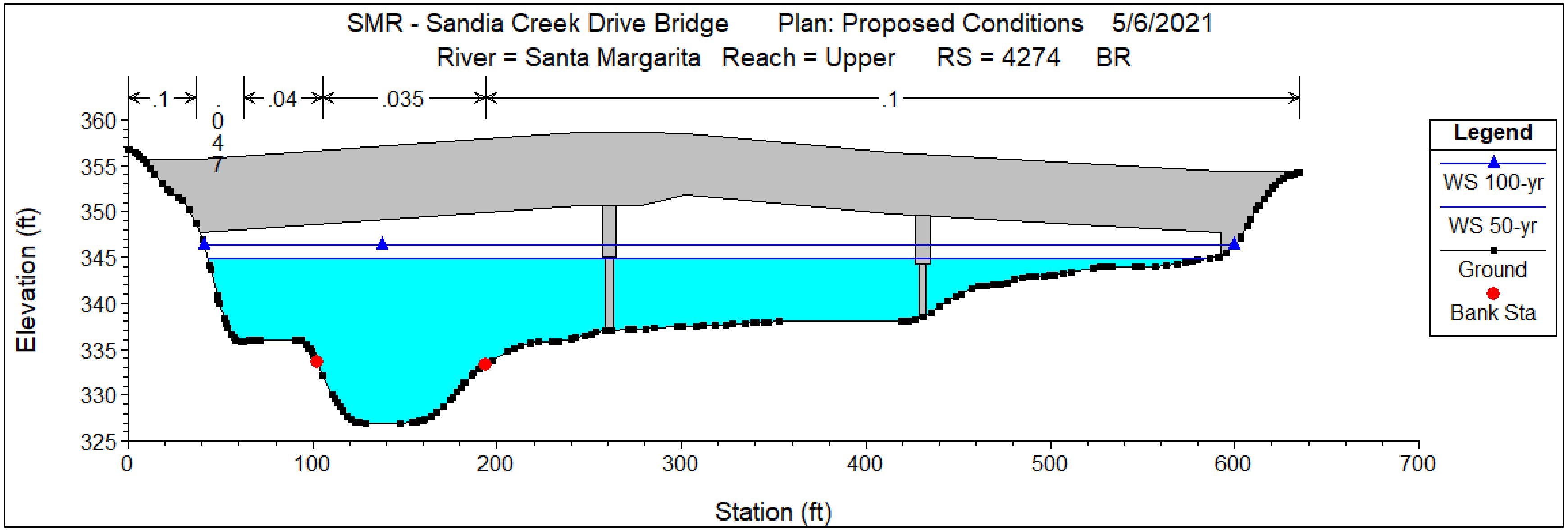

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4540
.025
.15
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

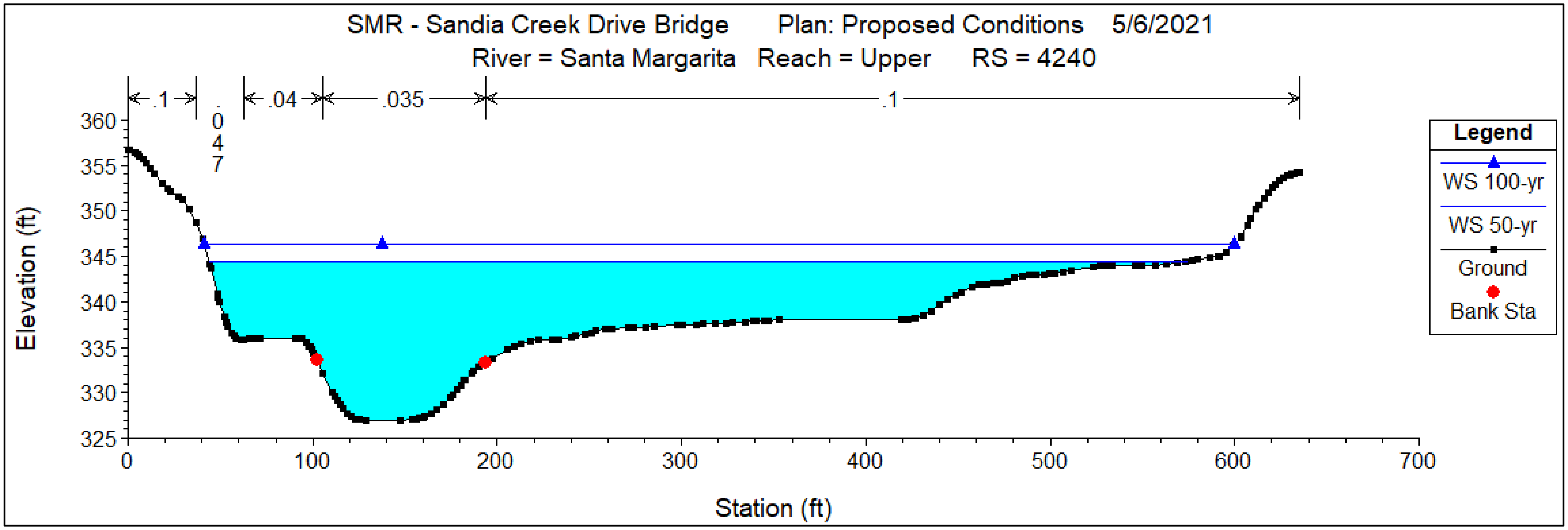

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4477
.025
.15
Elevation (ft)
360
355
350
345
340
335
330
0
100
200
300
400
500
600
700
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

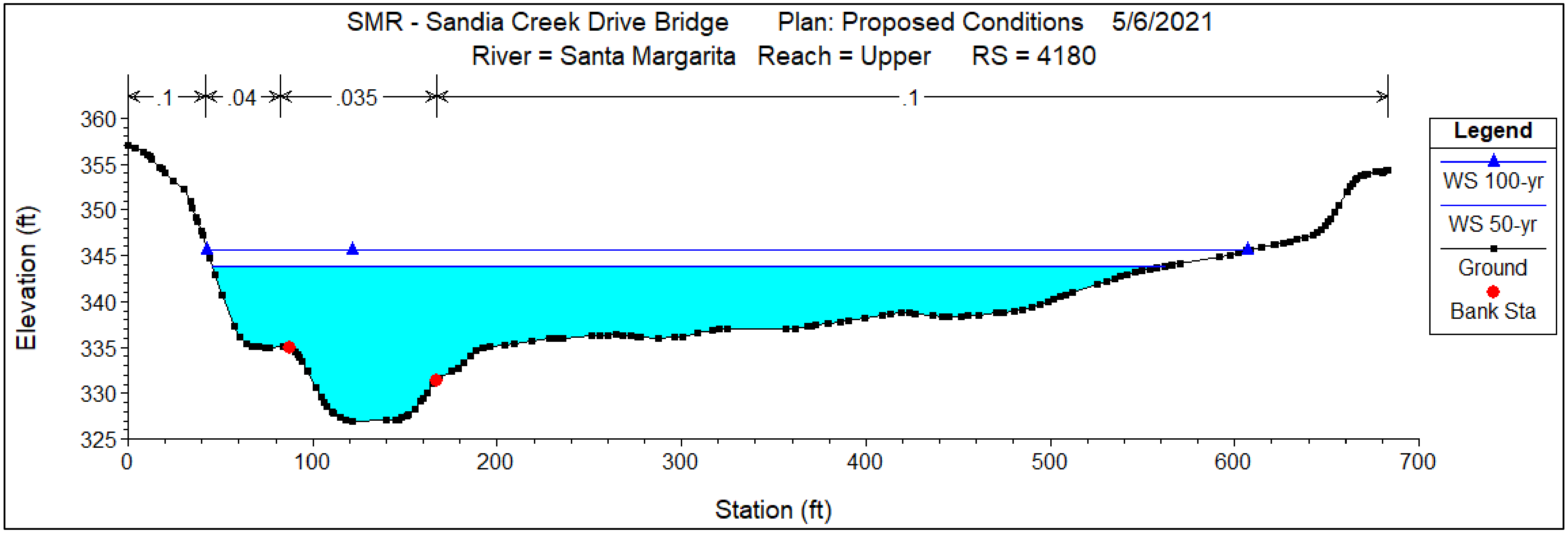

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4414
.02
.1
.05
.07
.1
Elevation (ft)
360
355
350
345
340
335
330
325
0
100
200
300
400
500
600
700
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

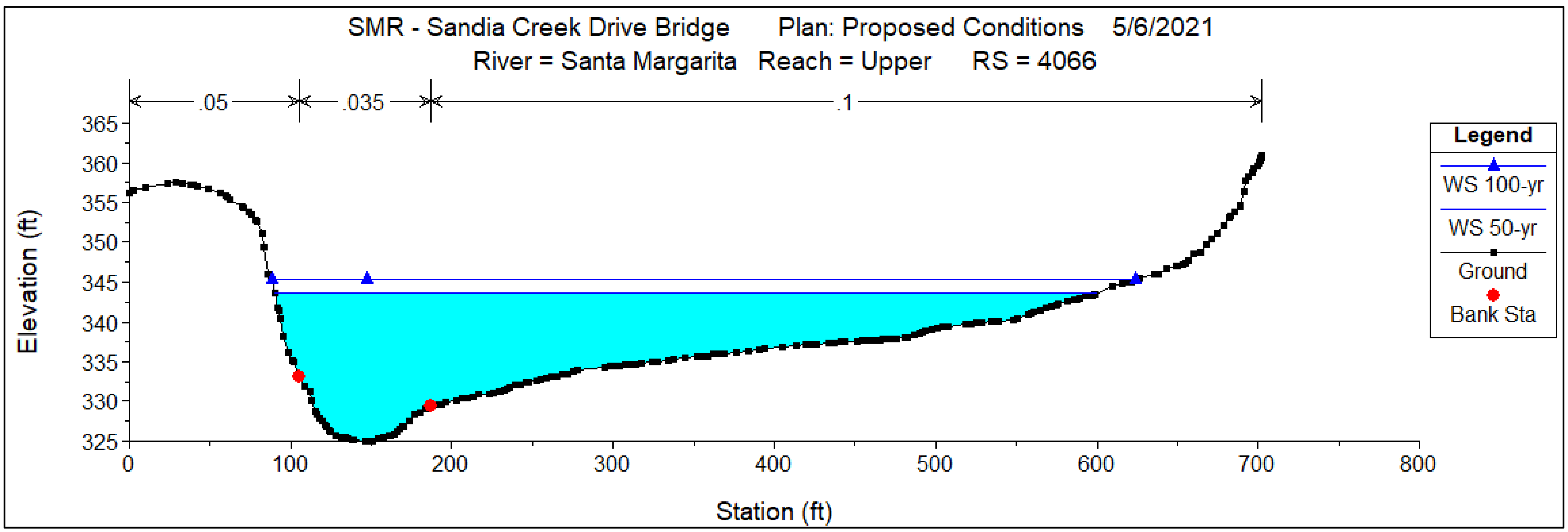

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4307
.1
.047
.04
.035
.1
Elevation (ft)
360
355
350
345
340
335
330
325
0
100
200
300
400
500
600
700
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

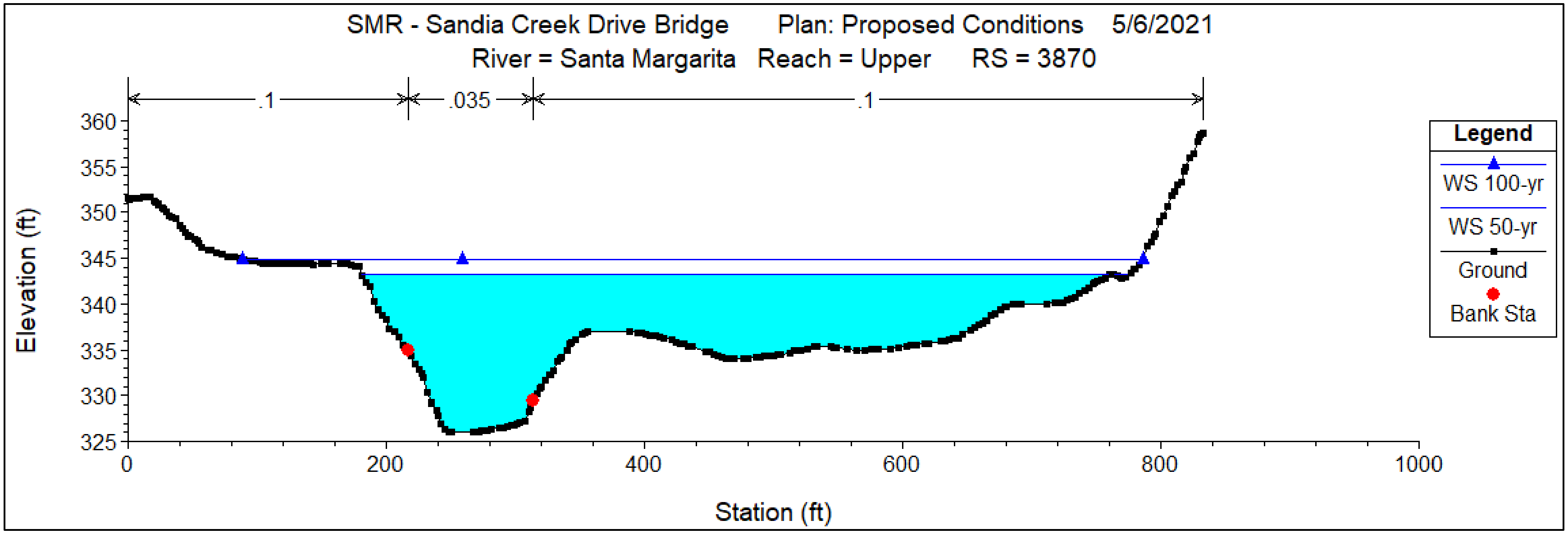

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4274 BR
.1
.047
.04
.035
.1
Elevation (ft)
360
355
350
345
340
335
330
325
0
100
200
300
400
500
600
700
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta
Pier Debris


SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4274 BR
.1
.047
.04
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

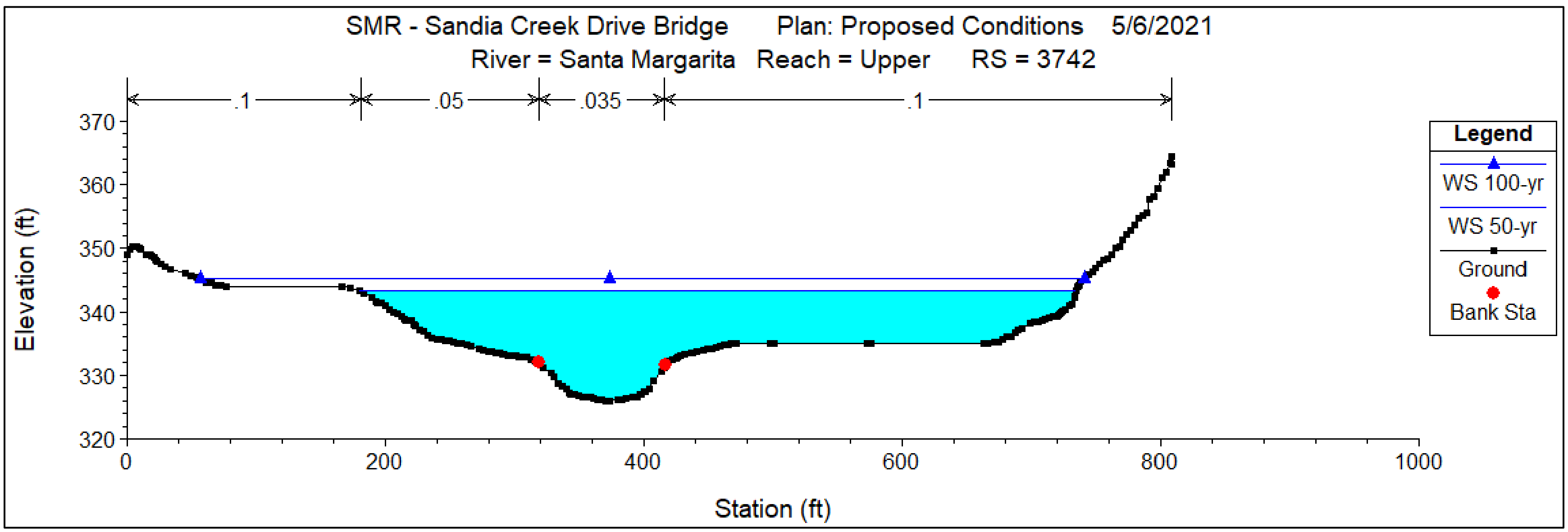

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4240
.1
.047
.04
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta


SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4180
.1
.04
.035
.1
Elevation (ft)
360
355
350
345
340
335
330
325
0
100
200
300
400
500
600
700
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

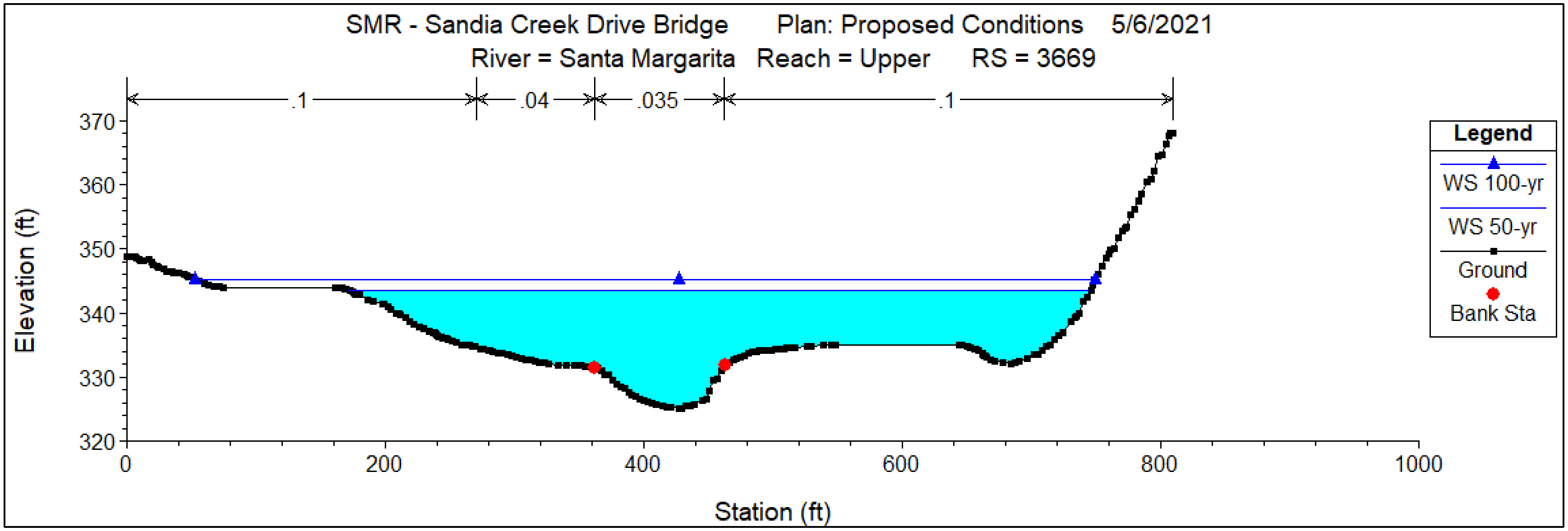

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 4066
.05
.035
.1
Elevation (ft)
365
360
355
350
345
340
335
330
325
0
100
200
300
400
500
600
700
800
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

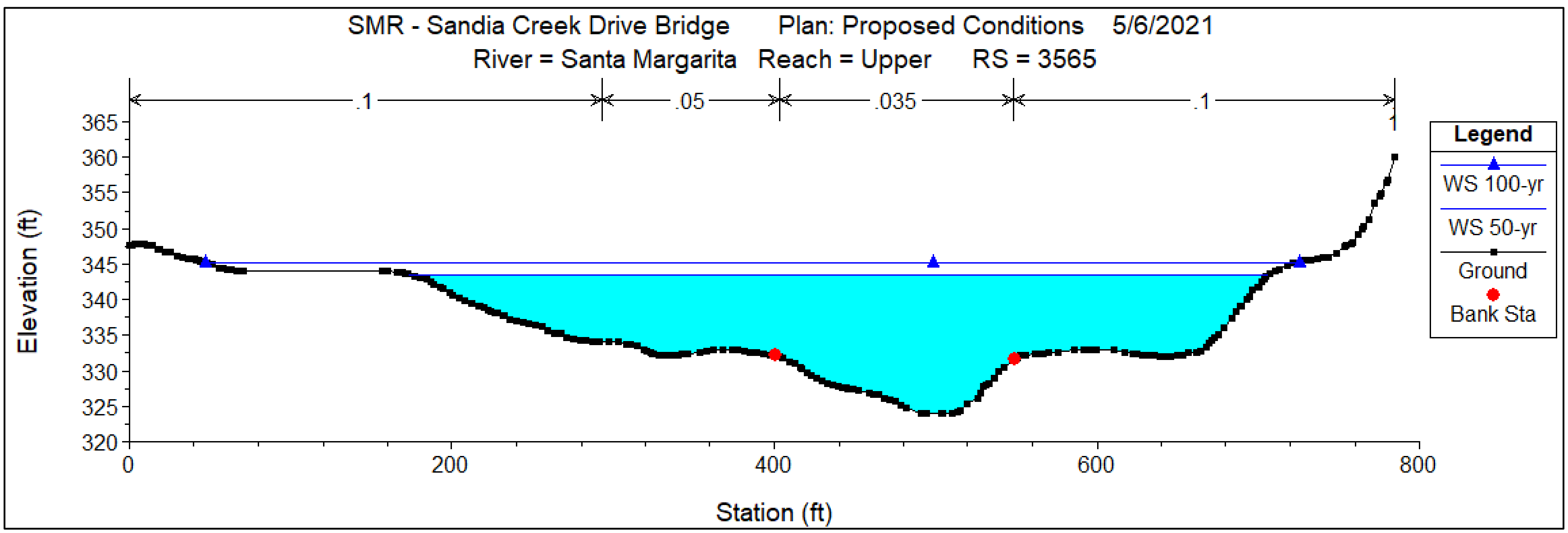


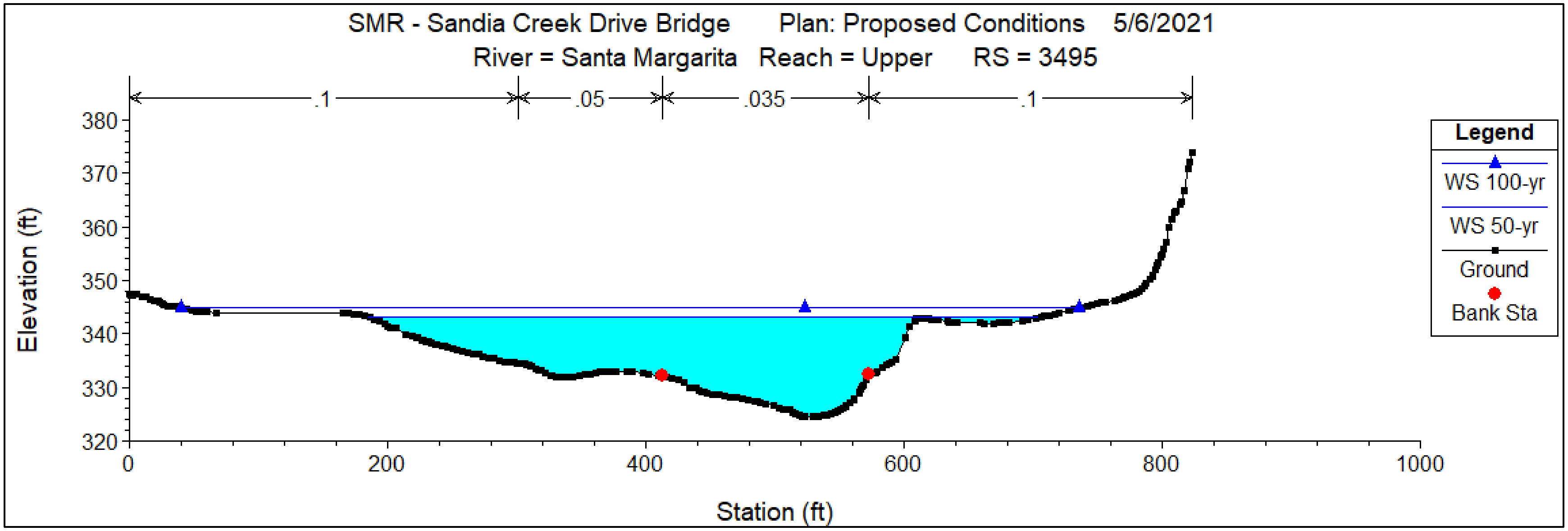
SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3870
.1
.035
.1
Elevation (ft)
360
355
350
345
340
335
330
325
0
200
400
600
800
1000
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta



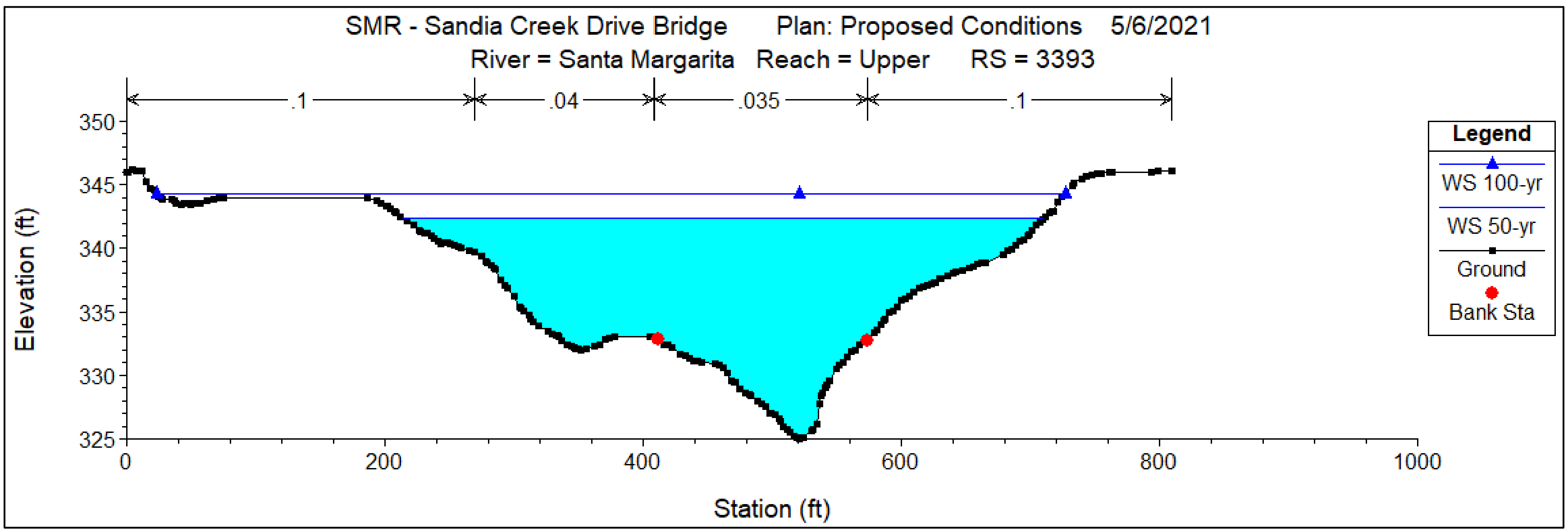
SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3742
.1
.05
.035
.1
Elevation (ft)
370
360
350
340
330
320
0
200
400
600
800
1000
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta


SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3669
.1
.04
.035
.1
Elevation (ft)
370
360
350
340
330
320
0
200
400
600
800
1000
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

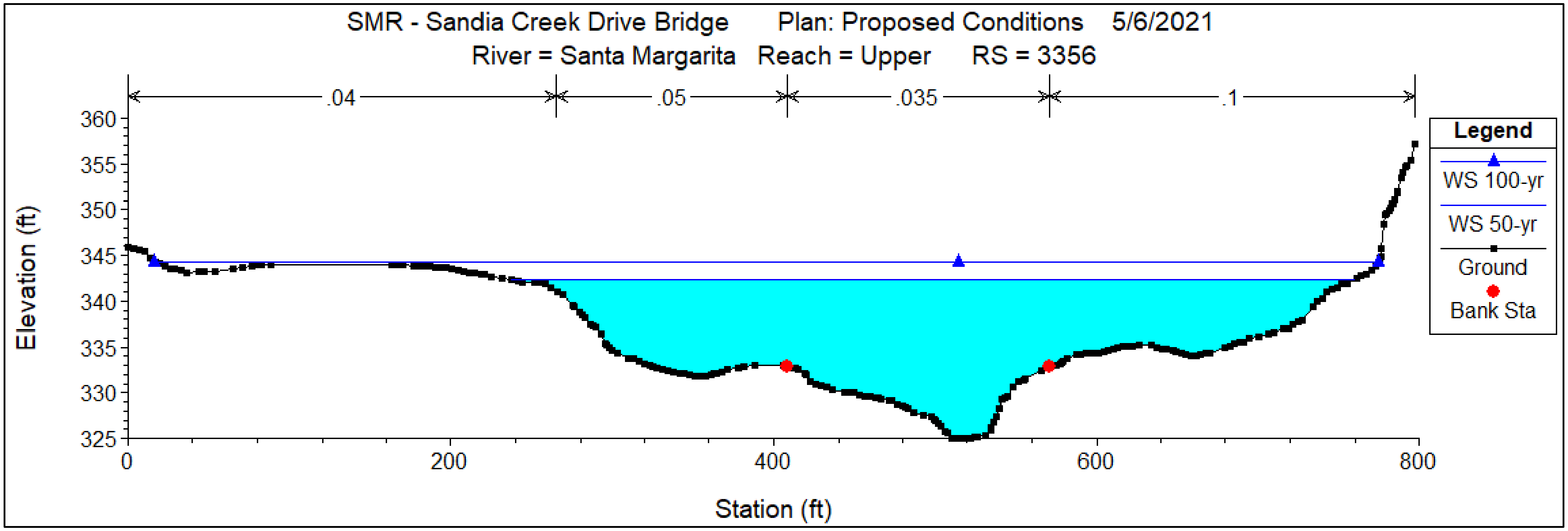

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3565
.1
.05
.035
.1
Elevation (ft)
365
360
355
350
345
340
335
330
325
320
0
200
400
600
800
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

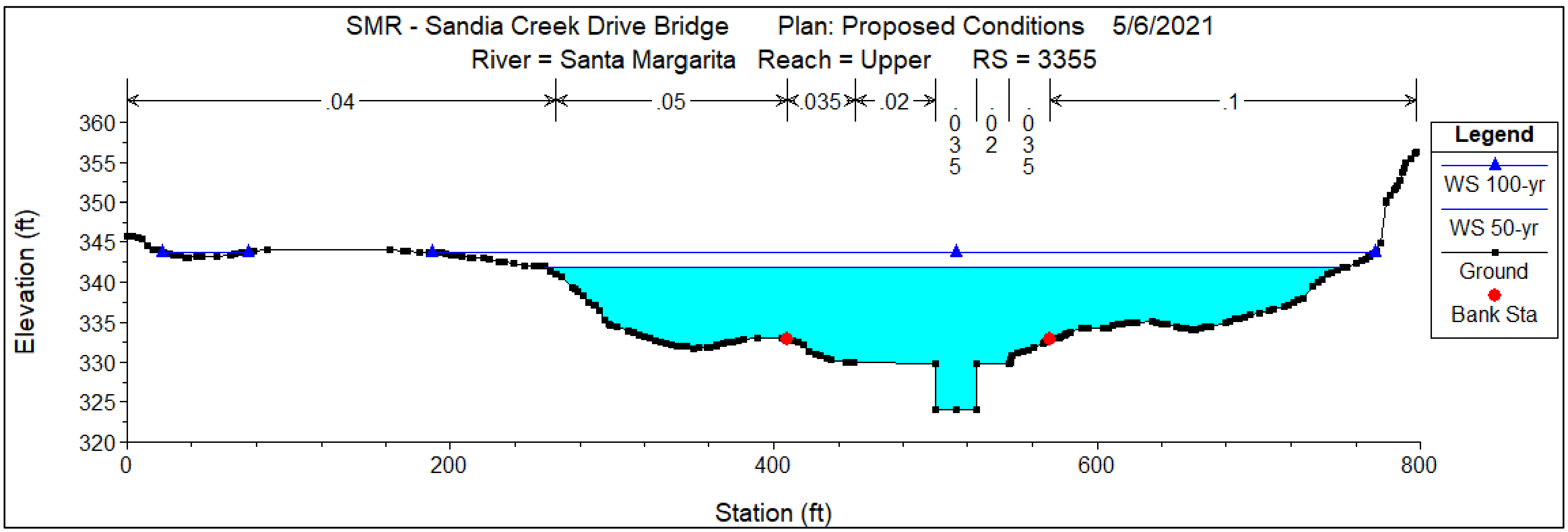


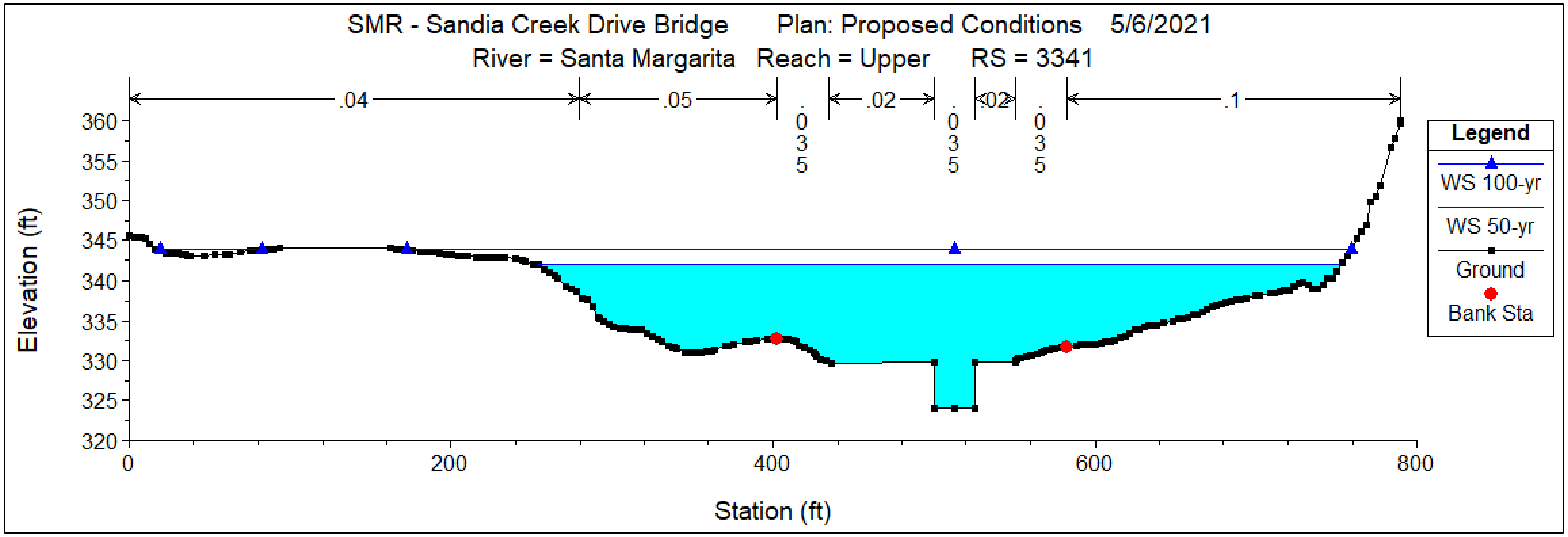
SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3495
.1
.05
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta



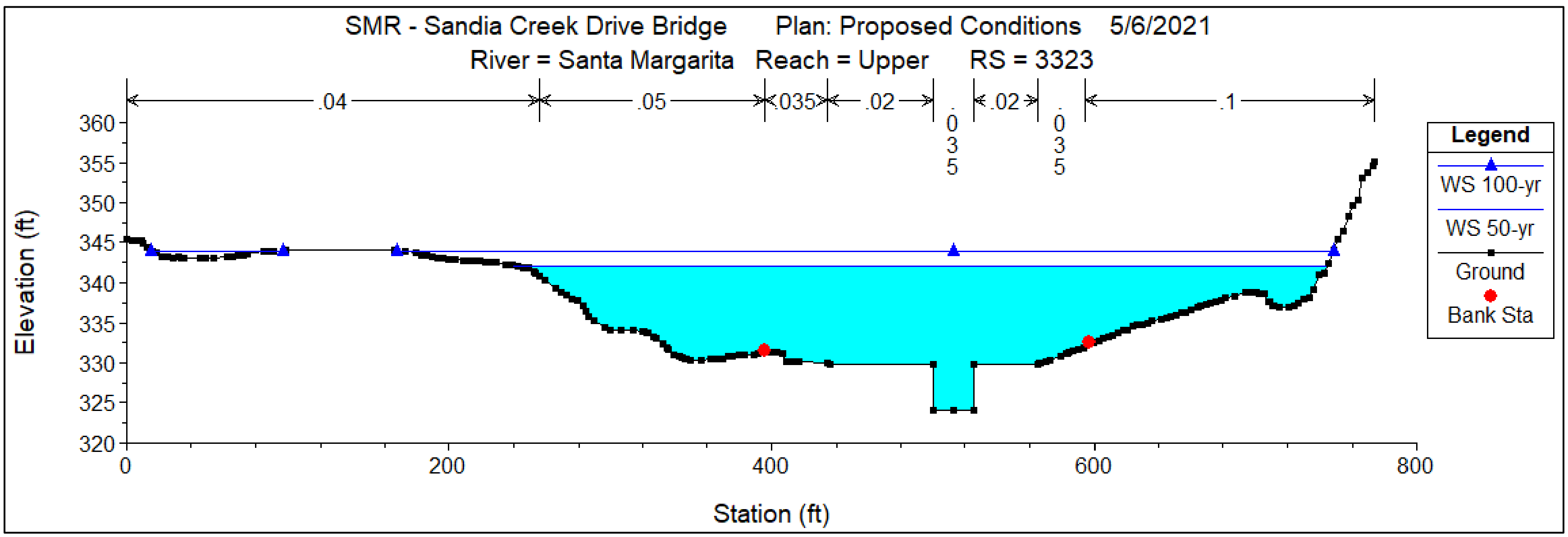
SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3393
.1
.04
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta


SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3356
.04
.05
.035
.1
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta
Elevation (ft)
360
355
350
345
340
335
330
325
0
200
400
600
800
Station (ft)

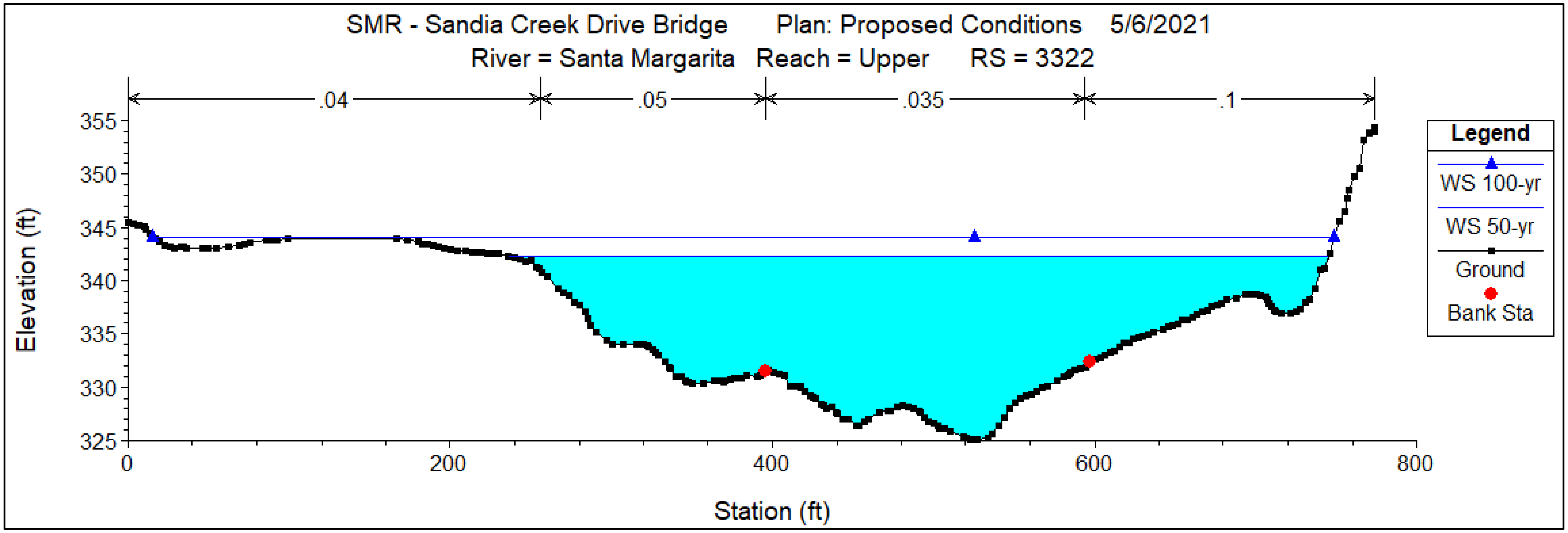

SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3355
.04
.05
.035
.02
.035
.02
.035
.1
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta
Elevation (ft)
360
355
350
345
340
335
330
325
320
0
200
400
600
800
Station (ft)

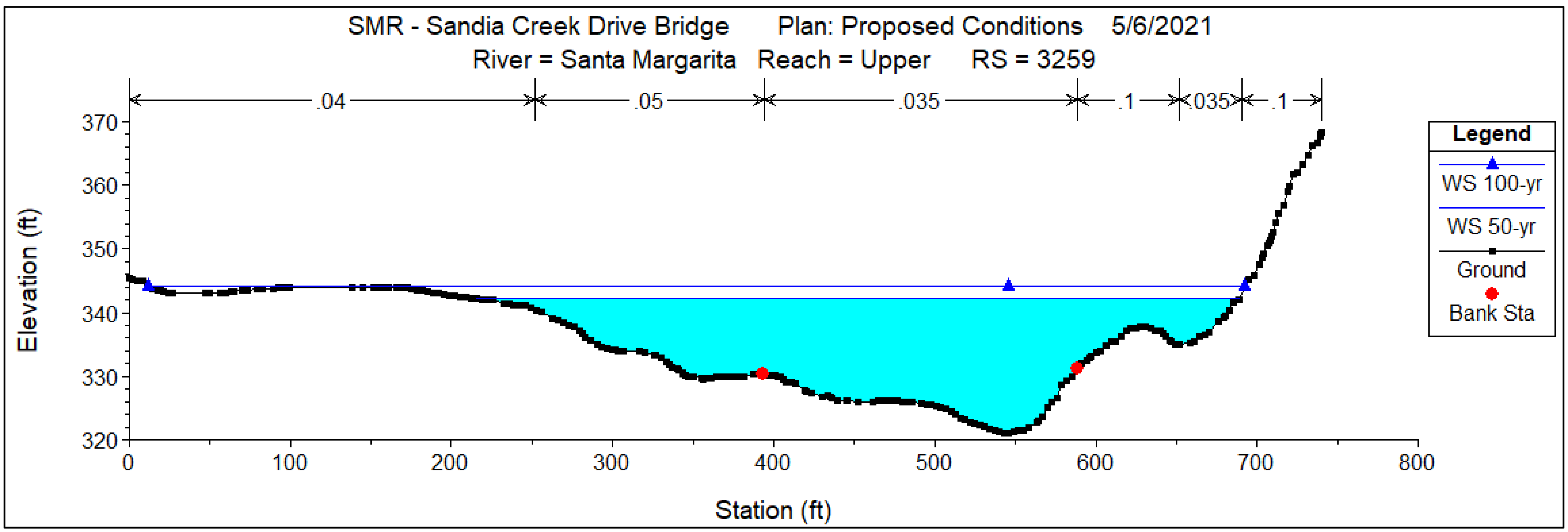


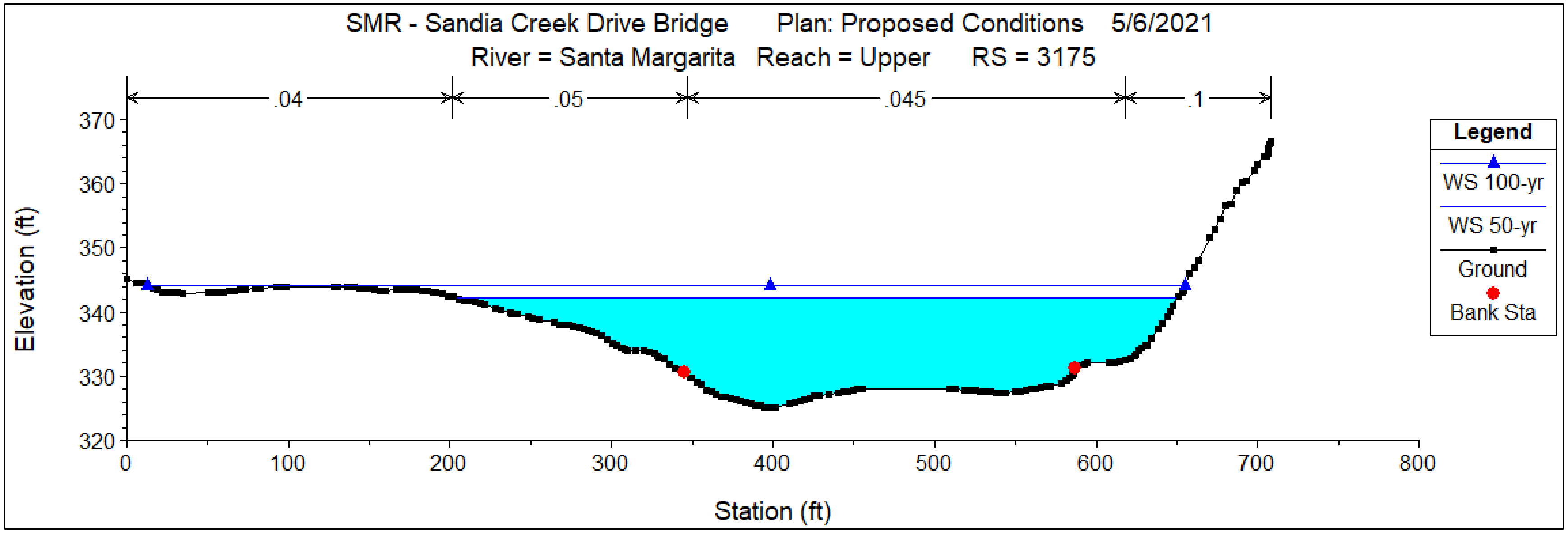
SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3341
.04
.05
.035
.02
.035
.02
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta



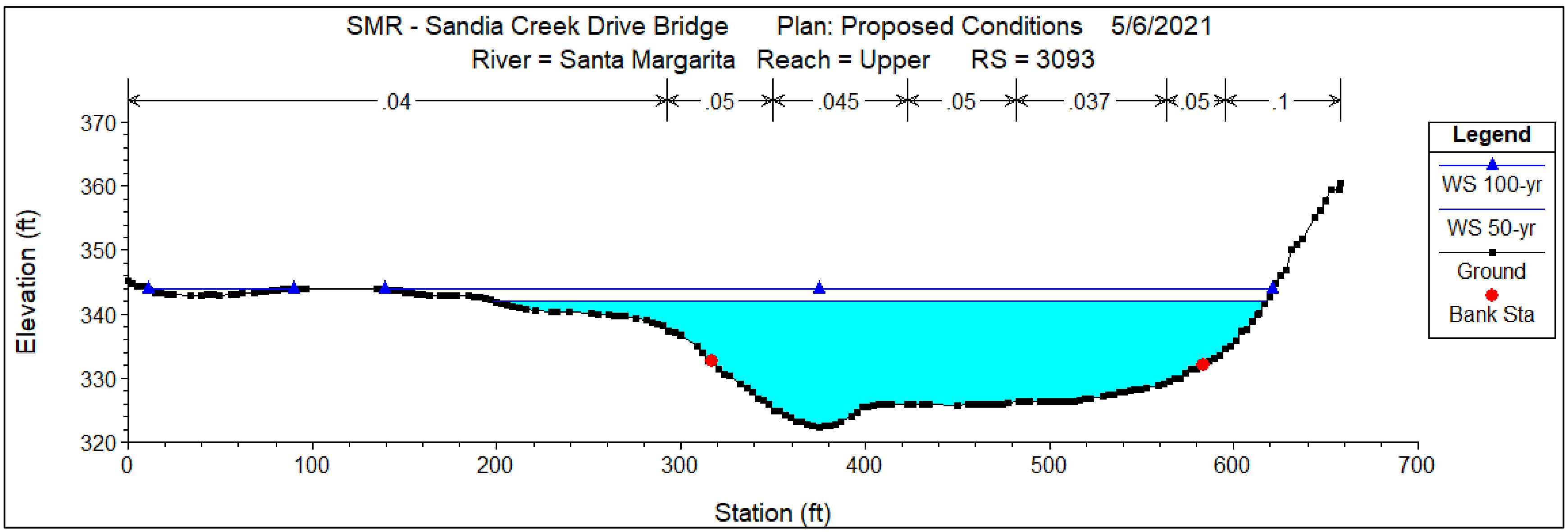
SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3323
.04
.05
.035
.02
.035
.02
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta


SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3322
.04
.05
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta


SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3259
.04
.05
.035
.1
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta



SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3175
.04
.05
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta



SMR - Sandia Creek Drive Bridge Plan: Proposed Conditions 5/6/2021
River = Santa Margarita Reach = Upper RS = 3093
.04
.05
.045
.05
.037
.05
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr
WS 50-yr
Ground
Bank Sta

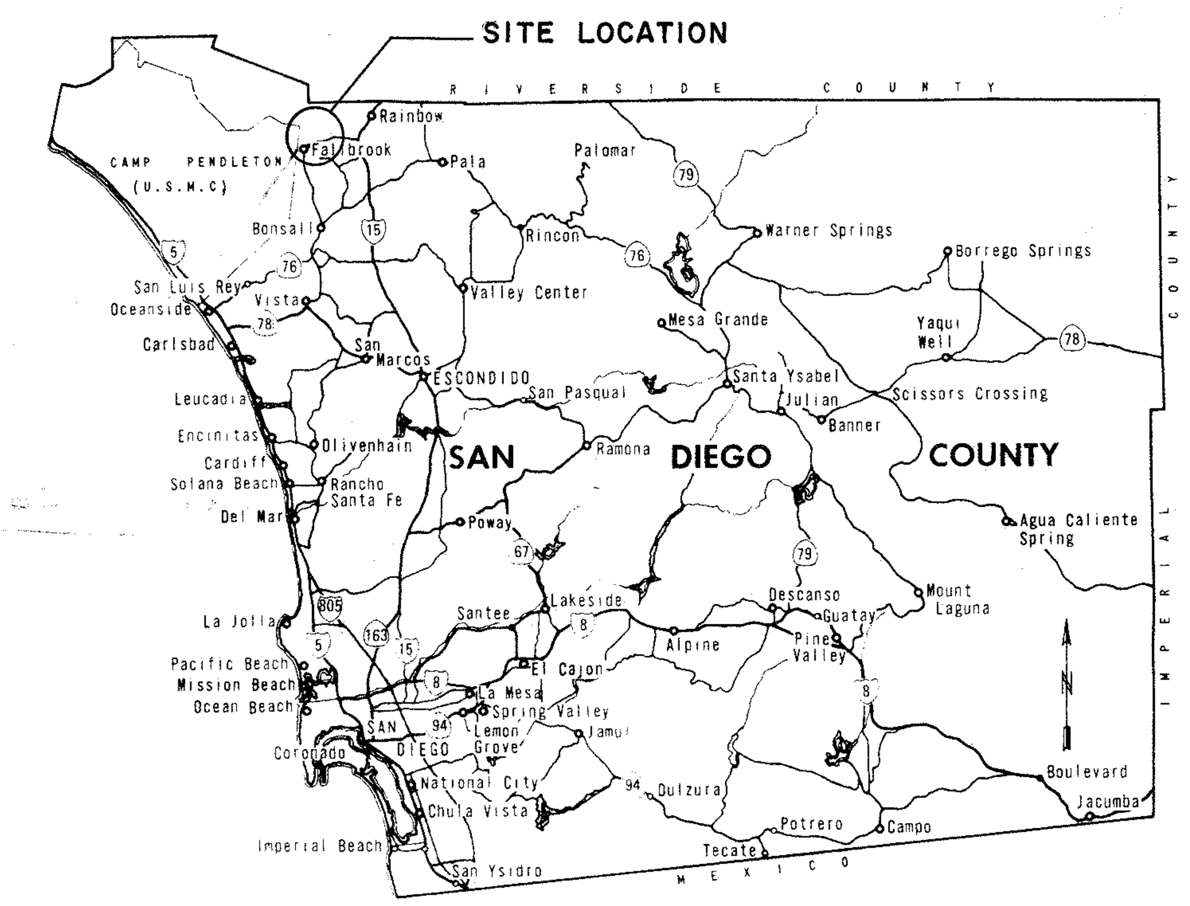
Appendix C – As-Built Plans

Existing Sandia Creek Drive Crossing

COUNTY OF SAN DIEGO, CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PLANS FOR RECONSTRUCTION OF PORTIONS OF SANDIA CREEK DRIVE R.S. 741-1
In The Vicinity Of Fallbrook

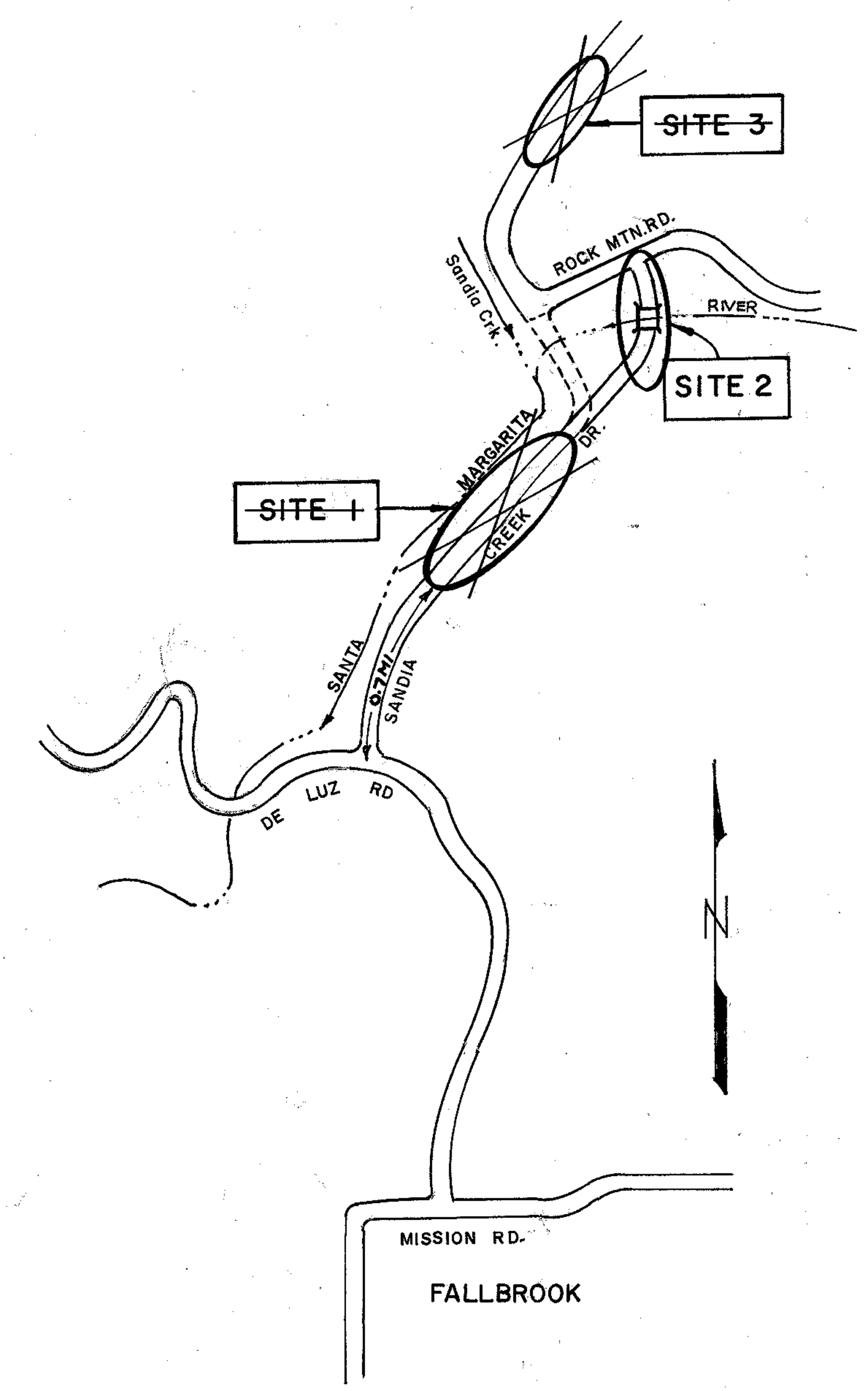
INDEX OF SHEETS



PROJECT LOCATION

REGIONAL STANDARD DRAWINGS

D-24 DOWNDRAIN PIPE
G-5 DIKE - TYPE A
D-36 L TYPE HEADWALLS - CIRCULAR PIPES
M-7 METAL BEAM GUARD RAIL INSTALLATION
M-8 METAL BEAM GUARD RAIL DETAILS
M-10 STREET SURVEY MONUMENT
D-78 TRIPLE BOX CULVERT
D-79 BOX CULVERT WINGWALL, TYPES A, B & C



VICINITY MAP
NO SCALE

"AS BUILT" REVISION
CONSTRUCTION COMPLETE 12-21-79
APPROVED H. Blankinship DATE 8-13-80

GENERAL NOTES:

"ATTENTION IS DIRECTED TO THE POSSIBLE EXISTENCE OF UNDERGROUND FACILITIES NOT KNOWN OR IN A LOCATION DIFFERENT FROM THAT WHICH IS SHOWN ON THE PLANS OR IN THE SPECIAL PROVISIONS. THE CONTRACTOR SHALL TAKE STEPS TO ASCERTAIN THE EXACT LOCATION OF ALL UNDERGROUND FACILITIES PRIOR TO DOING WORK THAT MAY DAMAGE SUCH FACILITIES OR INTERFERE WITH THEIR SERVICE."

BEFORE EXCAVATING, THE CONTRACTOR SHALL VERIFY THE LOCATION OF UNDERGROUND UTILITIES BY CONTACTING EACH OF THE FOLLOWING LISTED UTILITY COMPANIES:

GAS & ELECTRIC: S.D.G. & E. ________ 235-6323
TELEPHONE: PAC. TEL. CO. LOCATING SERVICE ____ 298-0595
WATER: ________ 728-1125
SEWER: NONE

~~SITE 1 =~~	~~W.O. UJ 0311~~
SITE 2 =	W.O. UJ 0291
~~SITE 3 =~~	~~W.O. UJ 0290~~

DEPARTMENT OF TRANSPORTATION
OFFICE OF THE COUNTY ENGINEER
COMMUNITY SERVICES AGENCY
County of San Diego, 5555 Overland Ave., San Diego, CA., 92123

RECOMMENDED BY: David S. Solomon DATE 5-4-79
R F Walsh DATE 5-7-79
APPROVED BY: For / Harry R. Hecht COUNTY ENGINEER R.C.E. 10358 DATE 5-7-79

REVISIONS	BY	APPROVED	DATE
△ Denotes "As Built" Revision			

COORDINATE INDEX
454 N. 1695 E.
CONST. COMPL. 12-21-79
AS BUILT REV. 7-7-80

SANDIA CREEK DRIVE
TITLE SHEET

SCALE: HOR. ______ VERT. ______
W.O. # SEE ABOVE R.S. R741
FILE NO. A2.00001
SHEET 1 OF 5 SHEETS

ATTACHMENT 'B' S.P. 220

	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	SHEET TOTAL
EXC.	115	513	984	1185	1236	406	127	128	32	0	0	4726
EMB.	5	0	0	0	0	3	210	117	203	1389	1914	3841

0 1 2 3 4 5 6 7 8 9 10 11

PLANS	BY	DATE
DESIGNED	[signature]	4/27/79
CHECKED	[signature]	5-1-79
DRAWN	[signature]	4/27/79

DEPARTMENT OF TRANSPORTATION
OFFICE OF THE COUNTY ENGINEER
COMMUNITY SERVICES AGENCY
County of San Diego, 5555 Overland Ave., San Diego, CA., 92123

RECOMMENDED BY: [signature] DATE 5-4-79
[signature] R F Walsh DATE 5-7-79
APPROVED BY: Harry R. Hecht DATE 5-7-79
For COUNTY ENGINEER R.C.E. 10358

REVISIONS | BY | APPROVED | DATE
Δ Denotes As Built Revision

COORDINATE INDEX 454 N. 1695 E.
CONST. COMPL. 12-21-79
AS BUILT REV. 7-7-80

SANDIA CREEK DRIVE, RS 741-1
SITE 2
PLAN AND PROFILE

SCALE: HOR. 1"=40' VERT. 1"=10'
W.O. # UJ0291 R.S. 741-1
FILE NO. A2.00001
SHEET 3 OF 5 SHEETS

S.P. 220

PLANS	BY	DATE
DESIGNED	J. Chr...	4/27/79
CHECKED	...	5/1/79
DRAWN	...	4/27/79

DEPARTMENT OF TRANSPORTATION
OFFICE OF THE COUNTY ENGINEER
COMMUNITY SERVICES AGENCY
County of San Diego, 5555 Overland Ave., San Diego, CA., 92123

RECOMMENDED BY: David J. Solomon DATE 5-4-79
R F Walsh DATE 5-7-79
APPROVED BY: Harry B. Hecht DATE 5-7-79
For / COUNTY ENGINEER R.C.E. 10355

REVISIONS	BY	APPROVED	DATE
△ Denotes As Built Revision			

COORDINATE INDEX
454 N. 1695 E.
CONST. COMPL. 12-21-79
AS BUILT REV. 7-7-80

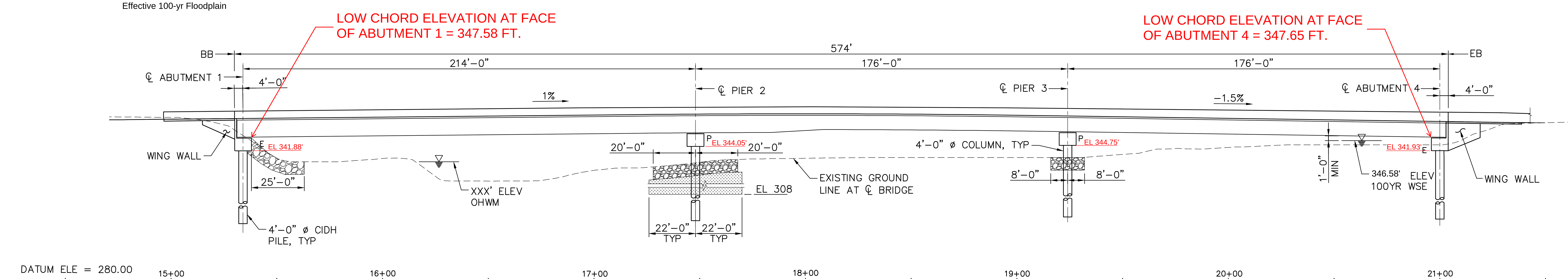
SANDIA CREEK DRIVE, RS 741-1
SITE 2
STRUCTURE DETAILS

SCALE: HOR. — VERT. —
W.O. # UJ0291 R.S. 741-1
FILE NO. A2 00001
SHEET 4 OF 5 SHEETS
SP 220

Appendix D – Design Plan/Profile

Proposed Bridge

PLAN
1" = 25'



ELEVATION
1" = 25'

HATCH	DESCRIPTION
(riprap hatch)	6'–0" THICK RIPRAP SCOUR PROTECTION. SEE RIPRAP SCOUR PROTECTION NOTES ON SHEET B2.
(dotted hatch)	GROUND IMPROVEMENTS

0 40 80 120
SCALE IN FEET

FULL SIZE = 22" x 34", HALF SIZE 11" x 17"

PROGRESS SET

Plotted: Feb 19, 2021 – 10:03am samimq Layout: Layout1
V:\1700232 (Santa Margarita Fish Passage)\Design\1700232-B1_PLAN-ELEVATION.dwg

kpff
1601 5th Avenue, Suite 1300
Seattle, Washington 98101
(206) 382-0600 Fax (206) 382-0500

NO.	DATE	BY	REVISION
			PROGRESS SET

SANDIA CREEK ROAD BRIDGE REPLACEMENT
SAN DIEGO, CALIFORNIA

PLAN AND ELEVATION

DRAWN: SQ	PROJECT NO.: 10092000118
DESIGN: PKG	SCALE: AS SHOWN
CHECKED: AMS	DATE: 2/19/2021
DRAWING NO.	B1
SHEET NO.	11 OF XX

Appendix E – Scour and Riprap Calculations

Proposed Bridge

RIVER FOCUS
WATER RESOURCE CONSULTANTS

HEC-18 5th Edition - Scour Calculation Spreadsheet

Live Bed Contraction Scour

***Live Bed Contraction Scour*: Scour at a contraction when the bed material in the channel upstream of the bridge is moving at the flow causing bridge scour.**

Modified Laursen's Equation (1):

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

Average Contraction Scour Depth:

$$y_s = y_2 - y_o$$

Parameter	Description	Metric Units		US Units		Notes
y_0	Existing Depth in the Contracted Section Before Scour	5.23	(m)	17.16	(ft)	*Flow area of bridge / W_2*
y_1	Average Depth in the Upstream Main Channe	5.50	(m)	18.06	(ft)	*Data from Chosen Upstream XS*
y_2	Average Depth in the Contraction Section	4.98	(m)	16.32	(ft)	*Modified Laursen's Equation*
Q_1	Flow in the Upstream Channel Transporting Sediment	1093.03	(m^3/s)	38600.00	(cfs)	*Flow in the main channel upstream of the bridge, not including overbank flow.*
Q_2	Flow in the Contracted Channel	1093.03	(m^3/s)	38600.00	(cfs)	*Flow at the bridge section (through the bridge opening)*
W_1	Width of the Upstream Main Channel that is Transporting Bed Material	34.75	(m)	114.00	(ft)	*Can be estimated by Upstream Channel Top Width. Data from Chosen Upstream XS*
W_2	Width of the Contracted Section Minus Pier and Debris Width	40.23	(m)	132.00	(ft)	*Effective Bridge Width Calculated Given Bridge, Pier, and Debris Width*
S_1	Slope of EGL of Upstream Main Channel	0.00	(m/m)	0.00	(ft/ft)	*Data from Chosen Upstream XS*
V*	Shear Velocity in the Upstream Main Channel	0.50	(m/s)	1.63	(ft/s)	*Calculated from data from Chosen Upstream XS(s). [$V^* = (gy_1 S_1)^{0.5}$]*
ω	Fall Velocity of Bed Material based on D50	0.05	(m/s)	0.17	(ft/s)	*See Fall Velocity Tab*
V^*/ω	Ratio of Shear Velocity to Fall Velocity	9.523	-	9.523	-	*Determine Mode of Bed Transport and k_1*
k_1	Top width of the upstream channel	0.69	-	0.69	-	*See Table 2 to the right.*

Average Live Bed Contraction Scour Depth (y_s)	**0.0**	**(ft)**
	0.0	(m)

RIVER FOCUS WATER RESOURCE CONSULTANTS

HEC-18 5th Edition - Scour Calculation Spreadsheet

Pier Scour

***Pier Scour* is a function of bed material characteristics, bed configuration, flow characteristics, fluid properties, and the geometry of the pier and footing.**

1). HEC-18 5th Edition Pier Scour Equation (based on the CSU Equation)

HEC-18 Equation:

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

In terms of y_s/a:

$$\frac{y_s}{a} = 2.0\, K_1\, K_2\, K_3 \left(\frac{y_1}{a}\right)^{0.35} Fr_1^{0.43}$$

Parameter	Description	Metric Units		US Units		Notes
y_1	Flow depth directly upstream of the pier	5.85	(m)	19.2	(ft)	*Obtained from (BR U) Flow Distribution Table; Bridge Information Macro*
θ	Angle of attack of the flow (skew)	0	(deg)	0	(deg)	*Bridge Skew*
K_1	Correction factor for Pier nose shape	**1.0**	-	**1.0**	-	*Use Figure 7.3 and Table 7.1* ***If θ > 5 degrees, K_1 = 1.0***
K_2	Correction factor for angle of attack of flow	1.0	-	1.0		*$K_2 = [(\cos(\theta) + \sin(\theta) * L / A)^{0.65}]$*
K_3	Correction factor for bed condition	**1.1**	-	**1.1**	-	*Use Table 7.3*
a	Pier Width (including bottom width)	1.2	(m)	4.00	(ft)	*Bottom Pier Width; no floating debris included*
L	Length of Pier	13.3	(m)	43.7	(ft)	*See Figure 7.3 for Guidance*
V_1	Velocity of flow directly upstream of the pier	5.35	(m/s)	17.6	(ft/s)	*Obtained from (BR U) Flow Distribution Table; Bridge Information Macro*
Fr_1	Froude Number directly upstream of the pier	0.71	-	0.71	-	*$Fr_1 = [V_1 / (gy_1)^{1/2}]$*

HEC-18 Equation Maximum Pier Scour Depth (y_s)		
	13	**(ft)**
	4.0	(m)

***Note for Round Nose Piers:**

Maximum Scour Depth (y_s) is typically ≤ (2.4 * a) for Fr ≤ 0.8 → 2.4 * a = 9.60

Maximum Scour Depth (y_s) is typically ≤ (3.0 * a) for Fr > 0.8 → 3.0 * a = 12.00

2.) Debris Loading Adjustment to HEC-18 5th Edition Pier Scour Equation

HEC-18 Guidance: The only change to the equation 7.2 is the value of pier width "a" is changed to effective pier width, a*. [#1 above]
This formulation of effective pier width **has not been** validated for the FDOT methodology. [#2 above]

Effective Pier Width:

$$a^*_d = \frac{K_1(HW) + (y - K_1 H)a}{y}$$

Parameter	Description		Metric Units		US Units		Notes
K_1	Debris Shape Factor. **Choose Debris Shape**	**Rectangular**	0.79	(mm)	0.79	(mm)	*Rectangular: 0.79; Triangular: 0.21*
H	Height (thickness) of the debris		1.83	(m)	6.00	(ft)	*See Figure 7.17 for guidance*
W	Width of debris perpendicular to the flow direction		3.05	(m)	10.00	(ft)	*See Figure 7.17 for guidance*
a	Pier Width		1.22	(m)	4.00	(ft)	-
y	Flow depth directly upstream of the pier		5.85	(m)	19.18	(ft)	-
a^*_d	Flow depth directly upstream of the pier		1.67	(m)	5.48	(ft)	-

HEC-18 Equation Maximum Pier Scour Depth with Debris Loading (y_s)		
	16	**(ft)**
	4.9	(m)

RIVER FOCUS
WATER RESOURCE CONSULTANTS

HEC-18 5th Edition - Scour Calculation Spreadsheet

Input Data Table

INPUT DATA BELOW

Parameter		**Entry (US)**		**Metric**		**Used In Tabs**
Median Particle Diameter	D_{50} =	**0.43**	(mm)	**0.43**	(mm)	Fall Velocity, Critical Velocity, Clear Water Scour
Average depth of flow upstream of Bridge	y_1 =	**18.1**	(ft)	**5.50**	(m)	Critical Velocity, Live Bed Scour, Abutment Scour
Average velocity of flow upstream of Bridge	V =	**10.4**	(ft/s)	**3.18**	(m/s)	Critical Velocity
Flow in the upstream channel	Q_1 =	**38600**	(cfs)	**1093.03**	(m^3/s)	Live Bed Contraction Scour, Abutment Scour
Flow in the contracted section	Q_2 =	**38600**	(cfs)	**1093.03**	(m^3/s)	Live Bed & Clear Water Contraction Scour, Abutment Scour
Existing depth in the contracted section before scour	y_0 =	**17.2**	(ft)	**5.23**	(m)	Live Bed & Clear Water Contraction Scour, Abutment Scour
Slope of energy grade line of main channel	S_1 =	**0.00459**	(ft/ft)	**0.004591**	(m/m)	Live Bed Contraction Scour
Top width of the upstream channel	W_1 =	**114**	(ft)	**34.75**	(m)	Live Bed Contraction Scour, Abutment Scour
Top width of the contracted section minus pier width	W_2 =	**132**	(ft)	**40.23**	(m)	Live Bed & Clear Water Contraction Scour, Abutment Scour
Flow depth directly upstream of pier	$y_{1\ (pier)}$ =	**19.2**	(ft)	**5.85**	(m)	Pier Scour
Velocity of flow directly upstream of pier	$V_{1\ (pier)}$ =	**17.6**	(ft)	**5.35**	(m)	Pier Scour

Known or Assumed Parameters

Parameter		**Known Value**	**Used in Tabs**
Gravity (g)	(m/s^2)	9.807	Fall Velocity
Density of water (ρ_w)	(kg/m^3)	1000	Fall Velocity
Density of sediment (ρ_s)	(kg/m^3)	2650	Fall Velocity
Specific weight of water (γ_w)	(kN/m^3)	9.807	Fall Velocity
Specific weight of sediment (γ_s)	(kN/m^3)	25.98855	Fall Velocity
Kinematic viscosity of water (ν_w)	(m^2/s)	1.3065E-06	Fall Velocity
Critical Velocity Parameter (K_u) - SI	($m^{1/2}/s$)	6.19	Critical Velocity
Critical Velocity Parameter (K_u) - US	($ft^{1/2}/s$)	11.17	Critical Velocity
Modified Laursen's Equation (2) (K_u) - SI	-	0.025	Clear Water Scour
Modified Laursen's Equation (2) (K_u) - SI	-	0.0077	Clear Water Scour

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Critical Velocity Calculation (Clear vs. Live Bed Determination)

***Critical Velocity* (V_c): The velocity above which the bed material of size D, D_{50}, etc. and smaller will be transported. Critical velocity is used as an indicator for clear-water or live-bed scour.**

→ If the mean velocity (V) of the upstream reach is equal to or less than the critical velocity (V_c) of the median diameter (D_{50}) of the bed material, then contraction and local scour will be clear-water.

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→ If the mean velocity (V) of the upstream reach is greater than the critical velocity (V_c) of the median diameter (D_{50}) of the bed material, then contraction and local scour will be live-bed.

Parameter	Metric		US	
Median Diameter of Bed Material (D_{50}):	0.4	(mm)	0.4	(mm)
Average Upstream Depth (y):	5.5	(m)	18.1	(ft)
Critical Velocity Parameter (K_u) - SI:	6.2	($m^{1/2}$/s)	11.2	($ft^{1/2}$/s)
Average Upstream Velocity (V):	3.2	(m/s)	10.4	(ft/s)
Critical Velocity (V_c):	0.6	(m/s)	**2.0**	(ft/s)

$$V_c = K_u\, y^{1/6}\, D^{1/3}$$

*Note: To determine Live Bed Scour vs Clear Scour, D in the equation above is set equal to D_{50}

Upstream V ≤ V_c: Clear Water Contraction Scour

Upstream V > V_c: Live Bed Contraction Scour

Proceed to Live Bed Contraction Scour Tab

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Fall Velocity Calculation

***Fall Velocity** (ω): The velocity at which a sediment particle falls through a column of still water.*

INPUT DATA BELOW (Light Blue Boxes)

One of Two Methods can be used:

1) Rubey's Law (Default)
2) HEC-18 Figure 6.8 (Alternative)

10

1). Rubey's Law (Default):

$$\omega = F\left[dg\left(\frac{\gamma_s-\gamma}{\gamma}\right)\right]^{1/2}$$

For particles > 1 mm, F = 0.79. Otherwise:

$$F = \left[\frac{2}{3}+\frac{36\upsilon^2}{gd^3\left(\frac{\gamma_s-\gamma}{\gamma}\right)}\right]^{1/2} - \left[\frac{36\upsilon^2}{gd^3\left(\frac{\gamma_s-\gamma}{\gamma}\right)}\right]^{1/2}$$

D_{50}:	0.43	mm
F:	0.626691	-
	0.052	m/s
Fall Velocity (ω):	**0.17**	ft/s
	52.3	cm/s

2). HEC-18 Figure 6.8 (Alternative):

Top width of the upstream channel

D_{50}:	0.43	mm
	0.06	m/s
Fall Velocity (ω):	**0.20**	ft/s
	60.0	cm/s

← Insert estimated Fall Velocity (ω) from Figure 6.8 below in the orange box to convert units.

Note: Move green lines below to help estimate ω using d_{50} as D_s.

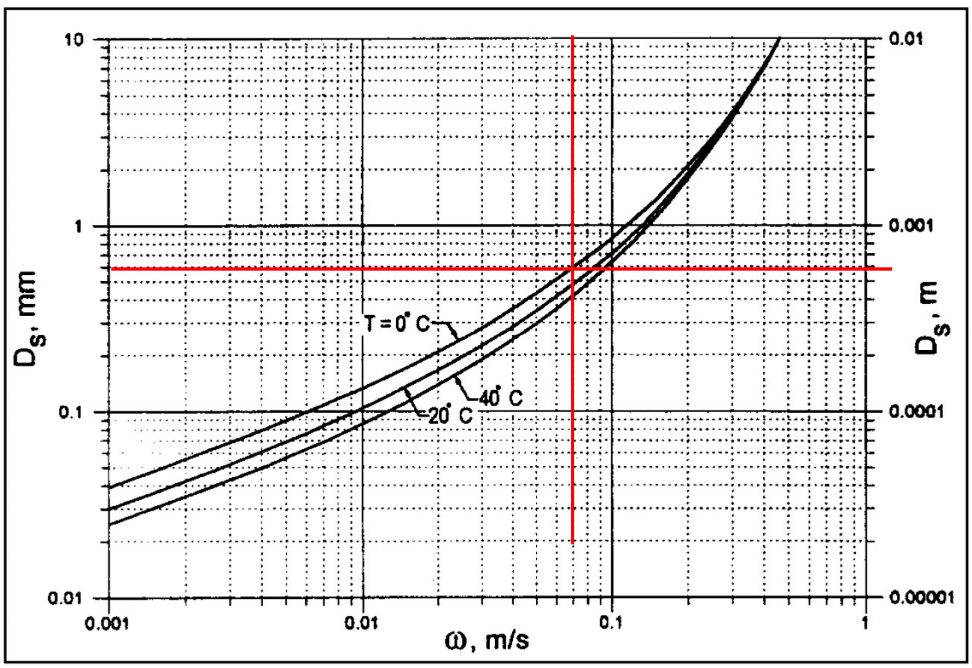

Figure 6.8: Fall velocity of sand-sized particles with specific gravity of 2.65 in metric units.

HEC-18 5th Edition - Scour Calculation Spreadsheet

Riprap Sizing (HEC-23 Guidelines)

***Riprap*: A scour mitigation countermeasure using large rock to minimize damage to regions where scour is prevalant (piers, abutments, etc.) Designed using the critical velocity near the boundary where the riprap is to be placed.**

1) Bridge Pier Riprap Sizing (Isbash Equation, 1936)

$$d_{50} = \frac{0.692(V_{des})^2}{(S_g - 1)2g}$$

$$V_{des} = K_1 V_{max}$$

**Note*: Ensure that the 'Bridge Information' Tab has been completed and run to determine V_{max}*

Parameter	Description		Metric Units		US Units		Notes
K_1	Pier Shape Coefficient **Choose Pier Type →**	**Round-Nosed**	1.5	-	1.5	-	*Shape Factor is added to account for additional stresses due to turbulence*
S_g	Specific Gravity of Riprap		2.65	-	2.65	-	*Usually taken as 2.65*
V_{max}	Maximum Velocity in the active channel		4.29	(m/s)	14.00	(ft/s)	*Taken from Bridge Cross-Section (equal to $V_{1\,(pier)}$) - Bridge Information Tab*
V_{des}	Design Velocity		6.44	(m/s)	21.00	(ft/s)	-
d_{50}	Median Riprap Stone Diameter		0.89	(m)	2.87	(ft)	*Isbash Equation*

Median Pier Riprap Stone Diameter	**35**	**(in)**
	89	(cm)
Pier Riprap Class (Table 4.1)	**IX**	**-**

HEC-23 Guidance: Once the riprap class is chosen, the depth and extent of riprap needs to be determined. The depth of Riprap is typically taken as the greater of 3*d_{50}, the contraction scour and long-term degradation depth, or the depth of bedform troughs

Parameter	Description		Metric Units		US Units		Notes
3 * d_{50}	3 * Median Riprap Stone Diameter		2.7	(m)	8.6	(ft)	*Used in determing riprap depth below streambed at pier*
y_s	Contraction Scour		0.0	(m)	0.0	(ft)	*Live Bed or Clear Water Contraction Scour, depending on 'Critical Velocity' Tab*
-	Are bedforms prevalent? If yes, enter bedform trough depth.	**No**	**19.7**	(m)	**6.0**	(ft)	*Bedform Trough depth can be indicative of necessary scour depth / riprap depth*

Minimum Depth of Pier Riprap	**8.6**	**(ft)**
	2.6	(m)

HEC-23 Guidance: The recommended riprap extent is at least <u>two times the pier width</u>.

Parameter	Description	Metric Units		US Units		Notes
a	Pier Width (including bottom width)	1.2	(m)	4.00	(ft)	*Bottom Pier Width; no floating debris included*

Minimum Pier Riprap Extent	**8.0**	**(ft)**
	2.4	(m)