Williams Creek Restoration Project: Alternatives Analysis

FINAL REPORT for CDFW Grant Agreements P1596013 & P1796009

March 2020

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DRAFT Report

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Executive Summary

The Humboldt County Resource Conservation District (HCRCD) was formed in the 1980's to address sedimentation, flooding and associated environmental and land-use impacts within the Salt River watershed including its largest tributary, Williams Creek. Legacy land practices coupled with high rainfall amounts and unstable geology have contributed to highly dynamic fluvial processes that have altered the lower watershed, impacting land-use and habitat. Additionally, historical changes to the landscape within the Eel River Valley have altered how lower Williams Creek processes flow and sediment. In April 2016 the Williams Creek Community and Humboldt County Supervisor requested that the HCRCD lead an effort to address flooding impacts specifically associated with lower Williams Creek. This initiated the development of feasible alternatives to address flooding along Williams Creek, as described in this report.

Williams Creek, as it emerges from the Willdcat Range onto the unconfined Eel River floodplain, deposits sediment that has built an alluvial fan. Historic maps indicate that Williams Creek has been artificially confined to its current alignment on the alluvial fan since the late 1800's. Through overbank deposition, Williams Creek has built a ridge that it flows along. As a result, the channel banks are over 10 feet higher than the valley bottom to the east and west.

Historically, the alluvial fan and large wetland areas on the Eel River floodplain minimized delivery of coarse sediment from Williams Creek to the Salt River. However, since the late 1800's much of this coarse sediment has been routed directly into the Salt River, where it deposits. Current Salt River bed elevations under the Highway 211 bridge, approximately 3,700 feet downstream of Williams Creek confluence, have risen over 13 feet since the bridge was constructed in 1968. Comparison of current channel elevations to a 1993 survey indicate Williams Creek channel bed has risen about 4 feet at the confluence with the Salt River, and about 1 foot at the Grizzly Bluff Road Bridge.

The frequency of out-of-bank flows increases in the downstream direction of Williams Creek, concurrent with decreases in channel width and depth. Debris jams, overhanging riparian vegetation, and tight meanders in the channel planform increase flow resistance, cause sediment deposition, and elevate water levels. Because the channel is located on a ridge above lower adjacent lands, out-of-bank flows cannot return to the channel, resulting in flooding and sediment deposition on the adjacent residential and agricultural properties. Depending on the flow event, the flooding and sediment deposition can be substantial. A hydraulic analysis indicated that channel capacity decreases substantially in the downstream direction. Overbank flow losses from the channel begin downstream of Grizzly Bluff Road, and by the time the flows reach the confluence with the Salt River the channel maximum conveyance is only approximately 147 cubic feet per second, which has a return period between 1.01 and 1.1 years. Therefore out-of-bank flows can be expected to occur along Williams Creek at least once per year, and typically more.

Flow and sediment transport rates were measured in Williams Creek during water year (WY) 2017 and 2018. WY 2017 is classified as being on the threshold between an “above average” and “wet” year. WY 2018 has been classified as a “below average” year. During WY 2017 a total of 96,753 tons of sediment was transported by Williams Creek, with only 83.4 tons transported as bedload. Of the amount of sediment transported, 78% of the sediment was silt and clay (finer than 0.0625 mm) and considered washload that remains in near permanent suspension when conveyed by flowing water. Coarser grain sizes in transport were predominantly very fine sands, but also included coarser sands and gravels. During the dry WY of 2018, Williams Creek transported a total sediment load of 13,027 tons, with bedload comprising only approximately 9 tons of the total, 23% of the transported sediment composed of sands, and the remaining being silts and clays. The sediment transport capacity in Williams Creek decreases by 98% between Grizzly Bluff Road and the Salt River during an approximately 3-year return period flow of 722 cfs. Some sediments are deposited in the channel, but most deposition occurs along the tops-of-banks and on the overbanks. The frequency and magnitude of sediment deposition is causing both the channel bed and banks to aggrade, further building-up the ridge that Williams Creek flows along.

A sediment transport analysis of the restored Salt River channel downstream of the Williams Creek confluence indicated that the Salt River will not have the capacity to transport the sediment load and associated grain sizes delivered from Williams Creek. Therefore, the rehabilitation approaches considered for Williams Creek need to include measures to trap the coarser sediment from Williams Creek, with a focus on materials coarser than very fine sand (>0.125 mm). To achieve this goal as well as other goals established for the project, multiple alternatives were evaluated and presented at community meetings on June 27, 2018 and February 13, 2020, as well as an agency meeting on February 2, 2020, and multiple individual landowner meetings over the past two years. Based on scoping of feasible approaches for addressing the flooding and sedimentation issues along Williams Creek, three alternatives were advanced into schematic design and evaluated in this report.

Each alternative includes channel widening/deepening between Grizzly Bluff Road and the confluence with the Salt River. The rehabilitated channel corridor will include low points along the eastern channel bank to allow water to spill out of the channel at select locations when the streamflow exceeds approximately a 2-year return period event. The designed overtopping will result in less overbank flow to the east than under current conditions and avoid overtopping of the streambanks along the western side of the channel up to a 10-year flow event. The channel improvements will also include riparian plantings to re-establish a conifer-dominated corridor and replacement of existing bridges to accommodate the widened channel.

Each alternative includes a sediment management area (sediment basin). The primary difference between the three alternatives is the location of the sediment basin, which will be subject to landowner approvals. Regardless of the final location, the sediment basin is anticipated to require removal up to approximately 4,000 cubic yards of sediment annually, comprised predominately of fine sands and some silts, with smaller portions of small gravel. Similar to the Salt River Ecosystem Restoration Project, where there is current landowner “waiting list” for available sediments, nearby beneficial reuse of the excavated sediments could include application to agricultural fields and lanes, as well as beach nourishment. The long-term maintenance will require development of a monitoring and adaptive management plan. The plan would include annual monitoring, anticipated maintenance activities, and agency reporting, and would be covered under the project permits. An entity such as the HCRCD, Salt River Watershed Council, or other would administer the long-term plan.

An environmental constraints analysis was conducted to determine the potential California Environmental Quality Act (CEQA) and permitting pathways for the project. Baseline studies, including wetland determinations, habitat mapping, and rare plant/animal species surveys indicate the project is feasible and, while there will be short-term temporal impacts associated with construction activities, the long-term net benefits would be greater from the improved stream corridor function. The next steps include further landowner outreach, establishing a lead entity for administering long-term adaptive management and maintenance, development of the CEQA document, 30% design plans and continued development of grant funding to support the next planning, design and implementation efforts. An opinion of probable construction cost was developed for each of the three alternatives. Given the similarities between the alternatives, the difference in costs was negligible. For planning purposes, a construction cost of approximately $7M, which includes a 30% estimating contingency, should be utilized.

1. Introduction

1.1 Purpose of Report

The purpose of this report is to summarize the findings and recommendations from a planning-level study to rehabilitate the lower reaches of Williams Creek near Ferndale, California. The intent of the study is to characterize the geomorphic condition and to identify viable solutions to address sedimentation within the Williams Creek channel, reduce flooding of adjacent properties, and minimize delivery of sediment to the Salt River. This alternatives analyses process can be used as the basis for the HCRCD and landowners to define a project that can be advanced into design, CEQA, permitting and implementation.

1.2 Project Background

Williams Creek is a tributary to the Salt River in Ferndale, California. An aerial photograph of Williams Creek is shown on Figure 1-1. Williams Creek has experienced chronic out-of-bank flooding for the past twenty years, inundating adjacent residents and ranchlands with both flow and sediment. Due in part to the excessive sediment load, Williams Creek currently splays across broad pastures at the historical connection with the Salt River, where it deposits sediment before slowly draining into the river downstream of Highway 211.

The Humboldt County Resource Conservation District (HCRCD) has been leading efforts to restore the Salt River since 1980s. Construction has been ongoing since 2013 to increase the channel capacity, reduce the frequency of out-of-bank flooding, and improve fish and other aquatic organism habitat. Restoration of the Salt River includes excavation of a new channel and floodplain along the historical Salt River alignment extending from Riverside Ranch to the Upper Salt River slough channel, upstream of the historical Williams Creek Confluence. The alignment for the Salt River project is shown on Figure 1-1.

The restoration of the Salt River includes re-connecting Williams Creek to the Salt River. However, the high sediment load in Williams Creek and chronic out-of-bank flooding and sedimentation that occurs along Williams Creek also necessitates rehabilitation of Williams Creek. The Salt River has limited sediment transport capacity due to its low slope, and likely will not transport some or all of the sediment delivered from Williams Creek. Excess sediment delivered to the Salt River from Williams Creek would likely result in in-channel sedimentation, which would be detrimental to the restoration project as a whole. Therefore, the rehabilitation of Williams Creek needs to address the sediment load that will be delivered to the Salt River after Williams Creek is re-connected.

1.3 Project Goals and Objectives

Through a grant from the California Department of Fish and Wildlife (CDFW), the HCRCD retained the services of GHD, Inc. (GHD) and Michael Love & Associates, Inc. (MLA) to characterize the study area and identify potential rehabilitation actions to Williams Creek. Following are the specific goals of the project:

- Establish hydrologic connectivity between Williams Creek and Salt River;
- Reduce flood and sedimentation risk to private and public infrastructure along Williams Creek;
- Improve agricultural land productivity by reducing flooding and sedimentation impacts;
- Minimize potential impacts to the Salt River Ecosystem Restoration Project from Williams Creek sediment loading
- Improve aquatic and riparian habitat function and value for salmonids and other dependent species in Williams Creek
- Initiate a long-term process for adaptively managing the project

This report summarizes activities performed to characterize the causes of the sedimentation and flooding along Williams Creek, presents multiple approaches to address these problems, and further develops three alternatives. This alternatives analysis study attempts to balance the needs of the landowners with the geomorphic site conditions and ecological needs of the area. This includes striving to meet the following objectives:

- Reduce flooding magnitude and frequency to the west side of Williams Creek, specifically along Ambrosini Lane/ Rose Avenue and are referred to as “Frog Alley”
- Reduce flooding magnitude and frequency onto the agricultural fields to the east of Williams Creek.
- Reduce unwanted sediment deposition in Williams Creek
- Minimize coarse sediment delivery to the Salt River
- Minimize maintenance needs and costs as practical
- Maintain existing land-uses to the extent practical
- Work within current-day regulatory constraints
- Improve fish and other aquatic organism habitat

Horizontal Datum: NAD83 California State Plane Zone I

Figure 1-1 Williams Creek Vicinity Map

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2. Evaluation of Existing Conditions

2.1 Previous Studies

There have been numerous studies of the Williams Creek watershed, and its sediment contributions to the Salt River. The following provides a brief description of these studies and their key findings as it relates to this effort:

- The Soil Conservation Service (SCS) (USDA, 1993) study provides background information on both the historical and current natural resources and land uses within the watershed. Included in the report was a discussion of the causes and estimated quantities of current sediment loads to the Salt River from various sub-watersheds, including Williams Creek. The report also notes problems with both natural and manmade resources, including sedimentation and flooding as well as losses of natural habitat, and makes recommendations on how these problems should be addressed. To address sediment loading into the Salt River from Williams Creek, the study recommends constructing a sediment basin at the confluence of Williams Creek with the Salt River, or construction of a sediment retention dam where Williams Creek exits the Wildcat Range.

- Downie et al. (2005) developed the Salt River Watershed Assessment which builds on the USDA (1993) report, focusing more on the natural resources of the Salt River watershed and impairments.

- Benda (2007) further evaluated the sediment sources and loads in Williams Creek and found that the SCS (1993) sediment budget for Williams Creek was under-estimated by at least 100%, if not more. A specific quantity was not provided. The report recommended that a sediment basin or dam be constructed in Williams Creek to reduce sediment to the Salt River.

- Timberland Resources Consultants (2010) conducted an upslope and instream erosion hazard inventory to identify sediment sources and best management practices to reduce downstream sediment loading. The report has been used to prioritize upslope sediment reduction projects funded through NRCS and other programs

- Kamman Hydrology (2011) estimated average annual suspended sediment yield from Williams Creek using multiple methods further described in subsequent sections of this report. These estimates were used in support of the Salt River Ecosystem Restoration Project Environmental Impact Report (EIR).

- McBain Associates/Moffat Nichols (2013) prepared recommendations to address sedimentation in Williams Creek for the U.S. Army Corps of Engineers, and included conceptual design and feasibility assessment to trap sediment along the length of Williams Creek with use of set-back berms.

- Fenton (2007-2018) performed suspended sediment sampling in Francis Creek between 2007 and 2018 at the Van Ness Avenue bridge. Francis Creek basin is directly to the west of William Creek and has similar land use and geology as Williams Creek, thus could be considered a surrogate for Williams Creek.

- The USDA Natural Resources Conservation Service (NRCS) has been working in the Williams Creek watershed with private landowners since 1993 to identify resource concerns by developing Resource Inventories. The most recent Resource Inventories were developed by NRCS between 2012 and 2018. Landowners in the Williams Creek watershed have been working to implement practices, identified in Resource Inventories, to reduce sediment delivery. Resource Inventories have not been developed for all parcels in the upper Williams Creek watershed due to the lack of private property owner access and interest in participating in NRCS programs.

- HCRCD (2019) updated the NRCS sediment source inventory for the Williams Creek watershed based on current conditions by utilizing the following methods: 1) review of remote sensing and historical aerial imagery to identify seasonal, permanent, and abandoned roads and hillslope gradients, and 2) field work to establish an inventory of upslope sites and instream sites that have the potential to deliver sediment to the watershed.

2.2 Topography

Topography of lower Williams Creek was obtained from the Coastal LiDAR provided by the California Ocean Protection Council. The LiDAR was flown between 2009 and 2011. The LiDAR topography did not contain sufficient detail of Williams Creek due to vegetation. Additionally, the LiDAR extents ends approximately 850 feet north of Grizzly Bluff Road.

To supplement the LiDAR, GMA Hydrology (GMA) performed a topographic survey of Lower Williams Creek channel in 2017, including the channel thalweg and toe and tops of banks. The survey included nearly 10,400 feet of channel, starting at the confluence to the Salt River and extending upstream to Grizzly Bluff Road. The dimensions and elevations of three private bridges spanning the channel were also surveyed.

GMA merged the LiDAR and field-run topographic survey to create a combined digital terrain model (DTM) and base-map of the project area with 1-foot contours, as shown on Figure 2-1. Approximate parcel lines were obtained from the Humboldt County geographic information website.

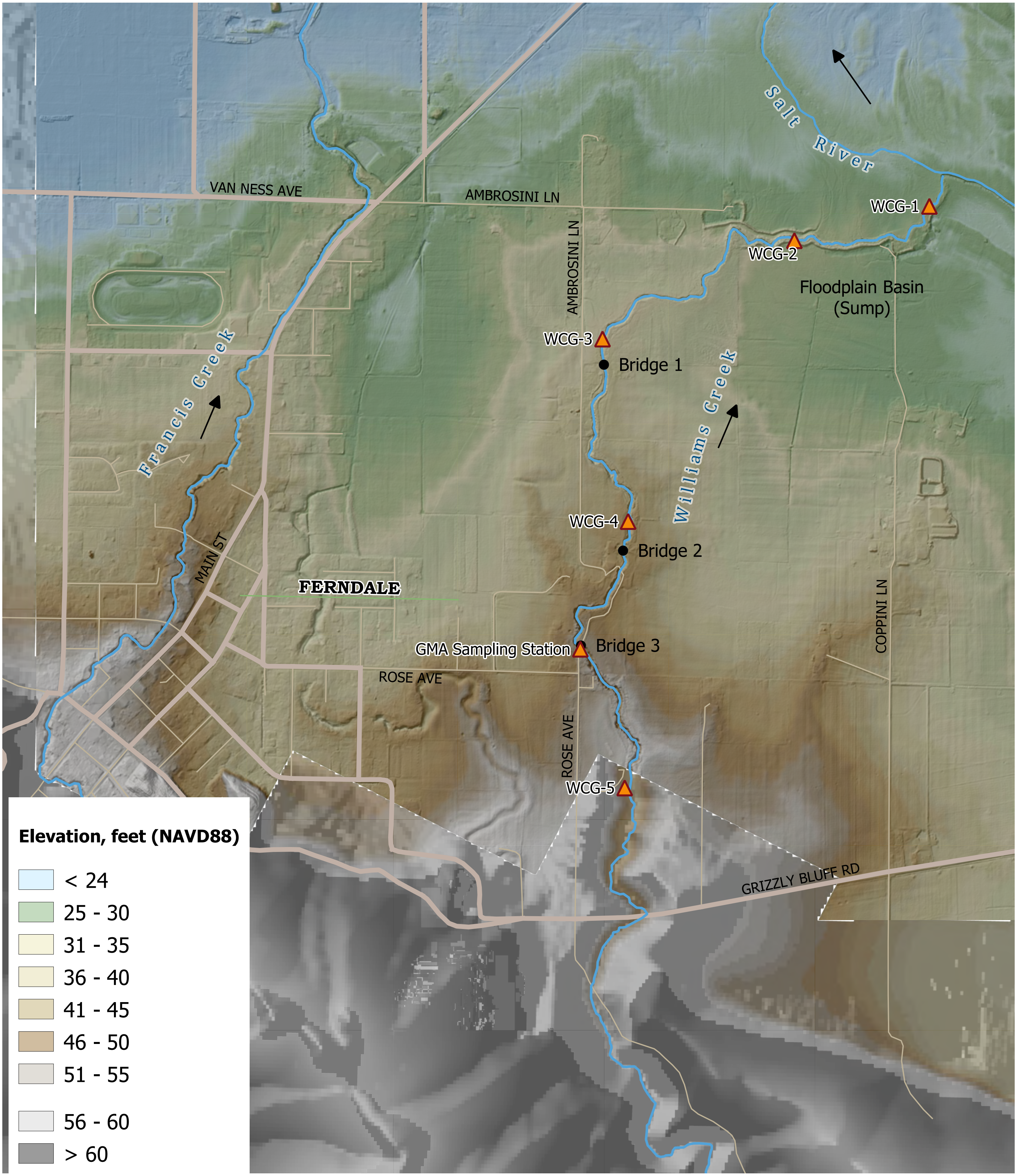
The horizontal control for the mapping is North American Datum 1983 (NAD83) California State Plane, Zone 1, in feet, and vertical control is North American Vertical Datum of 1988 (NAVD88) in feet.

A stationed channel alignment was developed based on the surveyed channel centerline, with stationing starting at the Williams Creek confluence with the Salt River and increasing upstream to Grizzly Bluff Road.

Coastal LiDAR was not available for a portion of the project area downstream of Grizzly Bluff Road and for all of the project area upstream of Grizzly Bluff Road. As part of the design for replacing the Grizzly Bluff Road bridge, Humboldt County obtained a topographic survey in 2014 of the Williams Creek channel thalweg. The survey extended from about 450 feet downstream of Grizzly Bluff Road to about 1,500 feet upstream of the bridge. This survey was used to obtain the channel profile in this reach.

A 30-meter DEM based on the USGS quad-sheet (1957) was obtained to supplement the County topography upstream of Grizzly Bluff Road. However, it was substantially different than the LiDAR topography, and was only used sparingly.

The level of detail of the surveys and base-map is sufficient for a planning-level study, but more detailed focused surveys will be required for final design.



Horizontal Datum: NAD83 California State Plane Zone I

Legend

Stream Gages

Figure 2-1 Colorized topographic map of Williams Creek

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2.3 Hydrology

Williams Creek has a contributing drainage area of 6.0 square miles at Bridge 3 off of Rose Avenue, about 3,000 feet downstream of Grizzly Bluff Road, where flow gaging and sediment transport sampling was performed for the project (See Section 2.10). Downstream of Bridge 3, Williams Creek is perched above its floodplain; thus the watershed size does not substantially increase downstream of Bridge 3. All flow computations are based on the contributing drainage area at Bridge 3.

The Williams Creek watershed upstream of Bridge 3 consists of a combination of ranches and forested hillslopes. Downstream of Grizzly Bluff Road the contributing watershed area is limited to the stream width, as the floodplain drains away from Williams Creek. The basin-average annual precipitation for the Williams Creek watershed is 50.7 inches (USGS StreamStats, 2019) and falls primarily as rain. Rainfall occurs primarily between October and May within the region. During late summer and early fall, the stream dries out in many locations due to a lack of precipitation during this period.

StreamStats summaries of the Williams Creek watershed are shown in Appendix A.

2.3.1 Peak Flows and Return Periods

Williams Creek streamflows have not historically been gaged; therefore, indirect methods were necessary to compute peak flow magnitude and associated return period in Williams Creek. For comparative purposes, peak flow return periods in Williams Creek at Bridge 3 were calculated using two different methods: (1) Log Pearson Type III probabilistic analyses of streamflows from a nearby USGS gage and (2) USGS regional regression equations (Gotvald et al, 2012).

Log Pearson Type III analyses were prepared using annual peak flow data from the USGS gage, Bull Creek near Weott (USGS No. 11476600), and applying methods in Bulletin 17B (USGS, 1982). Bull Creek was selected because it is the closest USGS gage with a relatively small watershed (27.6 square miles based on Gotvald et al., 2012), similar rainfall patterns as the Wildcat Range, and an extended period of continuous recorded (from 1961 through October 2018). The results of the analyses were normalized into units of cfs per square mile and then scaled linearly by the watershed area for Williams Creek at Bridge 3. Computed peak flows in Williams Creek and their associated return periods are provided in Table 2-1.

USGS regional regression equations from Gotvald et al. (2012) were also used to compute peak flow return periods for the Williams Creek at Bridge 3 using StreamStats (Gotvald, et al, 2012), as given in Table 2-1.

The two methods predicted similar peak flows for Williams Creek. Flows computed by the USGS regional regression equation are slightly lower than those based on the Log Pearson Type III analyses. For consistency, the results of the Log Pearson Type III analyses were used to reference peak flow magnitudes and return periods in this report.

Computations are presented in Appendix A.

Table 2-1. Williams Creek at Bridge 3 estimated peak flows using two different methods. The contributing drainage area at Bridge 3 is 6.0 square miles.

Analysis Method	Peak Flow (cfs) for Indicated Return Period							
	1.01-Year	1.2-Year	1.5-Year	2-Year	5-Year	10-Year	50-Year	100-Year
Scaled LP III of Bull Creek near Weott	107	299	440	584	971	1,239	1,837	2,089
USGS Regional Regression Equations	-	-	-	436	823	1,100	1,740	2,030

2.3.2 Water Level and Flow Gaging

GMA Hydrology, Inc. (GMA) established a water level and sediment sampling station at Bridge 3. They conducted flow and sediment sampling from October 26, 2016 through April 30, 2017, and from October 18, 2017 through May 2, 2018, representing water year (WY) 2017 and WY 2018 (GMA Hydrology, 2017, 2018). A water year extends from October 1 of the previous through September 30 of the named water year. The objective of the flow monitoring was to obtain continuous flow records for use in computing total annual bedload and suspended sediment load transported by Williams Creek at Bridge 3 for each water year.

Figure 2-2 shows a plot of gaged flows in Williams Creek during WY 2017 and WY 2018 (GMA, 2017, 2019). The 1.2-year flow is shown for reference. WY 2017 had numerous flow peaks well above a 2-year flow event. A peak flow of 788 cfs was recorded on December 15, 2016, which had a return period of between 3 and 4 years. WY 2018 had much lower peak flows, with only one event exceeding a 1.2-year return period magnitude.

GMA flow measurements and sediment sampling methods and results are presented in Appendix B. Sediment sampling results are presented in Section 2.10.

MLA, GHD and HCRCD installed five water level loggers along Williams Creek from November 11, 2017 through May 10, 2018 and the HCRCD downloaded the data regularly. The locations of the water level loggers are shown in Figure 2-1 and Figure 2-5**.**

Water levels at these locations combined with water level and streamflow data at Bridge 3 were used to calibrate an existing condition hydraulic model of the project area (Appendix C).

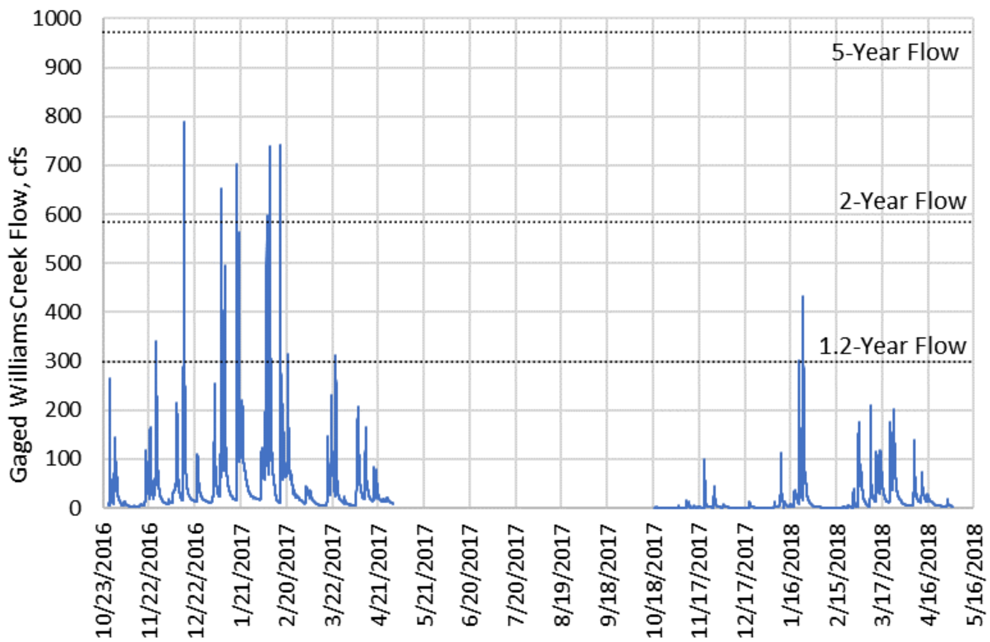


Figure 2-2. Gaged flows in Williams Creek during the 2017 and 2018 water years, with return periods indicated for reference.

2.3.3 Flow Duration Curves

For estimating more frequently occurring flows than annual peak flows, and for use in estimating long-term annual sediment loads that would be delivered to the Salt River, several flow duration curves (FDC)for William Creek were constructed. FDC's quantify the average amount of time that flows are equaled or exceeded on an annual basis. For example, the 10% annual exceedance flow is exceeded on average 3.65 days per year.

A long-term flow duration curve was also constructed for Williams Creek using 15-minute data from the USGS gage at Bull Creek near Weott (USGS 11276600), collected between 1988 and 2018 (Figure 2-3). Flows with exceedance values ranging from 0.0001% (peak gaged flow) through 100% (lowest recorded flow) were computed and normalized to the drainage are of the gage, and then linearly scaled to the Williams Creek watershed area at Bridge 3.

Figure 2-3 also shows the annual FDC's for Williams Creek during WY 2017 and WY 2018. These were constructed assuming flows during the dry season, when the gage was not operational, were consistently lower than during the gaging period.

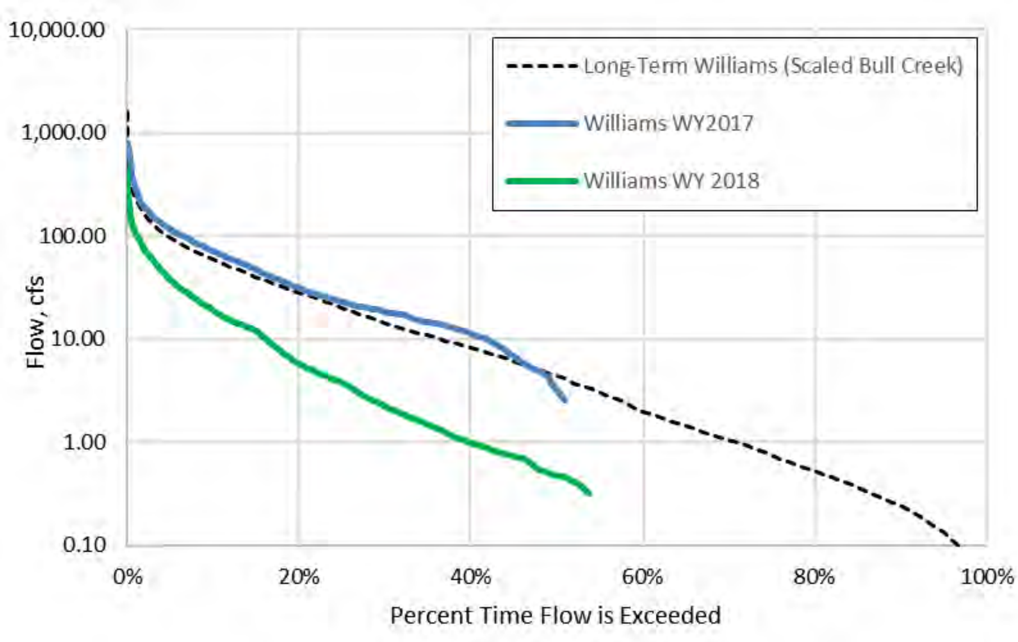


Figure 2-3. Annual flow duration curve for Williams Creek based on long-term flow record from Bull Creek scaled to Williams Creek drainage area. Flow duration curves constructed from Williams Creek at Bridge 3 gaged data during WY 2017 and WY 2018 are provided for comparison.

2.3.4 Water Year Classification

An analysis was performed to place the two years of flow gaging and sediment sampling on Williams Creek, WY 2017 and WY 2018, into the spectrum of “dry” to “wet” years over a longer flow record. To classify water years in terms of dry to wet, the total volume of streamflow, referred to as the annual yield, was calculated for each WY using average daily flow data from the USGS gage at Bull Creek near Weott (USGS 11276600). The Bull Creek gage has a record of daily average flow for water years1961 through 2018, a total of 58 years. The annual yield from each water year was ranked and plotted, as shown in Figure 2-3.

The annual yields for the past 15 water years are shown as red squares on the plot. The type of water year (dry to wet) is based on definitions by the California Department of Water Resources. The annual yield for WY 2016 is slightly less than the 50 percentile (median), with half the years wetter and half drier, and it classifies as an “Average” year. The annual yield for WY 2017 has only been exceeded five times during the period of record, placing it in the top 10 percentile and classifying it as on the threshold between an “Above Average” and “Wet” year. Conversely, the annual yield for WY 2018 has been exceeded 86% of the time, and is classified as a “Below Average” year.

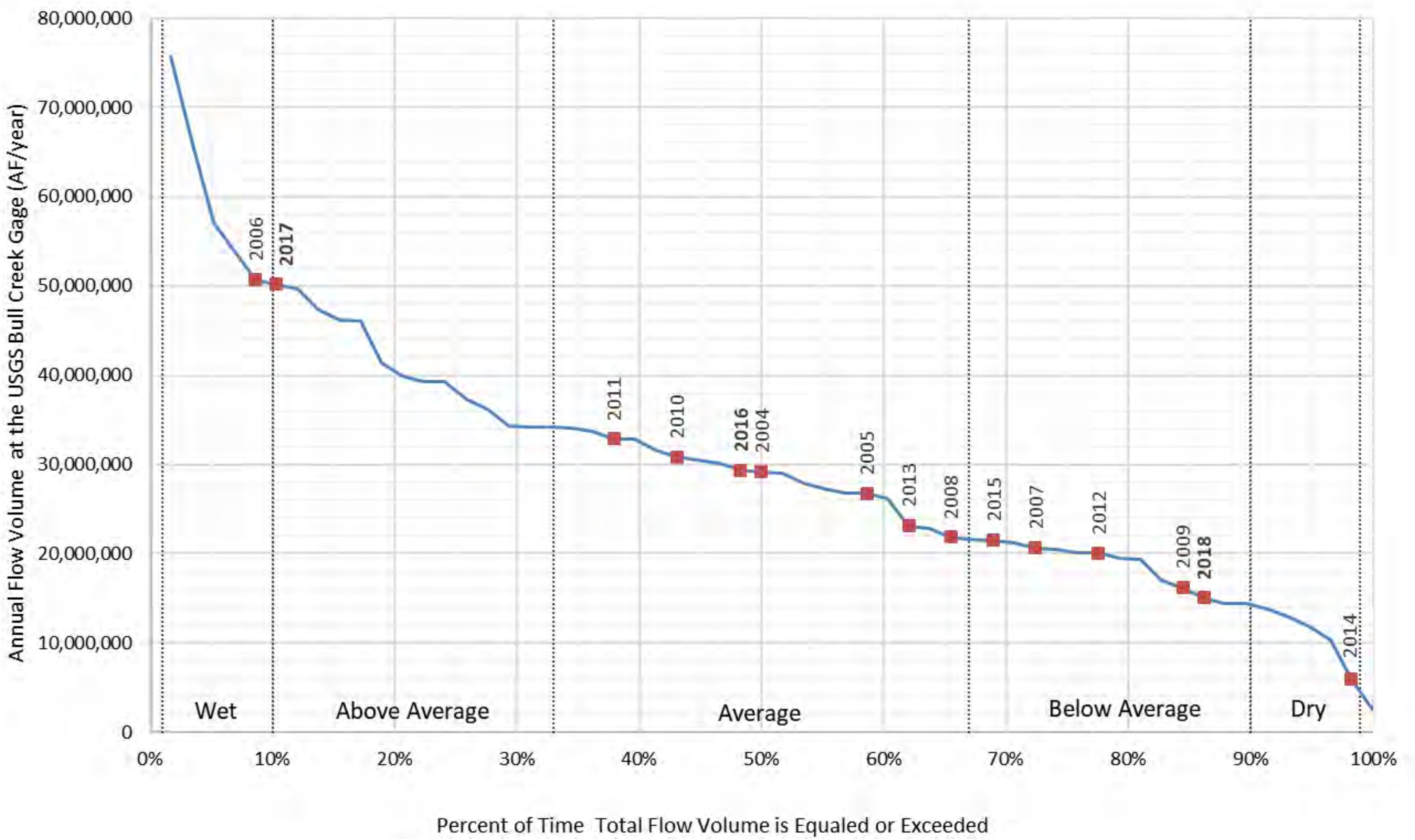


Figure 2-4. Annual water yield based on daily average flows measured at USGS Bull Creek near Weott (USGS 11276600) from WY1961 through WY2018. The annual yield for the past 15 water years are shown as red squares on the plot. Water year classifications (Wet to Dry) are based on definitions by the California Department of Water Resources.

2.4 FEMA Flood Insurance Mapping

Williams Creek is mapped by FEMA in Panels 1205 and 1184 of the Flood Insurance Rate Map (FIRM) prepared as part of the Flood Insurance Study (FIS) for Humboldt County, California Unincorporated Areas (FIRM MAP Number 06023C1205F, Effective Date November 4, 2016).

The main channel of Williams Creek is mapped as Zone AE, where base flood elevations were determined for the 100-year base flood event. The Zone AE designation is limited to the Williams Creek channel, indicating that the 100-year flow event is predicted to be contained within the channel. The overbank areas of Williams Creek are not mapped within the 100-year flood zone. A 100-year base flood flow of 1,985 cfs was use for the modeling.

The Flood Insurance Study (FIS) for Williams Creek appears to be out-of-date given the frequency of out-of-bank flooding along most of the length of Williams Creek. In the FIS Flood Profiles (Panels 64P65P), the channel bottom elevation of Williams Creek at the confluence with the Salt River was surveyed in 1993 to be 21.5 feet (NAVD88). Currently, the channel elevation of Williams Creek at the confluence is 25.4 feet, indicating the channel has filled in about 4 feet in the downstream reaches. At Grizzly Bluff Road, the Williams Creek bottom elevation was surveyed in 1993 as about 53 feet (NAVD88), and currently is at an elevation of 54.0 feet, indicating that the channel has filled in about 1 foot in this location since 1993.

The downstream reaches of Williams Creek are located with the Eel River floodplain, which is mapped as Zone AE. Large portions of the Salt River, and the downstream-most reaches of Williams Creek are also mapped as a floodway. This is further discussed in the environmental constraints section as it relates to beneficial reuse of excavated sediments.

2.5 Fisheries

Little documentation is available about the historical salmonid distribution in Williams Creek. California Department of Fish and Game (DFG) stocked steelhead in Williams Creek between 1930 and 1934 (Becker and Reining, 2009). An undated DFG report indicated the presence of steelhead in Williams Creek around 1934.

Prior to 1951, cutthroat trout were abundant in Williams Creek, but have not been found recently (Downie et al., 2005). In recent years, no salmonids have been observed in Williams Creek despite extensive sampling in 2003 and 2004. Sticklebacks are present, and pike minnow have been found upstream of Grizzly Bluff Road since 1999.

Fish habitat surveys summarized in Downie, et al. (2005) indicate that fish habitat within Williams Creek is well below optimal levels due to a high level of embedded cobbles, limited pools and poor pool shelter, lack of spawning gravels, and a low macroinvertebrate diversity index. A sediment plug that formed in the Salt River downstream of the Williams Creek confluence blocked fish access into Williams Creek at the time of the report in 2005, and the sediment blockage remains to today.

Downie et al. (2005) suggests that fisheries habitat can be improved within Williams Creek by reduction of upslope erosion not caused by natural processes, addressing flooding, and improving in-channel habitat and riparian function.

Fisheries are further described in the environmental constraints section of this report, and as related to the anticipated regularity permitting processes.

2.6 Watershed Geology

Within the Wildcat Range, the Williams Creek watershed is underlain by several rock formations within the highly unstable Wildcat Group (Ogle, 1953). The unstable geology of the Williams Creek watershed is compounded by high rates of tectonic activities and high rainfall rates.

The Rio Dell formation comprises most of the upper watershed, and consists of massive mudstones, alternating thin sandstone and mudstone, siltstones, and very fine-grained sandstones. Weathering patterns in the mudstones formation are typically an intricate system of cross fracturing or onion-skin weathering. Numerous landslides are mapped within the Rio Dell Formation.

Northward of the Rio Dell formation, where the channel slope decreases and the stream valley begins to widen, the Scotia Bluffs sandstone comprise the valley walls. The Scotia Bluffs sandstones are massive sandstones, colloquially called “Ferndale Sandstones,” and tend to form vertical cliff faces and ledges. The valley bottom is comprised of recent alluvium.

The Carlotta formation forms the north side of the Wildcats, consisting of resistant conglomerate made up of rounded material ranging from sand size to 8-inch boulders. The formation also contains sandstones and claystones that weather rapidly and form landslides. This formation typically forms tall vertical cliffs that undergo mass wasting with the erosion of the claystones and structural failure of the conglomerates and sandstones.

Where Williams Creek exits the Wildcats, it flows onto the Eel River floodplain, which is underlain by recent alluvium.

2.7 Williams Creek Geomorphic Processes through History

The Salt River basin, including Williams Creek, was settled by Euro-Americans in the early 1850’s. The watershed was cleared for timber and agriculture conversion, which destabilized already unstable soils in the Wildcat Range (Downie et al., 2005), thus increasing the sediment load to Williams Creek. An evaluation of historical maps found that, prior to Euro-Americans settlement, there were dense thickets of vegetation and an approximately 700-acre freshwater wetland between lower Williams Creek and Coffee Creek to the east (Downie, et al., 2005, USDA,1993). The presence of this wetland was likely a result of an alluvial fan that formed where Williams Creek exits the Wildcat Range. The alluvial fan trapped sediments and delivered water (surface and ground) to the Eel River floodplain, where a vast wetland formed.

The combination of sediment deposition across the alluvial fan and the large receiving wetland likely minimized the delivery of all but the finest sediment to the Salt River (USDA, 1993).

The freshwater wetland was ditched and drained around 1884 (Downie, et al., 2005), requiring the excavation through the natural high ground ("levee") running along the south bank of the Salt River. Most of the drainage network still exists and is in use today. Landowners also constructed makeshift berms along Williams Creek to reduce overbank flooding. This berming and ditching resulted in the direct and rapid delivery of flow and sediment from Williams Creek into the Salt River.

Prior to1967, the Salt River served as an active side-channel of the Eel River. During higher flows in the Eel River, waters would spill into the head of the Salt River channel across from the City of Fortuna and then flow back into the Eel River close to the ocean. This may have helped flush some of the accumulated fine sediment from the Salt River. In 1967, the Leonardo Levee was constructed to prevent overflows from the Eel River from entering the head of the Salt River (Downie et al., 2005), thus eliminating this aspect of the Salt River hydrology and geomorphology.

In 1998, sediment accumulation at the confluence of Williams Creek and the Salt River created a sediment plug isolating the Upper Salt River and its tributaries (Downie, et al., 2005). Shortly after, a ditch and berm system was constructed that directed Williams Creek flow upstream into the Upper Salt River, resulting in elevated water levels in existing slough channels east of Williams Creek. These ponded waters would drain into the Eel River during wet periods by flowing out Old River.

In either 2015 or 2016, flows overtopped and breached a portion of the berm at the Williams Creek confluence, causing Williams Creek to once again flow into the lower Salt River. Currently, flows from Williams Creek are conveyed to the northwest in a large sediment splay across low pasture before flowing under Highway 211 and joining the Salt River. The current flow pattern is evident on Figure 1-1, and is labeled as "Williams Creek Sediment Splay".

According to local landowners, flow conveyance in Lower Williams Creek was maintained by clearing sediment and removing low-hanging vegetation and debris jams that blocked the channel. With changes in the regulatory environment, in-part associated with the listing of Coho Salmon in 1997 under the Federal Endangered Species Act, clearing of woody debris from the channel and riparian corridor was curtailed. Wood jams comprised of smaller woody debris have since accumulated in many reaches of the channel, causing local aggradation, decreased channel capacity, and increased frequency and extents of overbank flooding.

Since 2011, in an effort to reduce sedimentation to Williams Creek, the Natural Resources Conservation Service (NRCS) and the HCRCD have been implementing upslope sediment reduction projects, including streambank stabilization, hillslope stabilization, roadway improvements, and cattle exclusion fencing along upper Williams Creek watershed. HCRCD has anticipated that they have currently addressed 35% of the non-natural sediment sources within the watershed (HCRCD 2019).

2.8 Geomorphic Setting

To understand the watershed condition, channel geomorphology, and potential sediment sources and sinks, a geomorphic assessment was conducted along Williams Creek. The results of the geomorphic assessment were used to identify a stable channel geometry for Williams Creek that could be used as part of the creek rehabilitation. Detailed methodologies and results of the geomorphic assessment are presented in the Williams Creek Geomorphology and Existing Condition Hydraulics Technical Memorandum in Appendix C. The following sections summarize the results of the geomorphic assessment.

An elevation map of Williams Creek from where it exits the Wildcat Range to the Salt River is show on Figure 2-1, where whites and browns represent higher elevations than greens and blues.

Channel thalweg profiles of Williams Creek downstream and upstream of Grizzly Bluff Road are shown on Figure 2-5 and Figure 2-6, respectively. Upstream of the County-provided thalweg survey, the channel profile shown on Figure 2-5 and Figure 2-6 were derived from the DEM of the 1957 USGS topographic map, which has a much lower resolution (30 meter) than the LiDAR generated topography, and may have changed substantially since 1957.

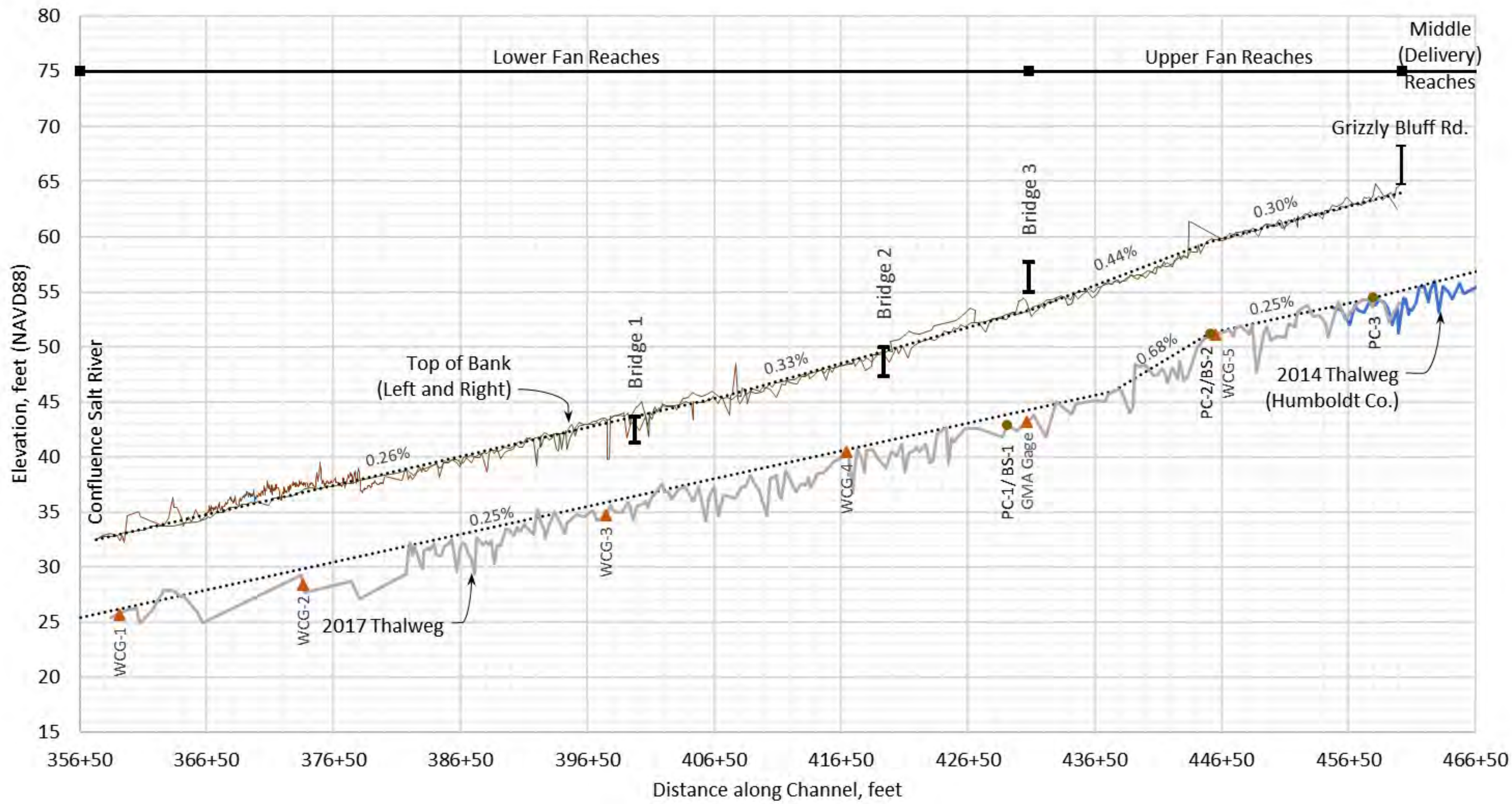


Figure 2-5. Longitudinal profile of the Williams Creek channel bottom (thalweg) and top-of-banks from the confluence of the Salt River to Grizzly Bluff Road. The dotted lines reflect overall slopes of the channel bottom and top-of-banks. Water level monitoring locations are shown as triangles. Streambed pebble count (PC) and bulk sample (BS) locations are shown as circles.

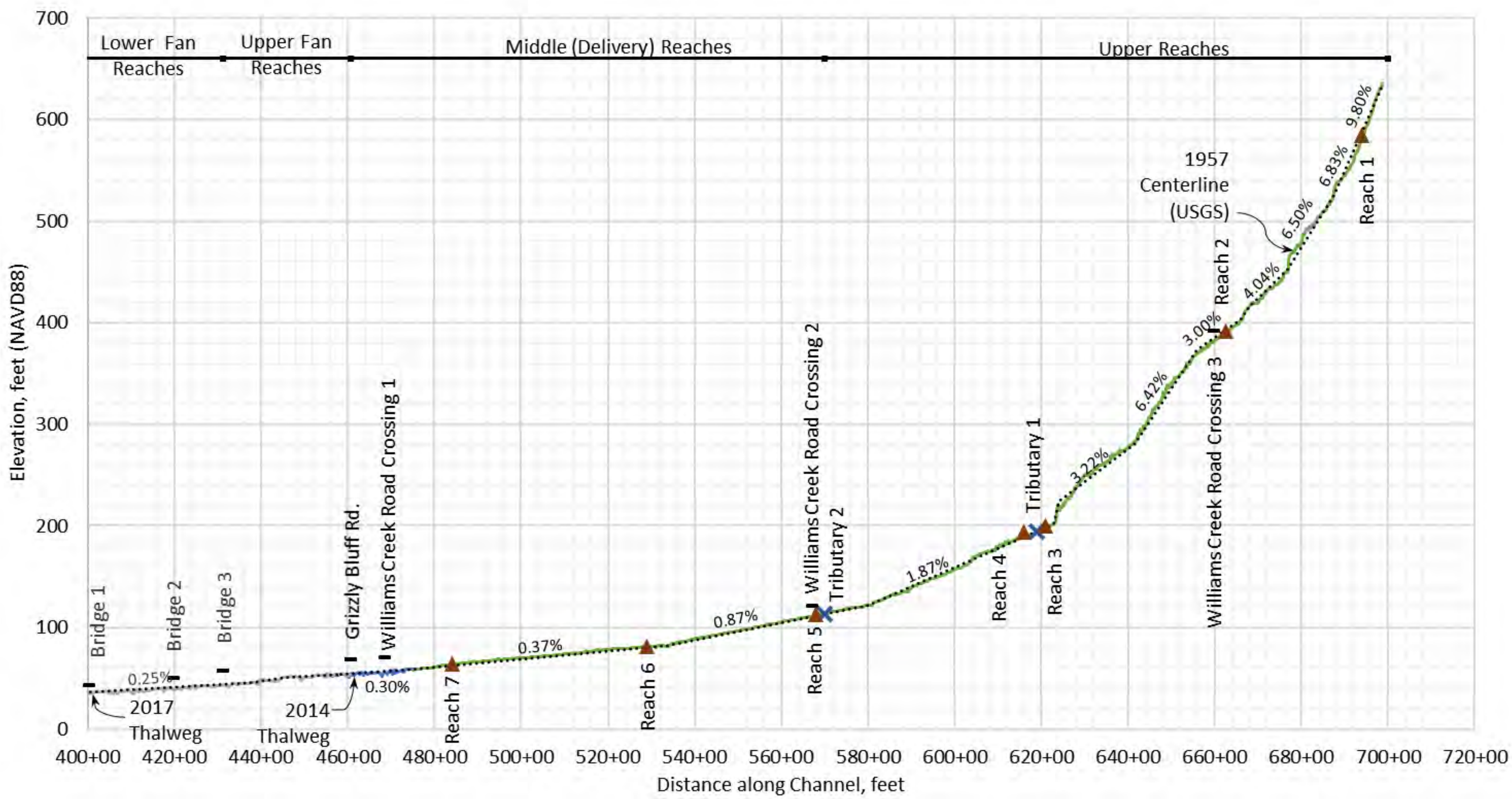


Figure 2-6. Stream centerline profile from Bridge 1 to the upper reaches of Williams Creek. The profile upstream of Williams Creek Road Crossing 1 was derived from 1957 USGS mapping and may have changed substantially since then. Locations where rapid geomorphic assessments were performed are shown as triangles.

2.8.1 Upper and Middle Reaches of Williams Creek

Williams Creek originates in steep and bedrock-confined gorges, then gradually transitioning to a lower-sloped semi-confined alluvial valley where the stream meanders before reaching the apex of its unconfined alluvial fan near Grizzly Bluff Road.

The upper reaches of Williams Creek, upstream of Tributary 2 on Figure 2-6 are comprised of a mix of bedrock and alluvial materials ranging in size from silts to small boulders. In most locations, the valley walls are comprised of bands of competent sandstones layered with thick deposits of highly erosive mudstones. Typically, the sandstones are relatively stable and the mudstones friable and very erosive. Areas of more competent sandstone appear to be the sources of the streambed material. The eroding mudstones in the upper reaches of Williams Creek deliver a substantial amount of sediment to the channel, primarily as finer grained materials. Sand and silt deposits are evident throughout the channel, and are thick in localized areas. A photograph of the upper reaches is show on Figure 2-7.

Figure 2-7. Confined channel in the upper reaches of Williams Creek. Thick silt deposition overlays coarse alluvial materials formed of sandstone (Photo 2018).

The middle reaches of Williams Creek are located between Tributary 2 and Grizzly Bluff Road. In these reaches, the channel slope decreases, the stream valley widens and the channel is typified by unconfined meanders with alluvial floodplains on one or both sides of the channel. The sediment sizes in the channel decrease gradually in the downstream direction. In general, it appeared that the middle reach is a sink for larger size particles, while delivering to the lower reaches finer materials. Silt deposition on the channel margins and upstream of channel obstructions is pervasive. The channel banks along this reach are typically unstable resulting from livestock access and minimal riparian vegetation. Streambank erosion contributes silts to gravel-size sediment to the channel.

The middle reaches were characterized as a s*ediment delivery reach* for smaller size sediments to Williams Creek downstream of Grizzly Bluff Road. As shown on Figure 2-6, in the lower part of the middle reaches, the channel maintains a slope of 0.37% for about 4,500 feet and is about 6 feet deep. Though some sedimentation occurs within the channel, the lack of pervasive sedimentation features, such as mid-channel bars, suggests this reach has the capacity to transport the supplied sediment load.

Figure 2-8. Unconfined channel in the middle reaches of Williams Creek where the valley is less confined. Streambed materials are smaller than upstream, but silt deposition remains pervasive and bank erosion is common (Photo 2018).

2.8.2 Alluvial Fan Morphology of Lower Williams Creek

Just upstream of the Grizzly Bluff Road crossing, Williams Creek exits the Wildcats and the stream becomes unconfined, the channel slope decreases, and the channel flows across an alluvial fan. Alluvial fans serve as the transition from steeper confined channels within the hills to an unconfined low-gradient floodplain. The loss of channel confinement and a decrease in channel slope leads to decreased sediment transport capacity and in-channel and overbank sediment deposition. The deposited sediments typically form a “fan-shaped” depositional pattern due to frequent sediment buildups and shifting of the channel location. Over time, the extents and overall elevation of the alluvial fan increase as both the channel bed and banks aggrade. Active alluvial fans are naturally dynamic and unstable, causing wide scale inundation from floodwaters that can negatively affect land use (Davies and McSaveney, 2006).

A schematic drawing of a typical alluvial fan is shown in Figure 2-9. Upstream of the apex (A) of the fan, the feeder channel (FC) to the alluvial fan is confined by the valley. Downstream of the apex, the channel is no longer confined and the channel is typically incised (IC) into the fan surface, with more frequent flows staying within the streambanks. As flow and sediment moves downstream, the channel becomes shallower and less incised, until reaching the intersection point (IP), where flows split into multiple channels and/or sheet flow across the middle and lower portions of the fan, until reaching the distal end.

Sediment deposition occurs as the channel becomes shallower and less defined, with coarser grained sediment depositing higher on the fan and finer grain sediments depositing lower on the fan. Typically, one area or “active depositional lobe” of the fan is worked at a time, before localized sediment deposition results in that lobe becoming higher than the surrounding area, and the entire channel jumps, or “avulses,” to a lower portion of the fan where the deposition process begins again. Avulsions typically occur during high flow events, or when obstructions, such as debris or excess sediment block the channel.

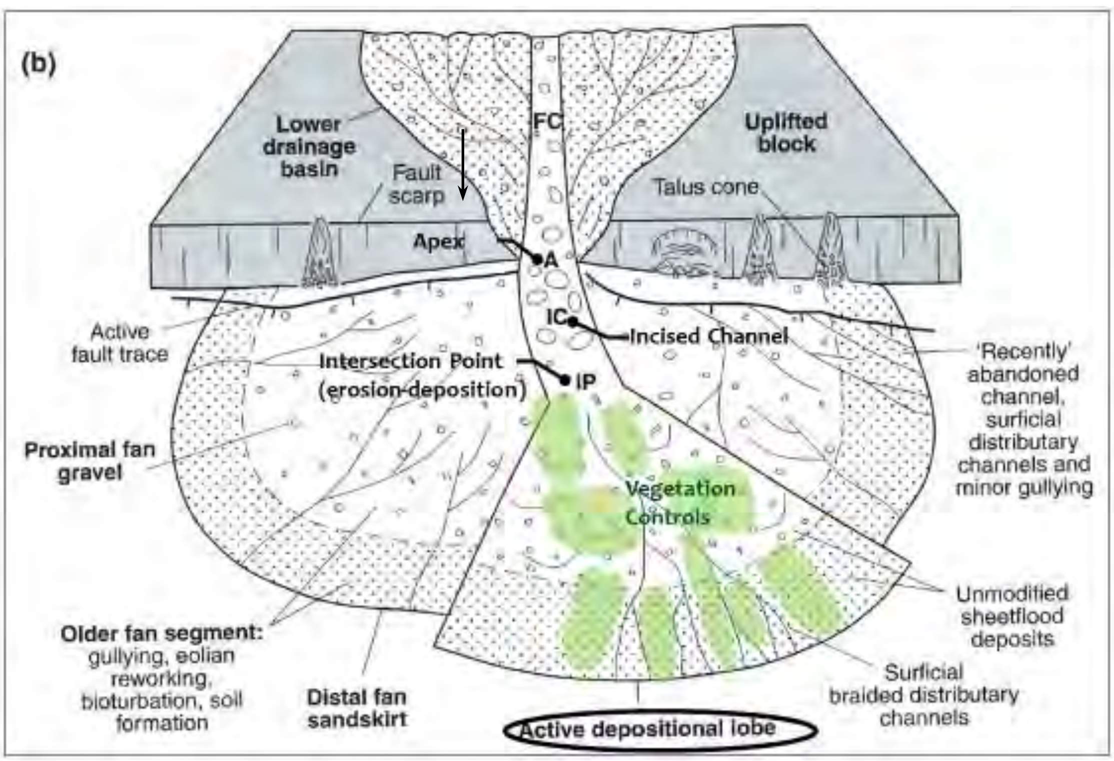


Figure 2-9. Schematic of a typical streamflow-dominated alluvial fan (adapted from Blair & McPherson, 2009).

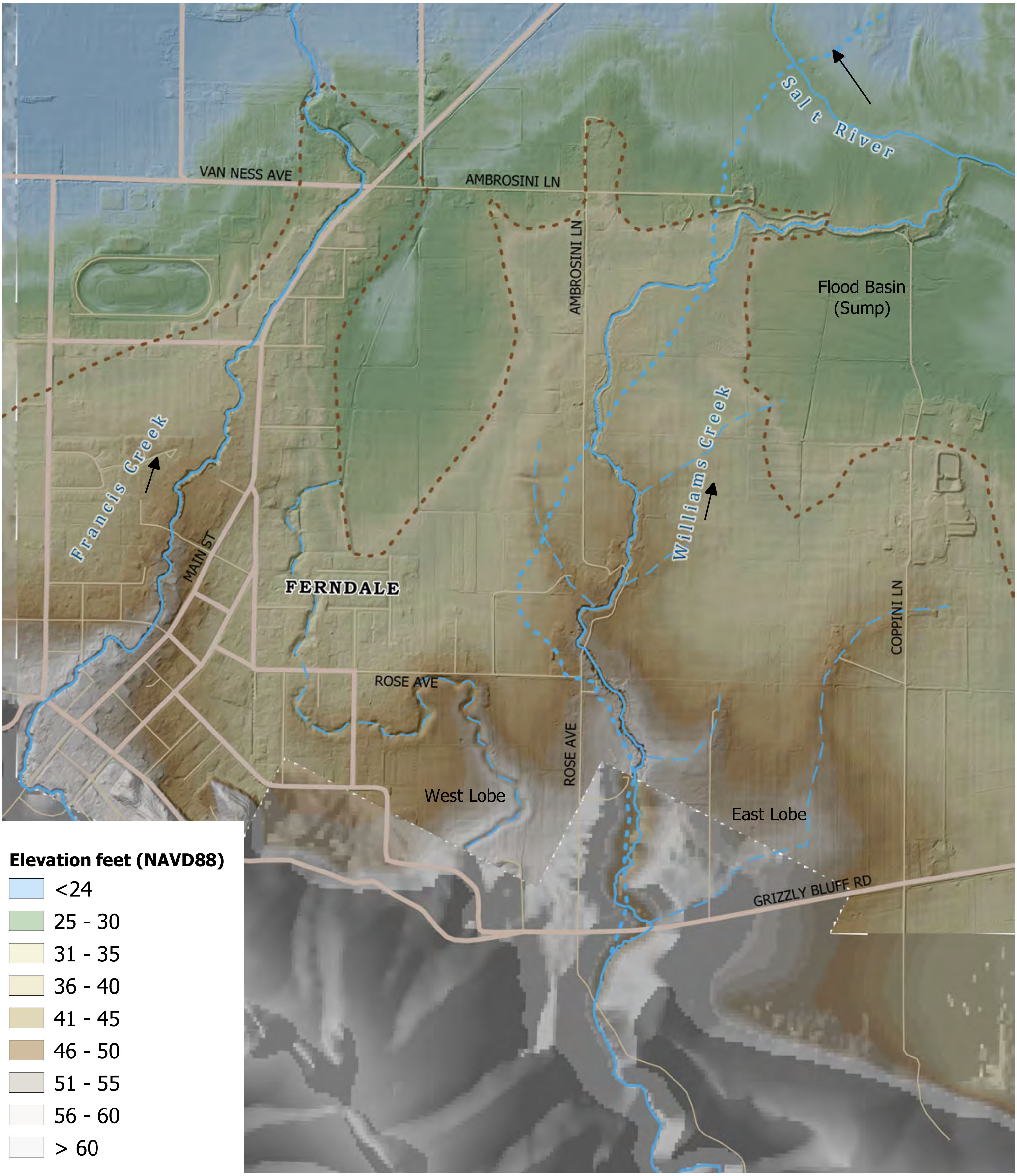
Along the distal end of an alluvial fan system, the sediment has deposited and flows are typically dispersed across a broad area, often forming large wetlands (sometimes referred to as sloped wetlands because they are at the base of the slope) before flowing into a receiving water body (Woods et al., 2006). Coarse sediments, and the bulk of fine sediments are stored on the fan surface rather than being delivered to a downstream water body. The extent of the Williams Creek fan, and the fine sediments comprising most of the fan surface, suggest that historically a large portion of the sediment load delivered from Williams Creek never reached the Salt River (Benda, 2007, Downie et al., 2005, SCS 1993).

Figure 2-10 shows an annotated elevation map highlighting the alluvial fan built by Williams Creek on top of the Eel River floodplain. The extents of the fan are approximated as a dotted line. The current alignment of Williams Creek and the approximate 1916 alignment are shown for reference. An alluvial fan built by Francis Creek is evident on the west side of the figure, overlapping with the Williams Creek alluvial fan. There are three primary lobes forming the Williams Creek alluvial fan, with lower ground (geomorphically referred to as “flood basins”) between the lobes.

The current alignment of Williams Creek forms the center lobe of the fan. Rose Avenue and Ambrosini Lane are located on the ridgeline formed by this lobe. Historic maps indicate that Williams Creek has been confined to its current alignment since the late 1800’s, with some differences in the location of the downstream-most portion of the stream. As shown on Figure 2-10, the 1916 alignment of Williams Creek was located to the west between Rose Avenue and Ambrosini Lane. This reach of channel shifted or was moved to its current alignment between 1916 and 1921. The downstream reaches of the 1916 channel flowed northward, and connected to Salt River further downstream than the existing confluence. Between 1916 and 1921, the lower reaches of the channel appear to have moved into its current alignment.

The other two fan lobes were formed prior to mapping of the area, thus are much older than the center lobe. The eastern lobe of the alluvial fan is located on the east side of Williams Creek, just west of Coppini Lane. Ranch buildings are located on slightly elevated ground at the downstream end of this lobe. West of Williams Creek is a fan lobe with a well-defined abandoned channel that flowed through what is now the town of Ferndale. This channel flowed to the west of Rose Avenue and into the low-lying fields that functioned as a “flood basin” for Williams Creek and possibly Francis Creek. Accumulated waters within this flood basin appeared to have flowed into Salt River through a water course called “Shaw’s” Creek in the 1854 plat map.

The active fan lobe that Williams Creek is currently building is much longer than the other two lobes, and the stream channel is located on a self-formed ridge over 10 feet higher than the adjacent valley bottom to the east and west. This suggests that Williams Creek is being artificially maintained along its current alignment and historical manipulations of the channel and banks have prevented it from jumping (avulsing) and migrating to a new location. The longer the time that a channel on an alluvial fan is maintained in one location, the active lobe will increase in both length and elevation, with channel deposition progressing in both the downstream and upstream directions.



0 1000 ft

N

Horizontal Datum: NAD83 California State Plane Zone I

LEGEND

Alluvial fan boundary

Williams Cr. (1916)

Undated historical alignments

Figure 2-10 Williams Creek alluvial fan and historical stream locations

2.8.2.1 Geomorphic Characterization of Lower Williams Creek

Lower Williams Creek was broken into two reaches, as shown on Figure 2-5. Upstream of Bridge 3 is the Upper Alluvial Fan Reach, where the channel is generally deeper, has less sediment deposition than downstream, and conveys more flow, with overbank spilling occurring only during large flow events. The Lower Alluvial Fan Reach is downstream of Bridge 3, where the channel becomes progressively narrower and shallower, depositional features are more evident, and out-of-bank flows increase in frequency in the downstream direction. Except for a short section, the channel slope in lower Williams Creek is 0.25%.

Upper Alluvial Fan Reach

The upper alluvial fan reach of Williams Creek is located between the fan apex just upstream of Grizzly Bluff Road and Bridge 3. The channel in this reach appears to transport most sediment from the upper watershed to the next reach downstream and can be considered a sediment delivery reach. Figure 2-11 shows a photograph of Williams Creek looking downstream from the Grizzly Bluff Road Bridge. At this location, the channel is trapezoidal in shape with an approximate13-foot bottom width and about 8 feet deep.

Sediments in this reach are typically sand and pea gravels. There is some localized evidence of in-stream sedimentation, mostly consisting of small gravel deposition upstream of debris jams. Silt deposit on the channel margins is not as pervasive as upstream, but is common on the channel banks.

Debris jams are pervasive in the upper portion of this reach, but are less frequent in the downstream portion of the reach, likely cleared by landowners. A riparian area comprised of mostly alder trees hangs over the channel in numerous locations forming transient debris jams. The channel planform is characterized by frequent tight, or tortuous, meander bends. The combination of debris jams and tortuous meander bends create high channel roughness (flow resistance) that elevates water levels.

In general, this reach can also be considered as a sediment delivery reach to the downstream portion of the alluvial fan. Because this reach of channel is incised into the fan, out-of-bank flows occur more rarely, and the in-channel flows appear to have the capacity to transport the bulk of the delivered sediment. Landowners adjacent to this reach along Rose Avenue indicate that overbank flooding occur less frequently than downstream, but does occur every year or two. Sandbag berms have been constructed around the property to the west of where the WCG-5 gage is located due to overbank flooding.

As shown in Figure 2-5, the slope of the alluvial fan in this reach, represented by the top-of-bank of the channel, ranges from 0.30% to 0.44%, with an overall slope of 0.35%.

Figure 2-11. Williams Creek in the upper alluvial fan reach. The channel is generally trapezoidal in shape and over 6 feet deep (Photo 2018).

Lower Alluvial Fan Reach

Downstream of Bridge 3, the channel become shallower in the downstream direction. As the channel shallows, the bottom width also decreases, resulting in a drastic reduction of channel flow capacity. In the FEMA Flood Insurance Study (FEMA, 2016) Flood Profiles (Panels 64P65P), the channel bottom elevation of Williams Creek at the confluence with the Salt River was surveyed in 1993 to be 21.5 feet (NAVD88). Currently, the channel elevation of Williams Creek at the confluence is 25.4 feet, indicating the channel has filled in approximately 4 feet in the downstream reaches since 1993. Though there are no measurements, it is assumed that substantial aggradation occurred in Williams Creek before 1993 due to a large amount of aggradation in the Salt River. Additionally, noted on Caltran's 1968 Highway 211 bridge replacement plans was a Salt River channel bottom elevation equal to 9 feet in the NAVD88 datum. Currently, the Salt River channel elevation at the Highway 211 bridge is approximately 22 feet, indicating the Salt River channel has filled in approximately 13 feet since 1968.

The channel planform is characterized by frequent tortuous meander bends. The channel bed material in this reach is finer than upstream; comprised of mostly fine-grained sediments with some pea gravels. Where the riparian area is present, overhanging trees block the channel and form debris jams as shown in Figure 2-12. Debris jams are relatively common along the lower reach of Williams Creek, though they tend to be transient and frequently shift locations. The combination of debris jams and tortuous meander bends create high channel roughness that elevates water levels and forces out-of-bank flows. Residents living adjacent to Williams Creek have indicated that the channel has shallowed and out-of-bank flooding has become more frequent since the late 1990's.

A combination of discontinuous earthen berms and natural alluvial berms along most of the channel in this reach serve to increase channel depth, help confine flows, and maintain in-channel sediment transport. However, the decrease in channel size and the high flow resistance of the debris jams and channel planform result in frequent overtopping of the streambanks. Residents living adjacent to the stream indicate that the location of frequent overtopping shifts from year to year. Because the channel is located on a ridge above lower-elevation lands, overbank flow cannot return to channel, resulting in flooding and sediment deposition on the adjacent properties.

Depending on the flow event, the out-of-bank flooding and sediment deposition can be substantial. Occasionally, a berm is breached, resulting in a more severe flood event, such as the berm breach in winter of 2019 that resulted in substantial flooding and sedimentation along Ambrosini Lane.

Overbank flows occur to both the east and west of the channel. Where overbank flows spill to the west and northwest, they inundate the roadway, residences and outbuildings on Ambrosini Lane, as well as pastures to the northwest. Figure 2-13 shows a photograph of Ambrosini Lane, where overbank flows from Williams Creek flowed northward down the lane. Due to removal of deposited sediments around houses and on the road following flood events, the ground along Ambrosini Lane has not aggraded, while the eastern banks have aggraded in recent years. This results in preferential overbank flooding to the west and has necessitated construction of berms to protect residential properties.

Where overbank flows spill to the east, they flow down the gently-sloped fields between the lobes of the alluvial fan, and become trapped in a low sump south of the upper Salt River, between Williams Creek and Coffee Creek. A combination of constructed berms and sedimentation prevents the ponded surface water from flowing into the Salt River or returning to Williams Creek. Figure 2-14 shows flooding patterns in April 2011.

The downstream-most reaches of Williams Creek, just upstream of the confluence with the Salt River, show evidence of substantial aggradation associated with the period when Williams Creek was diverted into the upper Salt River. Following the breach of the berm at the Salt River confluence circa 2016 and forming the Williams Creek Sediment Splay (Figure 1-1), the channel has since down-cut through some of these deposited sediments, as evident in the reach immediately downstream of Bridge 1 (Figure 2-15).

Figure 2-16 shows a partially-buried outbuilding located in the bermed area to the south of the channel just upstream of the Salt River confluence. The berms in this area were constructed in 1999 (Downie et al., 2005). The combination of the berms, the ponding resulting from routing Williams Creek flows into the upper Salt River, and high sediment load in the channel resulted in extensive deposition that rapidly buried this outbuilding.

The channel aggradation, berm overtopping, overbank flows, and overbank sediment deposition occurring in the lower fan reach of Williams Creek are typical of processes found in the lower portions of alluvial fans. Aggradation that is presently occurring within the sediment splay downstream of the Salt River confluence will continue to raise the base level, decreasing channel slope in the lower fan and further reducing channel and sediment transport capacity. Over time, the effects of the rising base-level will propagate upstream, causing overall increases in channel bed and overbank elevations. This process is cyclic and creates a negative feedback loop of in-channel deposition and overbank flooding that typically leads to a channel avulsion to a lower-elevation portion of the fan.

Figure 2-12. Overhanging trees and debris jam between Bridge 1 and Bridge 2 on Williams Creek causing sedimentation on the channel bed, banks, and overbanks (Photo 2018).

Figure 2-13. Overbank flows from Williams Creek flowing northward along Ambrosini Lane. Residents have installed various measures for flood protection (J. Svehla, December 2015).

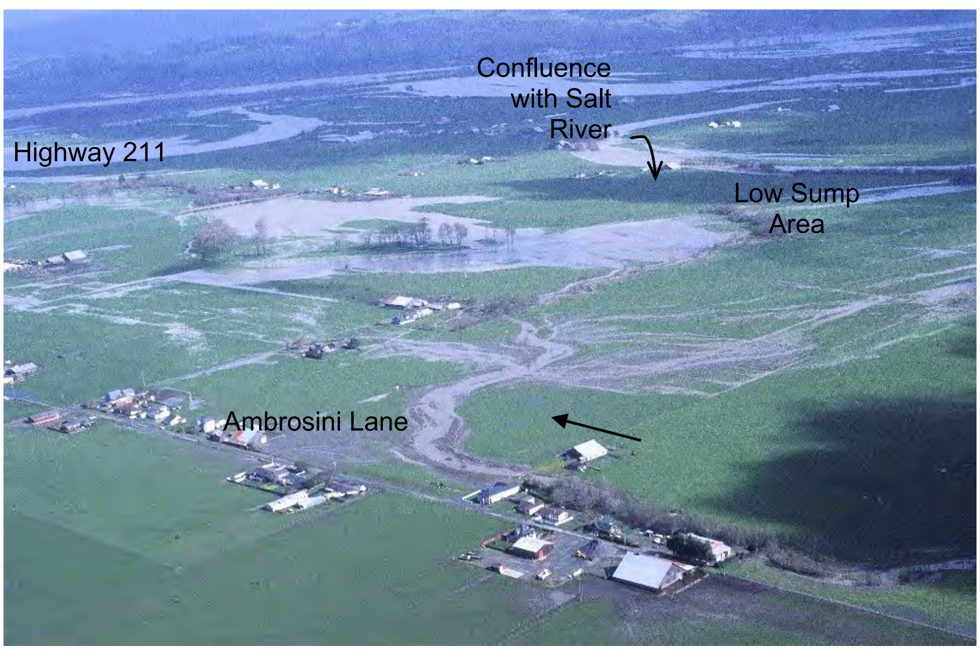


Figure 2-14. April 8, 2011 aerial view of Lower Williams Creek overbank flooding looking northeast (Photo by D. Tuttle).

Figure 2-15. Incision through recent in-channel sediment deposited associated with breaching of the berm that diverted Williams Creek into the upper Salt River from 1998 through 2015 (Photo 2018).

Figure 2-16. Buried outbuilding on south side of Williams Creek upstream of WCG-1 (Photo 2018).

2.9 Existing Conditions Hydraulics

Both 1-dimensional and 2-dimensional hydraulic models were used to evaluate existing conditions. The 1-dimensional (1-D) module of HEC-RAS 5.0.7 (USACE, 2016 a, c), was used to create a calibrated model of existing conditions of Williams Creek. The 2-dimensional module in HEC-RAS (USACE, 2016, a-c) was used to evaluate the magnitude and frequency of out-of-bank flows along Williams Creek and resulting flow patterns on the overbanks.

Detailed methodologies and results of hydraulic modeling are presented in the Williams Creek Geomorphology and Existing Condition Hydraulics Technical Memorandum in Appendix C. The following sections summarize the results of the modeling.

2.9.1 Existing Channel Flow Capacity

Figure 2-17 shows total flow in the Williams Creek channel from upstream to downstream, with the downstream decrease in flow associated with losses from overbank flooding. At Williams Creek confluence with the Salt River, the channel can convey only 147 cfs, regardless of incoming flows from upstream. The remainder of flow has spilled out the channel banks and does not return to Williams Creek. A flow of 147 cfs has a return period between 1.01- and 1.1-years. Therefore, out-of-bank flows can be expected to occur a minimum of once per year, and typically more frequently under existing conditions.

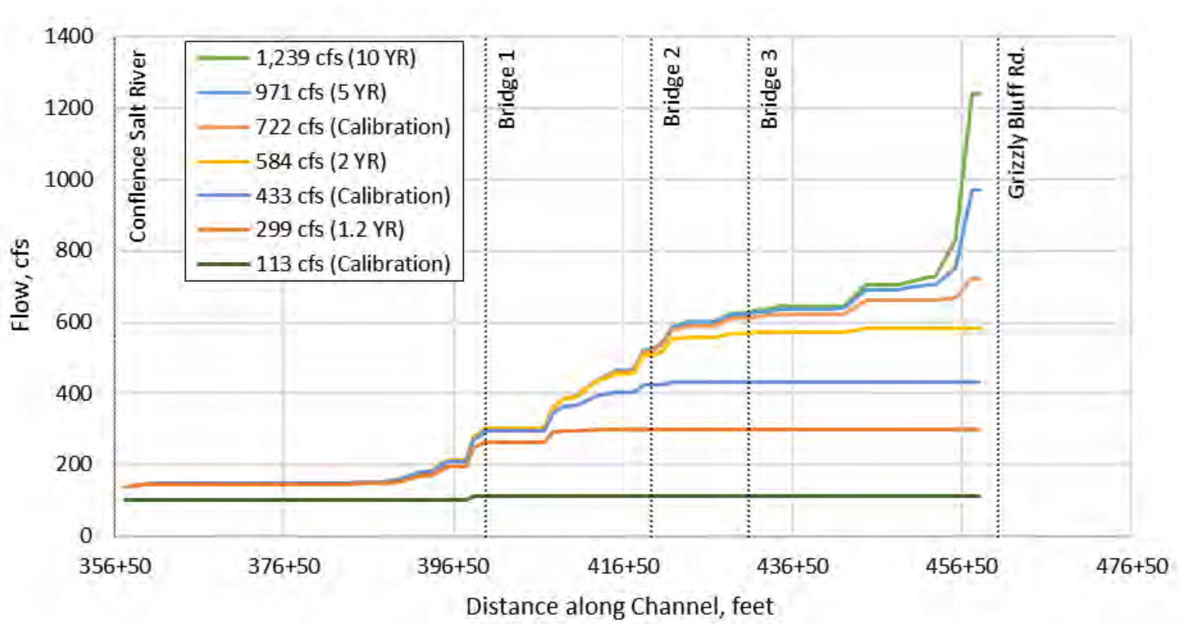


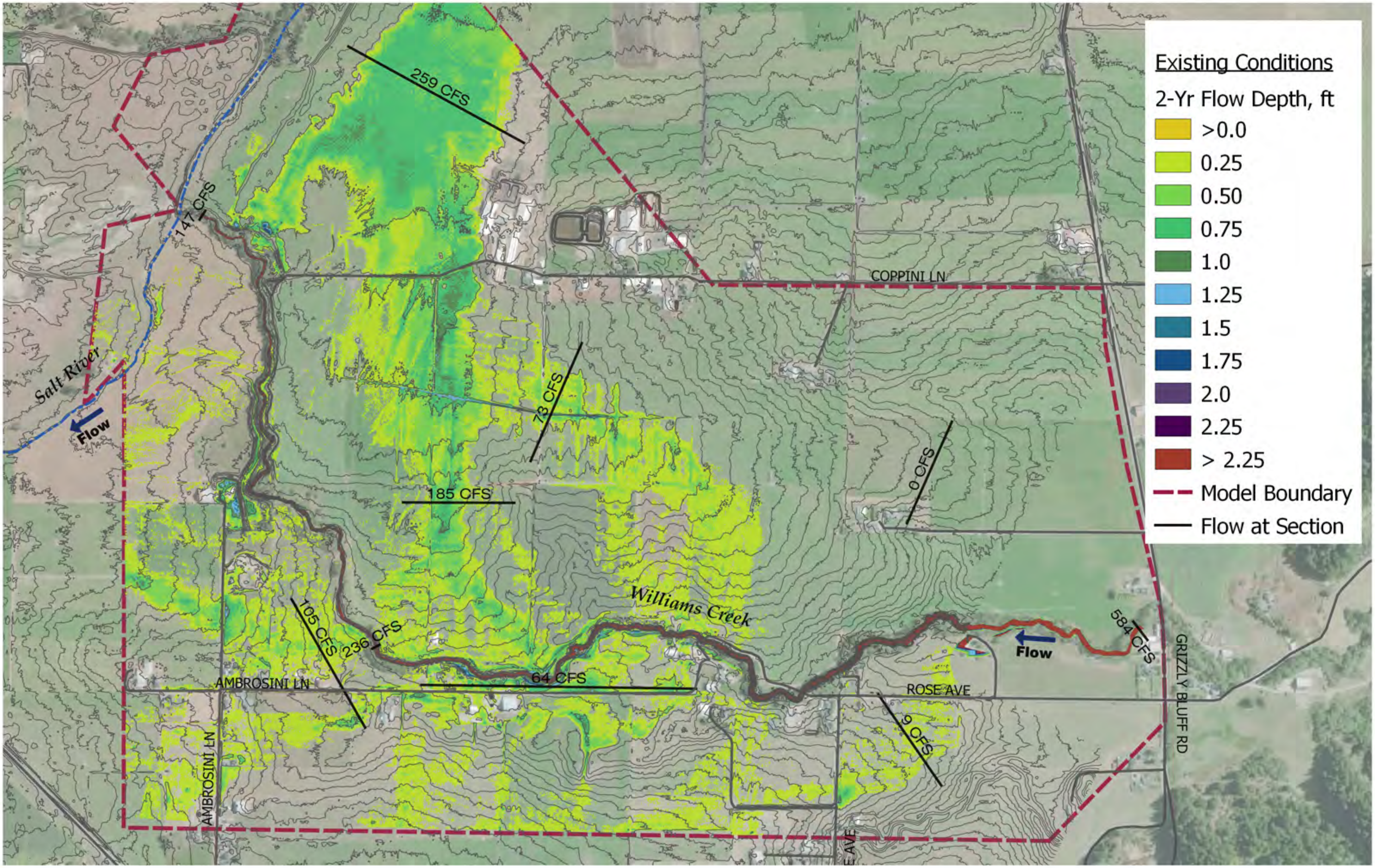
Figure 2-17. HEC-RAS model-predicted flows in Williams Creek for a range of flows. Flows decline in the downstream direction as water overtops and spill out of the channel banks and does not reenter the channel. The maximum capacity of the channel at the confluence with the Salt River is 147 cfs.

2.9.2 Channel and Floodplain Flow Patterns

Figure 2-18 and Figure 2-19 present typical results of the 2-D modeling, showing depths for 2- and 5-year flow events. Other results, including velocity and shear stress in the channel and across the floodplain are provided in Appendix C. Note that the modeling was based on a channel topography survey performed in 2017 and overbank LiDAR data from 2009-11. Therefore, the locations where out-of-bank flow is shown in the results may differ from current conditions.

Figure 2-18 shows the results of 2-D model predicted flow depths for a 2-year peak flow (584 cfs) on Williams Creek. In-channel and overbank flows are labeled at various locations. During a 2-year flow event, 584 cfs is conveyed within the channel just downstream of Grizzly Bluff Road. About 178 cfs spills out of Williams Creek to the west, with a small amount spilling out of the channel near Rose Avenue and flowing down a wide swale to the west of Ambrosini Lane. Larger amounts of flow spill out of the channel to the west between Rose Avenue and along Ambrosini Lane, and to the northwest downstream of Ambrosini Lane. On the east side, about 259 cfs spills out of the channel, mostly opposite Ambrosini Lane, flowing down broad swales to a low sump to the south of the Williams Creek and the upper Salt River channel, where the landowner has indicated that flows pond. At the downstream end of Williams Creek, a total of 147 cfs remains within the channel, and 437 cfs has flown out-of-bank to the east and west.

Figure 2-19 shows the results of 2-D model predicted flow depths for a 5-year peak flow (971 cfs) on Williams Creek. In-channel and overbank flows are labeled at various locations. The number of areas along both channel banks where flows exceed the top-of-banks increase from the 2-year event. Out-of-bank flows to the west increase to about 284 cfs, with increased depth of flow on Ambrosini Lane. Low channel banks on the east side of Williams Creek, allow about 540 cfs to spill out-of-bank opposite Rose Avenue, and activate a broad drainage swale that was dry during a 2-year flow event. At the downstream end of Williams Creek, a total of 147 cfs remains within the channel, and 824 cfs has left the channel.



0 750 1500 ft CA STATE PLANE ZONE 1 FEET	Michael Love & Associates *Hydrologic Solutions*	**Figure 2-18** 2-D Existing Condition Model Predicted Flow Depths for a 2-Year Peak Flow (584 cfs)

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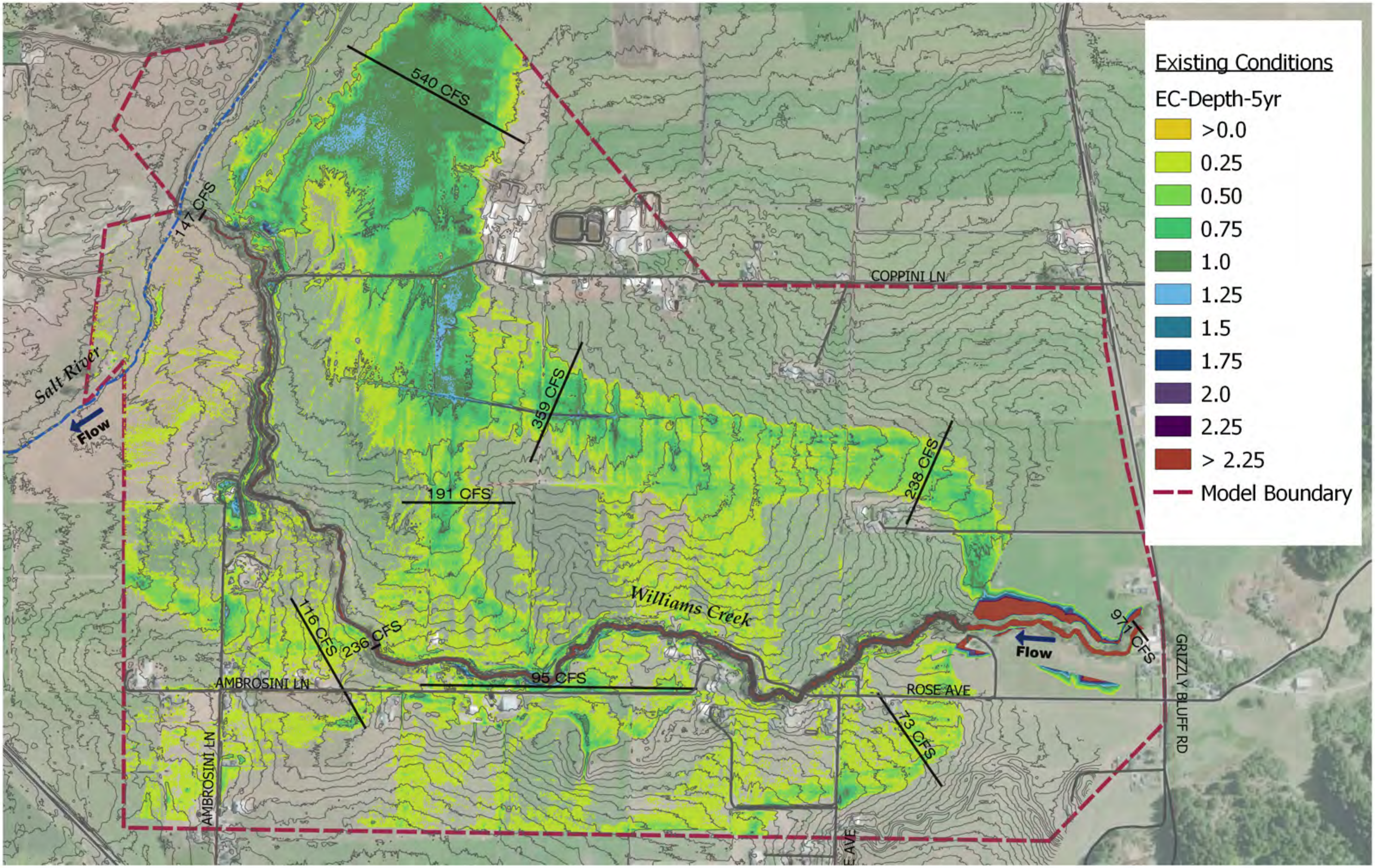
Michael Love & Associates, Inc. P.O. Box 4477, Arcata, CA 95521 (707) 822-2411



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Michael Love & Associates
Hydrologic Solutions

Figure 2-19

2-D Existing Condition Model Predicted Flow Depths for a 5-Year Peak Flow (971 cfs)

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Michael Love & Associates, Inc. P.O. Box 4477, Arcata, CA 95521 (707) 822-2411

2.10 Sediment Sampling and Analysis

Sediment transport sampling was conducted to obtain estimates of bedload and suspended sediment loads and gradations conveyed by Williams Creek downstream of Grizzly Bluff Road. This information was necessary to evaluate existing sediment transport and depositional patterns in Williams Creek, evaluate the ability of the receiving Salt River to convey delivered Williams Creek sediment, and to inform the overall alternatives development process.

Detailed methodologies and results of the sediment transport sampling and analyses are presented in the Williams Creek Geomorphology and Existing Condition Hydraulics Technical Memorandum in Appendix C. The following sections summarize the results of sampling and analyses.

2.10.1 Previous Studies

Several previous studies have estimated the sediment load delivered to the Salt River from Williams Creek, though no direct measurements were made. USDA (1993) estimated that 9,960 tons (7,661 cy assuming 1.3 cy per ton) of sediment is generate within the Williams Creek watershed. Sediment storage on the floodplain was expected to trap about 52% of that load, with 5,240 tons (4,030 cy) of sediment being delivered to the Salt River per year. The SCS reported that about 71% of the sediment was derived from streambank erosion and landslides, and the sediment load from William Creek contributed 46% of the total sediment load to the Sat River.

Benda (2007) further evaluated the sediment sources and loads in Williams Creek and found that SCS (1993) underestimated sediment load from landslides, earthflows, and stream channel erosion, and over-predicted the amount of sediment stored on the Salt River floodplain. In total, Bendan (2007) estimated the SCS (1993) sediment budget for Williams Creek was under-estimated by at least 100%, if not more. A specific quantity was not provided.

Kamman Hydrology (2011) estimated that the average annual suspended sediment yield from Williams Creek is about 7,500 cubic yards/mi^2 and up to 11,000 cy/mi^2 for wetter years. Multiplied by the drainage are of Williams Creek to Bridge 3 (6.0 mi^2), the total suspended sediment load in Williams Creek would be 66,000 cubic yards (cy) during a wet year. Because of their method of analysis, Kamman Hydrology felt that this volume was conservative.

Fenton (2007-2018) performed suspended sediment sampling in Francis Creek between 2007 and 2018 at the Van Ness Avenue bridge. Francis Creek basin is directly to the west of William Creek and has similar land use and geology as Williams Creek, thus could be considered a surrogate for Williams Creek. Section 2.10.3 presents additional information on sediment sampling results obtained by Fenton.

2.10.2 Sediment Sampling

To obtain estimates of the actual sediment load in Williams Creek, GMA Hydrology, Inc. performed flow gaging and sediment transport sampling for WY 2017 and WY 2018. Based on the result of the sampling, GMA computed the total bedload and suspended sediment load transported in Williams Creek for each water year. All sampling and flow gaging were performed at Bridge 3, near Rose Avenue.

Table 2-2 summarizes the results of the sediment sampling for WY 2017 by tonnage and cubic yards (CY) for a range of grain sizes. Tonnage was converted to volume assuming 1.3 tons per cubic yard of sediment. Of the total, 96,753 tons of sediment transported in Williams Creek during WY 2017, bedload comprised only 83 tons, with the remaining being transported as suspended load.

Of the amount of sediment transported, about 22% or 21,349 tons, was greater than 0.0625 mm. Grains smaller than 0.0625 mm are typically considered washload, consisting of silts and clays (Biedenharn, et al., 2000). These grain sizes are in near-permanent suspension and, therefore, transported through the stream without deposition as long as the water continues to flow.

During WY 2018, the total sediment load ((bedload + coarse suspended load, excluding washload) transported in Williams Creek was only 2,735 tons or 2,104 cubic yards. This was considered a dry year with minimal rainfall-runoff events.

Table 2-2. Estimated total sediment load transported by Williams Creek during WY 2017, including bedload and washload.

Grain Size (mm)	Size Class	Tonnage	Cubic Yards[1]	Percent of Load
<.0625	Silts and Clays	75,404	58,003	78%
0.0625-0.125	Very Fine Sand	16,436	12,643	17%
>0.125-0.5	Medium Sand	4,838	3,722	5%
>0.5 to 2.0	Coarse to Very Coarse Sand	25	20	0.03%
>2 to 8	Very Fine to Fine Gravel	32	24	0.03%
>8 to 22.4	Medium to Coarse Gravel	18	14	0.02%
	Total Load	**96,753**	**74,426**	**100.%**

[1] *Assumes specific weight of 1.3 tons per cubic yard*

2.10.3 Long-Term Annual Sediment Load

Sediment sampling was conducted for only 2 years at Williams Creek. WY 2017 was an exceptionally wet year and WY 2018 was an exceptionally dry year. Understanding the

Williams Creek sediment load in a longer-term context is needed to develop and evaluate potential project alternatives.

The total annual suspended sediment load [collected by Fenton (2007-2018] on adjacent Francis Creek between 2007 through 2018 was used to estimate long-term sediment delivery rates for Williams Creek. The coarse fraction of the total suspended load at higher flows in Francis Creek appears to be 21-25%, similar to the measured coarse fraction transported in Williams Creek (Fenton, 2018). Therefore, the total annual coarse suspended sediment loads were predicted for Williams Creek using data from Francis Creek by multiplying the Francis Creek total load for each year by 22%. These results were then scaled by drainage area to achieve an estimate of the total annual sediment load in Williams Creek.

Table 2-3 shows the predicted sediment load in Williams Creek based on measurements of sediment loads in Francis Creek data, and the actual bedload and coarse suspended sediment loads measured for Williams Creek in WY 2017 and WY 2018. The difference between actual and predicted annual sediment transport loads was about ±34%. This difference is not unexpected, given that each watershed has highly unstable geology prone to landslides. A landslide in one watershed and not the other could result in substantially different watershed sediment yields until the landslide material is processed by the stream. A landslide occurred in the Francis Creek watershed in 2011, resulting in high sediment loads in 2012 and 2013, despite the fact the annual water yields in those years were below average. The sediment from this landslide may still be working through the system.

For planning purposes, it was assumed that long-term sediment delivery loads per unit drainage area measured in Francis Creek are similar to Williams Creek, and that the Francis Creek sediment data can be used as surrogate data for Williams Creek during years when sediment was not measured in Williams Creek. Based on the available 12-years of data from Francis Creek (WY2007-2018), the estimated average annual sediment load for Williams Creek (excluding washload) is 9,000 cubic yards. For WY 2016, an average water year, the total annual sediment load (excluding washload) in Williams Creek is estimated at nearly 12,000 cubic yards**.** For a wet year the total annual load in Williams Creek is about 16,500 cubic yards based on the actual measured load in WY2017. These volumes provide a range that are useful for planning purposes.

Table 2-3. Estimated sediment loads in Williams Creek (excluding wash load) based measured suspended sediment loads in Francis Creek from WY 2007 – WY 2017, compared to actual sediment loads sampled in Williams Creek.

Water Year	Total Annual Load (Excluding Washload)		Percent Difference
	Williams Creek Load based on Scaled Francis Creek Load (CY)	Sampled Williams Creek Load (CY)	
2007	3,580	-	-
2008	6,291	-	-
2009	1,896	-	-
2010	5,877	-	-
2011	10,605	-	-
2012	9,929	-	-
2013	21,004	-	-
2014	365	-	-
2015	12,732	-	-
2016 (Average Year)	**11,628**	-	-
2017 (Wet Year)	22,117	**16,422**	-34.7%
2018	1,473	2,865	33.2%

2.10.4 Existing Sediment Transport Rates along Williams Creek

Existing condition hydraulic modeling was used to provide insights into changes in sediment transport rates along the length of the Williams Creek channel downstream of Grizzly Bluff Road. Detailed methodologies and results of the analyses are presented in the Williams Creek Geomorphology and Existing Condition Hydraulics Technical Memorandum in Appendix C.

Figure 2-20 shows the HEC-RAS model-predicted sediment transport rate along Williams Creek for a 722 cfs flow event lasting 6 hours, having about a 3-year return period. The modeling predicted that the sediment transport rate declines by about 98% from Grizzly Bluff Road to the Salt River. The decrease in transport rate is a combination of the decrease in channel slope, width, and depth in the downstream direction, as well as loss of flow and sediment associated with out-of-bank flooding.

Figure 2-21 shows the model-predicted changes in the channel bed elevation during a constant 722 cfs flow event lasting 6 hours. Sediment transport modeling predicted that some pools would locally scour, but up to1 feet of sediment accumulation could occur in the channel. Most aggradation is shown in the middle reaches, where flows are spilling out of the channel on both sides. Though not modeled explicitly, the sediment that leaves the channel with overbank flows can be expected to deposit on the channel overbanks and adjacent pasture, where flows become shallower and the high roughness of riparian and pasture vegetation decreases transport capacity.

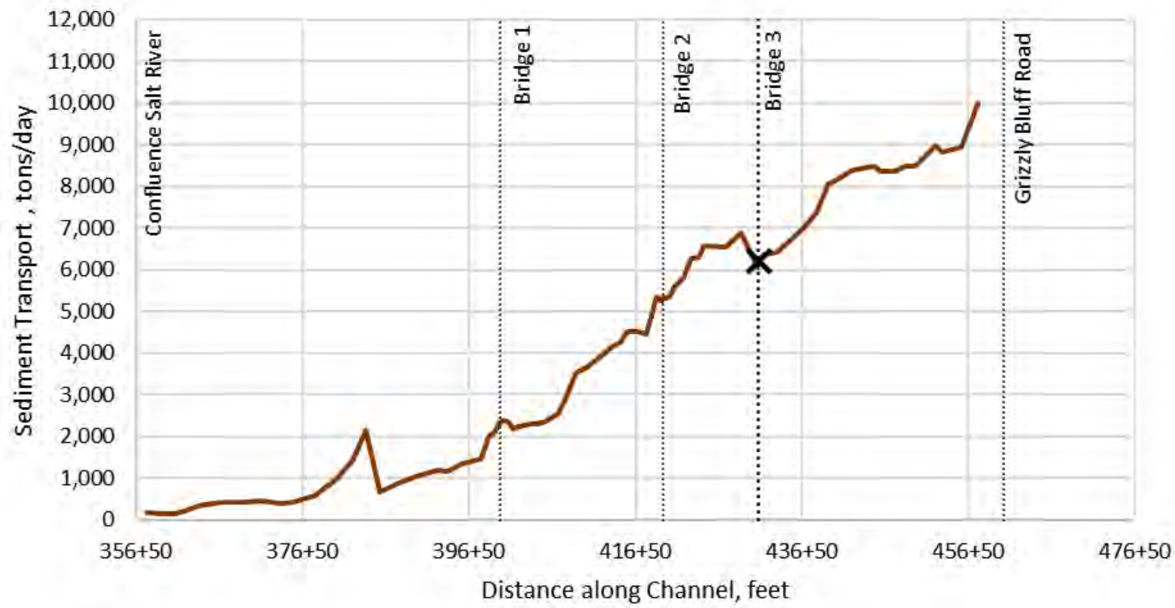


Figure 2-20. HEC-RAS model predicted sediment transport in Williams Creek during a constant 722 cfs flow event lasting 6 hours (~3-year return period). The actual measured transport rate at Bridge 3 is shown as an "X".

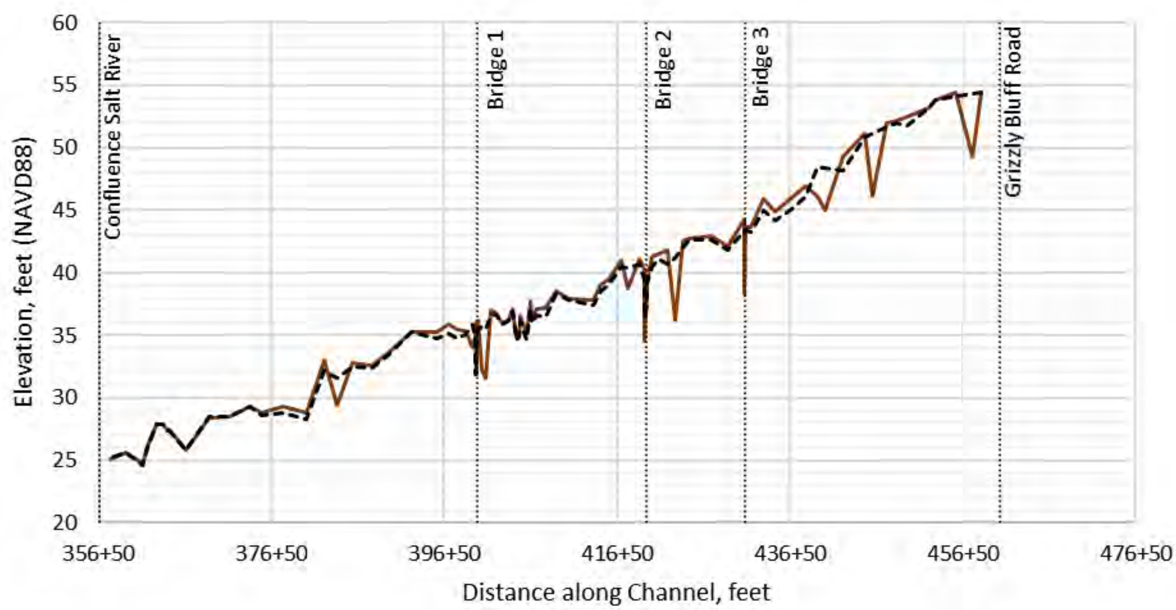


Figure 2-21. HEC-RAS model predicted changes to the channel bed of Williams Creek during a constant 722 cfs flow event lasting 6 hours. The dashed line indicates the bed elevation prior to the flow event, and the solid line represents the model-predicted bed elevation after the flow event.

2.11 Salt River Sediment Transport Capacity

Williams Creek currently acts as the headwaters of the Salt River. Even when restored and flows from the upper Salt River channel are re-connected, flows from the upper Salt River are relatively free of sediment.

As discussed in Section 2.7, the Williams Creek alluvial fan and a large wetland area on the Salt River floodplain historically minimized the amount of sediment delivered to the Salt River from Williams Creek. However, over the past 150 years manipulations of Williams Creek has routed the stream's flow and sediment directly into the Salt River, overloading the river's ability to process received sediments. As part of the overall restoration of the Salt River, Williams Creek will be re-connected to the Salt River. The restored Salt River channel slope will be three times less than the slope of Williams Creek. The low slope of the Salt River provides limited sediment transport capacity, especially for larger grain size materials.

Before identifying a rehabilitation approach for Williams Creek, it was necessary to determine if the restored Salt River will have the capacity to transport some or all of the sediment delivered from Williams Creek. The appropriate rehabilitation approach for Williams Creek depends on these findings.

Figure 2-22 shows the predicted sediment transport capacity rating curve for the Salt River assuming that Williams Creek is delivering its full sediment load and complement of grain sizes. The analysis suggests that the Salt River may not have the capacity to transport the higher volume and coarser sediment load delivered from Williams Creek, and deposition would occur.

The analysis also found that the transport capacity of the Salt River is highly dependent on the size and proportion of material delivered from Williams Creek. Figure 2-23 shows the predicted sediment load from Williams Creek and the Salt River sediment transport capacity if the coarser grain sizes (> 0.125 mm) in Williams Creek were trapped rather than being delivered to the Salt River. This analysis indicates that it is necessary to prevent coarser sands and gravels from being delivered to the Salt River from Williams Creek, and any rehabilitation alternative considered for Williams Creek must provide a mechanism to accomplish this.

Detailed methodology and results of these analyses are presented in Appendix C.

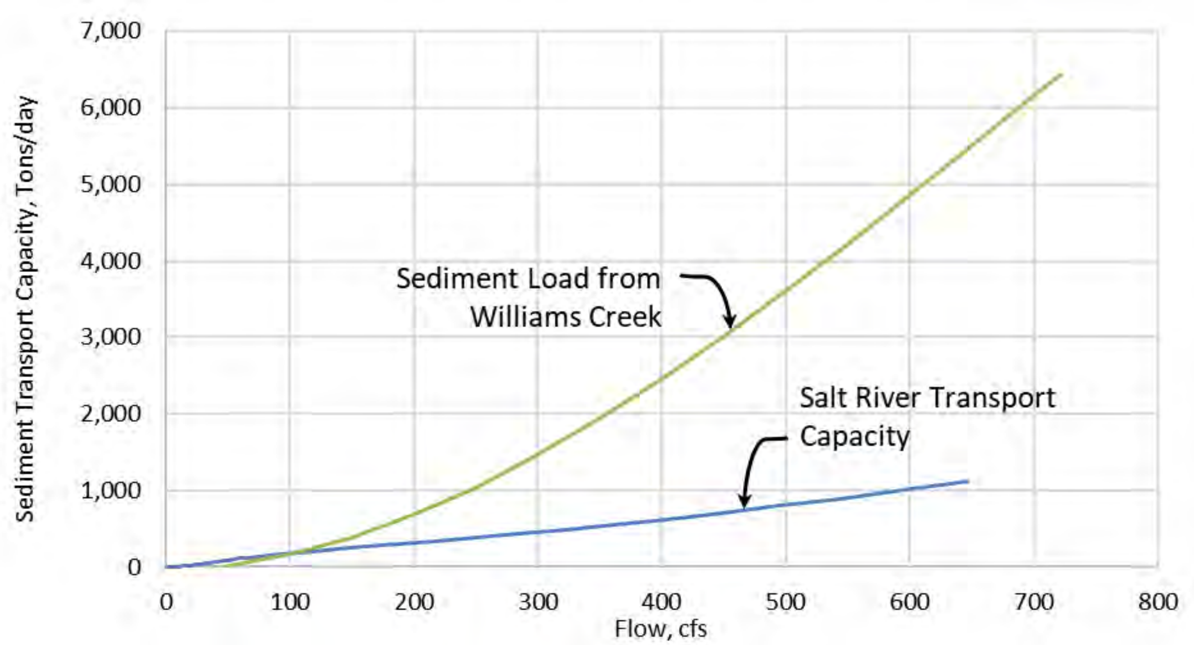


Figure 2-22. Comparison of the sediment load in Williams Creek at Bridge 3 with median grain size (D_{50}) of 0.18 mm to the sediment transport capacity of the Salt River for the same median grain size.

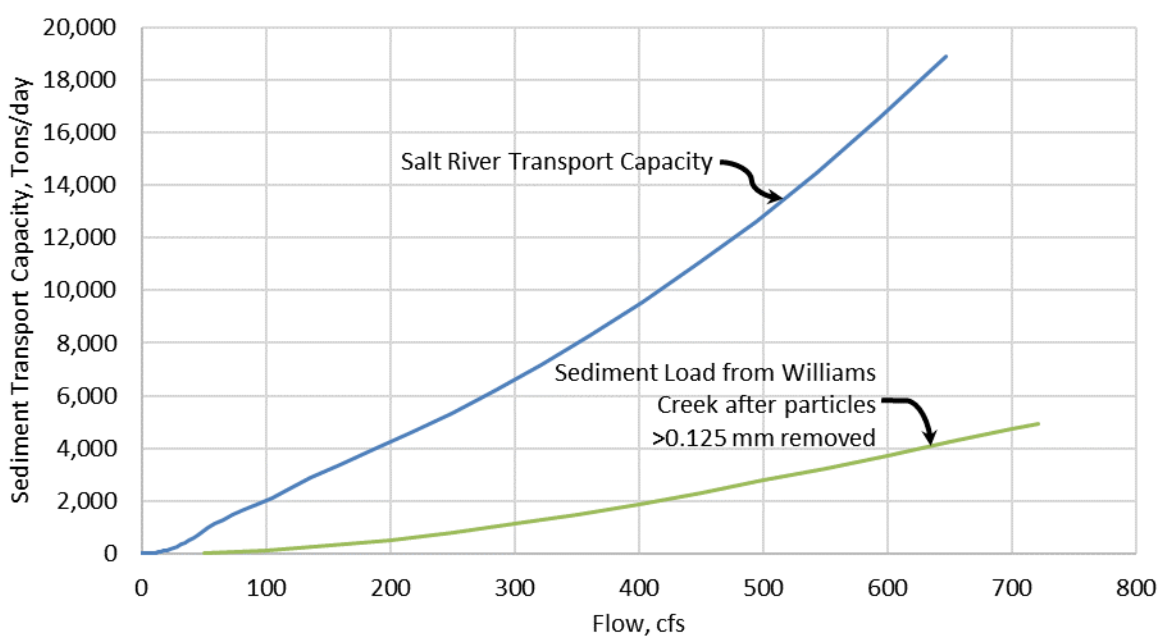


Figure 2-23. Comparison of Salt River sediment transport capacity to the Williams Creek sediment load, assuming all particles >0.125 mm are trapped and prevented from entering the Salt River (delivered sediment D_{50} = 0.09 mm).

2.12 Summary of Findings for Existing Conditions

The following is a summary of findings from the evaluation of existing conditions:

2.12.1 Geomorphic Setting (Section 2.8)

- The geology of the Williams Creek watershed consists primarily of the highly erosive mudstones of the Rio Dell formation. The unstable geology of the Williams Creek watershed is compounded by high rates of tectonic activities and high rainfall rates.
- Though there are some land-use inputs to channel sediment, the overall contribution is relatively small, and the high sediment load is natural to the watershed.
- The stream channel upstream of Grizzly Bluff Road delivers from the watershed to the project area a large volume of silts, sands, and to a lesser extent, gravels.
- Where Williams Creek emerges from its confined stream valley in the Wildcat Range and flows on to the broader, lower-sloped Eel/Salt River floodplain, it forms an alluvial fan, naturally losing flow and sediment transport capacity in a downstream direction.
- Historically, the alluvial fan and a large wetland area on the Salt River floodplain minimized delivery of coarse sediment from Williams Creek to the Salt River.
- Historic maps indicate that Williams Creek has been artificially confined to its current alignment since the late 1800's, The active fan lobe that Williams Creek is currently building is much longer than the other two fan lobes, and the stream channel has created a ridge that it flows along, which is over 10 feet higher than the valley bottom to the east and west.
- Review of current channel elevations with a 1993 survey indicated that Williams Creek has aggraded about 4 feet at the confluence with the Salt River, and about 1 foot at the Grizzly Bluff Road Bridge.
- The upper portions of Williams Creek between where it exits the Wildcats to downstream of Bridge 3 is located within the upper regions of the alluvial fan. In this area, the channel is incised, and maintains flow and sediment transport to the lower fan. Out-of-bank flows occur less frequently than downstream.
- The frequency of out-of-bank flows increases in the downstream direction of Williams Creek, concurrent with decreases in channel width and depth. Debris jams, overhanging riparian vegetation, and tight meanders in the channel planform increase flow resistance, cause sediment deposition, and elevate water levels.
- Discontinuous earthen berms along portions of the channel serve to increase channel depth and help confine flows.

- The location of flow overtopping the channel banks changes frequently, likely associated with transient nature of debris jamming and accretion of sediment along the top of banks.
- Because the channel is located on a ridge above lower elevation lands, out-of-bank flows cannot return to channel, resulting in flooding and sediment deposition on the adjacent properties. Depending on the flow event, the flooding and sediment deposition can be substantial.
- A large storm event or a high sediment load delivered from upstream could cause Williams Creek to, jump (avulse) into a lower-elevation area, abandon its current alignment, and resume natural alluvial fan processes if not put back into its current alignment.

2.12.2 Flow Conveyance and Flooding Patterns (Section 2.9)

- A hydraulic analysis indicated that channel capacity decreases substantially in the downstream direction. Overbank flow losses from the channel begin downstream of Grizzly Bluff Road, and by the time the flows reach the confluence with the Salt River, the channel is conveying only approximately 147 cfs, regardless of incoming flows from upstream.
- The maximum flow conveyance of the channel near the confluence with the Salt River is approximately 147 cfs, which has a return period between 1.01 and 1.1 years. Therefore out-of-bank flows can be expected to occur at least once per year, and typically more.
- During a 2-year flow event (584 cfs at Grizzly Bluff Road), flows spill to the west, inundating Ambrosini Lane and surrounding low areas to the northwest. Along the east bank of the channel opposite Ambrosini Lane, out-of-bank flows spill down broad swales to a low area (sump) to the south of the Williams Creek and the upper Salt River channel, where water ponds.
- As flows increase above a 2-year event, water starts to spill out of the channel to the east and west further upstream. Flows spilling to the west inundate Rose Avenue before flowing westerly to a low swale. Flow and water depths increase along Ambrosini Lane and to the northwest.

2.12.3 Sediment Transport (Section 2.10)

- Sediment sampling was performed during water year (WY) 2017 and 2018. WY 2017 is classified as being on the threshold between an “above average” and “wet” year. WY 2018 has been classified as a “below average” year.
- During WY 2017 a total of 96,753 tons of sediment was transported by Williams Creek, with only 83.4 tons transported as bedload. Of the amount of sediment transported, 78% of the sediment transported was silt and clay (finer than 0.0625 mm) and considered washload that remains in near permanent suspension when conveyed by flowing water.

Coarser grain sizes in transport were predominantly very fine sands, but also included coarser sands and gravels.

- During the dry WY of 2018, Williams Creek transported a total sediment load of 13,027 tons, with bedload comprising only approximately 9 tons of the total, 23% of the transported sediment composed of sands, and the remaining being silts and clays.
- The sediment transport capacity in Williams Creek decreases by 98% between Grizzly Bluff Road and the Salt River during an approximately 3-year return period flow of 722 cfs. Some sediments are deposited in the channel, but most deposition occurs along the tops-of-banks and on the overbanks. The sediment deposition is causing both the channel bed and banks to aggrade, and to form deep sediment deposits on the overbanks.
- A sediment transport assessment of the restored Salt River channel downstream of the Williams Creek confluence indicated that the Salt River will not have the capacity to transport the sediment load and associated grain sizes delivered from Williams Creek. Therefore, the rehabilitation approaches considered for Williams Creek need to include measures to trap the coarser sediment load from Williams Creek, with a focus on materials coarser than very fine sand (>0.125 mm).

3. Scoping Project Approaches

Findings from the existing condition evaluations in Section 2 identified the limited Williams Creek channel capacity and associated flooding downstream of Grizzly Bluff Road are primarily driven by a watershed with a naturally high sediment load and its location on an alluvial fan. The alluvial fan processes are out of equilibrium since the mid to late 1800's due to land-use activities. This has prevented the channel from avulsing (jumping) into a new alignment. It is necessary to address these alluvial fan processes to address the associated flooding. Generally, there are three approaches to integrating alluvial fan processes on an occupied landscape (Davies and McSaveney, 2008):

- Approach 1: Allowing natural fan processes to occur within a controlled area
- Approach 2: Constructing and maintaining a designated sediment basin for collection and removal of excess sediment
- Approach 3: Creating a sediment delivery channel to transport all sediment from the upper fan directly to the receiving river

The sediment transport analyses discussed in Section 2.11 indicated that the restored channel of the Salt River does not have the capacity to transport the full sediment load and larger grain sizes delivered from Williams Creek. Therefore, Approach 3 is not a feasible option for Williams Creek and is not recommended.

The following sections present an evaluation of rehabilitation options using Approaches 1 and 2. Section 4 presents a summary of the rehabilitation approaches for Williams Creek, ability to meet project objectives, and advantages and disadvantages.

3.1 Approach 1: Allowing Natural Fan Processes to Occur

One means of managing alluvial fans is allow natural fan processes to occur within a controlled area using natural ground features or containment berms to contain flows and sediment. This allows the stream to form multiple channels as it deposits sediment across the large surface of the fan. This approach requires a large area to accommodate the volume of sediment anticipated to deposit.

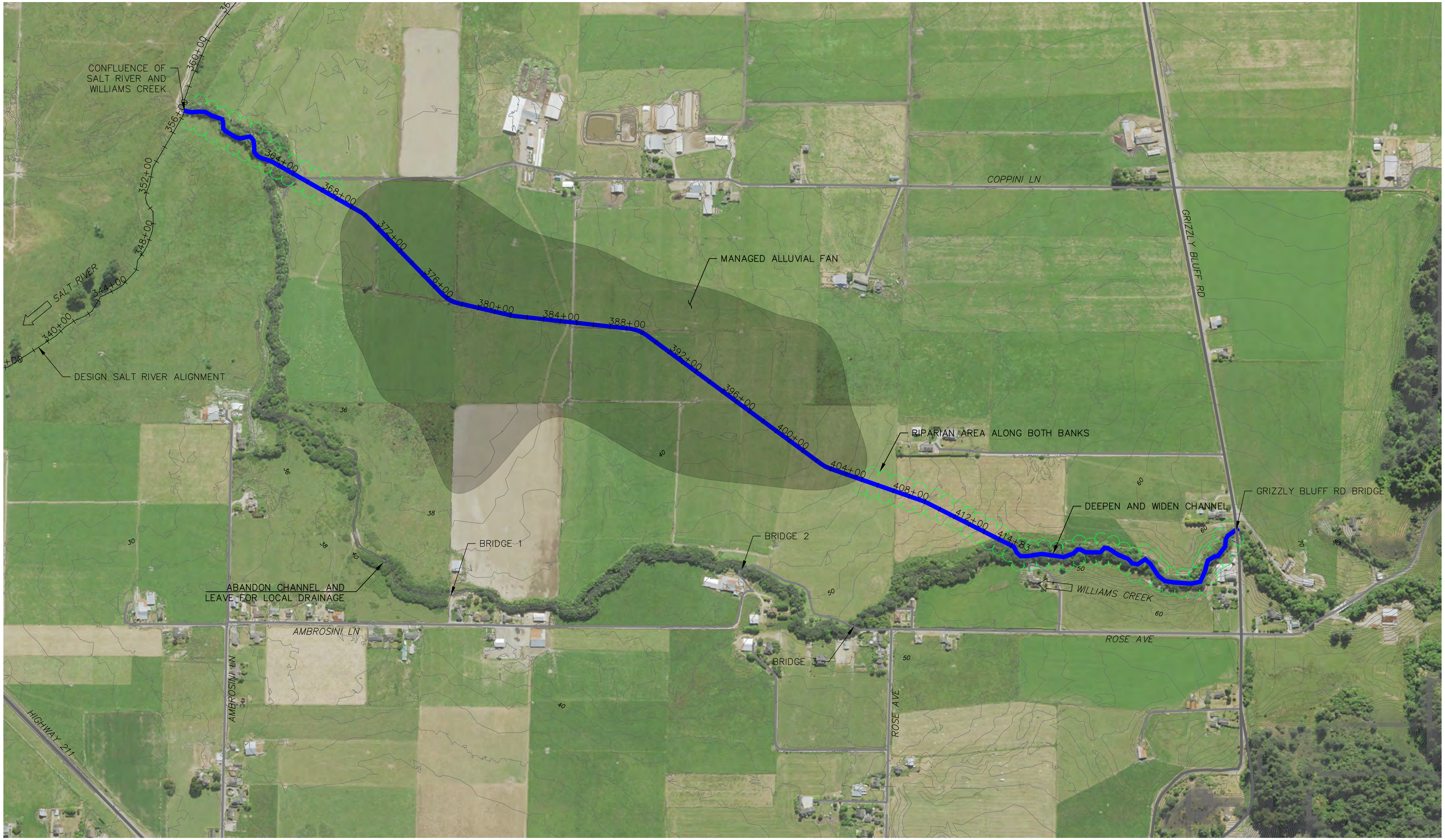
A plan view of Approach 1 is shown in Figure 3-1 and a profile view shown in Appendix D. Under this approach, Williams Creek would be deepened and widened starting just downstream of Grizzly Bluff Road. The middle reaches of the channel would be realigned to the east, with the channel "daylighting" into an about 80-acre low flood basin (sump), where sediments would drop out in a managed alluvial fan area. One or several pilot channels would be constructed through the fan area to be re-occupied by Williams Creek as it shifts in response to sediment depositional areas.

At the downstream end of fan area, flows would be redirected back into Williams Creek to enter into the Salt River. Flows reaching the Salt River channel would be largely free of sediment, as the sediment would have deposited on the surface of the alluvial fan. Containment berms may be necessary to protect existing ranch buildings from flooding and sedimentation.

To reduce impacts to existing land use within the designated alluvial fan area, low-height berms along the pilot channels would create depositional cells within the fan footprint. Over time, as a cell fills-in, the berms could be moved or overtopped, and a new depositional cell started. The cells that become filled with sediment could then be restored to active agricultural lands. Managing the overall fan as a series of lateral depositional cells would allow large portions of the fan to be maintained as active agricultural lands. A moveable temporary bridge could be used to access property beyond the active cell.

Based on recommendations in Appendix C, it was assumed that the stored sediment slope when the fan is “full” would be about 0.35%. Preliminary calculations indicate that an alluvial fan with a 0.35% slope would have a total storage volume of approximately 185,000 cubic yards of sediment before the fan becomes “full” and begins to deliver sediment directly to the Salt River. Assuming that all the coarse sediment delivered by Williams Creek gets trapped in the fan, but the washload continues to be conveyed to the Salt River, the average depositional volume would be approximately 16,500 cubic yards of sediment per year (Section 2.10.2), resulting in about 12 years of sediment storage before the fan becomes “full.” The actual lifetime of the fan before it fills would depend on the actual sediment grain size that gets stored and the sediment loads delivered, which could differ substantially from average conditions dependent on watershed conditions and magnitude of storm event.

Given that the service life of this alternative is only approximately 12 years while impacting approximately 80 acres of agricultural land, it was considered less feasible than other alternatives and it was not further developed.



WILLIAMS CREEK - PLAN VIEW

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PROJECT APPROACH 1
MANAGED ALLUVIAL FAN

DATE
MARCH 2020

FIGURE
3-1

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3.2 Approach 2: Active Sediment Management and Enlarged Williams Creek

The sediment transport analyses discussed in Section 2.11 indicated that the restored channel of the Salt River does not have the capacity to transport the full sediment load, and especially the larger grain sizes delivered from Williams Creek. Approach 2 addresses the excess coarse sediment load from Williams Creek by constructing and maintaining a sediment management area designed to capture coarse sediment that is mechanically removed on a routine basis.

A sediment management area (SMA), commonly referred to as a sediment basin, requires on-going maintenance in the form of regular clean-out. Trapping and removing sediment in one location along the channel allows the area to be controlled for maintenance and minimizes impacts to aquatic and riparian habitat along the remaining stream length. Regular cleanout, typically on an annual or bi-annual basis, results in the footprint of a sediment basin being smaller than if it were only cleaned out after multiple years. Regular cleanout also ensures a basin will provide its fullest storage capacity in the event of an extreme storm event that delivers a substantial sediment load in the following year.

The feasibility of constructing a sediment basin at several different locations on Williams Creek was evaluated, including along the existing channel alignment and along realigned channel reaches. Re-profiling and/or realignment of the channel was also considered concurrently with the sediment basin alternatives to address the flooding issues on the adjacent properties. A total of four different channel alignments were considered, with the downstream-most feasible locations for a sediment basin identified.

Figure 3-3 shows a composite view of the four channel alignments considered, with the downstream-most sediment basin locations that are feasible on the channel alignment. For all of the alignments, sediment basins could be placed anywhere between this location and Grizzly Bluff Road. Additionally, a potentially suitable location exists upstream of Grizzly Bluff Road, near the apex of the alluvial fan.

Individual plan and profile-view figures for each channel alignment are shown in Appendix D.

3.2.1 Sediment Basin Design Parameters

The schematic Williams Creek sediment basin was sized so that sediment removal would be necessary on an annual basis while providing adequate capacity for larger sediment loads during wetter years. The analyses in Section 2.11 suggests that the restored Salt River does not have the capacity to transport the sediment load from Williams Creek without removing material coarser than 0.125 mm. Therefore, sediment basin designs should focus on trapping these coarser sized materials while allowing finer material to continue downstream to the Salt River.

Initial sediment basin sizing was based on the volume necessary to trap <u>4,000 cubic yards</u> of sediment, reflecting the coarser fraction (>0.125 mm) of the sediment load that could be delivered during wetter years (Table 2-2 and Section 2.3.4). Based on recommendations in Appendix C, it was assumed that the stored sediment slope when the basin is “full” would be about 0.35%. Therefore, a basin about 600 feet long and 500 feet wide, encompassing about 5 to 6 acres, as shown on Figure 3-2 would be necessary to store 4,000 cubic yards of sediment. The basin would have a flat bottom equal to the elevation of the downstream channel. A pilot channel through the basin would initially convey lower flows after clean-out, minimizing the potential for fish stranding on the flat basin bottom. Maintenance access roads would be incorporated into the basin design and would likely include a bridge upstream or downstream of the basin to allow access to both sides.

A steeper channel, with a slope around 3% stabilized with rock, would form the head of the sediment basin. It serves as a drop structure that would provide fish passage.

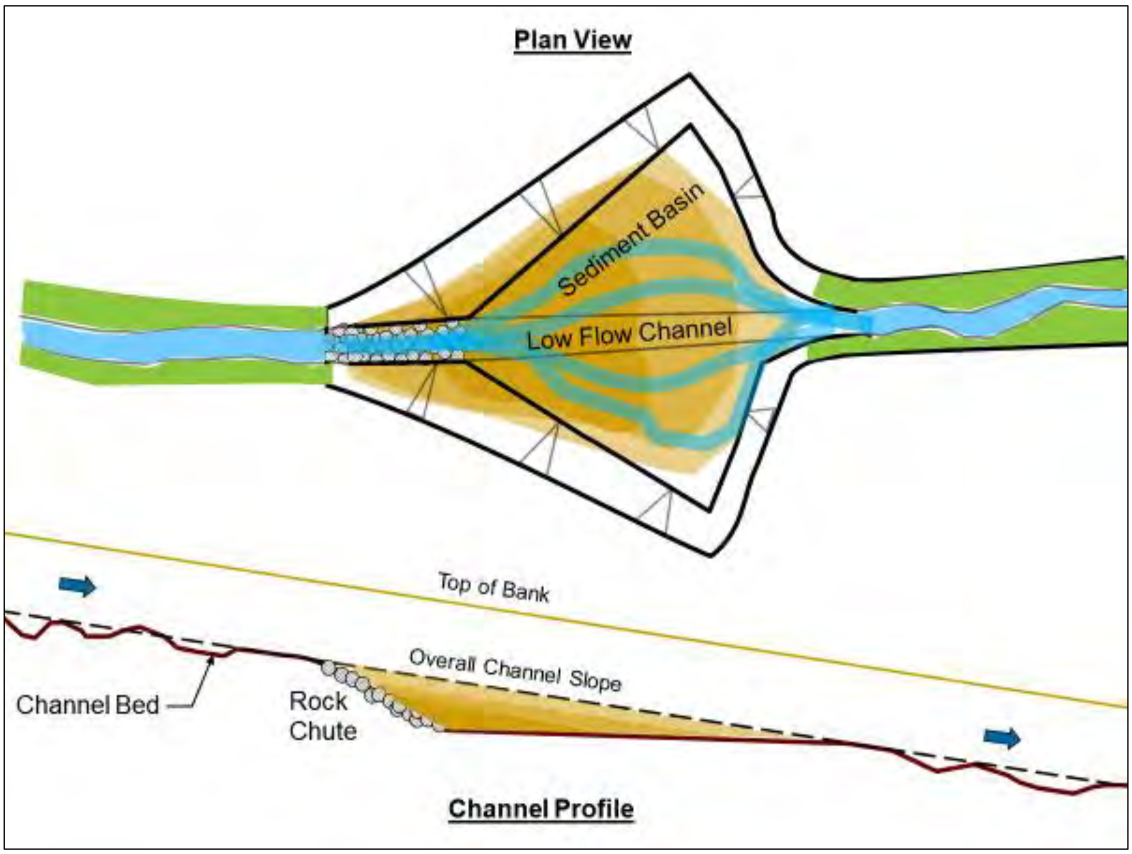


Figure 3-2. Conceptual plan and profile view of what a sediment basin could look like on Williams Creek.

In addition to the project objectives stated in Section 1.3, several other objectives were considered when considering the layout and placement of a sediment basin, including:

- Optimize the design of the sediment basin so it traps larger grain sizes that the receiving channel downstream and Salt River is unable to transport, but minimizes capture of finer grained materials that the channel can transport;
- Maintain sediment basin outlet above the 2-year Salt River flood elevation to avoid backwatering from the river that would increase sediment trapping efficiency;
- Layout of the basin for good maintenance accessibility;
- Provide fish passage through the basin;
- Locate the basin to minimize impacts to existing land-use.

3.2.2 Channel Design Parameters

To increase flow and sediment transport capacity requires enlarging or deepening Williams Creek along some or all of its channel length, depending on the channel alignment and location of the sediment basin. Where the channel will be realigned, a new channel will be excavated.

As indicated in the geomorphic assessment, the upstream reaches of Williams Creek just downstream of Grizzly Bluff Road are choked with debris jams. The flow and sediment transport capacity of Williams Creek in the upper reaches could possibly be increased by removing these debris jams and allowing the channel to self-adjust downward.

The geomorphic assessment also identified that the channel depth decreased in the downstream direction of Williams Creek. Widening and deepening the channel along the existing alignment would improve the flood and sediment transport of the channel. However, widening and deepening Williams Creek so that it would fully convey larger flows, such as a 100-year flow event is not geomorphically feasible because of the amount of aggradation that has occurred in the Salt River, which has raised the base-level of Williams Creek. Even restored, the Salt River will have a higher elevation channel and floodplain than it did historically.

The dimensions of the channel reach upstream of the sediment basin are critical to ensure that there are sufficient flows to convey the sediment load to the sediment basin without deposition. Based on recommendations in Appendix C, the stream upstream of a sediment basin channel should have a slope of 0.35%, similar to the sediment delivery reaches identified in the geomorphic analyses. The channel should be trapezoidal in shape with a bottom width ranging from 10-18 feet, with a minimum depth of 6-9 feet. For planning purposes, downstream of the sediment basin, the minimum channel slope was assumed to be 0.2%, slightly less than the existing channel slope, and of sufficient depth to contain frequent flow events and maintain sediment transport to the Salt River. It was assumed that a slope slightly less than the existing slope of 0.25% would be sufficient to transport the sediment load that is not trapped in the basin. This slope will be verified with hydraulic modeling as part of final design.

To minimize flooding on the west side of Williams Creek, spilling flows out-of-bank will be necessary. To control the locations where out-of-bank flooding will occur, a series of floodplain openings would be placed along the east side of Williams Creek to preferentially spill excess flows to the east. The intent of the floodplain openings is to reduce the magnitude and frequency of flooding to the west side of Williams Creek, specifically Ambrosini Lane and Rose Avenue. Flows from the floodplain openings would drain down existing swales to the low-lying flood basin (sump) upstream of the Williams Creek/Salt River confluence, similar to flow patterns east of the channel during current-day flooding. Flows draining to the existing sump would be routed to the Salt River or lower end of Williams Creek, accelerating the time necessary to drain this area. Flooding and sediment deposition would still be expected to occur to the east of Williams Creek, but in more controlled locations dictated by the locations of the floodplain openings.

A conifer riparian buffer would be planted along the length of the channel. Over time, the conifers would shade-out and reduce the number of willow and alder trees that are currently obstructing large portions of the channel.

The extent of channel grading along existing and realigned channel reaches, channel capacity, and the amount of flows to be spilled through the floodplain openings will vary depending on the location of the sediment basin.

3.2.3 Alignment 1: Sediment Basin Along Existing Channel Alignment

Figure 3-3 presents a plan view of the location of Alignment 1 for Williams Creek, which would follow the existing channel alignment. The downstream-most feasible locations for a sediment basin on this alignment is shown. A sediment basin could be placed along this alignment anywhere from this location to Grizzly Bluff Road, and potentially at a location upstream of Grizzly Bluff Road, near the apex of the alluvial fan. The flow and sediment transport capacity of Williams Creek would be increased by deepening and widening Williams Creek by a combination of debris removal and allowing the channel to self-adjust, and excavation. Individual plan and profile-view figures for this Alignment are shown in Appendix D.

3.2.4 Alignment 2: Sediment Basin Along Existing Channel Alignment, Reroute Downstream Reach

Alignment 2 follows the existing Williams Creek alignment but reroutes a portion of the downstream reaches of Williams Creek to connect more directly with the Salt River. The rerouted portion of the channel will be excavated to connect to the Salt River.

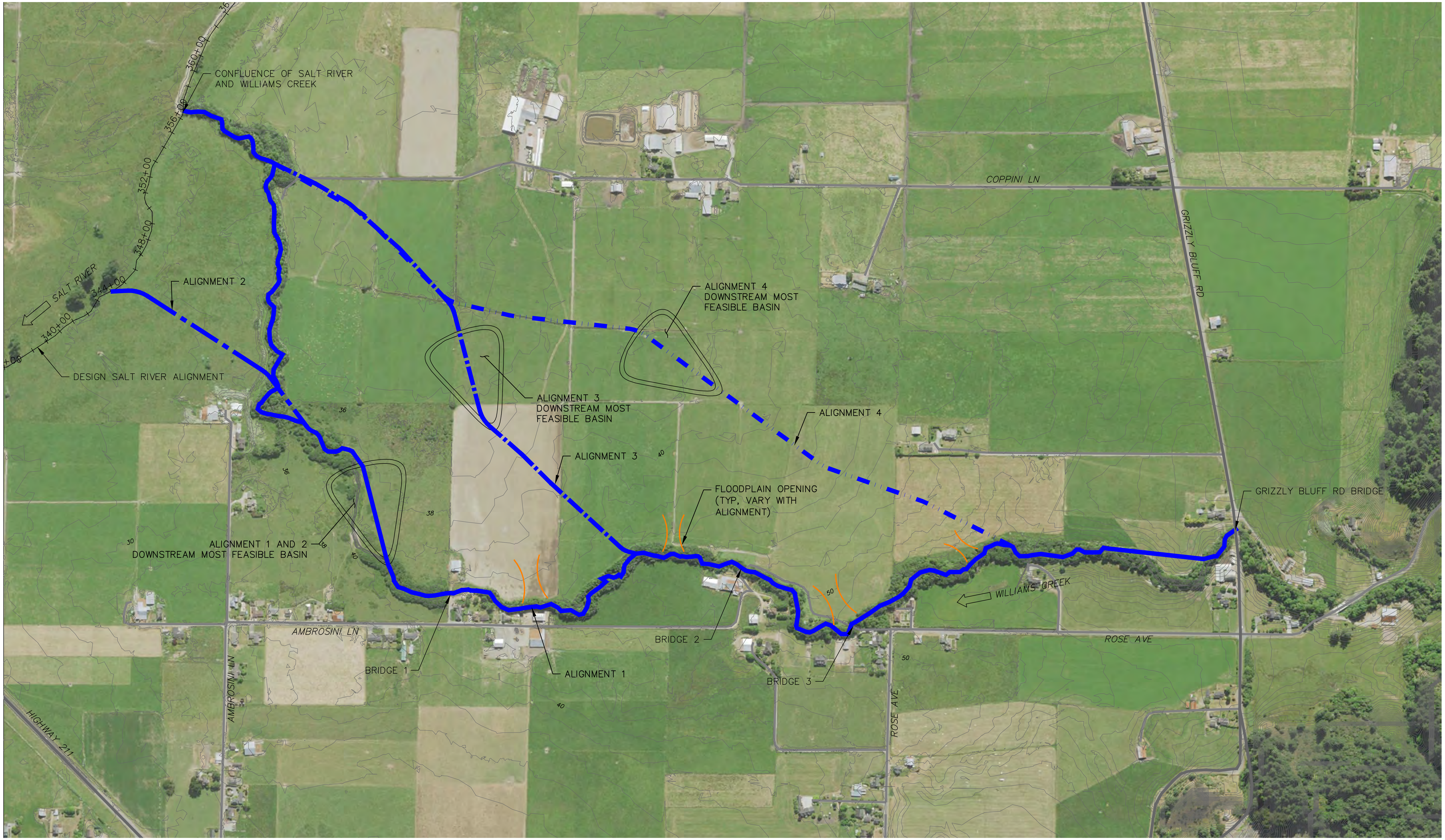
The rerouted portion of the channel would result in a steep channel slope downstream of the sediment basin, improving flow conveyance to the Salt River and reducing the frequency of overbank flooding. The realigned channel would also improve the confluence angle with the Salt River, reducing the amount of sedimentation that could occur at the confluence. A sediment basin could be located anywhere along this alignment to the downstream location shown on Figure 3-3. It could also be located upstream of Grizzly Bluff Road, near the apex of the alluvial fan. Individual plan and profile-view figures for this Alignment are shown in Appendix D.

3.2.5 Alignment 3: Reroute Downstream Channel Reach and Sediment Basin on Rerouted Reach

Alignment 3 follows the existing Williams Creek alignment, but would reroute Williams Creek channel downstream of Bridge 2 towards the east to follow an existing swale in the topography of the alluvial fan, and through the existing low flood basin (sump) before meeting the existing Williams Creek channel alignment just upstream of the confluence with the Salt River. The rerouted portion of the channel will be excavated to create a channel connecting to the Salt River. A sediment basin could be located anywhere along this alignment from downstream of Grizzly Bluff Road to the downstream location shown on Figure 3-3. Individual plan and profile-view figures for this Alignment are shown in Appendix D.

3.2.6 Alignment 4: Fully Realign Williams Creek with Sediment Basin

Alignment 4 would fully realign Williams Creek along all but a short reach downstream of Grizzly Bluff Road. Alignment 4 follows one of several potential alignments that the channel would naturally occupy if an avulsion event were to happen. This alignment follows a well-defined swale on the alluvial fan and confines the channel with the natural topography. Feasible sediment basin locations could be anywhere between Grizzly Bluff Road and the location shown on Figure 3-3. It could also be located upstream of Grizzly Bluff Road, near the apex of the alluvial fan. Individual plan and profile-view figures for this Alignment are shown in Appendix D.



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COMPOSITE VIEW OF FOUR POTENTIAL ALIGNMENTS &SEDIMENT BASIN LOCATIONS

DATE
MARCH 2020

FIGURE
3-3

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3.3 Approaches Considered but Not Further Developed

Several approaches were evaluated, but ultimately removed from consideration and not further developed. Descriptions of these are provided in this section.

3.3.1 No-Action

A no-action approach would include no improvements or maintenance on the Williams Creek channel to reduce sedimentation or flooding. A no-action approach would effectively be the status quo on Williams Creek, with continued out-of-bank flooding, sedimentation and damage to agricultural fields, impacts to residential structures, and disruption to County roads and State Highway 211.

If no-action is taken, fish passage and aquatic habitat within the channel would continue to be compromised. The sediment aggradation will continue to prevent formation of deep pools that would provide holding habitat for fish. Overbank flows and ponding of water in low areas with no outlets may cause fish entrainment and fish stranding on the floodplain.

Additionally, the project objective of minimizing the amount of sediment delivered to the Salt River would not be achieved. If coarse sediment, or an excessive sediment load were delivered to the Salt River, it could result in excess sedimentation with the Salt River that could jeopardize the recent restoration investment in the river.

3.3.2 Realign Williams Creek to West

Realigning Williams Creek to drain to the west was considered. The channel realignment would route Williams Creek into a low area to the west along Rose Avenue and into the low area (flood basin) east of Main Street and north of Ambrosini Lane. Flows from Williams Creek could then drain into the East-Side Drainage and eventually discharge into Francis Creek near its confluence with the Salt River. Alternatively, these flows could be routed under Highway 211, through the Scalvini Swale, and directly into the Salt River. Both of these routes would require installing several large stream crossings, including on Rose Avenue, Ambrosini Lane, and Highway 211 (Main Street). The channel would be routed close to numerous residences. A sediment basin would need to be sited as well, with the likely suitable location being to the south and west of Rose Avenue. Due to the amount of public infrastructure, residential neighborhoods to the west of existing Williams Creek, and the risks and costs associated with this alignment, this option was not further developed.

3.3.3 Sediment Management Recommendations from Previous Studies

3.3.3.1 USDA Soil Conservation Service (SCS) (1993) Recommandations

A study by the SCS (USDA, 1993) suggested two alternatives for sediment basins in Williams Creek to reduce sedimentation in the Salt River.

Sediment Basin

The first alternative included construction of a sediment basin on Williams Creek just upstream of the confluence with the Salt River. The basin would consist of an over-widened trapezoidal channel with a concrete drop structure into the basin and a rocked outlet. It would be about 1,800 feet long, and store about 11,000 cubic yards of sediment. It was estimate that the basin would need to be cleaned out every 5 years.

This alternative was not pursued as part of this study because it was found to be too low in the system and subject to the backwaters of the Salt River. This backwatering would result in too efficient of a sediment trap. Additionally, the overall geometry of the basin, which would consist of a long low-sloped channel, could result in trapping a large portion of fine materials, causing the basin to be under-sized. Sediment sampling performed as part of the current study found that during a wet year, Williams Creek transports 24,423 cy of sediment, excluding washload. Therefore, a basin more than twice the size of what was recommended by the SCS would be necessary.

Section 4.1.2 of this report presents a sediment basin geometry similar to the SCS basin, in a different location.

Dam

To reduce sediment loads to the Salt River, the SCS proposed construction of a 41.3-foot tall dam about a mile upstream of Grizzly Bluff Road, where Williams Creek exits the Wildcats. It was estimated that the storage capacity behind the dam would last about 50 years. It was recommended by the report authors that a dam was not a viable option and was not considered further.

3.3.3.2 McBain Associates/Moffat Nichols (2013)

McBain Associates/Moffat Nichols (2013) prepared recommendations to address sedimentation In Williams Creek for the U.S. Army Corps of Engineers. They recommended building a series of “Floodway Openings” along Williams Creek. The floodway openings would consist of a series of breaches along the existing east bank of Williams Creek, allowing flows to spill out of channel. A continuous berm would be constructed to the east, down slope from the top of channel bank. The area between the channel and the berm would be used to trap sediment and route flows downstream and back into Williams Creek near the Salt River. The length of the berm and area used for sedimentation varied depending on the alternative. A similar configuration could also be constructed on the northwest side of the channel in the downstream-most reach of Williams Creek.

This alternative was not pursued as part of this study because the various arrangements of berms and sediment depositional areas took large acreages of pasture out of production. Additionally, there was a concern that the floodplain openings would result in the retention of coarser-grained sediments in Williams Creek, which would ultimately be transported to the Salt River. Also, the configuration appeared to encourage channel avulsion (jumping), which would likely result in the channel moving to the east and flowing along the toe of the constructed berm, which could cause the berm to erode and fail. Additionally, the proposed berms would be situated on agricultural wetlands requiring mitigation that would likely not be achievable onsite through creation of an equivalent fill area. Although this approach was not further developed, the use of floodplain openings was incorporated into final alternatives.

3.3.3.3 Benda (2007)

Benda (2007) found that a substantial amount of sediment is being generated along Williams Creek by channel erosion. Because the channel is incised, sediments are being delivered to the Salt River rather than being deposited on the floodplain as they were historically. To reduce the amount of sediment delivered to the Salt River, Benda (2007) recommended implementation of a maintained sediment basin as recommended by SCS (1993), though much larger than what SCS recommended.

In lieu of an actively maintained sediment basin, Benda (2007) recommended either installing large wood or rock structures within the Williams Creek channel, or implementing the ‘pond-and-plug method’. Both of these methods would install structures within the Williams Creek channel to trap sediment, ultimately raising the channel bed. Over time, sufficient sediment deposition would be trapped within the channel that it would frequently spill its banks, and onto the floodplain, where deposition would then occur. In the 13 years since Benda studied the sediment load in Williams Creek, the channel bed has continued to aggrade downstream of Grizzly Bluff Road, resulting in increased frequency of out-of-bank flows and resulting deposition on the floodplain/alluvial fan surface.

This approach would result in the restoration of natural processes along Williams Creek. However, it would result in increased flooding and sedimentation along the Williams Creek corridor, severely affecting current land-use activities, and could ultimately result in channel avulsion. Additionally, allowing Williams Creek to spill to the west would not address the current flooding and sedimentation that occurs along Ambrosini Lane. Therefore, this approach was not further considered.

3.4 Comparison of Approaches and Alignments

Table 3-1 presents a summary of the rehabilitation approaches for Williams Creek, how they meet project objectives, and their advantages and disadvantages. All considered rehabilitation approaches would reduce the size fraction and volume of sediment delivered to the Salt River. Each would also reduce the flooding potential for Ambrosini Lane and Rose Avenue, with differences depended on the approach.

The following is a discussion of various attributes of each approach, and their advantages, shortcomings, and risks.

Potential Reduction in Flood Risk

All rehabilitation approaches would increase channel flow and sediment transport capacity by removing debris jams and enlarging and deepening the channel to various degrees. However, deepening and enlarging Williams Creek so that it can convey a larger flow, such as a 10-year event, without out-of-bank flooding is not geomorphically feasible. The tie-in elevation with the restored Salt River channel at the confluence and resulting depth of Williams Creek thalweg below the top of bank limits the potential capacity of the channel. Therefore, to reduce the flooding frequency on Ambrosini Lane, excess flows can either be spilled to the east through floodplain openings, or through portions of the channel realigned to the east, away from these areas.

Deepening and enlarging Williams Creek within its current alignment (Approach 2: Alignments 1 and 2) will increase channel capacity to a limited degree, but floodplain openings on the east side of the channel will be necessary to spill high flows onto the floodplain to the east to prevent flooding along Rose Avenue and Ambrosini Lane. Flooding and sediment deposition to the east of Williams Creek would occur less frequently and in more controlled locations dictated by placement of the floodplain openings. Hydraulic modeling will determine when the floodplain openings are activated and the amount of flow conveyed through them. The low flood basin (sump) to the northeast will receive flows from the floodplain openings, but would be connected to either Williams Creek or the Salt River to allow these waters to efficiently drain-off.

Realigning the channel to the east along some, or most, of its alignments (Approach 1 and Approach 2: Alignments 3, and 4) would reduce the risk of flooding at Ambrosini Lane by moving the channel into lower terrain. Moving the channel into a lower area would also provide it with a floodplain that drains back into the channel, reducing the amount of flow and sediment trapped on the floodplain. It is expected that the more that the channel is realigned, less reliance on floodplain openings is needed, and the risk of flooding to the west decreases.

In-Channel Sedimentation Potential

Increasing the channel flow and sediment capacity by removing debris jams and enlarging and deepening the channel is expected to increase the sediment transport potential of the channel. However, the sediment load needs to be conveyed through Williams Creek to the sediment basin. The risks of in-channel sedimentation and resultant overbank flooding increases the further downstream the sediment basin is located. Locating the sediment basin at the downstream-most feasible location on the existing channel alignment would require coarse sediment to be routed a longer distance along Williams Creek, past Ambrosini Lane, before reaching the basin. The longer distance coarse sediment needs to be routed increases the chance for sedimentation within the Williams Creek channel. Additionally, the further downstream the basin is located increases risk that backwater influences from the lower gradient Salt River will increase trapping efficiency of fine sediment, making the basin size inadequate.

Avulsion Potential

Maintaining Williams Creek along its existing alignment (Approach 2 Alignments 1, 2, and upper part of Alignment 3) will maintain the channel in its currently perched position, placing the top of streambanks higher than the receiving floodplain. As such, overbank flows will still not be able to return to the channel. During a large flow event, there is a moderate chance that the channel could breach its banks and avulse, establishing a new channel in a lower overbank area and abandoning the current channel. An avulsion could occur to the east or to the west. An un-managed avulsion event could result in a large volume of flows and sediments flowing into agricultural or residential areas, creating unforeseen damage.

Similarly, the more the channel is realigned out of its existing alignment (Approach 2, lower part of Alignment 3, and Alignment 4), the less risk would be of an uncontrolled channel avulsion and its consequences. Additionally, as more of the lower channel reaches are routed to the east, the risk of flooding to the west substantially decreases.

Agricultural Impacts

Rehabilitation approaches that stay within the existing stream alignment (Approach 2, Alignments 1 and 2) would necessitate the smallest footprint on adjacent agricultural lands. However, the landowners have indicated that the higher-elevation banks to the east side of the stream channel are better quality agricultural lands than the lower-elevation ground that receives frequent flooding and deposition. Alignments 1 and 2 will also necessitate spilling flows to the east, which would still result in flooding and sediment deposition in the low-lying areas, though not as frequently.

Rehabilitation approaches that bisect fields (Approach 1, and Approach 2 Alignments 3 and 4) would have a higher impact to agricultural lands by taking land out of production, requiring bridges to access areas across the creek. Additionally, routing the creek through existing fields would require the installation of a riparian buffer that may reduce productivity.

Ease of Maintenance Access

All rehabilitation approaches will require annual maintenance. For Approach 1, this would require grading sediment deposited in depositional cells, building new cells once one is full, and moving the temporary bridge to maintain access across the creek.

For Approach 2, annual mechanical removal of the sediment from the sediment basin will be necessary. Up to 4,000 cy of sediment may deposit in a sediment basin per year, which is the equivalent of about 400 loads in a standard 10-yard dump truck. Therefore, maintenance roads and bridges into the basins will be necessary. Additionally, a maintenance road will need to be constructed to the closest public road to allow trucks to transport sediment for disposal/reuse. The closer the basin is located to Grizzly Bluff Road, Rose Avenue, or Ambrosini Lane, the shorter the maintenance road, and shorter trucking distance will be necessary.

Fisheries and Aquatic Habitat Benefits

Enlarging and deepening the channel to improve flow conveyance and sediment transport (all approaches) would result in improving fisheries and aquatic habit by reducing the amount of fine sediment that deposit in the channel, filling pools and fouling spawning habitat. In addition to a healthy riparian area, in-stream habitat features would also be constructed to create habitat diversity, scour deeper pools, and refuge from predators. All of the approaches involve a substantial temporary impact to native fish residing in Williams Creek, including brook lamprey and sculpin. However, these temporary impacts are offset by the creation of long-term habitat in Williams Creek and preservation of habitat in Salt River.

Construction of a sediment basin somewhere along the channel alignment (Approach 2) would provide a defined area about 800 feet long where sediment can be trapped and mechanically removed without impacts to the remaining stream channel. The remainder of the stream channel would remain un-disturbed. Approach 1, creating a managed alluvial fan, would re-establish natural depositional processes in the watershed, to which native species are adapted.

Table 3-1. Summary and comparison of the two approaches and various channel alignments considered for Williams Creek.

Project Approach/ Alignment	Description	Potential Flood Risk	In-Channel Sedimentation Potential	Avulsion Potential	Agricultural Impacts	Ease of Basin Maintenance Access	Advantages	Shortcomings/Risks
Approach 1	Managed Alluvial Fan	Lowest to west Highest to east	High, as it restores natural fan processes	Low in realigned channel reach Moderate otherwise	Highest (Large depositional area)	More Difficult	• Restores natural processes • Managed depositional “cells” to keep more pasture in production • Raises low ground, improving long-term ag. productivity	• Extensive loss of agricultural fields • Only ~16-year service life • Potential unexpected sedimentation patterns • Regular maintenance of sediment cells
Approach 2, Alignment 1	Existing Alignment Sediment Basin in Upper Reaches	Lower to west Lower to east	Increases in downstream direction	Moderate	Moderate (Small basin, but on most productive pasture)	Good	• Traps coarse sediment upstream of Ambrosini Lane residences	• Potential for avulsion • Relies on floodplain openings to reduce flooding to west
	Existing Alignment Sediment Basin at Downstream Most Extents				Low (Small basin on lower productivity pasture)	Moderate	• Sediment basin located on lower quality agricultural land	• Potential for avulsion • Requires routing coarse sediment past Ambrosini Lane to reach sediment basin • Increased risk for Salt River backwater to cause excess sedimentation in basin • Relies on floodplain openings to reduce flooding to west
Approach 2, Alignment 2	Existing Alignment with Reroute near Salt River Sediment Basin at Downstream Most Extent	Lower to west Lower to east	Increases in downstream direction	Moderate	Low (Small basin on lower productivity pasture))	Moderate	• Steeper slope downstream of basin facilitates sediment transport • Better confluence angle with Salt River	• Requires routing coarse sediment past Ambrosini Lane to reach sediment basin • Relies on floodplain openings to reduce flooding to west
Approach 2, Alignment 3	Reroute Channel Upstream of Ambrosini Lane Sediment Basin on Rerouted Reach	Lowest to west Higher to east	Increases in downstream direction	Low in realigned channel reach Moderate otherwise	High (Small basin, but channel bisects pastures)	Moderate, increasing with downstream basin location	• Moves channel and flood risk away from Ambrosini Lane • Reduces avulsion potential along realigned channel • Less reliance on floodplain openings for flood reduction • Topography contains flows in realigned reach	• Requires longer, deeper channel excavation to achieve channel depth • Channel slope upstream of basin potentially steeper than stable, may require grade control • Potential for Salt River backwater to cause excess sedimentation in downstream-most basin location • Requires bridge(s) to access across stream
Approach 2, Alignment 4	Fully Realigned Williams Creek Sediment Basin on Realigned Reach	Lowest to west Highest to east	Low (much steeper channel)	Low	Highest (Small basin, but channel bisects large extent of pastures)	More difficult	• Moves channel and flood risk away from Ambrosini Lane • Reduces avulsion potential along longest length of channel • No floodplain openings needed • Topography contains flows	• Splits existing continuous ag. field • Requires deeper channel excavation • Requires bridge(s) to access across stream

3.5 Selection of Alternatives to Evaluate

All of the Williams Creek rehabilitation approaches and alignments, and potential sediment basin locations were presented to the individual landowners. Through these discussions, the RCD staff selected three alternatives to further develop and evaluate. All three would keep the channel in its current alignment and include a sediment basin, floodplain openings, and channel widening/deepening. Two of the alternatives would place the sediment basins downstream of Grizzly Bluff Road, and one alternative would place it upstream. Not all these basins are needed, however all are considered at this planning level as technically viable and subject to further discussions between the HCRCD and landowners. The alternative basin locations are described in the subsequent section as individual locations. Selecting two smaller basins is another consideration for redundancy. However, this could result in overall higher construction and operation/maintenance costs long-term.

4. Evaluated Alternatives

This section describes the development and evaluation of three alternatives. These alternatives include Approach 2 along the existing alignment (Alignment 1), with an upstream or a downstream sediment basin location downstream of Grizzly Bluff Road (herein called Alternatives 1 and 2). For these two alternatives, schematic-level design channel profile, cross sections, sediment basin layout, and floodplain opening grading were developed. Two-dimensional hydraulic modeling was performed for Alternative 1 and 2 for the 2-, 5-, and 10-year flow events to assess the expected performance of each alternative.

Schematic design plans for a sediment basin upstream of Grizzly Bluff Road (herein called Alternative 3) were also prepared. Schematic level grading was developed for this basin. No hydraulic modeling was performed for this alternative, but the performance of the channel downstream of Grizzly Bluff Road would be similar to Alternative 2.

Information on the design development and the results of the hydraulic modeling for each alternative are discussed in the following sections. Note that the designs were prepared to the schematic level, and there is some flexibility in the final shape, size, and location of each sediment basin. These details will be resolved as part of the final design.

4.1 Alternatives 1 and 2: Rehabilitated Williams Creek Channel with Sediment Basin Downstream of Grizzly Bluff Road

Alternatives 1 and 2 consist of deepening and enlarging the Williams Creek channel, installing a sediment basin at one of two locations, and constructing floodplain openings to spill excess flow out of the channel to the east. The sediment basin would have dimensions similar to what is described in Section 4.1.2. The following objectives were used to guide the design development:

- Deepen and widen channel as needed to increase flow and sediment transport capacity, while remaining geomorphically stable;
- Maintain a minimum of a 0.35% channel slope and minimum 6-foot channel depth to the sediment basin to ensure efficient transport of coarse sediment;
- Relax tight meander bends along channel alignment;
- Design sediment basin to trap 4,000 cubic yards of coarser grained sediment, while passing finer grained sediments as practical;
- Maintain sediment basin outlet above the 2-year Salt River flood elevation (about elevation 30.0 feet, NAVD88);
- Locate floodplain openings on the east side of the channel to preferentially spill out-of-bank flows to the east at controlled locations;
- Spill flow out of floodplain openings at greater than a 2-year flow, if feasible;

- Aim for 10-year water surface elevation below existing top-of-bank along entire west (left) bank.

Additional design objectives for the sediment basin are described in Section 4.1.2.

Hydraulic modeling was used to refine the designs to meet the objectives and obtain quantitative estimates of the hydraulic performance of each alternative.

4.1.1 Design Plan View

Figure 4-1 and Figure 4-3 show the schematic design plan view layouts of Alternatives 1 and 2. The sediment basin for Alternative 1 would be located near the downstream end of Williams Creek to the south of the existing channel. The channel would be locally re-routed to the south to pass through the center of the sediment basin.

The sediment basin for Alternative 2 is located about midway down Williams Creek on the east side of the channel. The channel would be locally rerouted to the east to past through the center of the sediment basin and Bridge 3 would be relocated.

The design channel alignment for Alternatives 1 and 2 are the same, except where the sediment basins will be located. The design channel alignment generally follows the existing channel alignment, but reduces the tightness of some of the channel bends. Smoothing out the tighter channel bends is expected to increase flow efficiency at the bends, better maintaining sediment transport.

The hydraulic modeling indicated that deepening and enlarging the entire stream channel from Grizzly Bluff Road to the Salt River is necessary to obtain 10-year flood protection to the west side of Williams Creek (See Section 4.1.4).

The entire length of the widened and deepened channel will have a conifer riparian buffer planted at the top of the channel banks. Over time, the conifers would shade-out and reduce the number of willow and alder trees that are currently obstructing large portions of the channel. A total of five floodplain openings would be located on the east side of the channel.

4.1.2 Sediment Basin Design

The sediment basins for Alternatives 1 and 2 were designed with the same objectives discussed in Section 3. Spatially, the volume of the basin was designed to store about 4,000 cubic yards of sediment, which was identified as the volume of the coarser fraction of sediment delivered by Williams Creek during a wetter year. This necessitated a basin about 600 feet long and 500 feet wide, encompassing approximately 5 to 6 acres, as shown schematically on Figure 3-2 and specifically for Williams Creek on Figure 3-3. To ensure sufficient sediment storage, it is assumed that the sediment basin will be cleaned out on an annual basis.

The sediment basins shown on Figure 4-1 and Figure 4-3 have a slightly different shape than shown on Figure 3-3. The ultimate shape of the sediment basin will be determined as part of final design to optimize selective trapping of coarser sediments and continued transport of finer sediments through the basin. Topography and land use constraints will also influence the final position of the basin at the selected site.

The basin would have a flat bottom where sediment will be stored, with approximately a 1-foot deep pilot channel to convey smaller flow events directly through the basin immediately after cleanout to minimize the potential for fish stranding on the flat basin bottom.

For each sediment basin, a 150-foot long channel with an overall slope of 3% would drop 4.5 feet into the 1-foot deep pilot channel in the bottom of the basin. This steeper channel would consist of a series or rock chutes or chutes and pools to stabilize the channel and provide fish passage. Over time, sediment is expected to deposit at about a slope of 0.35%, forming a wedge shape in profile about 2.5-feet high at the upstream end of the basin and tapering to a minimal depth at the downstream end of the basin, as shown on Figure 3-2. To ensure that accumulated sediment does not back-up into the upstream channel (upstream of the rock chutes), an additional 1-foot of freeboard was incorporated into the depth of the sediment basin, resulting in the total 4.5-foot drop into the basin.

Maintenance access roads would be incorporated into the final basin design, and would likely include a bridge to allow access to both sides of the basin. Upstream of the rock chute a water control structure consisting of stoplogs could be included to isolate the basin during cleanout while providing fish passage for the remainder of the year. A streamflow bypass pipeline may be included on the upstream side of the water control structure to facilitate bypassing of streamflows during cleanout. This could be designed to also accommodate safe downstream passage for fish.

4.1.3 Design Profiles

4.1.3.1 Alternative 1

Figure 4-2 shows the design profile for Alternative 1 with the sediment basin located near the downstream end of Williams Creek. Upstream of the basin, the stream channel would be deepened and widened between Grizzly Bluff Road and the head of the basin, with an overall slope of 0.35%. Downstream of the basin, the channel would have a 0.20% slope to maintain transport of finer sediments to the Salt River.

The original design intent for the sediment basins was to set its outlet elevation above the 2-year water surface elevation of the Salt River. However, at the request of the landowner, the feasibility of moving the sediment basin further downstream and lowering the outlet elevation was assessed. Reducing the curvature of the channel downstream of basin shortened its length allowing the sediment basin to be moved further downstream while retaining a minimum downstream channel slope of 0.20%.

4.1.3.2 Alternative 2

Figure 4-4 shows the design profile for Alternative 2 with the sediment basin located in the middle reaches of Williams Creek. The channel between Grizzly Bluff Road and the sediment basin would be deepened and widened, with a slope of 0.39%, slightly steeper than the slope of the sediment delivery reaches upstream. The slightly steeper slope is a result of reducing the channel curvature and length in the reaches upstream of the sediment basin. Downstream of the basin, the channel would have a 0.28% slope, sufficient slope to maintain transport of finer sediments to the Salt River.

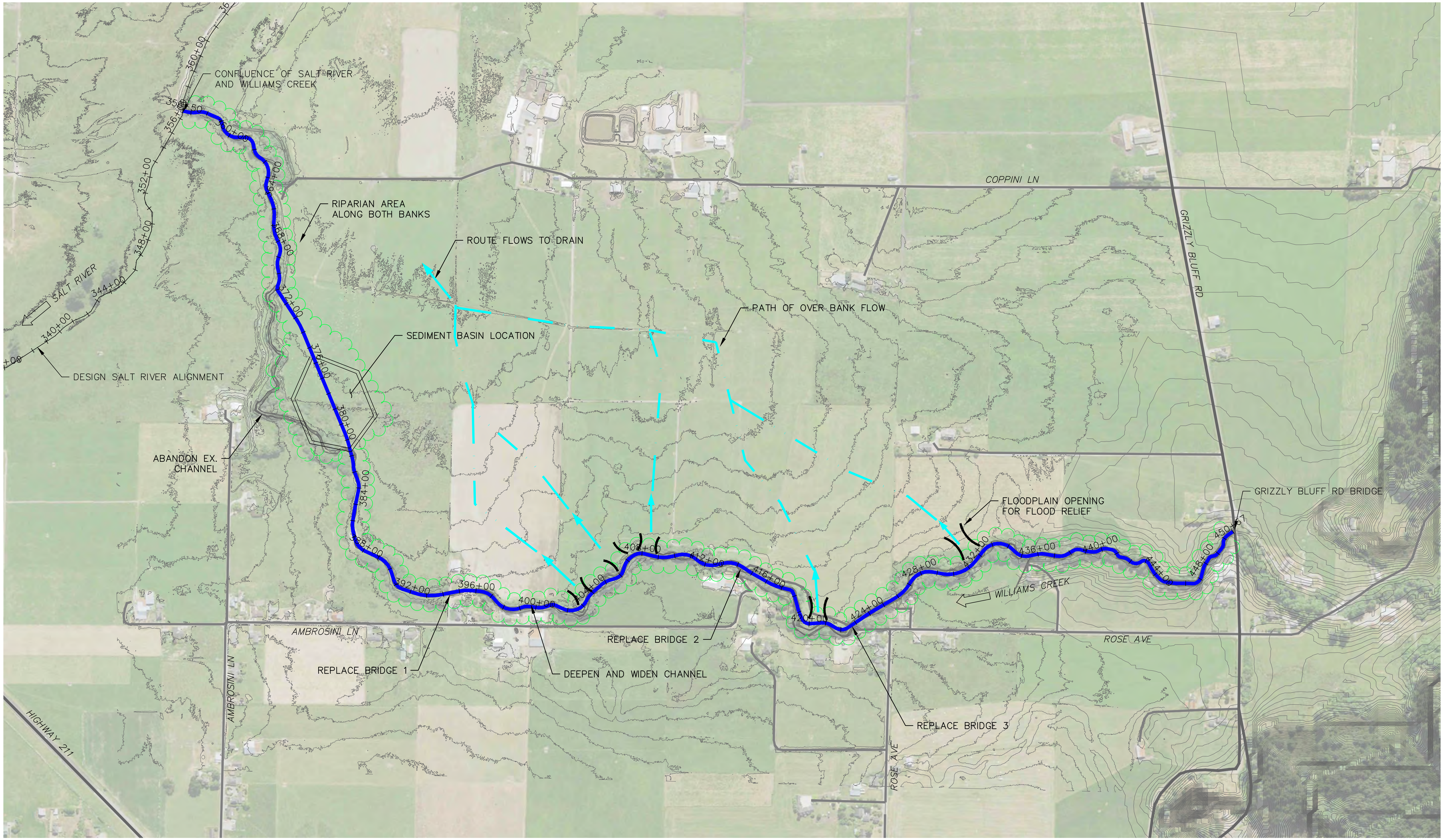
Figure 4-5 shows overlays of the design channel profiles for Alternative 1 and 2. The channel profile for Alternative 1 would be about 1 to 3 feet higher than the channel for Alternative 2 along most of the creek. The higher-elevation channel for Alternative 1 was necessary to keep the outlet elevation of the sediment basin at 25 feet and to maintain a minimum slope of 0.2% between the sediment basin and the Salt River. Because the channel profile for Alternative 1 would be higher than Alternative 2, the channel will have less flow capacity, and additional flows will need to be spilled to the east to maintain 10-year flood protection to the west side of Williams.

4.1.4 Design Channel Cross Section

A trapezoidal-shaped cross section with a 10-foot bottom width and 1.5H:1V side slopes was selected as the design cross section for the entire length of Williams Creek. This cross section is similar to the cross section in the Middle (Sediment Delivery) and Upper Alluvial Fan reaches.

The actual channel dimensions, and specifics on how the channel will be graded will be determined during final design. It is anticipated that channel grading would occur only on one side of the channel, but shifting sides dependent on the specific location and site constraints. Channel grading will be a balance between maximizing channel conveyance, minimizing the amount of higher quality pasture taken out of production, proximity of adjacent residential and agricultural buildings, and impacts to more sensitive environmental features such as older stands of trees.

Figure 4-6(a) shows three potential ways that the Williams Creek will be widened and deepened. If the channel is graded on one side or the other, the portion of the channel that is not graded will remain undisturbed, retaining any existing berms, stabilizing materials, and riparian vegetation. Similar to Figure 4-6(a), the anticipated grading cross sections for Alternative 1 and 2 are overlain, showing the difference in elevation between alternatives. Because the Alternative 2 channel would be deeper, the limit of grading will be slightly wider. Where the existing channel is narrower, channel grading may be necessary on both sides to sufficiently increase the flow capacity. As part of the channel grading, debris jams and overhanging vegetation that is impeding channel flow will be removed. Figure 4-6(b) shows the proposed riparian plantings for a typical Williams Creek cross-section that is widened and deepened.



WILLIAMS CREEK - PLAN VIEW

0 300 600
GRAPHIC SCALE

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PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

HUMBOLDT COUNTY RESOURCE CONSERVATION DISTRICT
100 Berding Street Ferndale, CA 95536

GHD

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

HUMBOLDT COUNTY RESOURCE CONSERVATION DISTRICT
WILLIAMS CREEK RESTORATION PLANNING
FERNDALE, CA

ALTERNATIVE 1
DOWNSTREAM SEDIMENT BASIN

DATE
MARCH 2020

FIGURE
4-1

2/26/2020 Q:\Williams_C_Alternatives\7_CAD-GIS\Civil3D\Sheets\2_WilliamsCr_Alternative 1.dwg

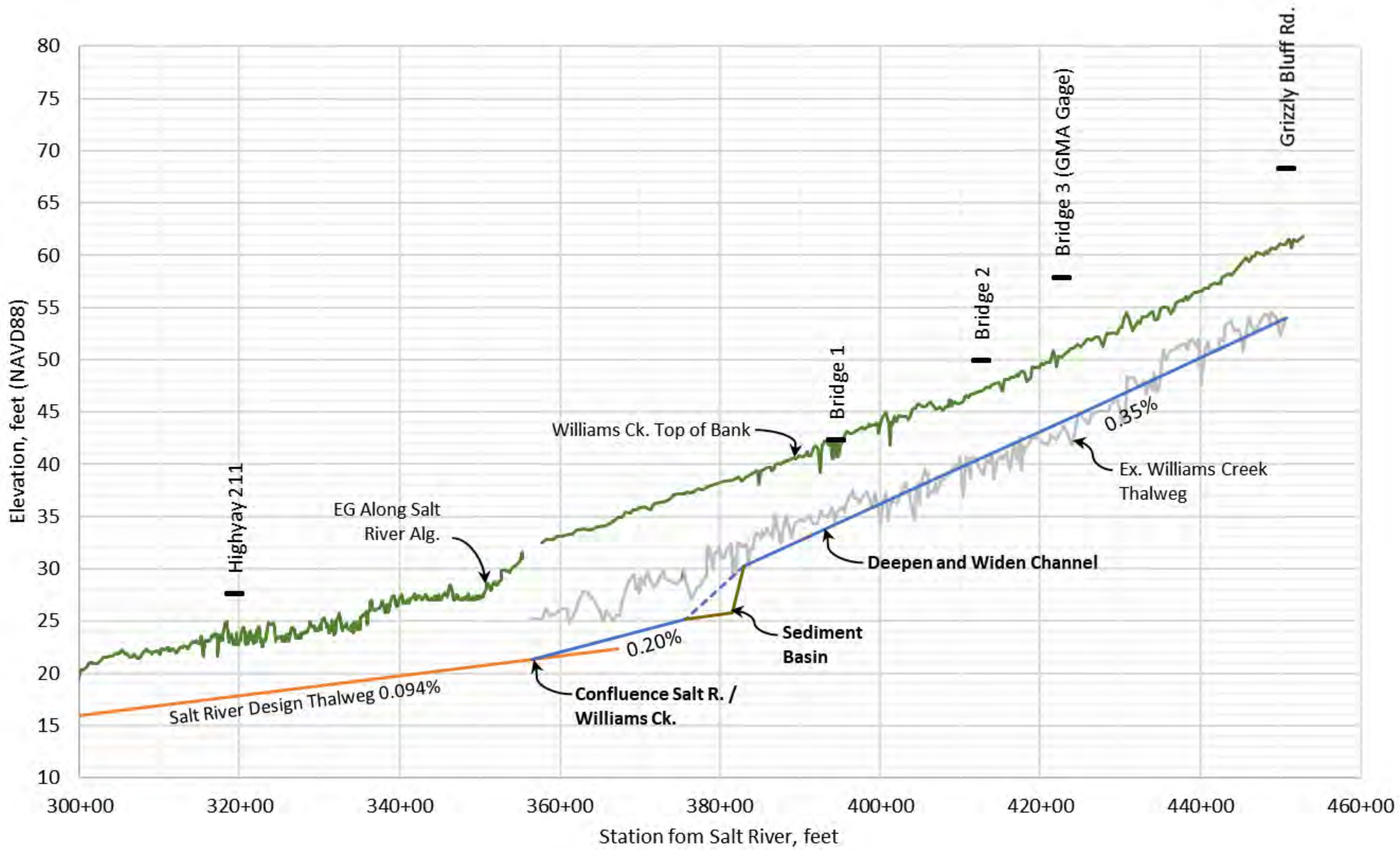
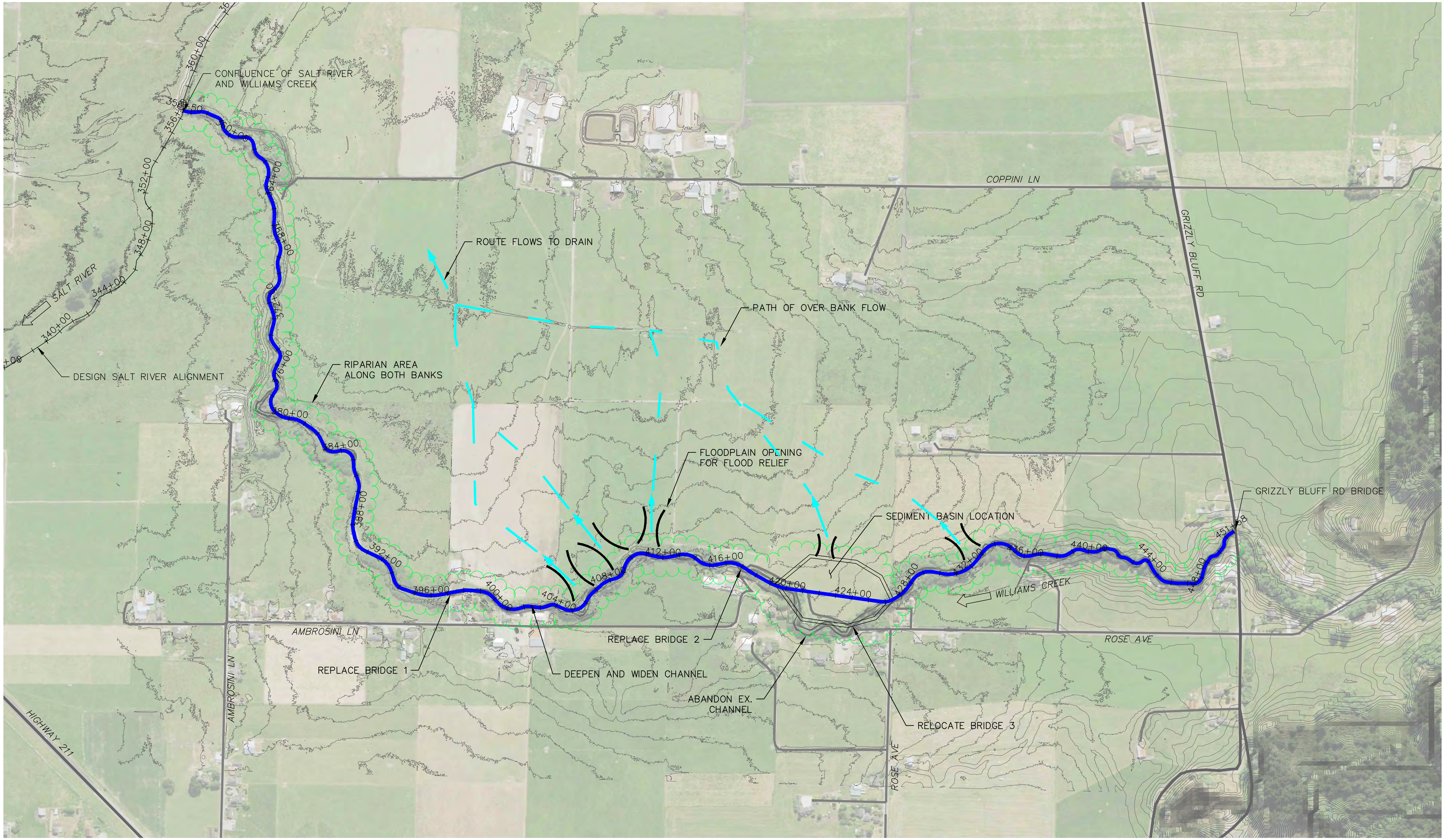


Figure 4-2. Profile view of Alternative 1 showing the proposed channel profile and location of sediment basin.



WILLIAMS CREEK - PLAN VIEW

0 300 600
GRAPHIC SCALE

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WILLIAMS CREEK RESTORATION PLANNING
FERNDALE, CA

ALTERNATIVE 2
MIDDLE SEDIMENT BASIN

DATE
MARCH 2020

FIGURE
4-3

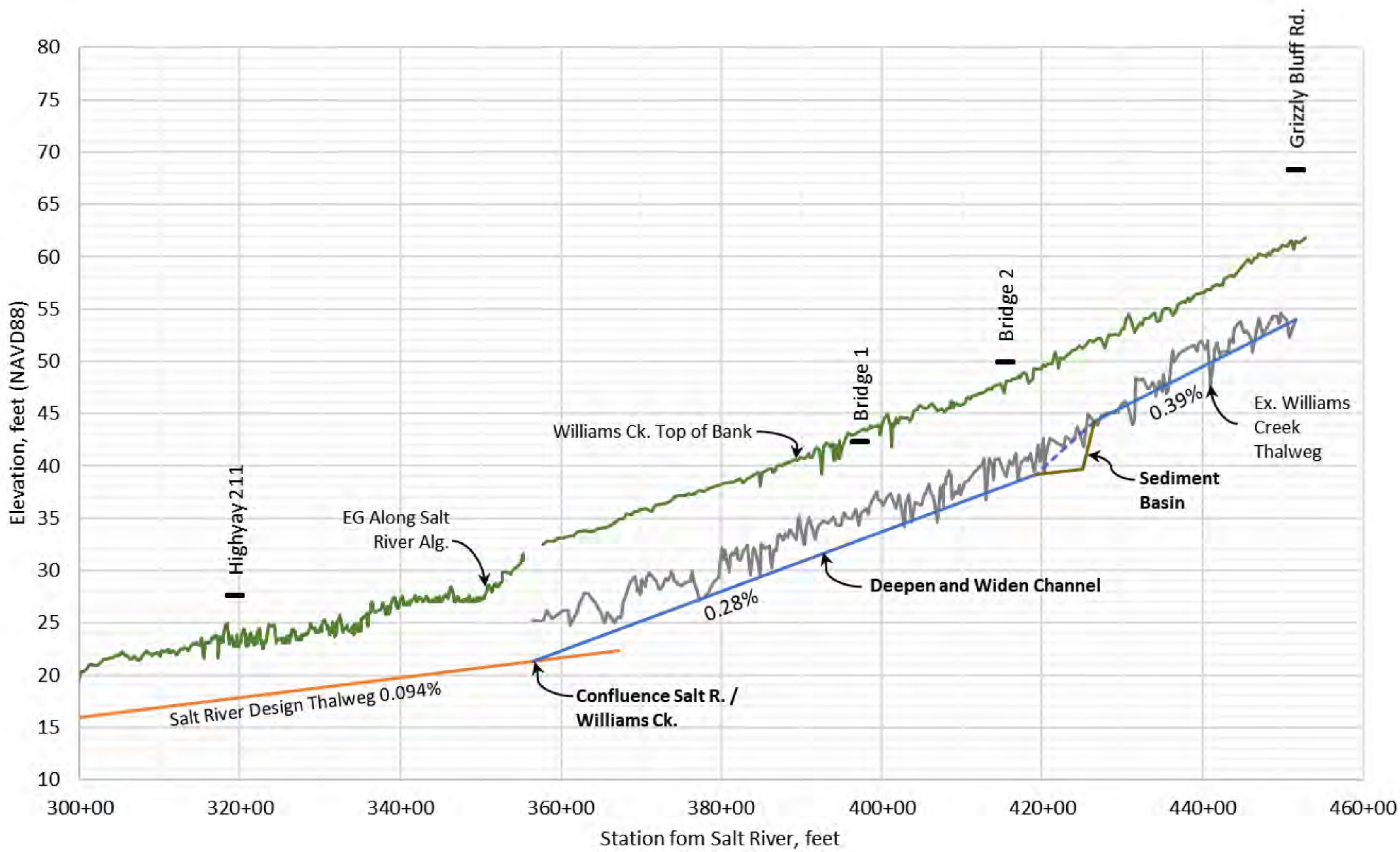


Figure 4-4. Profile view of Alternative 2 showing the proposed channel profile and location of sediment basin.

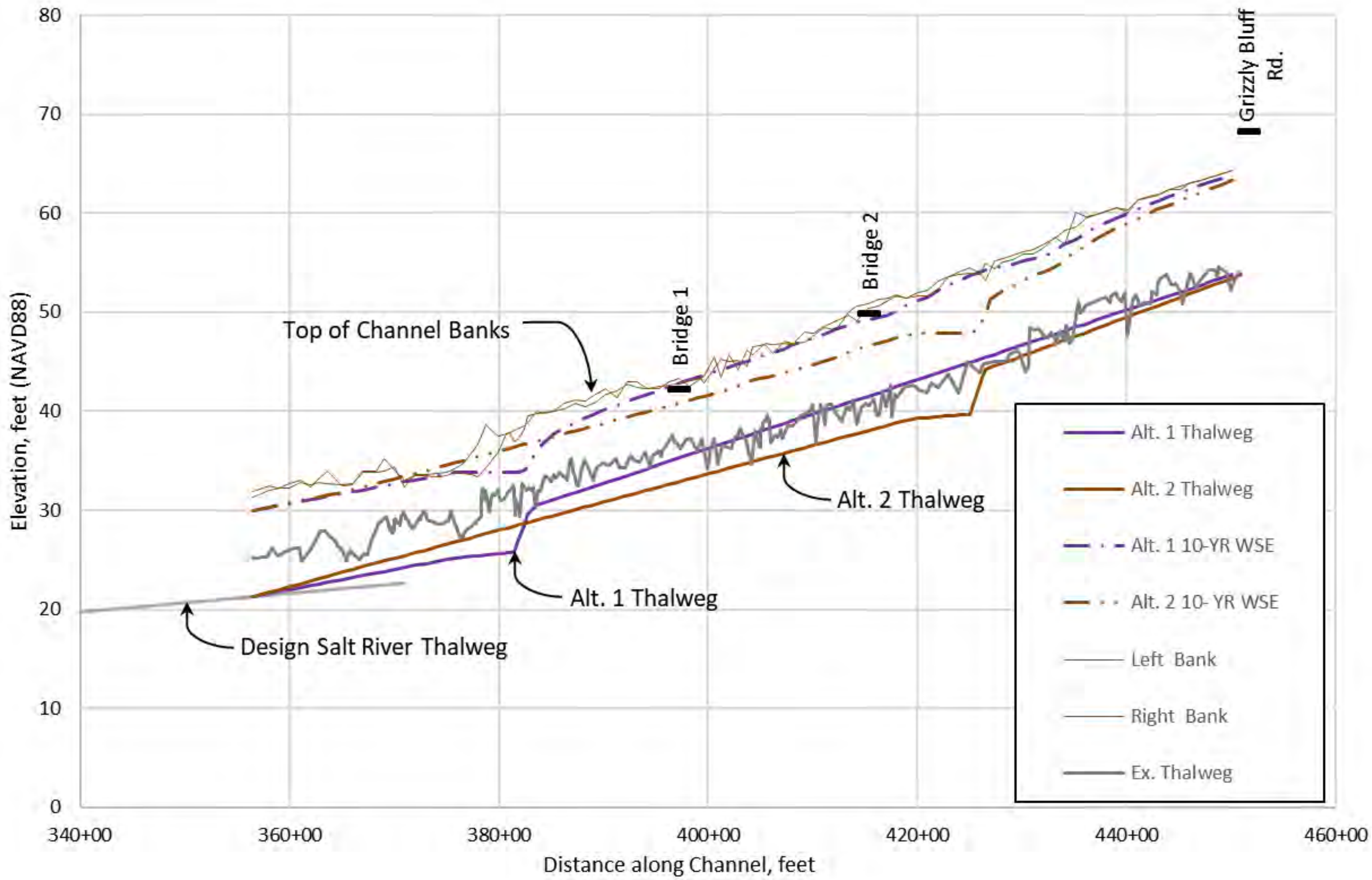


Figure 4-5. Overlay of Alternative 1 and Alternative 2 channel profiles. HEC-RAS model predicted 10-year water surface elevations (WSE) are shown for each alternative. Note the bridges are removed from the hydraulic analysis.

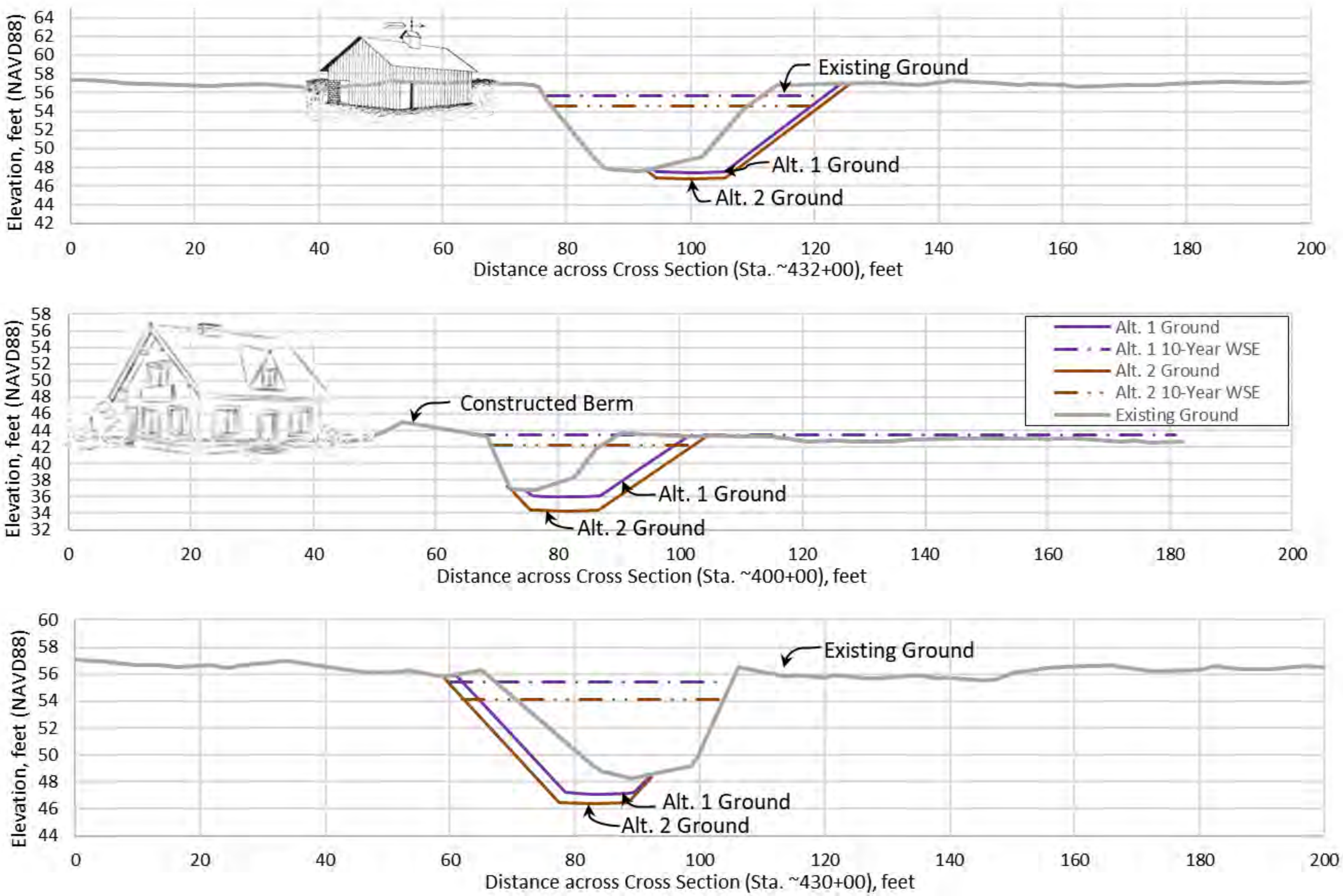
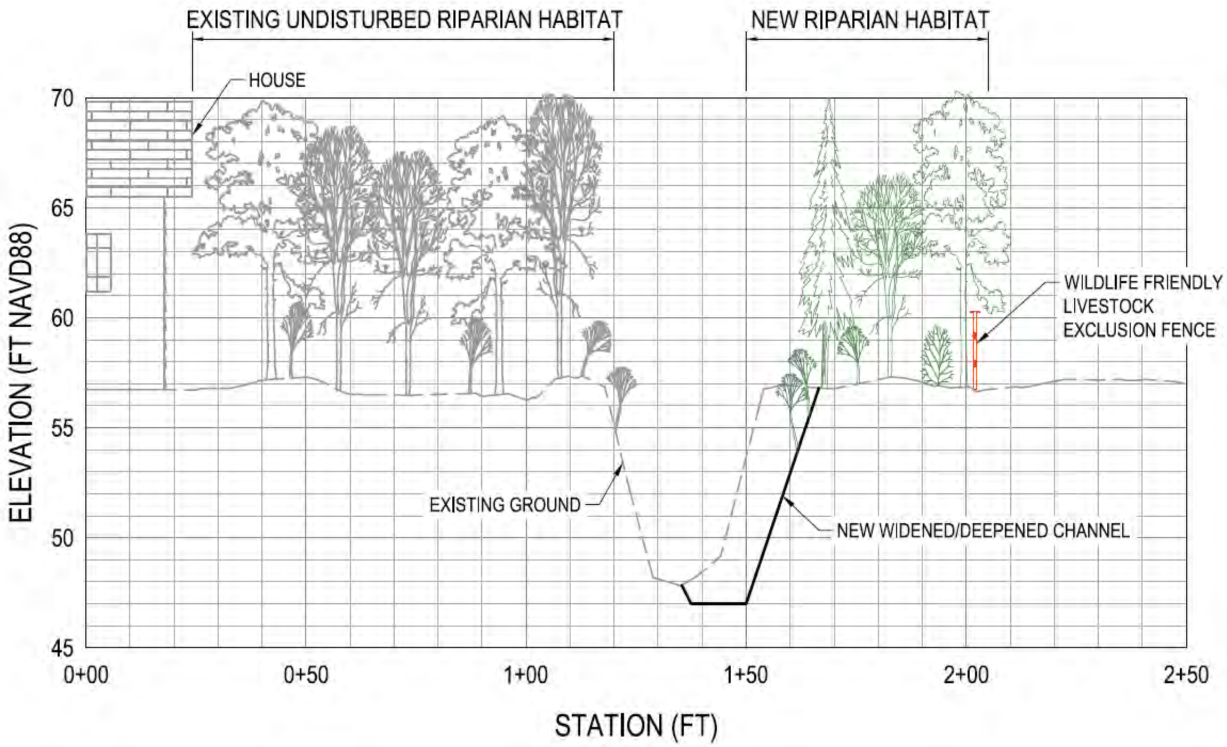


Figure 4-6(a). Typical channel cross section grading for Alternatives 1 and 2, showing various grading configurations. HEC-RAS model predicted 10-year water surface elevations (WSEL) are shown for each alternative.



RIPARIAN PLANTINGS

SITKA SPRUCE (PICEA SITCHENSIS)
GRAND FIR (ABIES GRANDIS)
RED ALDER (ALNUS RUBRA)
BIGLEAF MAPLE (ACER MACROPHYLLUM)
PACIFIC WILLOW (SALIX LUCIDA SSP. LASIANDRA)
RED CURRANT (RIBES SANGUINEUM)
TWINBERRY (LONICERA INVOLUCRATA)
BLACK COTTONWOOD (POPULUS BALSAMIFERA SSP. TRICHOCARPA)
CASCARA (FRANGULA PURSHIANA)
WAX MYRTLE (MORELLA CALIFORNICA)
THIMBLEBERRY (RUBUS PARVIFLORUS)
SALMONBERRY (RUBUS SPE CTABILIS)
RED ELDERBERRY (SAMBUCUS RACEMOSA)
SLOUGH SEDGE (CAREX OBNUPTA)
BULLRUSH (SCIRPUS MICROCARPUS)
COMMON SPIKE RUSH (ELEOCHARIS MACROSTACCHYA)

Figure 4-6(b). Typical Williams Creek Cross-section with Proposed Riparian Planting Palette.

4.1.5 Floodplain Openings

Though the alternatives include deepening and widening Williams Creek along its full length between Grizzly Bluff Road and the Salt River, the channel capacity is still limited by its depth before it spills onto the overbanks. To reduce the magnitude and frequency of flooding to the west side of Williams Creek and to control the locations where overbank flooding will occur, a series of five broad floodplain openings would be notched into the streambanks along the east side of Williams Creek. The floodplain openings would be located to focus flows down existing swales in the alluvial fan overbank areas, and towards the low flood basin (sump) near the Salt River/Williams Creek confluence. Flows routed to the sump would be routed to either Williams Creek or the Salt River, decreasing the duration and amount of ponding that occurs in this area.

Each of the floodplain openings would be trapezoidal in shape, about 2 to 3 feet deep at the edge of the channel, then shallowing to a minimal depth on the overbank. The channel bottom would have about a 100-foot wide bottom and gentle 10H:1V side slopes. The floodplain openings would be designed so that pasture grass within the openings would remain stable during overflow events. This would allow the floodplain openings to remain as grazeable pasture land and accessible by agricultural equipment.

The elevations of the floodplain openings were designed to start spilling flow near the water surface elevation of a 2-year peak flow event in Williams Creek, and are different for Alternative 1 and 2. The distance that the floodplain opening channel would extend away from the channel would vary, depending on the elevation of ground adjacent to the opening. In general, the channels leading from the floodplain openings to the overbank areas openings would be up to 250 feet long, assuming that the channel slope of the opening is about 0.1%.

The number, location and dimension of floodplain openings may change during final design based on landowner comments, the volume of flow necessary to spill through the openings, and stability of the opening and downstream channel.

It is likely that accumulated sediment may need to be removed occasionally from the upstream end of the floodplain opening. To reduce flow resistance in the opening, which would cause sedimentation, the grasses should be relatively short, with no trees or shrubs.

4.2 Alternative 3: Sediment Basin Upstream Grizzly Bluff Road and Rehabilitated Williams Creek Channel

At the request of stakeholders, siting a sediment basin upstream of Grizzly Bluff Road was investigated. Construction of a sediment basin upstream of Grizzly Bluff Road would still require channel rehabilitation downstream of Grizzly Bluff Road. The channel construction would be similar to what is described for Alternative 2, which would reduce overbank flows to the east and provide flood protection up to a 10-year event along the west side of the channel.

For this alternative, the project team identified the most suitable location for a sediment basin is 1,400 feet upstream of Grizzly Bluff Road, as shown on Figure 4-8. This area was selected because of broadness of the valley and presence of lower floodplain surfaces. Topographic ground survey was not performed in the area. Locating a sediment basin further downstream of this area was not feasible due to several reasons, including more riparian impacts, proximity of ranch buildings, and the two county-maintained bridges that were replaced in recent years.

The valley width is relatively narrow where the Alternative 3 sediment basin is sited. Therefore, the more traditional sediment basin proposed for Alternatives 1 and 2, which would be about 500 feet wide, is not feasible for this location. Instead, a "stepped sediment basin" is proposed, consisting of two flat sediment retention areas, each about 460 feet long and a 150 wide bottom, separated by two 1.8 foot high steps, as shown in Figure 4-7 and Figure 4-8. Additional width would be used to construct maintenance roads around the basin.

A sketch of a stepped sediment basin is shown on Figure 4-7. Stepped sediment basins have been applied in Europe, and are designed specifically to trap coarser sediment and maintain finer materials in transport (Chiari, et al., 2011). The steeper channels between the sediment retention areas also create a water-surface drawdown at the downstream end of each retention area, maintaining transport of finer grained sediment.

The steps in the basin would be constructed as rock chutes with a maximum overall slope of 3% to provide passage for adult and juvenile salmonids. The broad vee-shape of the cross section would concentrate lower flows into the center of the channel, allowing fish passage. As flows increase, the shoulders of the vee-shaped cross section would be submerged, allowing flow to spill across a wider area of the sediment retention area downstream.

The sediment retention areas in stepped sediment basins trap sediment across the width of the step. Sediment deposition occurs in a wedge-shape that progresses from upstream to downstream within the basin, as shown on the profile view of Figure 4-9. Similar to the traditional sediment basins for Alternative 1 and 2, the slope of the sediment deposition is expected to be about 0.35%. The dimensions of a stepped sediment basin are designed so that once a sediment retention area is "full," it forms a channel with a slope matching the upstream and downstream channel profile.

The channel reach through the stepped basin would contain a pilot channel to concentrate lower flows following clean-out to avoid fish stranding. The stepped sediment basin would be constructed by excavating the existing valley bottom to form the steps and sediment retention areas. Where the sediment basin is sited, as shown on Figure 4-8, no topographic survey was performed and the ground elevation was approximated from the 1957 USGS topographic map. If this site is selected as the preferred location, topographic survey of the channel will be required to verify all elevations and dimensions of the sedimentation basin.

Just upstream of the proposed sediment basin location, the stream valley narrows and goes through tight meanders. Just downstream of the proposed sediment basin, ranch buildings are located on the western streambank, limiting the total basin length to about 1,000 feet. It is estimated that the stepped sediment basin for Alternative 3 would be able to provide storage for about 3,500 cy of sediment, which is less than the desired 4,000 cy storage volume.

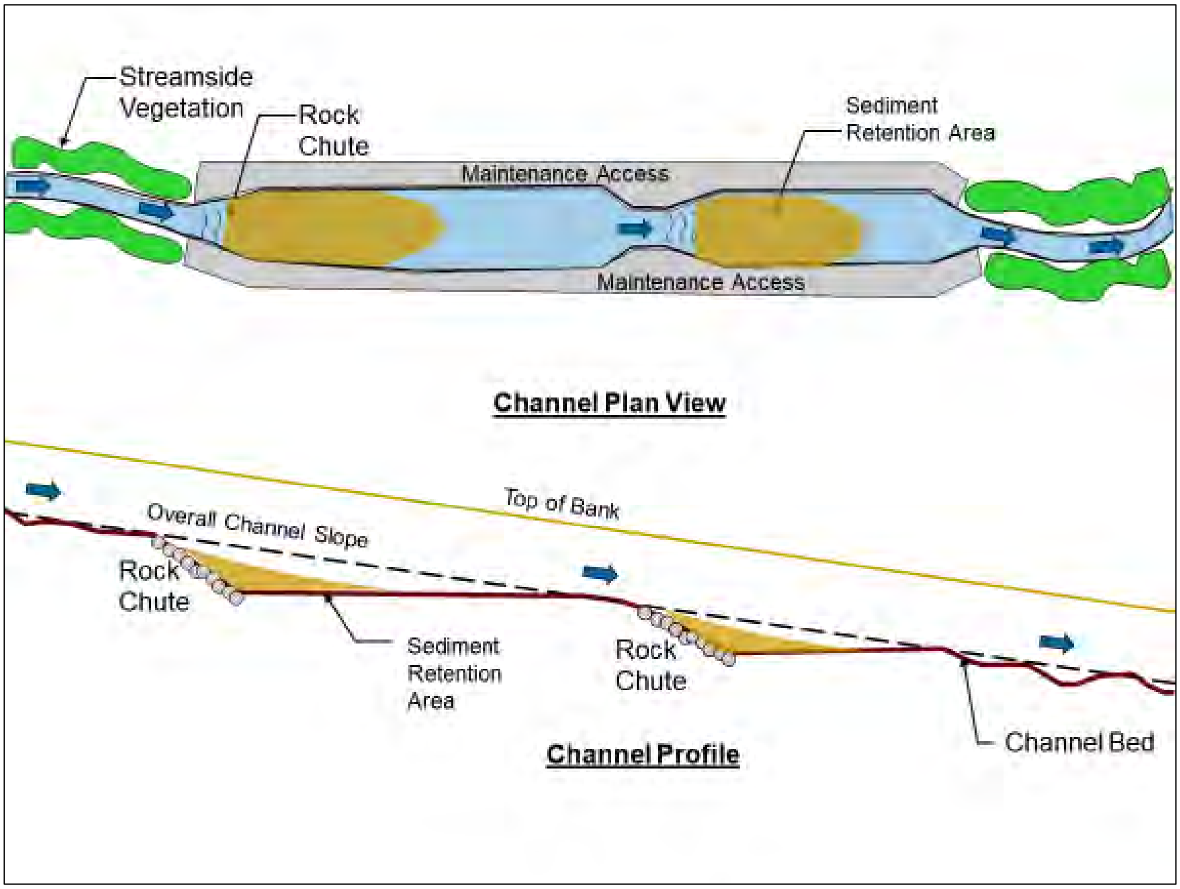
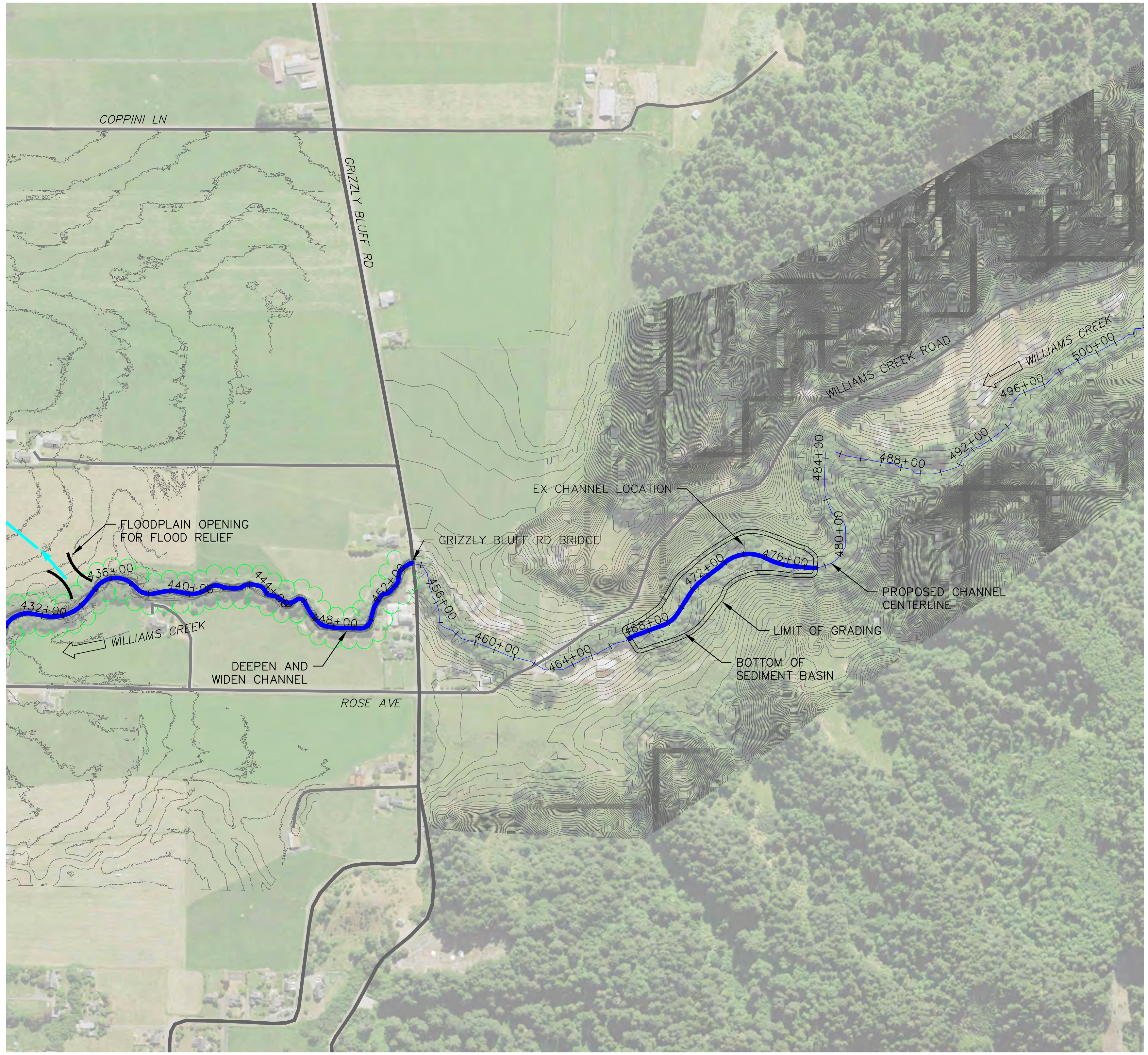


Figure 4-7. Conceptual plan and profile view of a stepped sediment basin.



WILLIAMS CREEK - PLAN VIEW

0 300 600
GRAPHIC SCALE

N

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100 Berding Street Ferndale, CA 95536

GHD

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

HUMBOLDT COUNTY RESOURCE CONSERVATION DISTRICT
WILLIAMS CREEK RESTORATION PLANNING
FERNDALE, CA

ALTERNATIVE 3
UPPER SEDIMENT BASIN

DATE
MARCH 2020

FIGURE
4-8

2/26/2020 Q:\Williams_C_Alternatives\7_CAD-GIS\Civil3D\Sheets\2_WilliamsCr_Alternative 3.dwg

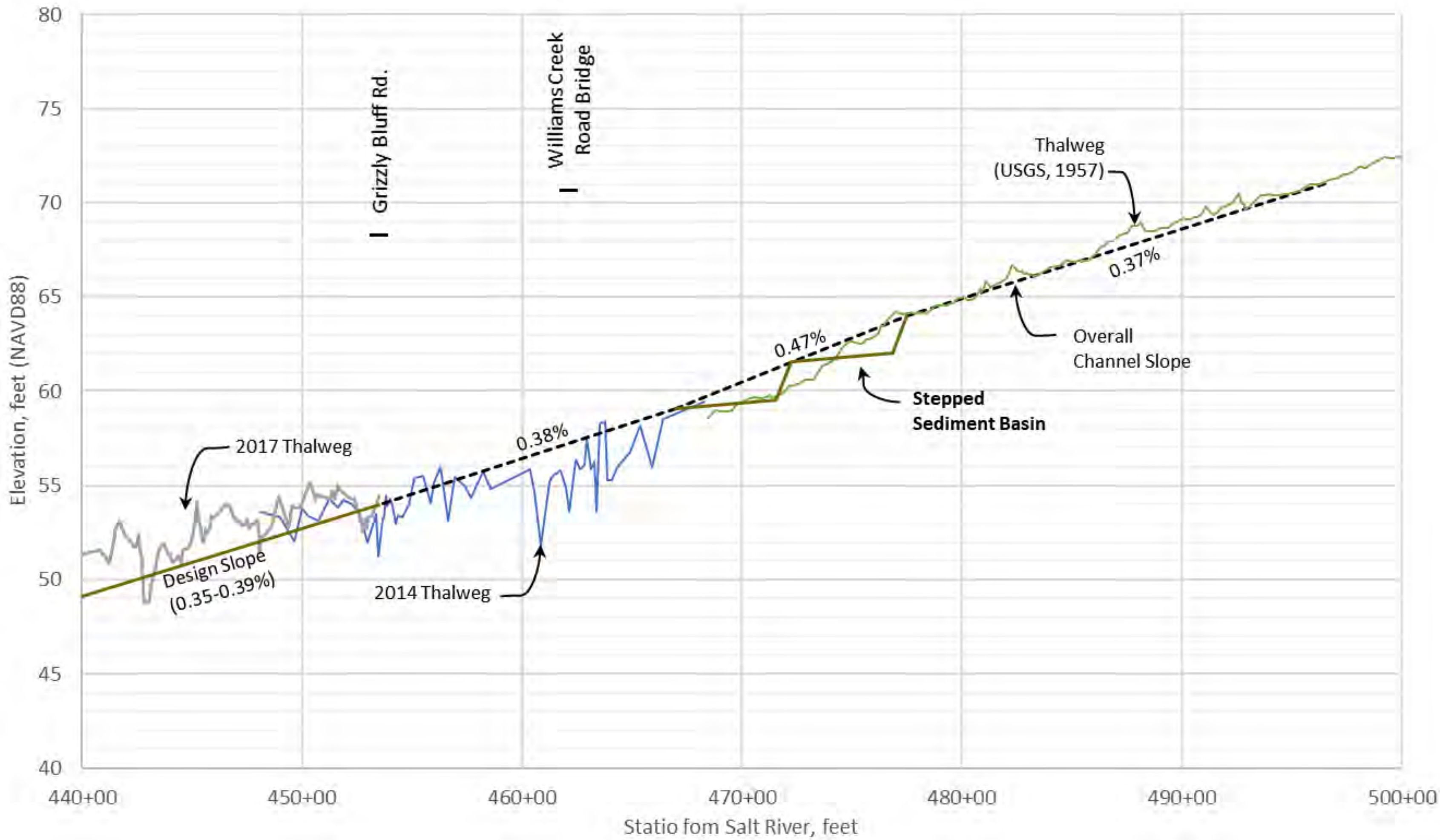

Figure 4-9. Profile view of Alternative 3 stepped sediment basin located upstream of Grizzly Bluff Road.

4.3 Hydraulic Modeling of Alternatives 1 and 2

Two-dimensional hydraulic modeling was performed to evaluate the anticipated performance of Alternatives 1 and 2. Alternative 3 includes channel grading downstream of Grizzly Bluff Road similar to Alternative 2. Therefore, hydraulic results for Alternative 2 can be used to also evaluate Alternative 3.

The specific intent of the model was to:

1. Assess the flow conveyance of the design channel
2. Set the elevations and determine the flow through each floodplain opening
3. Evaluate flow patterns and extents of out-of-bank flows through floodplain openings and other low areas along the channel
4. Assess stability of floodplain openings and along the paths of overbank flows.
5. Evaluate the effects of the Salt River backwater on the performance of the Alternative 1 sediment basin
6. Assess sediment transport competence of the design channel

4.3.1 Model Setup

For each alternative, the existing condition 2-D HEC-RAS model described in Appendix C was updated to include preliminary channel grading, floodplain openings and sediment basin grading. Modeled Manning's channel roughness values were reduced to 0.07 from an existing condition value of 0.09, to reflect the reduction in number of debris jams and overhanging vegetation resulting from the channel excavation and debris clearing. The overbank roughness remained the same as for existing conditions, except at the floodplain openings, where the roughness was modeled using a value of 0.035. All modeling was executed with the downstream boundary condition set at a constant elevation of 30 feet, the approximate elevation of the Salt River 2-year water surface elevation. All other model grid cells and settings remained unchanged from the existing model.

A 2-D model for each alternative was prepared for 2-, 5-, and 10-year flow events.

4.3.2 Model Results

4.3.2.1 Alternative 1

Figure 4-10 and Figure 4-11 show the model predicted maximum flow depths for a 2-year (584 cfs) and 5-year peak flow (971 cfs) on Williams Creek. In-channel and overbank flows are labeled at various locations. Additional modeling results for Alternative 1 are shown in. Table 4-1 compares existing condition and expected overbank flows for both Alternatives 1 and 2.

As shown on Figure 4-10 and Table 4-1, during a 2-year flow event, out-of-bank flows both to the east and west of Williams Creek would be virtually eliminated, compared to existing conditions. The total amount of flow to the west would be reduced by 99%, and flows to the east would be reduced 93%.

Figure 4-11 and Table 4-1 show that during a 5-year flow event out-of-bank flows are primarily spilling to the east through the floodplain openings, rather than as sheet flow along extended portions of the streambanks under existing conditions. Minimal flows are spilling out-of-bank towards Ambrosini Lane. The total amount of flow to the west would be reduced by 95%, and flows to the east would be reduced by 34%.

Model predicted flow depths and out-of-bank flows for a 10-year event for Alternative 1 are shown in Appendix F and Table 4-1. A 93% reduction in out-of-bank flows can be expected to occur to the west, and a 21% reduction in out-of-bank flows to the east.

Model-predicted shear stresses for a 10-year flow event were used to assess the ground and vegetation stability in the floodplain openings. Silt erosion begins to occur at a shear stress of about 0.05 pounds/square foot (Fischenich, 2001). Silt erosion could occur on the Williams Creek overbanks where there is recently tilled ground where a cover crop has not yet established. Short grazed pasture grasses are expected to begin to erode when flow shear stresses are about 0.6 pounds/square foot, and longer, un-grazed pasture grasses would be expected to begin to erode when flow shear stresses are about 1 pounds/square foot (Fischenich, 2001).

Figure 4-12 show the results of model-predicted shear stresses that would occur during a 10-year flow event. Shear stresses are expected to be locally higher within the floodplain openings, compared to existing conditions However, they are not not exceed the stability threshold of 0.06 pounds/square foot for erosion of short grasses. Therefore, it is expected that floodplain openings with good coverage of mature pasture grasses will remain stable.

Downstream of the floodplain openings east of the channel, the reduced overbank flow volumes are expected to result in reduced shear stresses on existing pastures compared to existing conditions. Erosion of fine sediment would still be expected to occur if a cover crop has not become established before winter. It can be concluded that the reduction in frequency of overtopping events reduces the risk of overbank erosion compared to existing conditions.

The results of the hydraulic modeling were assessed to identify if the Salt River 2-year water surface affects the water surface elevation or water surface slope in the Alternative 1 sediment basin. The modeling indicates that the backwater affect does not extend to the sediment basin.

Model-predicted water surface elevations for this alternative are shown on the profile in Figure 4-5 and on the cross sections in Figure 4-6. The model-predicted water surface elevation for Alternative 1 would be higher than Alternative 2. During final design, efforts will be focused on increasing channel capacity sufficient to avoid the need for berms to provide 10-year protection along the west side of Williams Creek.

The results of the hydraulic modeling indicate that, if selected as the preferred alternative for implementation, Alternative 1 would result in substantial reductions in overbank flooding for up to the 10-year flow event. The channel grading and floodplain openings could be refined to eliminate overbank flooding for flow events smaller than a 2-year event, and eliminate western flooding towards Ambrosini Lane and Rose Avenue for up to a 10-year flow event. The modeling also indicates a substantial reducing in the amount of flow conveyed to the east, even during a 10-year flow event. The floodplain openings appear to have sufficient velocity and shear stress to minimize sedimentation within them, while remaining within the acceptable limits for stability with mature pasture grasses.

Table 4-1. Summary overbank flows along Williams Creek for existing conditions and Alternatives 1 and 2 for 2-, 5- and 10-year flow events. The relative amount of flow reduction is shown in parentheses compared to existing conditions. Alternative 3 is expected to have similar overbank flow conditions as Alternative 2.

Flow	Existing Conditions		Alternative 1		Alternative 2	
	West	East	West	East	West	East
2-Year (584 cfs)	~178 cfs	~259 cfs	~2 cfs (99%)	~19 cfs (93%)	0 cfs (100%)	~7 cfs (97%)
5-Year (971 cfs)	~284 cfs	~540 cfs	~13 cfs (95%)	~358 cfs (34%)	~2 cfs (99%)	~308 cfs (43%)
10-Year (1,239 cfs)	~313 cfs	~772 cfs	~23 cfs (93%)	~612 cfs (21%)	~2 cfs (99%)	~566 cfs (27%)

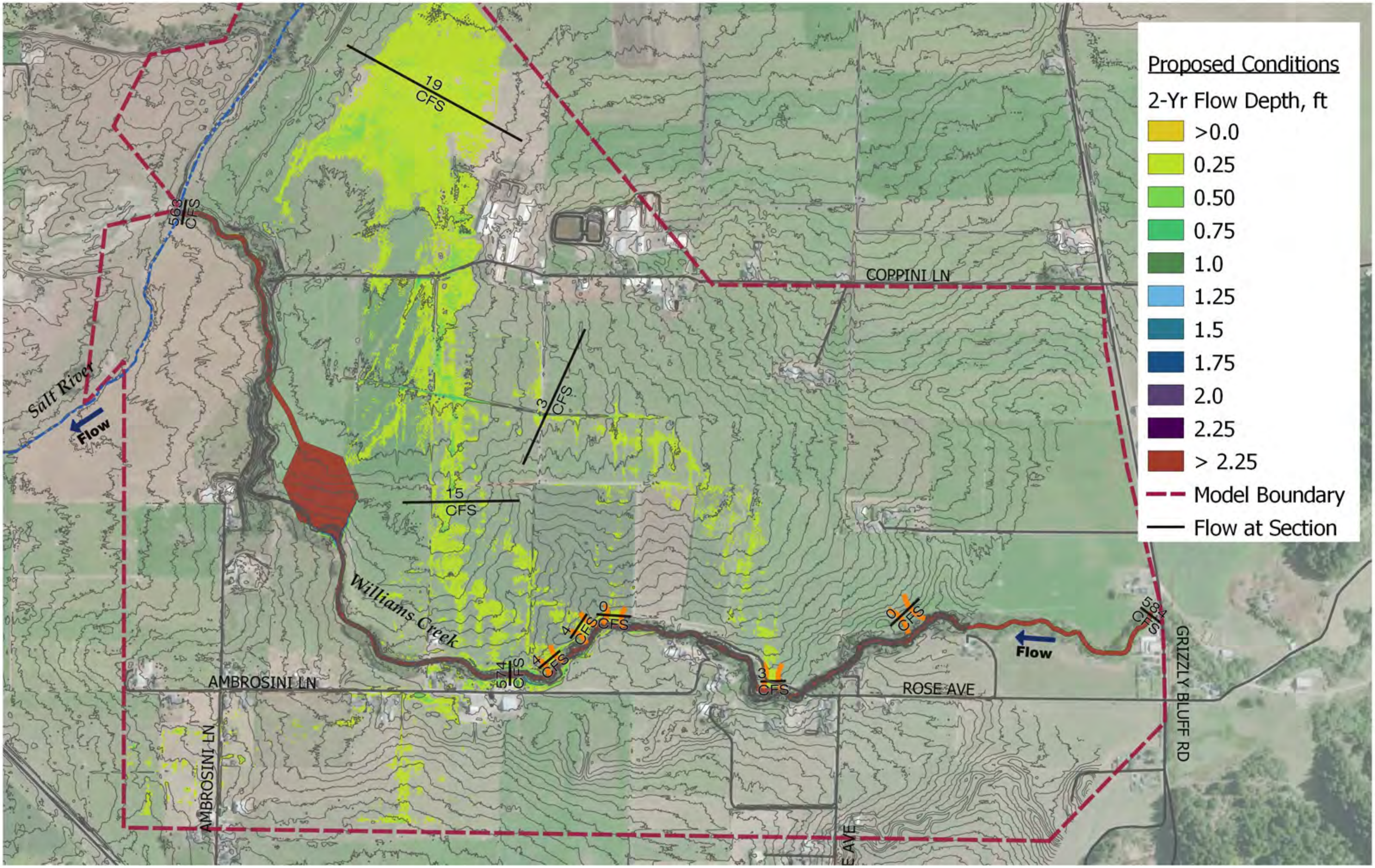

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Figure 4-10
2-D Model Predicted Flow Depths for Alternative 1 During a 2-Year Peak Flow (584 cfs)

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_Depth.qgz

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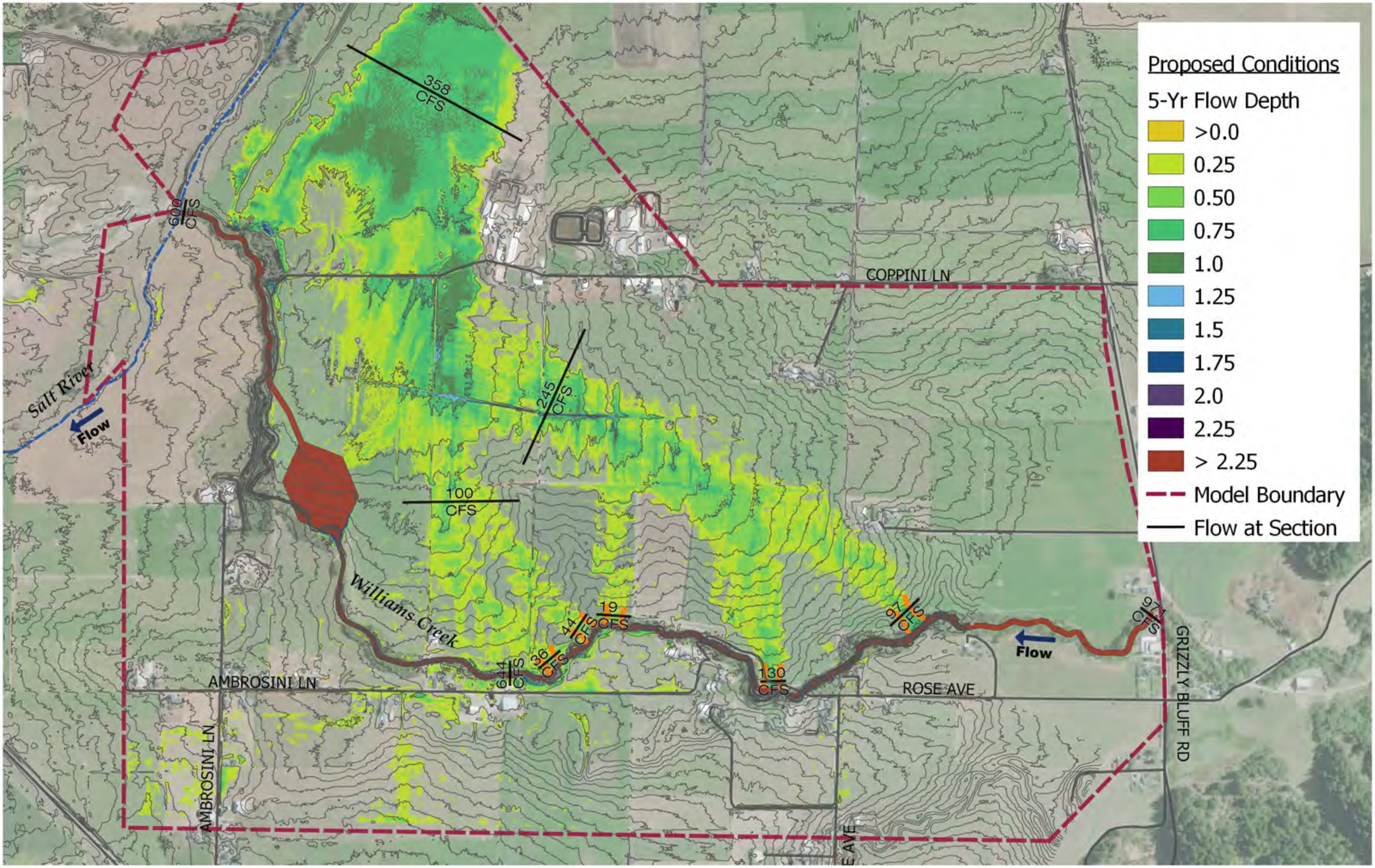

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Figure 4-11
2-D Model Predicted Flow Depths for Alternative 1 During a 5-Year Peak Flow (971 cfs)

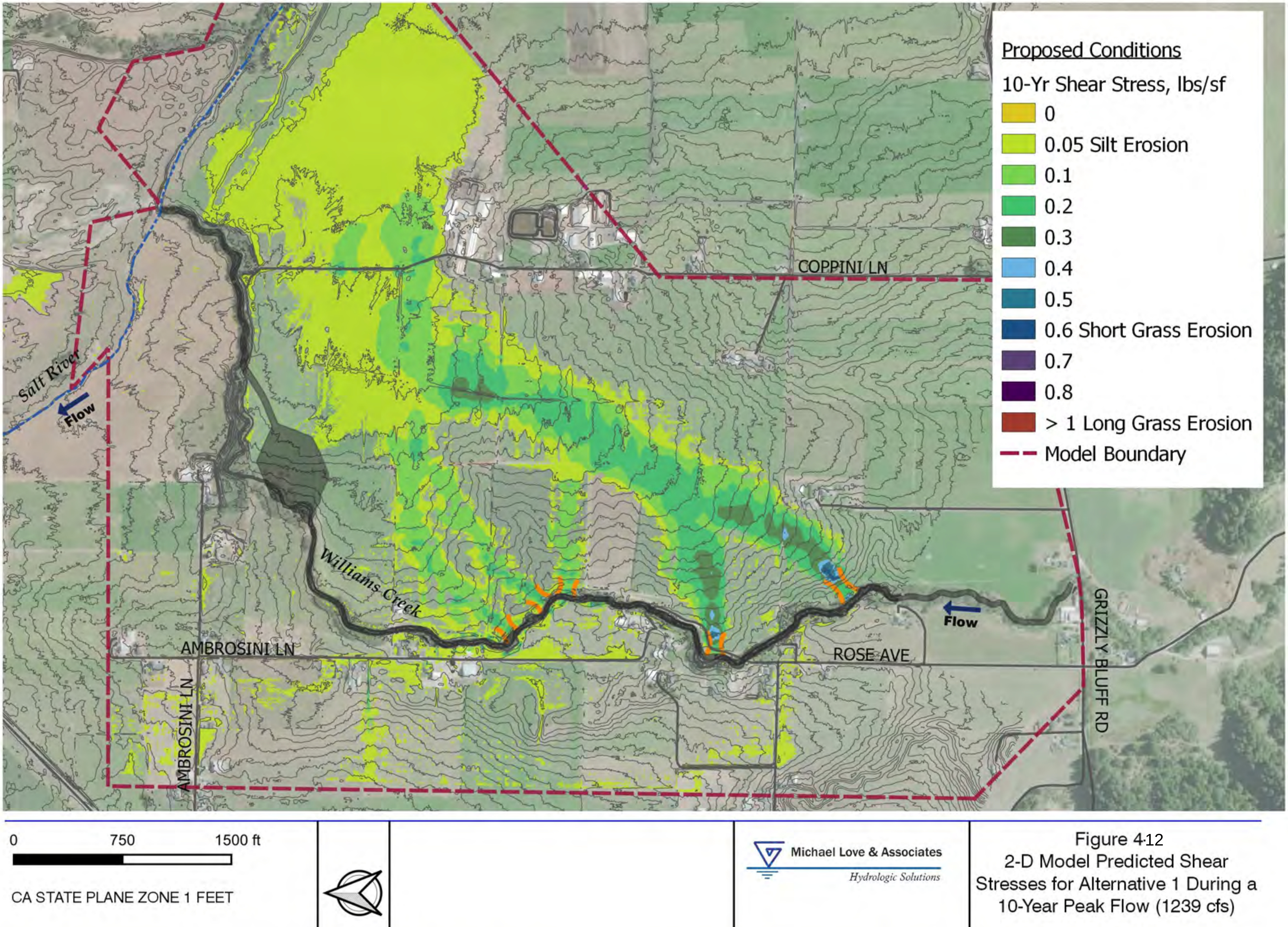

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Figure 4-12
2-D Model Predicted Shear Stresses for Alternative 1 During a 10-Year Peak Flow (1239 cfs)

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_SHEAR.qgz

4.3.2.1 Alternative 2

Figure 4-13 through Figure 4-15 show select model results for Alternative 2. Additional modeling results for Alternative 2 are shown in Appendix F. Table 4-1 compares existing condition and expected overbank flows for both Alternatives 1 and 2.

Figure 4-13 and Figure 4-14 show the model predicted flow depths for a 2-year (584 cfs) and 5-year peak flow (971 cfs) on Williams Creek. In-channel and overbank flows are labeled at various locations. As shown in Figure 4-13, Alternative 2 would effectively eliminate overbank flows to the west (99-100% flow reduction), providing flood protection up to a 10-year event along Rose Avenue and Ambrosini Lane. Flows to the east would be also be reduced from current conditions by 97% for a 2-year event and 27% for a 10-year event.

Figure 4-15 shows the results of the model-predicted shear stresses for a 10-year flow event. Shear stresses are locally higher within the floodplain openings, compared to existing conditions However, they do not exceed the stability threshold of 0.06 pounds/square foot for erosion of short grasses. Therefore, it is expected that the floodplain openings will remain stable with coverage of mature pasture grasses.

Downstream of the floodplain openings, the reduced overbank flow result in lower shear stresses compared to existing conditions. Erosion would still be expected to occur if a cover crop has not become established before winter. The frequency of overtopping events will be reduced compared to existing conditions, and thus the amount of erosion will be reduced compared to existing conditions.

Model-predicted water surface elevations for this alternative are shown on the profile in Figure 4-5 and on the cross sections in Figure 4-6. The model-predicted water surface elevation for Alternative 2 would be lower than Alternative 1 because the channel will be deeper and wider. Generally, the water surface during the 10-year event would be below the base of all the existing berms.

The results of the hydraulic modeling indicate that, if selected as the preferred alternative for implementation, Alternative 2 would result in substantial reductions in overbank flooding for up to the 10-year flow event. Initial modeling indicates that Alternative 2 would result in less overbank flow to the east compared to Alternative 1 because the stream channel would be deeper and have more capacity. During final design, channel grading and floodplain openings could be refined. The modeling also indicates that the erosion potential of pasture grassed in overbank areas would decrease because of the reduction of overbank flows.

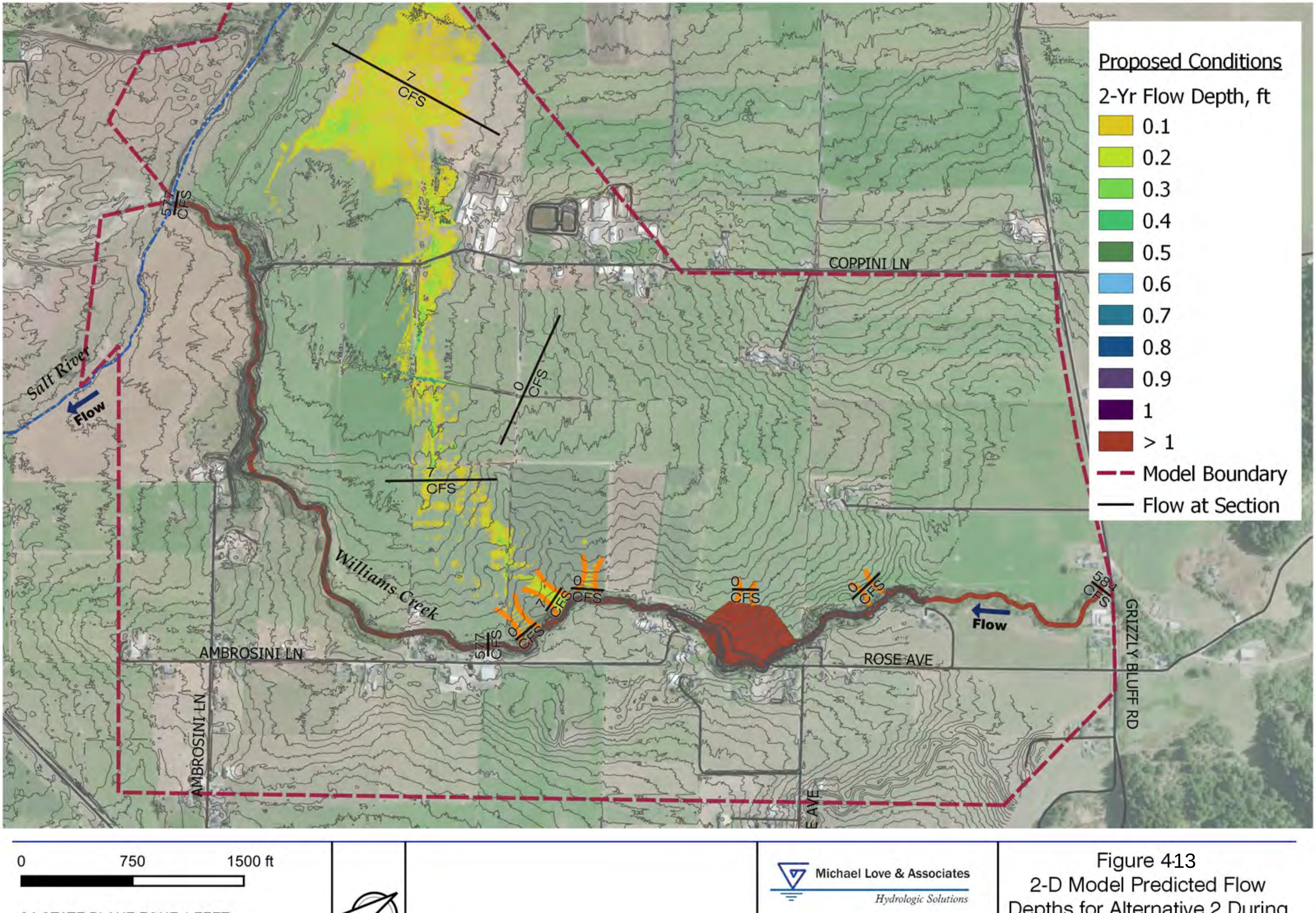

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Figure 4-13
2-D Model Predicted Flow Depths for Alternative 2 During a 2-Year Peak Flow (584 cfs)

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_Depth.qgz

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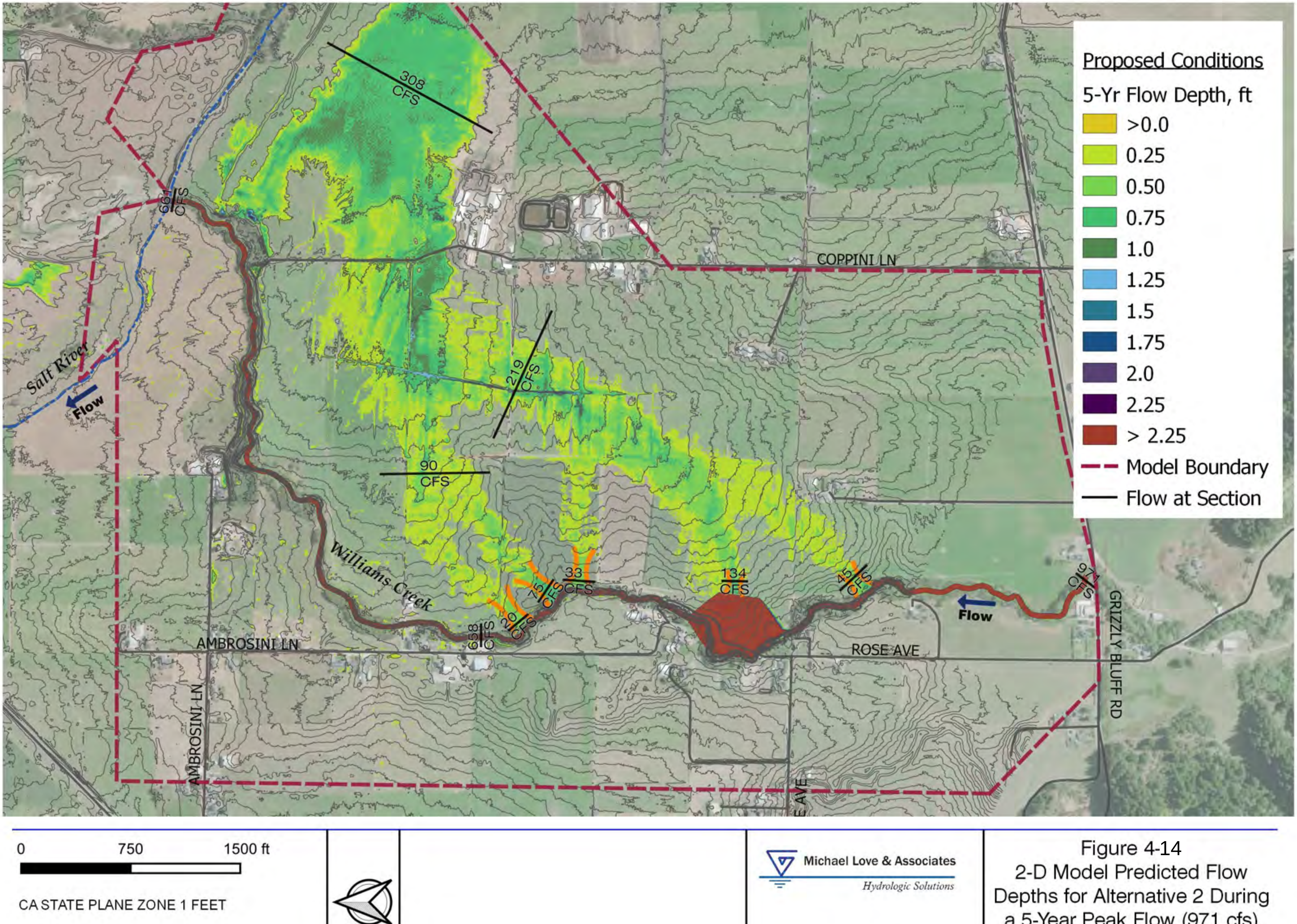

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Figure 4-14
2-D Model Predicted Flow Depths for Alternative 2 During a 5-Year Peak Flow (971 cfs)

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_Depth.qgz

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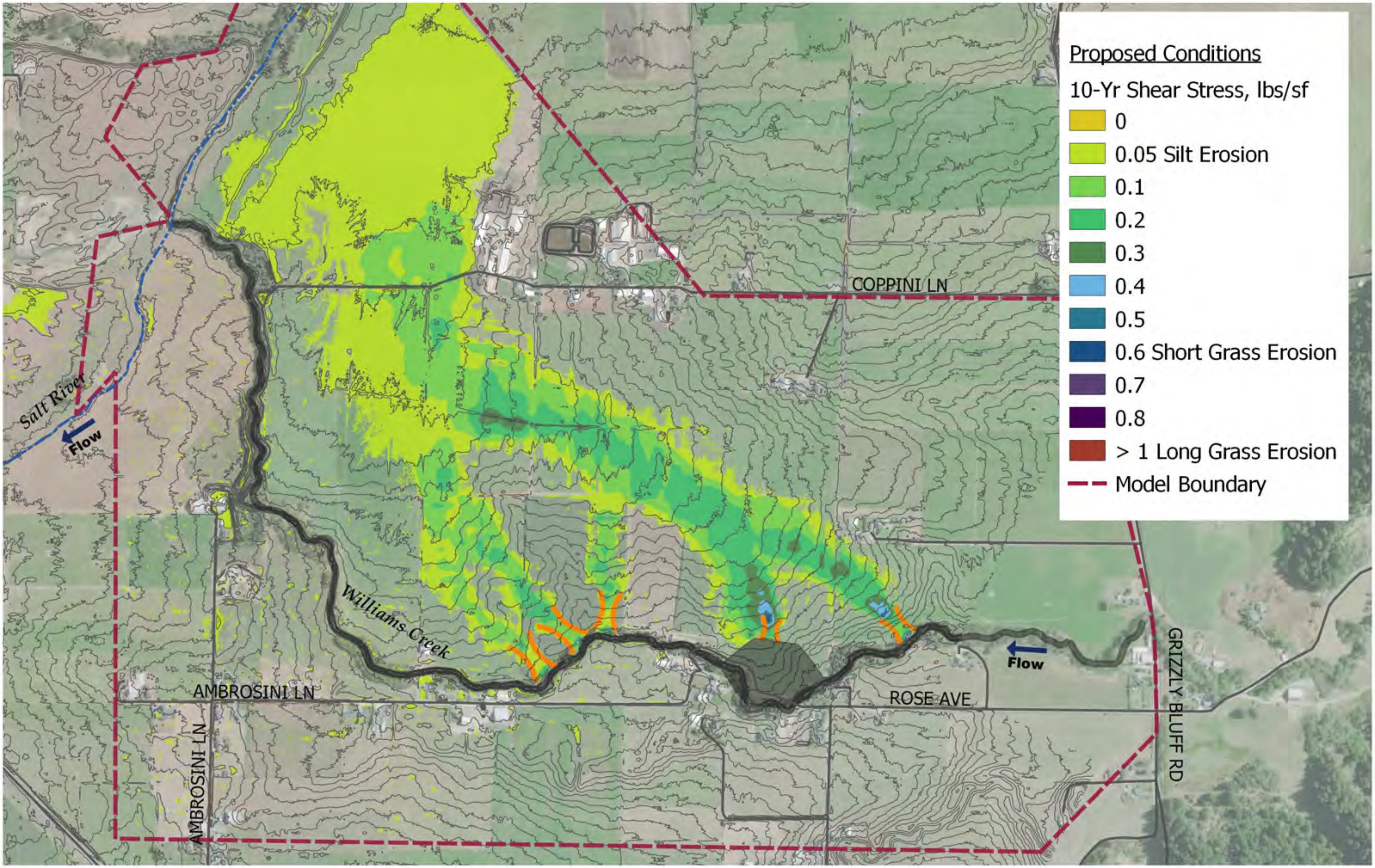

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Figure 4-15
2-D Model Predicted Shear Stresses for Alternative 2 During a 10-Year Peak Flow (1239 cfs)

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_SHEAR.qgz

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4.3.3 Sediment Transport Analysis for Alternative 1

The 1-dimenisonal portion of the HEC -RAS model developed for Alternative 1 was used to assess sediment transport in Williams Creek. Because the excavated channel would be shallower for this alternative, and more flow is spilled to the overbanks, it was assumed that the Alternative 1 modeling would reflect lower transport capacity of the two alternatives. The modeling was also used to preliminarily assess sediment deposition within the sediment basin, though a 2-D model with a bed-evolution component would be more suitable for the complex sedimentation patterns expected to occur in the basin.

Sediment transport modeling was conducted for a constant 722 cfs event lasting 6 hours, using the Laursen/Copeland equations (USACE, 2016c),and the same sediment gradation and model settings used for the existing condition sediment transport analysis (Section 2.10.4). The model focuses on transport of coarse sediment (sand and larger). The bridges were removed from the model, assuming they will be replaced with crossings that do not influence stream hydraulics.

Figure 4-16 shows the model-predicted channel bed elevation compared to the design elevation for Alternative 1 after a constant 722 cfs flow event lasting 6 hours. Though there are a few localized areas of deposition and scour, the channel is predicted to transport the delivered sediment load to the sediment basin, and shows sediment deposition within the basin.

Figure 4-17 shows the model-predicted sediment transport rate along Williams Creek for Alternative 1 for a flow of 722 cfs. Generally, the sediment transport rate for Alternative 1 is substantially increased compared to existing conditions (Figure 2-20). The localized drops in sediment transport rate shown in the figure are coincidental with the localized sediment deposition shown on Figure 4-16. The localized decreased in sediment transport appear to be associated with flow expansions that may be occurring at the floodplain openings.

Figure 4-18 shows model predicted in-channel shear stresses for Alternative 1 during a 722 cfs flow event. Channel shear stress upstream of the sediment basin typically range from 1 to 1.5 pounds per square foot, indicating that the channel would have the capacity to transport particle sizes up very coarse gravels (32 to 64mm) (Julien, 1998). Therefore, it can be concluded that the proposed channel design will have the capacity to transport coarser grains delivered from upstream to the sediment basin.

As shown in Figure 4-17and Figure 4-18, the channel shear stress and sediment transport rate drop substantially within the sediment basin. Average shear stresses within the basin are predicted to be about 0.003 pounds/square foot, indicating that only materials smaller than fine sand (0.125 to 0.25 mm) would be transported through the basin, and all coarser materials would be deposited in the basin. Therefore, it appears that the proposed sediment basin would function as intended.

During final design, more detailed sediment transport modeling will be performed to refine the channel and floodplain opening designs to minimize the amount of sediment deposition within the channel. Additionally, 2-dimensional sediment transport modeling that includes a bed-evolution component will be used to refine the size and shape of the sediment basin and based on the specific location.

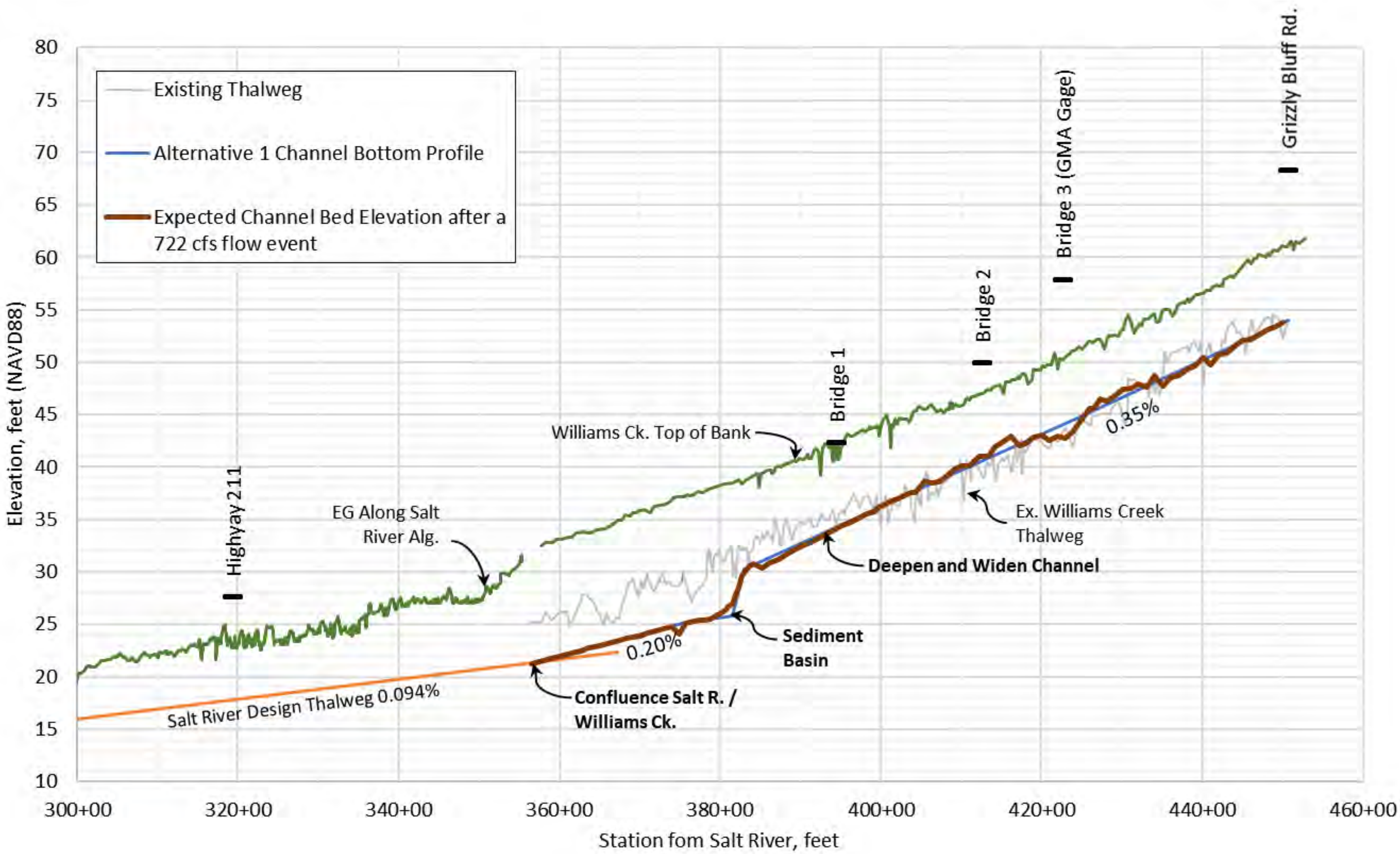


Figure 4-16. HEC-RAS model predicted changes to the Alternative 1 channel bottom profile of Williams Creek after a 722 cfs event lasting 6 hours.

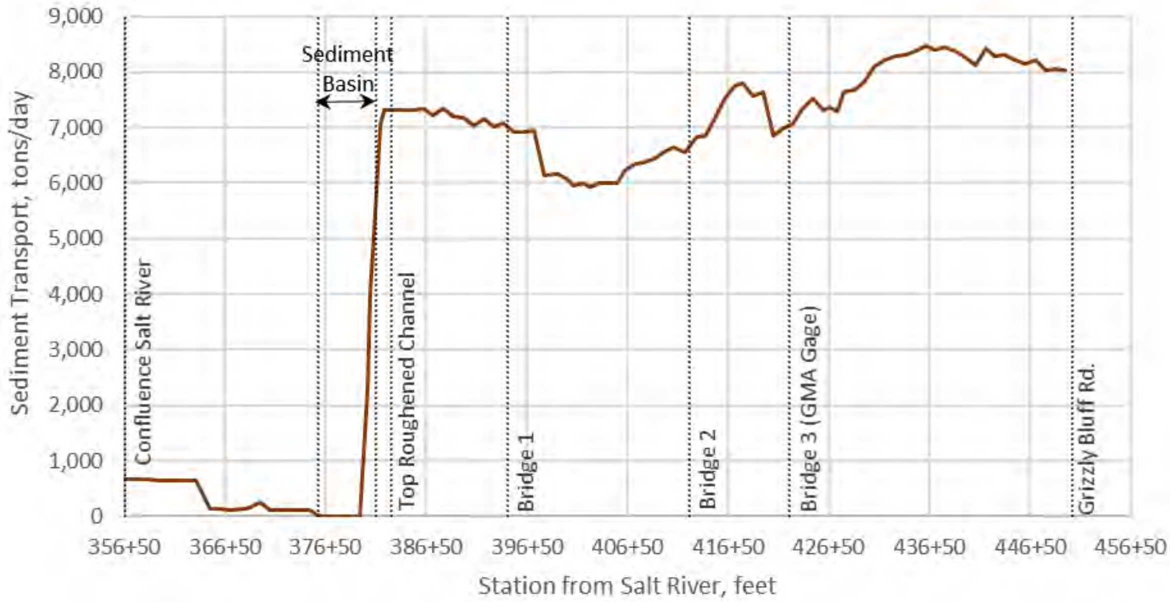


Figure 4-17. HEC-RAS model predicted sediment transport for a 722 cfs flow event along Williams Creek under Alternative 1.

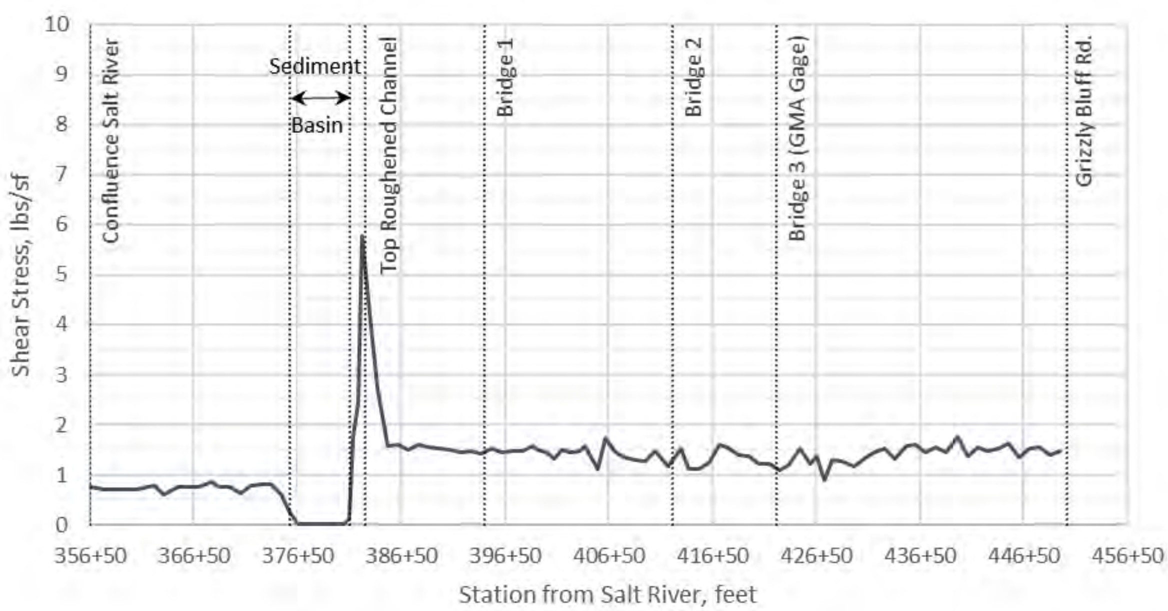


Figure 4-18. HEC-RAS model predicted channel shear stresses for a 722 cfs flow event along Williams Creek under Alternative 1.

5. Opinion of Probable Construction Cost

An opinion of probable construction cost (OPC) was developed and tabulated in Appendix G for the alternatives presented above and can be used for planning and budgeting purposes. The OPC consist of a combination of estimated labor, equipment and materials necessary to implement the alternatives. An estimating contingency was included in the OPC to account for material and construction cost volatility and uncertainties at the time the project is released for bid. OPC unit costs are based on recent bid results of similar projects and the basis of professional experience. Construction costs associated with habitat restoration projects are difficult to estimate given the unique nature of work and lack of applicable industry standard construction estimating resources such as R.S. Means data. Site conditions such as saturated soils and the presence of sensitive species increase construction costs. The risks associated with working in these environments are much higher relative to typical construction projects. Project construction costs are subject to variations in contractor bidding, labor rates, material costs and availability, permitting conditions, site accessibility, general economic pressures and other unforeseen costs associated with a project in the current planning level. Given these potential variations, GHD makes no warranty, express or implied, that actual project costs will not vary from the provided OPC. Construction-related professional services will be required to advance the project designs, implement and oversee construction and should be considered for project budgeting. These services include advance hydraulic/sediment modeling, finalizing the designs, compiling the bid packages(s), bidding assistance, construction management, inspection and monitoring for environmental compliance and long-term monitoring/maintenance. An opinion of only the construction costs have been provided in this report.

6. Environmental Constraints Analysis

The purpose of this regulatory constraints analysis is to synthesize the results of completed reconnaissance-level biological studies, environmental constraints, and anticipated regulatory requirements necessary prior to Project implementation. The regulatory constraints analysis will provide a road map for next steps related to completing permitting and the California Environmental Quality Act (CEQA), with an emphasis on Project-specific considerations. The analysis will also be used to inform design considerations related to potential impacts to wetlands, sediment management, riparian impacts and replanting, dewatering, and site access, among other design features and permitting constraints.

6.1 Baseline Biological Assessments

A California Natural Diversity Database (CNDDB) was conducted to evaluate the potential environmental constraints for botanical and avian species. Results were considered in both the reconnaissance-level survey for avian resources (GHD 2020a) and the rare plant and vegetation community mapping (GHD 2020b), summarized below.

6.1.1 Avian Resources

A reconnaissance-level survey for avian resources was conducted in May 2019 (GHD 2020a). The survey results did not detect any federal or state special status species but noted federally and state listed Western Yellow-billed Cuckoo (*Coccyzus americanus ocidentalis*) has the potential to occur in the Project Area. Survey results further noted state listed Little Willow Flycatcher (Empidonax traillii) was not present at the time of survey, although the survey occurred in advance of the recommended observation window.

Habitat in the Project Area was found to be sub-par for nesting Willow Flycatchers and Western Yellow-billed Cuckoo but may provide temporary shelter and stop-over habitat for migrants. A narrow riparian corridor with a limited understory and shrub layer, combined with heavy cattle grazing, a lack of riparian exclusion fencing in some areas, and the observed presence of Willow Flycatcher nest parasite Brown-headed Cowbird (Molothrus ater) contributed to the determination.

CNDDB results for the Marbled Murrelet (*Brachyramphus marmoratus)* and Northern Spotted Owl *(Strix occidentalis caurina)* were used to evaluate if the species could occur within or juxtaposed to the Project Area. Results indicated the closest known Marbled Murrelet occurrence, and the only one along Bear River ridge, occurred on Mattole Road between Francis and Williams Creeks, approximately 2.5 miles from the Project Area. There is no evidence of use of the Project Area or immediate vicinity by Marbled Murrelets. Based on this lack of evidence and required habitat, there is no likelihood that the species would occur in the Project Area.

Northern Spotted Owls have been documented nearby on private timberlands along Bear River Ridge, south of the Project Area. There are 26 positive detection records and one activity center within a 1 mile radius of the Project Area. However, there are no detections within a half mile radius of the Project Area, which is the typical nest buffer size for Northern Spotted Owls. Additionally, the habitat within the Project Area north of Grizzly Bluff Road is a limited riparian zone, and the immediately surrounding areas are residential and agricultural. South of Grizzly Bluff Road, forested habitat is located along the open fields on either side of Williams Creek. However, there is no nesting, roosting, or foraging habitat for Northern Spotted Owls within the Project Area or immediate vicinity and there is no likelihood that the species would occur in the Project Area (GHD 2020a).

Based on the results of the avian reconnaissance-level investigation, impacts to avian species are not anticipated and formal consultation with the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW) under Section 7 of the Endangered Species Act (ESA) and the California Endangered Species Act (CESA), respectively, is not anticipated. Standard avoidance and minimization measures related to nesting birds, compliance with the Migratory Bird Treat Act, and vegetation clearing would be implemented during construction to further minimize any potential impacts to avian species (see Section 6.9).

6.1.2 Special Status Plants and Vegetation Community Mapping

Special status plant surveys and vegetation community mapping occurred throughout the Project Area in May 2019 (GHD 2020b). Special status plants were not observed. Mapping identified two communities considered Sensitive by CDFW: the arroyo willow shrubland association and the red alder/arroyo willow association. Areas of both communities may be impacted during construction. Two invasive species, Canada thistle (*Cirsium arvense)* and reed canary grass *(Phalaris arundinacea*) were observed near the channel.

6.1.3 Wetlands

A reconnaissance-level upland investigation occurred on December 1, 2017 throughout the portion of the Project Area north of Grizzly Bluff Road (GHD2020c). The purpose of the reconnaissance was to determine presence/absence of wetlands to support future Project planning, specifically for the beneficial reuse of excavated sediments. The investigation evaluated the presence of wetlands along seven transects. Results found sampling locations nearest Williams Creek were predominantly upland but transitioned to wetland with greater distance from the stream channel (GHD 2020c). Results were similar to the National Wetlands Inventory dataset, which classifies the entire Project Area outside the immediate channel as freshwater emergent wetland but does not note a corridor of uplands parallel to the channel alignment.

A second reconnaissance-level wetland investigation occurred on February 4, 2020 in Project Areas south of Grizzly Bluff Road. Seven transects were also completed. Results from the follow-up reconnaissance-level assessment south of Grizzly Bluff Road in the upstream reach of Williams Creek indicated predominantly upland soils across all transects. Three wetland detections occurred nearest the riparian drainage near Williams Creek, with most of the area being uplands.

Wetlands are present in the Project Area and would be impacted by channel improvements and riparian replanting. Placement of sediments via beneficial re-use (see Section 6.3) would be required to avoid an additional loss of wetlands. If wetlands are impacted, a Habitat Mitigation and Monitoring Plan would be required by the regulatory agencies (see Section 6.7.1).

6.1.4 Salmonids

Juvenile Coho Salmon were observed in the Salt River near Highway 211 in January 2020. Fish surveys conducted in June 2018 for the Grizzly Bluff Road bridge replacement detected non-anadromous lamprey and stickleback, but did not detect salmonids. Additional fish sampling in the Salt River near Williams Creek is planned in 2020.

6.2 Conversion of Agricultural Land

The Project Area predominantly consists of farmland designated as prime farmland based on soil classifications in custom soil reports generated by the U.S. Department of Agriculture/Natural Resources Conservation Service (USDA/NRCD 2020a, USDA/NRCS 2020b) and the Humboldt County Web GIS data viewer (Humboldt County 2020). Affected properties are not enrolled in Williamson Act contracts. Soils in the Project Area north of Grizzly Bluff Road are primarily mapped as 110 –Weott and designated as prime farmland.

The Williams Creek channel itself is mapped as 131 – Typic Fluvaquents and is mapped as prime farmland if drained and either protected from flooding or not frequently flooded during the growing season (USDA/NRCS 2020a). South of Grizzly Bluff Road, soils in the upper watershed are mapped as 110 –Weott, designated as prime farmland, and 131 – Typic Fluvaquents, which is mapped as prime farmland if drained (USDA/NRCS 2020b).

Per Section 30241 of Eel River Area Plan Local Coastal Program (LCP) portion of the County General Plan, *the maximum amount of prime agricultural land shall be maintained in agricultural production to assure the protection of the area's agricultural economy...* No division or development of such lands shall be approved which would lower the economic viability of continued agricultural operations (Humboldt County 2007). For property zoned for agricultural use, which includes the Project Area, Humboldt County requires a Conditional Use Permit for any proposed use not directly a part of agriculture production. Under the LCP, other uses considered conditionally compatible with agriculture production include management for watershed, fish, and wildlife habitat (Section 30241 (B) (a) and (b)) (Humboldt County 2007).

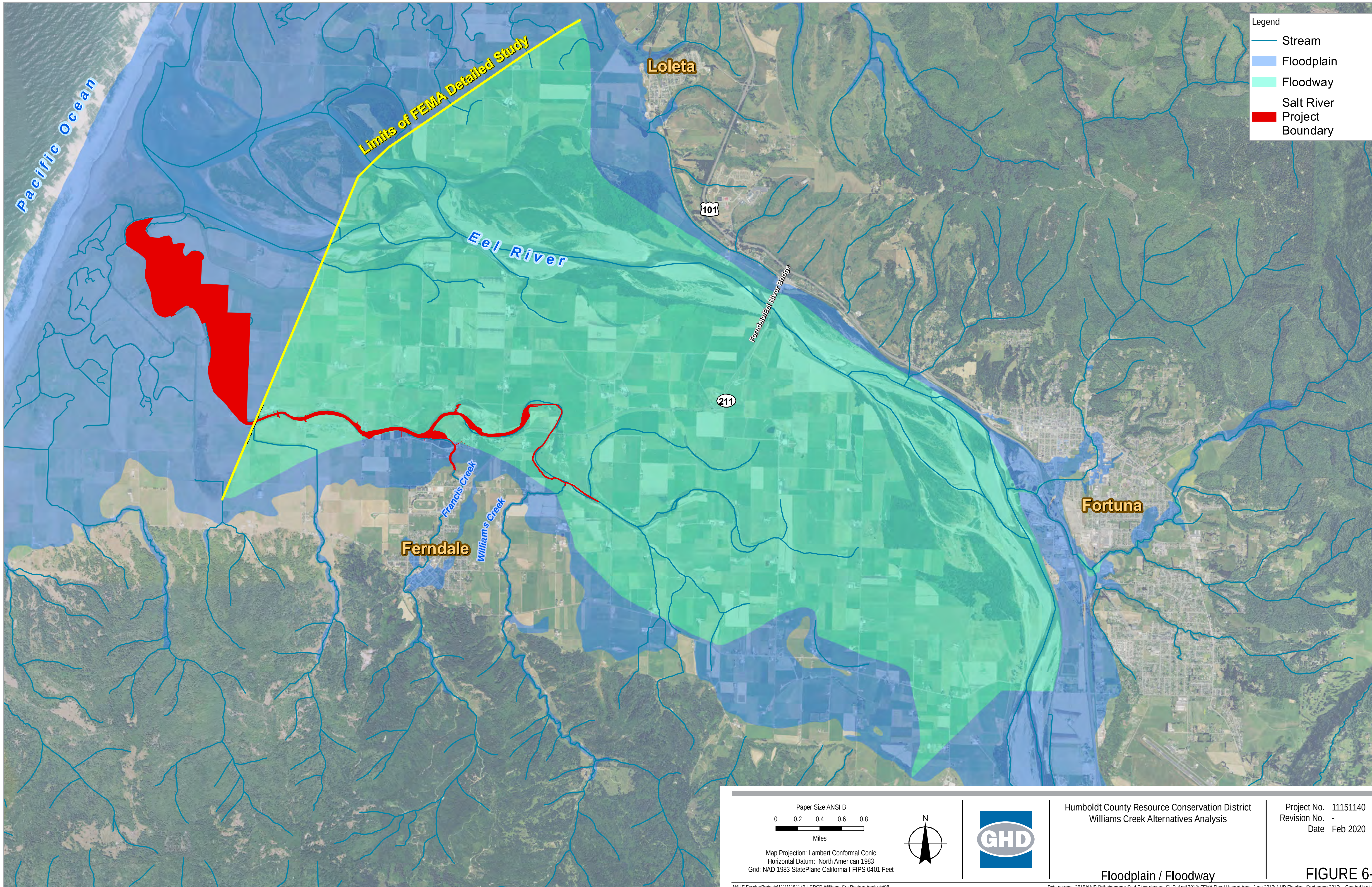
Shifting the restored riparian corridor away from the existing alignment to allow for channel widening could impact prime farmland. The Project would need to justify this reduction in prime farmland by describing improvements to the balance of prime farmland in the Project Area that would occur as a result of the Project, such as improved drainage, decreased soil erosion and related loss of prime agriculture soils, increased productivity, and riparian exclusion fencing. As mapped by the NRCS, soils mapped as 131 - Typic Fluvaquents are only considered prime farmland if drained and protected from flooding or not frequently flooding. Because the Project would be reducing the frequency, duration, and severity of flood-related impacts in these areas, the prime farmland characteristics of soils mapped as 131 – Typic Fluvaquents would benefit (increased production) as a result of the Project.

6.3 Opportunities for Beneficial Re-Use of Sediments

Initial construction would result in the need to re-use approximately 120,000 cubic yards (CY) of sediments. Identifying suitable locations for re-use nearest the Project Area would be less expensive and result in the least amount of environmental impact under CEQA, associated with transportation, greenhouse gas emissions, and air quality. Placement of the initial 120,000 CY would occur outside of the FEMA-regulated Eel River floodway because most of the channel excavation is outside the Eel River floodway (Figure 6-1).

Long-term maintenance would generate approximately 4,000 CY annually for re-use. Placement of long-term maintenance sediments may be placed within the Eel River floodway as they are currently depositing in the floodway; however, further coordination and confirmation from the Humboldt County Floodplain Administrator would be required to confirm feasibility of sediment placement within the floodway for long-term maintenance.

Excavated sediments would be most preferably placed on nearby agricultural uplands. However, availability of uplands is limited in the vicinity. Excavated sediments may also be placed as a thin veneer on existing three-parameter wetlands; however, the placement of a thin veneer would only be allowable if the existing wetlands would remain wetlands after the sediment is spread, thereby avoiding mitigation. This action would require approval by several agencies.



Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

Humboldt County Resource Conservation District
Williams Creek Alternatives Analysis

Project No. 11151140
Revision No. -
Date Feb 2020

Floodplain / Floodway

FIGURE 6-1

N:\US\Eureka\Projects\111\11151140 HCRCD-Williams Crk Restore Analysis\08-GIS\Maps\Deliverables\ReportFeb2020\11151140_006-1_FloodplainFloodway_RevB.mxd
Print date: 20 Feb 2020 - 16:47

Data source: 2016 NAIP Orthoimagery; Sald River phases, GHD, April 2018; FEMA Flood Hazard Area, June 2017; NHD Flowline, September 2017; . Created by: jclark2

6.4 Riparian Constraints and Opportunities

Project implementation would result in removal and replacement of riparian habitat. In most locations, riparian habitat would be removed from one bank or the other; removal of existing riparian habitat from both banks would be limited. Based on vegetation community mapping (see Section 6.1.2 above) and assuming only half of mapped riparian habitat would be impacted, it is estimated that approximately 15 acres of existing riparian habitat may be removed to accommodate channel widening. Note this value is used for planning purposes only and would be refined during the design development process. Impacts to riparian habitat would be mitigated at a ratio of no less than one to one under the Habitat Mitigation and Monitoring Plan (see Section 6.7.1).

Due to anticipated channel widening, the replanted riparian buffer would be replanted at variable widths, balancing agricultural impacts and floodplain grading, no less than current conditions. Existing riparian habitat is patchy of poor quality (GHD 2019b). Through restoration and replanting, species diversity and overall riparian function would be significantly enhanced. Where absent, wildlife-friendly cattle exclusion fencing would be installed.

6.5 Coastal Zone Implications

The entire Project Area north of Grizzly Bluff Road is located within the Coastal Zone (GHD 202b), with most of the area being in primary permitting jurisdiction of the county. Williams Creek and the immediate area on either side of the channel corridor falls within the Appeal jurisdiction. The balance of the Project Area is located within Local jurisdiction and thus under the purview of the Eel River Area Local Coastal Plan (LCP). The State jurisdiction was verified by a boundary determination from the California Coastal Commission and extends along the Salt River corridor includes the William Creek confluence with the Salt River and is covered under the existing Salt River Project Coastal Development Permit (CDP). Project activities are not expected to include areas within the State's jurisdiction of the Coastal Zone (California Coastal Commission). As such, the Project would seek coverage under the Coastal Act through a CDP application to the County of Humboldt. Pre-project coordination and concurrence with the California Coastal Commission to minimize the risk of a potential State appeal to a CDP issued by the County of Humboldt is recommended.

Locations for beneficial sediment re-use have not yet been identified. Near the Project Area, State jurisdiction is generally limited to the Salt River corridor where placement of excavated sediments would be unlikely. Placement of beneficial re-use sediments within an area under State jurisdiction would have the potential to instead require a CDP authorized by California Coastal Commission, and therefore should be avoided during the planning process to remain consistent with the balance of the Project footprint, which is outside the State jurisdictional boundary.

6.6 Permitting and CEQA Approach

Based on the available data and surveys, this section describes the anticipated required regulatory approvals. An agency meeting was held on February 3, 2020 to introduce the Project to regulatory agencies and confirm CEQA and permitting pathways. Regulatory agencies in attendance included the North Coast Regional Water Quality Control Board (Regional Board), Humboldt County

Planning Department, California Department of Fish and Wildlife, U.S. Army Corps of Engineers, California Coastal Commission, and NOAA Fisheries. Initial feedback from regulatory agencies during the meeting indicated the proposed CEQA and permitting pathways were acceptable.

6.6.1 Development of a Project Description

A Project Description describing all Project elements and related activities would need to be prepared and submitted along with the permit applications. The Project Description would also serve as the basis for impact assessment under CEQA (see Section 6.6.5). The Project Description should include a summary of the Project's goals and objectives, assessor's parcel numbers and associated zoning, descriptions of all Project elements including access, staging, dewatering, relocation of aquatic species, installation of erosion control protection measures, site preparation (clearing, grading, and vegetation removal, excavation and fill, revegetation, and site closure. Additional details in the Project Description should include equipment to be used, anticipated construction schedule and duration, hours and days of construction, hauling and traffic control, and a spoiling plan (approximate quantity and location). The Project Description will also include a description of long-term monitoring and maintenance and the role of the Monitoring and Adaptive Management Plan.

6.6.2 Permitting Pathways

Project activities would require coverage under Section 401 and Section 404 of the Clean Water Act, administered by the North Coast Regional Water Quality Control Board (Regional Board) and U.S. Army Corps of Engineers (USACE), respectively. Additionally, the Project would require coverage under Section 7 of the Endangered Species Act (ESA), the Coastal Act, the California Department of Fish and Wildlife's fish and game code, and the California Endangered Species Act (CESA). Recommended permitting pathways are summarized below in Table 6.1.

Table 6.1 Permitting Pathway Summary

Agency	Approval/Permit
US Army Corps of Engineers	CWA Section 404 Permit
ESA Section 7 USFWS and NMFS	Concurrence Letter or BA/BO
NHPA Section 106	Submission of cultural resources investigation documenting impacts to cultural resource would not occur
Regional Board	Clean Water Act Section 401 Water Quality Certification SWPPP or Water Pollution Control Plan
California Department of Fish and Wildlife	Section 1602 Streambed Alteration Agreement CESA Compliance
Humboldt County	CDP and Use Permits
Humboldt County	Grading Permit (issued prior to construction with final plans)

6.6.3 ESA Requirements

Since this Project would require a federal 404 permit from the USACE, the USACE would need to evaluate Project impacts to all federally-listed species in the Project Area. Impacts would be analyzed and evaluated pursuant to Section 7 of the ESA, in consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS). Due to lack of surface water connectivity with the Salt River, anadromy in Williams Creek is very limited. However, once Williams Creek is restored and re-connected to the Salt River, anadromous habitat is expected and annual sediment management would have the potential to impact anadromous species. Thus, formal consultation with NMFS would be required. Pre-Project coordination with the USFWS is recommended to determine anticipated consultation requirements for avian species; however, the requirement for consultation is not anticipated.

6.6.4 CESA Requirements

Federally-listed salmonids are also listed under CESA. CDFW typically reviews Projects for CESA compliance concurrent with permitting review. Potential CESA pathways include a consistency determination, Safe Harbor Agreement, Incidental Take Permit (ITP), or a Memorandum of Understanding (MOU), with the RCD as the applicant. A Safe Harbor Agreement was recently issued by CDFW for a Project in the Eel River estuary that had similar temporal and construction impacts to salmonids along with long-term benefits from habitat restoration. In order to avoid a large fee, a Safe Harbor Agreement or an MOU would be recommended for this Project as the preferred CESA pathway and should be discussed further with CDFW during the permit scoping process.

6.6.5 CEQA Approach

Given the Project disturbance area would be larger than 5 acres, a Class 33 Categorical Exemption for Small Habitat Restoration Projects would not be applicable. The recommended CEQA pathway is an Initial Study/Mitigated Negative Declaration (IS/MND). The IS/MND would evaluate potential impacts as established in the CEQA Appendix H checklist and, where necessary, propose mitigation measures to ensure all Project activities and long-term maintenance would ultimately result in impacts that would be less than significant. The RCD would be the lead agency under CEQA.

6.7 Remaining Special Studies and Supporting Documents

6.7.1 Monitoring and Adaptive Management Plan

A Habitat Mitigation and Monitoring Plan (HMMP) would be required by permitting agencies as a result of impacts that may occur to sensitive vegetation communities (riparian) and wetlands. The HMMP would detail methods for establishing new riparian and wetland habitats, associated performance criteria, monitoring methodology and timing, reporting, and related information. Most typically, monitoring is required for a period up to five years following implementation.

While the Project requires an HMMP for regulatory purposes, long-term maintenance requires an adaptive management plan (AMP). Two separate documents were developed for the Salt River

Project to satisfy both HMMP requirements and long-term AMP maintenance needs. However, for the Williams Creek Project, a combined document (**Monitoring and Adaptive Management Plan**) is instead proposed. Long-term, annual sediment maintenance would occur following initial construction. Sediment would be removed annually from a sediment management basin. Sediment may also be removed from the channel corridor. The Monitoring and Adaptive Management Plan would detail the monitoring and adaptive management activities of sediment removal from sediment basins and the channel, including planned volumes, removal techniques, designated areas for relocation, and a schedule for maintenance. The plan would detail physical and biological monitoring, triggers and resulting management actions, and long-term sediment management.

Activities described under the Monitoring and Adaptive Management Plan would be included in the initial Project activities and the long-term monitoring and anticipated maintenance activities assessed in CEQA and permit applications. Permits are typically valid for a period of five years, after which renewals may be required to support ongoing maintenance and adaptive management.

6.7.2 Cultural Resources Investigation

A Cultural Resources Investigation will be necessary to submit with the USACE 404 permit application and will include outreach to local tribal representatives. The investigation would also be used as a basis for impact assessment to cultural resources in the CEQA IS/MND.

6.7.3 Quantification of Wetland Impacts

Permanent and temporary wetland fill resulting from construction activities would be minimized. Final wetland fill quantities, if any, would be determined upon finalization of the 30% Project designs. The area of wetland impacts will be quantified based on dimensions of the access roads to the sediment basins, agricultural access lanes, and other design features that may result in wetland fill. Wetland mitigation would occur on-site at a ratio of no less than one to one. Following this approach, a formal wetland delineation of existing conditions may not be necessary in the specific disturbance areas where permanent fill is proposed.

6.8 Water Management and Diversion

During initial construction and prior to channel excavation, the Williams Creek channel will be dewatered in phases across discrete reaches within the established in-water work window (typically June 15 through October 31). Prior to dewatering each reach, aquatic species will be relocated to suitable habitat in upstream reaches of Williams Creek above the Project Area or previously dewatered reaches pursuant to NMFS and CDFW requirements. Block nets will be installed to prevent aquatic species from re-entering dewatered habitat.

During dewatering, William Creek will be diverted downstream around the individual dewatered reach and into the channel immediately downstream to maintain baseflow. Dewatering will also occur pursuant to NMFS and CDFW requirements and any additional provisions established in the Biological Opinion and CESA document.

Following initial construction, dewatering would be required in the sediment management area during maintenance activities within the in-water work window. The sediment management area would be isolated prior to aquatic species relocation and subsequent dewatering. Under the adaptive management plan, sediment management within the Williams Creek channel (beyond the limits of the sediment management area) may also occur and require dewatering. All dewatering related to sediment management would be similar to channel dewatering during initial construction and would be limited to discrete reaches and adhere to NMFS and CDFW requirements.

6.9 Vegetation Removal

To minimize potential impacts to birds, riparian vegetation could be removed prior to March 15 or after August 15. Vegetation removal would include mowing, weed eating riparian scrub, and tree falling. Removal of large woody material within the active stream channel requiring heavy equipment would occur coincident with construction during the in-water work period, after March 15. If vegetation removal or ground disturbance cannot be confined to work outside of the nesting season, a qualified ornithologist would conduct pre-construction surveys within the vicinity of the Project Area, to check for nesting activity of native birds and to evaluate the site for presence of raptors and special-status bird species. The ornithologist would conduct a minimum of one day pre-construction survey within the 7-day period prior to vegetation removal and ground-disturbing activities. If ground disturbance and vegetation removal work lapses for seven days or longer during the breeding season, a qualified biologist would conduct a supplemental avian pre-construction survey before Project work is reinitiated.

If active nests were detected within the construction footprint or within the construction buffer established by the Project biologist, the biologist would flag a buffer around each nest. Construction activities would avoid nest sites until the biologist determines that the young have fledged or nesting activity has ceased. If nests are documented outside of the construction (disturbance) footprint, but within construction buffer, nest buffers would be implemented as needed. In general, the buffer size for common species would be determined on a case-by-case basis in consultation with the California Department of Fish and Wildlife (CDFW). Buffer sizes would take into account factors such as (1) noise and human disturbance levels at the construction site at the time of the survey and the noise and disturbance expected during the construction activity; (2) distance and amount of vegetation or other screening between the construction site and the nest; and (3) sensitivity of individual nesting species and behaviors of the nesting birds.

7. Next Steps

7.1 Selection of Preferred Alternative

This report will be provided to the landowners, stakeholders, and agencies for review, comment and selection of an alternative to reduce sedimentation and flooding along Williams Creek. As indicated in Chapter 3, this study found that the only feasible approach for the project area is active sediment management within Williams Creek, which would require trapping sediment in a discrete location, such as a sediment basin, and routine mechanical removal of the deposited sediment.

7.2 Established Lead for Long-term Monitoring and Adaptive Management

Sediment basins require on-going maintenance in perpetuity. Additionally, the reaches of rehabilitated stream channel will require maintenance until the planted riparian area become mature enough to shade out the alders, willows, and low brush that are presently forming in-channel debris jams. Even after the riparian corridor has matured, limited maintenance of large wood within the channel may be required.

Necessary maintenance activities, maintenance responsibilities, and funding sources should be established prior to construction of the project to ensure long-term viability of the project. It is recommended that before final design begins on a preferred alternative, detailed project planning should be conducted. The detailed planning should culminate in development of a long-term monitoring and adaptive management plan. Additionally, a framework must be developed with interested parties to establish roles and responsibilities, and possible funding mechanisms for conducting the ongoing monitoring and adaptive management activities and associated reporting requirements. The entity could be an individual landowner, a commercial entity, a formalized community group or a non-profit organization such as the Salt River Watershed Council, which was formed upon request from the landowners to oversee long-term monitoring and adaptive management for the Salt River Ecosystem Restoration Project. This entity would be responsible to identify funding sources for maintenance, potential commercial sale of the sediment for beneficial reuse, or establishment of a community drainage fees that would fund the maintenance. This entity with support from appropriate qualified professionals, would work with the community to implement the long-term monitoring and adaptive management plan.

As previously described, specific activities necessary for the monitoring and maintenance of the sediment basin and stream channel must also be identified and formalized in the monitoring and adaptive management plan for approval by regulatory agencies. These activities would include but not be limited to maintenance of access roads to the basin, cleaning out the basins as much as once per year, clearing large debris jams from the channel that could compromise the project, and maintenance of riparian revegetation effort.

7.3 Design Development

Once a preferred alternative is selected and detailed project planning is complete, funding should be obtained to complete the final design for the project. This report is a planning-level study. Additional studies and analyses will be necessary to fully assess and design a project that meets project objectives. The following sections detail these additional studies.

7.3.1 Field-Run Topography

This report was prepared using limited field-run topographic survey and LiDAR generated topography. To allow more accurate project layout, more detailed hydraulic analyses, and to prepare construction drawings, a field-run topographic survey would be necessary along the alignment of the preferred alternative.

7.3.2 Hydraulic Modeling

Additional hydraulic modeling will be necessary to refine the design and to evaluate design changes requested by the stakeholders.

Additionally, more detailed 2-dimensional (2-D) hydraulic modeling will be necessary to establish the final shape and dimensions of a sediment basin. The 2-D model should include a sediment transport analysis using a bed evolution model, that would better simulate the two-dimensional sediment transport and depositional processes that occur in a sediment basin. The modeling would also be used to optimize the design of the sediment basin so it traps larger grain sizes and allows finer grain sizes to pass downstream. The 2-D model would also be useful to better understand the long-term performance of a sediment basin and for use in development of a maintenance plan.

7.3.3 Design Plan Preparation

Upon completion of the additional studies discussed above, design plans for construction of the project should be produced. Design plans are typically developed at progressing levels of detail, including 30%, 65%, 90%, and final (100%) design. This progressing level of detail provides opportunities for review coordination with landowners and agencies so that the constructed project is acceptable to all.

7.4 Environmental Compliance

The following are recommended next steps to further clarify regulatory pathways and/or environmental constraints:

- Coordination with the Humboldt County Floodplain Administrator to determine if annual beneficial re-use of sediment from maintenance can be placed within the Eel River FEMA regulatory floodway;
- Coordination with the Humboldt County Planning Department to confirm sediment disposal via a thin veneer placement on existing wetlands will be allowable;

- Coordination with the Regional Water Board to determine if a SWPPP or alternate stormwater construction plan would be required for construction;
- Coordination with CDFW to determine the preferred CESA pathway (e.g. MOU vs Safe Harbor Agreement); and
- Coordination with USFWS to confirm consultation would not be required for avian species.

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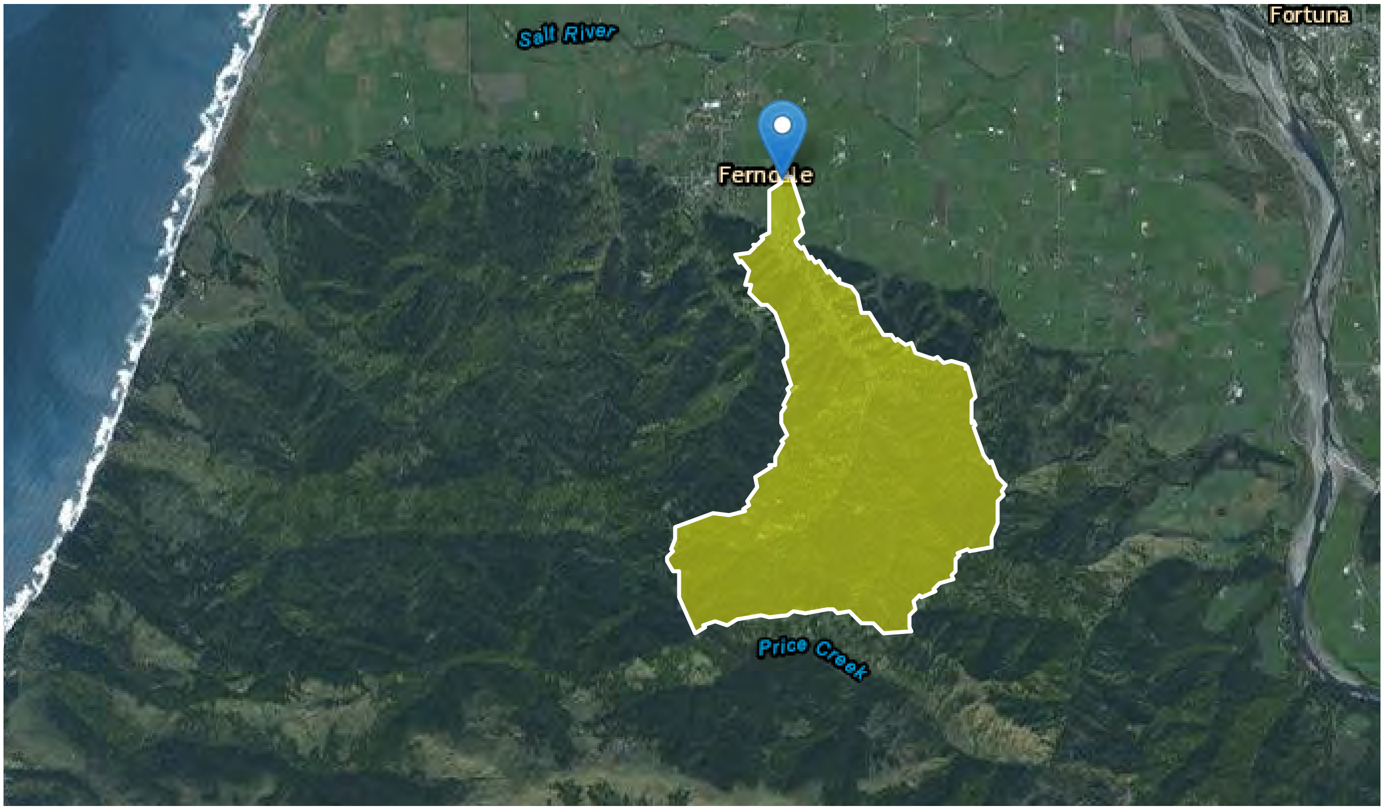
Appendices

Appendix A
Hydrology

Williams Creek at Bridge 3

StreamStats Report

Region ID:
CA
Workspace ID:
CA20170721192620462000
Clicked Point (Latitude, Longitude):
40.57770, -124.24996
Time:
2017-07-21 16:27:02 -0700



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	6	square miles
PRECIP	Mean Annual Precipitation	50.7	inches
BASINPERIM	Perimeter of the drainage basin as defined in SIR 2004-5262	16.7	
BSLDEM30M	Mean basin slope computed from 30 m DEM	33	percent
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	-2336895.4	

Parameter Code	Parameter Description	Value	Unit
CENTROIDY	Basin centroid vertical (y) location in state plane units	2297341.8	
EL6000	Percent of area above 6000 ft	0	percent
ELEV	Mean Basin Elevation	660	feet
ELEVMAX	Maximum basin elevation	1757	feet
FOREST	Percentage of area covered by forest	67.4	percent
JANMAXTMP	Mean Maximum January Temperature	54.39	degrees F
JANMINTMP	Mean Minimum January Temperature	38.73	degrees F
LAKEAREA	Percentage of Lakes and Ponds	0	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	2.4	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.1	percent
LFPLENGTH	Length of longest flow path	6	miles
MINBELEV	Minimum basin elevation	39	feet
OUTLETELEV	Elevation of the stream outlet in thousands of feet above NAVD88.	39	feet
RELIEF	Maximum - minimum elevation	1718	feet
RELRELF	Basin relief divided by basin perimeter	103	feet per mi

Peak-Flow Statistics Parameters [100 Percent (6.03 square miles) 2012 5113 Region 1 North Coast]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	6	square miles	0.04	3200
PRECIP	Mean Annual Precipitation	50.7	inches	20	125

Peak-Flow Statistics Flow Report [100 Percent (6.03 square miles) 2012 5113 Region 1 North Coast]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SEp
2 Year Peak Flood	436	ft^3/s	179	1060	58.6

Statistic	Value	Unit	PIl	PIu	SEp
5 Year Peak Flood	823	ft^3/s	394	1720	47.4
10 Year Peak Flood	1100	ft^3/s	547	2220	44.2
25 Year Peak Flood	1460	ft^3/s	751	2860	42.7
50 Year Peak Flood	1740	ft^3/s	891	3410	42.7
100 Year Peak Flood	2030	ft^3/s	1010	4070	44.3
200 Year Peak Flood	2300	ft^3/s	1150	4620	44.4
500 Year Peak Flood	2670	ft^3/s	1300	5480	46

Peak-Flow Statistics Citations

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl. (http://pubs.usgs.gov/sir/2012/5113/)

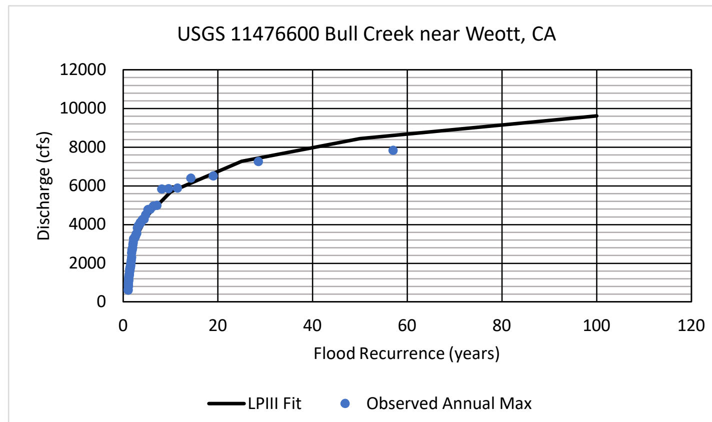
Log Pearson Type III Probabilistic Analysis
Williams Creek

Peak flows were estimated using a Log-Pearson type III distribution as described in Bulletin 17B (Guidelines for Determining Flood Flow Frequency, 1982).

Stream Name	Location	Drainage Area (mi^2)	1.01 yr (cfs/mi^2)	1.01 YR (cfs/mi^2)	1.2 yr (cfs/mi^2)	1.5-yr (cfs/mi^2)	2-yr (cfs/mi^2)	5-yr (cfs/mi^2)	10-yr (cfs/mi^2)	25-yr (cfs/mi^2)	50-yr (cfs/mi^2)	100-yr (cfs) (cfs/mi^2)
			Recurrence Interval of Peak Flows									
Bull Creek	Weott, CA	27.6	17.78	37.14	49.86	73.30	97.39	161.81	206.50	263.65	306.14	348.24

Williams Creek

Drainage Area (mi^2)	Q 1.01-yr (cfs)	Q 1.1-yr (cfs)	Q 1.2-yr (cfs)	Q 1.5-yr (cfs)	Q 2-yr (cfs)	Q 5-yr (cfs)	Q 10-yr (cfs)	Q 25-yr (cfs)	Q 50-yr (cfs)	Q 100-yr (cfs)
6.0	107	223	299	440	584	971	1,239	1,582	1,837	2,089



Flood Frequency based on Annual Maximum Series

USGS 11476600 Bull Creek near Weott, CA

Station #: 11476600

Drainage Area (sq. miles) 27.6

Maximum Daily Average Discharge

Water Year	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Annual Exceedance Probability	Water Year	Discharge (cfs)	Discharge (cms)	Log-Discharge (cfs)
1961	2/10/1961	3400	1	57.00	0.02	1997	7830	221.72	3.89
1962	2/9/1962	1380	2	28.50	0.04	2013	7260	205.58	3.86
1963	1/31/1963	4120	3	19.00	0.05	1965	6520	184.63	3.81
1964	1/20/1964	1930	4	14.25	0.07	1995	6400	181.23	3.81
1965	12/22/1964	6520	5	11.40	0.09	1983	5880	166.50	3.77
1966	1/4/1966	5000	6	9.50	0.11	2003	5860	165.94	3.77
1967	12/5/1966	4800	7	8.14	0.12	1974	5830	165.09	3.77
1968	1/14/1968	2710	8	7.13	0.14	1966	5000	141.59	3.70
1969	12/24/1968	3550	9	6.33	0.16	2015	4960	140.45	3.70
1970	1/26/1970	4280	10	5.70	0.18	1967	4800	135.92	3.68
1971	12/3/1970	2970	11	5.18	0.19	1986	4780	135.36	3.68
1972	1/22/1972	4000	12	4.75	0.21	2017	4520	127.99	3.66
1973	1/16/1973	1370	13	4.38	0.23	1970	4280	121.20	3.63
1974	1/16/1974	5830	14	4.07	0.25	1978	4260	120.63	3.63
1975	3/18/1975	3290	15	3.80	0.26	2006	4130	116.95	3.62
1976	2/26/1976	1590	16	3.56	0.28	1963	4120	116.67	3.61
1977	9/19/1977	173	17	3.35	0.30	1972	4000	113.27	3.60
1978	12/14/1977	4260	18	3.17	0.32	2004	3950	111.85	3.60
1979	1/11/1979	878	19	3.00	0.33	1982	3840	108.74	3.58
1980	1/14/1980	2540	20	2.85	0.35	1969	3550	100.53	3.55
1981	1/27/1981	1770	21	2.71	0.37	1985	3500	99.11	3.54
1982	11/16/1981	3840	22	2.59	0.39	1961	3400	96.28	3.53
1983	12/16/1982	5880	23	2.48	0.40	1996	3370	95.43	3.53
1984	11/10/1983	2810	24	2.38	0.42	1993	3300	93.45	3.52
1985	11/12/1984	3500	25	2.28	0.44	1975	3290	93.16	3.52
1986	2/17/1986	4780	26	2.19	0.46	2016	3270	92.60	3.51
1987	3/5/1987	1460	27	2.11	0.47	2008	3070	86.93	3.49
1988	12/6/1987	2310	28	2.04	0.49	1971	2970	84.10	3.47

Generalized Skew=	-0.4	A=	-0.301271246
Station Skewness (log Q)=	-0.36	B=	0.846631549
Station Mean (log Q)=	3.41	(station skew)	
Station Median (log Q)=	3.46	=	0.11622
Station Std Dev (log Q)=	0.28		
Weighted Skewness (G_W)=	-0.37		

Log Pearson Type III Distribution

Return Period (years)	Exceedence Probability	Log-Pearson K	Est. Discharge [mean] (cfs)	Est. Discharge [median] (cfs)
1.01	0.990	-2.59437	490.69	548.57
1.1	0.909	-1.44382	1025.12	1146.06
1.2	0.833	-0.98389	1376.20	1538.55
1.5	0.667	-0.38222	2023.05	2261.71
2.0	0.500	0.06161	2688.05	3005.15
2.33	0.429	0.23581	3005.25	3359.77
2.4	0.417	0.26960	3070.98	3433.26
2.6	0.385	0.35611	3245.91	3628.82
2.8	0.357	0.43026	3403.76	3805.29
5.0	0.200	0.85442	4465.98	4992.82
10	0.100	1.23528	5699.46	6371.81
25	0.040	1.61683	7276.83	8135.26
50	0.020	1.85014	8449.41	9446.16
100	0.010	2.05136	9611.38	10745.21

Flood Frequency based on Annual Maximum Series

USGS 11476600 Bull Creek near Weott, CA

Station #: 11476600

Drainage Area (sq. miles) 27.6

Maximum Daily Average Discharge

Water Year	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Annual Exceedance Probability	Water Year	Discharge (cfs)	Discharge (cms)	Log-Discharge (cfs)
1989	11/22/1988	1150	29	1.97	0.51	1984	2810	79.57	3.45
1990	1/8/1990	806	30	1.90	0.53	1968	2710	76.74	3.43
1991	3/4/1991	2040	31	1.84	0.54	2000	2700	76.46	3.43
1992	2/16/1992	635	32	1.78	0.56	1980	2540	71.93	3.40
1993	1/20/1993	3300	33	1.73	0.58	1988	2310	65.41	3.36
1994	1/23/1994	1110	34	1.68	0.60	2010	2180	61.73	3.34
1995	1/9/1995	6400	35	1.63	0.61	1991	2040	57.77	3.31
1996	12/12/1995	3370	36	1.58	0.63	1964	1930	54.65	3.29
1997	12/31/1996	7830	37	1.54	0.65	2007	1870	52.95	3.27
1998	3/23/1998	1690	38	1.50	0.67	2009	1830	51.82	3.26
1999	11/30/1998	1430	39	1.46	0.68	2012	1790	50.69	3.25
2000	2/14/2000	2700	40	1.43	0.70	1981	1770	50.12	3.25
2001	2/22/2001	970	41	1.39	0.72	1998	1690	47.86	3.23
2002	1/6/2002	1680	42	1.36	0.74	2002	1680	47.57	3.23
2003	12/16/2002	5860	43	1.33	0.75	1976	1590	45.02	3.20
2004	2/17/2004	3950	44	1.30	0.77	1987	1460	41.34	3.16
2005	12/8/2004	1270	45	1.27	0.79	1999	1430	40.49	3.16
2006	12/30/2005	4130	46	1.24	0.81	1962	1380	39.08	3.14
2007	12/26/2006	1870	47	1.21	0.82	1973	1370	38.79	3.14
2008	1/4/2008	3070	48	1.19	0.84	2011	1330	37.66	3.12
2009	2/23/2009	1830	49	1.16	0.86	2005	1270	35.96	3.10
2010	1/19/2010	2180	50	1.14	0.88	1989	1150	32.56	3.06
2011	12/21/2010	1330	51	1.12	0.89	1994	1110	31.43	3.05
2012	3/27/2012	1790	52	1.10	0.91	2001	970	27.47	2.99
2013	12/2/2012	7260	53	1.08	0.93	1979	878	24.86	2.94
2014	3/29/2014	614	54	1.06	0.95	1990	806	22.82	2.91
2015	2/6/2015	4960	55	1.04	0.96	1992	635	17.98	2.80
2016	1/17/2016	3270	56	1.02	0.98	2014	614	17.39	2.79

Values From K-Table for Linear interpolation

Weighted Skewness =	-0.40	-0.30	-0.37
P	K	K	K
0.99	-2.61539	-2.54421	-2.59437
0.9	-1.31671	-1.30936	-1.31454
0.8	-0.81638	-0.82377	-0.81856
0.7	-0.47228	-0.48600	-0.47633
0.6	-0.18916	-0.20552	-0.19399
0.500	0.06651	0.04993	0.06161
0.429	0.24037	0.22492	0.23581
0.200	0.85508	0.85285	0.85442
0.100	1.23114	1.24516	1.23528
0.040	1.60574	1.64329	1.61683
0.020	1.83361	1.88959	1.85014
0.010	2.02933	2.10394	2.05136

Sample Size, n =	56		
Skewness =	0.70	0.70	-0.36
Mean=	3103.27	87.88	3.41
Median=	2890.00	81.84	3.46
Std Dev=	1797.29	50.89	0.28
Outliers			
Kn=		2.811	
Q_{LOW}		427.13 cfs	
Q_{HIGH}		15632.98 cfs	

Appendix B
WY 2017 and 2018 Stream Flow and Sediment Transport Monitoring Technical Memorandums

GMA HYDROLOGY, Inc.

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Weaverville, CA 96093
(530) 623-0520

Arcata Office:
5435 Ericson Way, Suite 1
Arcata, CA 95521
(707) 825-6681

Placerville Office:
1973 Smith Flat Rd.
Placerville, CA 95667
(530) 623-0402

Hydrology – Geomorphology – Stream Restoration – Sediment Transport
Land and Hydrographic Surveys

TECHNICAL MEMO: Williams Creek Streamflow and Sediment Transport Monitoring, Water Year 2017 (to date)

Date: June 22, 2017

TO:
Humboldt County Resource Conservation District (HCRCD)
5630 South Broadway
Eureka, CA 95503

FROM:
Brooke Pittman
Senior Hydrologist, Project Manager
GMA Hydrology, Inc. (GMA)
1973 Smith Flat Rd.
Placerville, CA 95667
(707) 834-2297
brooke@gmahydrology.com

FOR:
Fulfillment of October 5, 2017 agreement (**Contract #GMA-WILLIAMS-01)** between HCRCD and GMA (amended January 20, 2017). This memo serves as the final written deliverable for the Water Year 2017 Williams Creek Stream Gaging and Sediment Transport Monitoring Project. All deliverables (electronic or written) are described in the Table of Contents below.

Contents

Figures

Tables

Appendix

Electronic Deliverables

1. **15 Minute Gage height data**
2. **15 Minute Streamflow data**
3. **15 Minute Turbidity data**
4. **15 Minute Suspended Sediment Concentration**
5. **15 Minute Suspended Sediment Load**
6. **15 Minute Bedload**

INTRODUCTION

In the fall of 2016, Humboldt County Resource conservation District (HCRCD) requested GMA Hydrology, Inc (GMA) to develop a gaging station and oversee streamflow (discharge) and sediment data collection on Williams Creek near Ferndale, CA (Figure 1). The original performance of six months was later amended to include the period from October 2016 through April 2017 (we refer to this period hereafter at “Water Year 2017”). In the same amendment (dated January 20, 2017), HCRCD directed GMA to take over (rather than oversee) low and mid flow data collection in addition to completing four high flow data collection trips. The broad objectives for the project included computing continuous discharge from continuous stage, suspended sediment discharge from turbidity and bedload discharge. Objectives are more clearly described in the task descriptions below.

Figure 1. Location map for Williams Creek near Ferndale, CA. North is toward top of page.

Scope of Work Defined

Project Management

- Oversee and schedule gage maintenance and field data collection efforts;
- Coordinate with HCRCD staff; and
- Provide monthly progress reports and invoices to HCRCD.

Gage Installation and Maintenance (three trips)

- Conduct a field reconnaissance of the gaging location;
- Acquire gaging materials and supplies;

- Install a data collection platform, a pressure transducer, staff plates, crest gages, solar panel, turbidimeter and cellular telemetry;
- Conduct a site survey of: gage datum (arbitrary elevation) level loop of reference marks, sampling cross section and rebar pins;
- Perform a low flow streamflow and sediment transport measurement;
- Train HCRCD personnel in data collection techniques, gage maintenance and data transfer protocols.

Sediment Sampling and Streamflow Measurements

- GMA will collect data during an anticipated four high flow events;
- HCRCD staff will collect additional low to mid flow data;
- *Revised to direct GMA collect all data after January 2017.*

Streamflow, Bedload and Suspended Load Computations and Reporting

- Data entry and QA of streamflow and sediment sample data;
- Evaluation and correction of continuous stage and turbidity records;
- Develop suspended sediment and bedload rating curves;
- Compute continuous suspended and bedload discharge and sum into annual loads;
- Develop detailed station analyses for streamflow and sediment;
- Produce a short data summary report.

Laboratory Sediment Sample Analyses

- Suspended sediment and bedload samples will be analyzed in GMA's Placerville, CA laboratories.

METHODS

Gaging: Stage and Turbidity

The gage at Williams Creek was originally installed on October 26, 2016. Gaging equipment included 3 staff plates, a Campbell 850 data collection platform, a DTS-12 turbidimeter, and an H-310 pressure transducer (Figure 2). These devices are powered by a common 12 volt solar supported system. On October 27, 2016 during the first storm event following gage installation, it was determined that the DTS-12 turbidimeter would not have a high enough range (1600 FNU) to capture high flow turbidities on Williams Creek. At that time an OBS3+ turbidimeter was ordered. The OBS3+ turbidimeter (1-4,000 FBU) was installed on December 5, 2016. Additionally, on November 18, 2016 a telemetry modem was installed at the site. Due to troubleshooting issues with US Cellular, the modem did not become fully operational until December 7, 2016. The gage was downloaded monthly and checked for drift periodically.

The site surveys were conducted using a Topcon ATG2 auto level, following the methodologies outlined in Harrelson et. al. (1995).

Figure 2. Upstream view of sampling section, turbidimeter boom on cable, gage house and solar panel.

Streamflow Measurement

Streamflow measurements were generally collected according to standard USGS protocols and as described in the GMA Surface Water QA Plan (GMA 2002) Wading techniques for lower flows and bridge techniques for high flows were employed using Price Pygmy or AA current meters.

All discharge measurements were entered and catalogued using a modified USGS-type 9-207 discharge measurement summary form.

Sediment Data Collection

Low to mid-range suspended sediment data were collected by wading using a US DH-48 handheld sampler. High flow data were collected from the bridge using a crane, reel, and either a D-74 or DH-59 suspended sediment sampler and a cable-deployed Elwha bedload sampler with 1 mm mesh. Measurements were taken over a range of flows and at various positions on the hydrograph. Protocols followed standard USGS procedures (Edwards and Glysson, 1999) for Equal Width Increment (EWI) sampling. Information recorded for each sample included: time, date, site, stage, bottle #, pass#, method, equipment used, etc. The GMA suspended and coarse sediment laboratories in Placerville, CA processed the sediment samples.

Computations

Streamflow

Stage/discharge relationships (rating curves) were developed and applied to the adjusted continuous-stage records to generate 10 minute discharge records. Discharge records were computed in the WISKI software suite, a comprehensive hydrologic time-series database management system developed by Kisters AG. The WISKI Suite incorporates complete USGS standards for surface water streamflow computations which utilize methods according to WSP 2175, Measurement and Computation of Streamflow vols.1 and 2 (Rantz 1982).

Suspended Sediment

Suspended sediment transport curves were generated in order to develop estimates of continuous suspended sediment concentration (SSC). SSC points for the transport curve plots were obtained from depth-integrated suspended sediment samples and the corresponding turbidity values. Continuous concentration was transformed into continuous suspended sediment discharge (SSD) using the standard equation:

$$Q\ (\text{cfs}) * SSC\ (\text{mg/l}) * 0.002697 = SSD\ (\text{tons/day})$$

Continuous suspended sediment discharge was then summed over the period to compute the load for the following size classes (partial loads): < 0.063mm, ≥0.063mm and total. Total suspended sediment load was computed by summing the partial loads. For detailed information on suspended sediment discharge computations see the Station Analysis in Appendix A. Regressions utilized in the computation of fine (<0.063mm) and coarse (≥0.063mm) suspended load are provided in Appendix B.

Bedload

Transport curves were developed from discharge-bedload sample pairs and continuous bedload discharge was estimated as a function of stream discharge for total bedload (no partial loads were computed as was done for suspended sediment). Bedload sedigraphs (graphical depictions of continuous sediment discharge) were constructed and are typically manually fitted through measured sediment discharge points (see Appendix A for more detail). Since the sampler bag mesh was 1mm, an unknown quantity of bedload <1mm was not measured. This is a common issue and it is usually assumed that most of the <1mm load is captured by the suspended sediment sampling effort.

RESULTS

Figure 3. Downstream view of sampling section during a high flow in February 2017.

Gaging

The data collection platform and pressure transducer system functioned properly throughout the monitoring period with one exception; a steep drop in gage height occurs on February 12, 2017 at 16:40 for unknown reasons. The turbidimeter experienced brief failures which are detailed in the Station Analysis (Appendix A) but generally functioned well with regard to describing high flow events.

Streamflow

The low water control at the site is a downstream riffle. The low water control appears to be prone to shifts. At high water, channel control dominates and was stable through the computational period. Nineteen discharge measurements were collected during the water year. Measured flows ranged from 2.81 to 617 cfs (Table 1) and computed instantaneous discharged ranged from 2.58 cfs to 788 cfs (Appendix A). Rating 1.1 (Figure 4) was developed using Measurements 1 (Fair) through 11 (Fair), taken from October 30, 2016 through January 10, 2017. A stage variable shift was applied in February 2017 which is detailed in Appendix A. The hydrograph and the continuous trace for turbidity are provided in Figure 5. The cross section, surveyed in October 2016 and May 2017, shows a small amount of aggradation, commensurate with a negative shift to the rating (Figure 6).

Table 1. Water Year 2017 Discharge Measurement Summary for Williams Creek near Ferndale, CA.

DISCHARGE SUMMARY SHEET

LOCATION: Williams Creek near Ferndale **WATER YEAR: 2017**

STATION NUMBER: 11479554

Measurement Number	WY Msmt #	Date	Made By	Width (feet)	Mean Depth (feet)	Area (ft2)	Mean Velocity (ft/sec)	Staff Height (feet)	Gage Height (feet)	Discharge (cfs)	Rating 1.0 Comp. Shift	Rating 1.0 Used Shift	Rating 1.0 Percent Diff.	Method	No. of Msmt sections	Begin Time (hours)	End Time (hours)	Msmt Rating	GZF Level (feet)	Notes
1	2016-01	10/30/2016	T. Grey	19.5	2.01	39.24	1.60	3.50	3.49	63.0	-0.07	0.00	-4	Cable	14	10:22	11:17	Fair		
2	2016-02	11/15/2016	S. Dougherty	7.6	0.71	5.37	1.17	NA	1.04	6.27	0.00	0.00	0	Wading	9	14:05	14:20	Poor		
3	2016-03	11/27/2016	T. Grey	22.5	2.90	65.28	1.80	5.13	4.95	118	-0.03	0.00	-2	Cable	12	10:36	11:33	Fair		
4	2016-04	12/05/2016	S. Dougherty	8.4	0.84	7.02	1.61	1.35	1.35	11.3	NA	NA	NA	Wading	16	11:15	11:46	Excluded		Aquacalc malfunction, used check measurement (2016-05) for Rating development
5	2016-05	12/05/2016	S. Dougherty	9.1	0.89	8.10	1.60	1.35	1.34	12.9	0.02	0.00	2	Wading	20	11:54	12:40	Fair		
6	2016-06	12/09/2016	S. Dougherty	17.0	1.52	25.91	1.80	2.83	2.86	46.6	0.00	0.00	0	Wading	27	15:00	15:40	Fair		
7	2016-07	12/14/2016	T. Grey	26.0	3.74	97.14	1.79	6.27	6.25	176	-0.05	0.00	-3	Cable	17	13:05	14:05	Fair		
8	2016-08	12/15/2016	T. Grey	30.3	5.75	174.13	1.91	8.91	8.87	333	0.10	0.00	2	Cable	15	9:14	10:07	Fair		
9	2016-09	12/15/2016	T. Grey	27.8	4.43	123.19	1.89	7.21	7.16	232	0.13	0.00	3	Cable	15	12:33	13:20	Fair		
10	2016-10	01/10/2017	T. Grey	32.2	6.43	207.08	2.29	9.78	9.60	475	0.01	0.00	0	Cable	20	14:06	15:37	Fair		
11	2016-11	01/10/2017	T. Grey	30.7	5.80	177.99	2.07	9.06	9.09	369	-0.01	0.00	0	Cable	16	16:27	17:14	Fair		
12	2016-12	02/09/2017	T. Grey	35.9	6.10	218.85	2.82	NA	10.51	617	-0.33	0.00	16	Cable	22	8:53	10:16	Poor		Aquacalc resetting during msmt. Only collected 0.6' depth msmts
13	2016-13	02/10/2017	D. Sheldon	23.0	2.70	62.07	2.06	4.90	4.96	128	0.19	0.00	8	Wading	22	9:55	11:18	Fair		
14	2016-14	03/25/2017	D. Sheldon	17.0	1.43	24.34	2.05	3.10	3.08	50	-0.10	-0.09	0	Wading	21	9:14	10:26	Fair		
15	2016-15	03/25/2017	D. Sheldon	17.0	1.38	23.41	2	3.01	3.00	47	-0.13	-0.10	-2	Wading	25	11:20	12:06	Fair		
16	2016-16	03/25/2017	D. Sheldon	17.0	1.32	22.38	2.09	2.92	2.92	47	-0.04	-0.12	5	Wading	25	12:57	13:37	Fair		
17	2016-17	04/10/2017	D. Sheldon	13.8	0.98	13.50	1.6	2.34	2.32	22	NA	NA	NA	Wading	23	15:07	15:40	Excluded		
18	2016-18	04/10/2017	D. Sheldon	13.8	0.98	13.57	1.76	2.32	2.30	24	-0.35	-0.37	2	Wading	23	15:50	16:28	Fair		
19	2016-19	05/23/2017	T. Grey	8.0	0.33	2.64	1.06	1.20	1.18	2.81	-0.40	-0.37	-9	Wading	22	10:32	11:06	Poor		

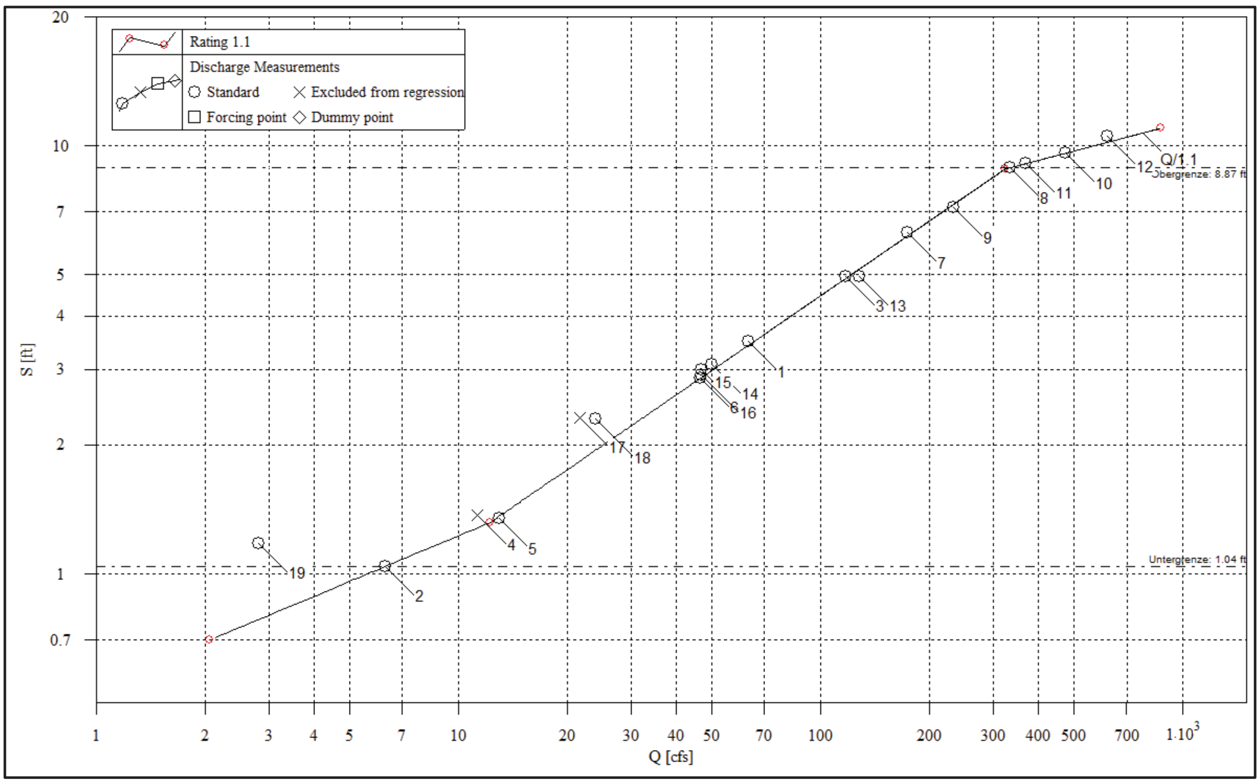

Figure 4. The Water Year 2017 stage discharge rating (1.1) for Williams Creek near Ferndale.

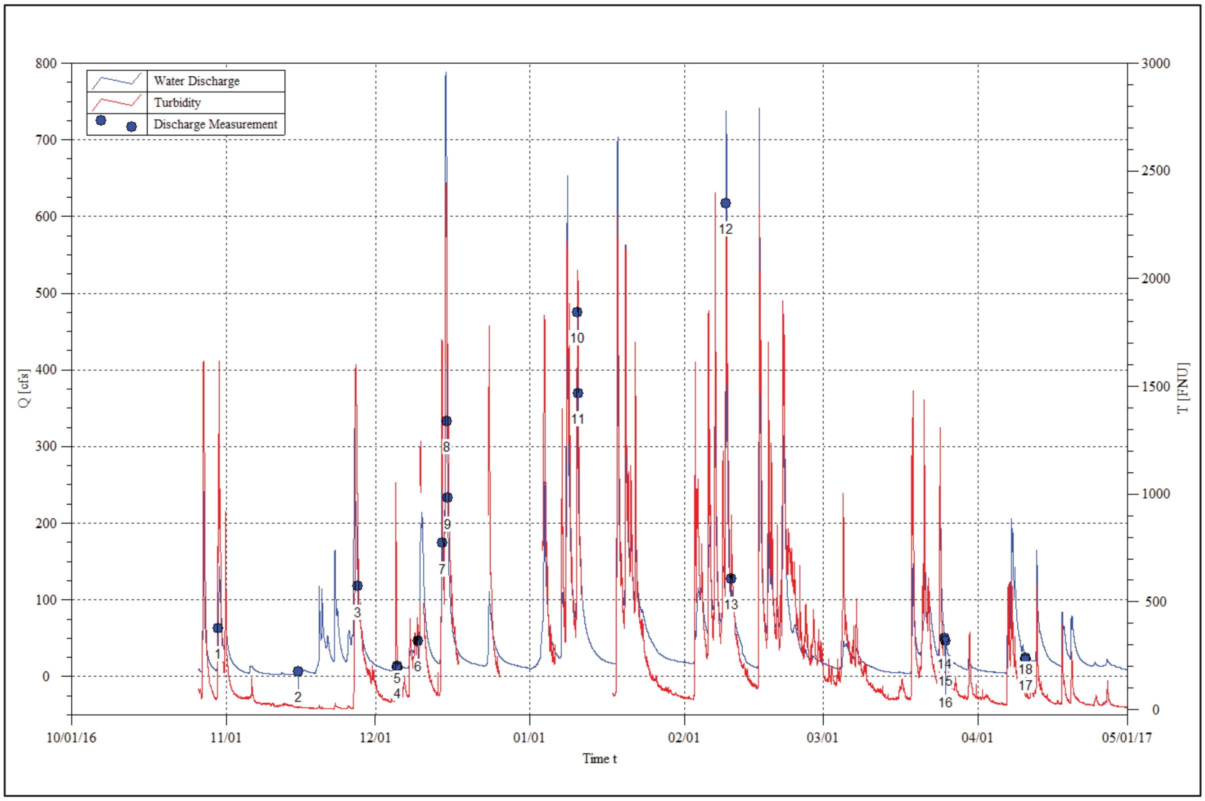

Figure 5. Water Year 2017 hydrograph and continuous turbidity for Williams Creek near Ferndale.

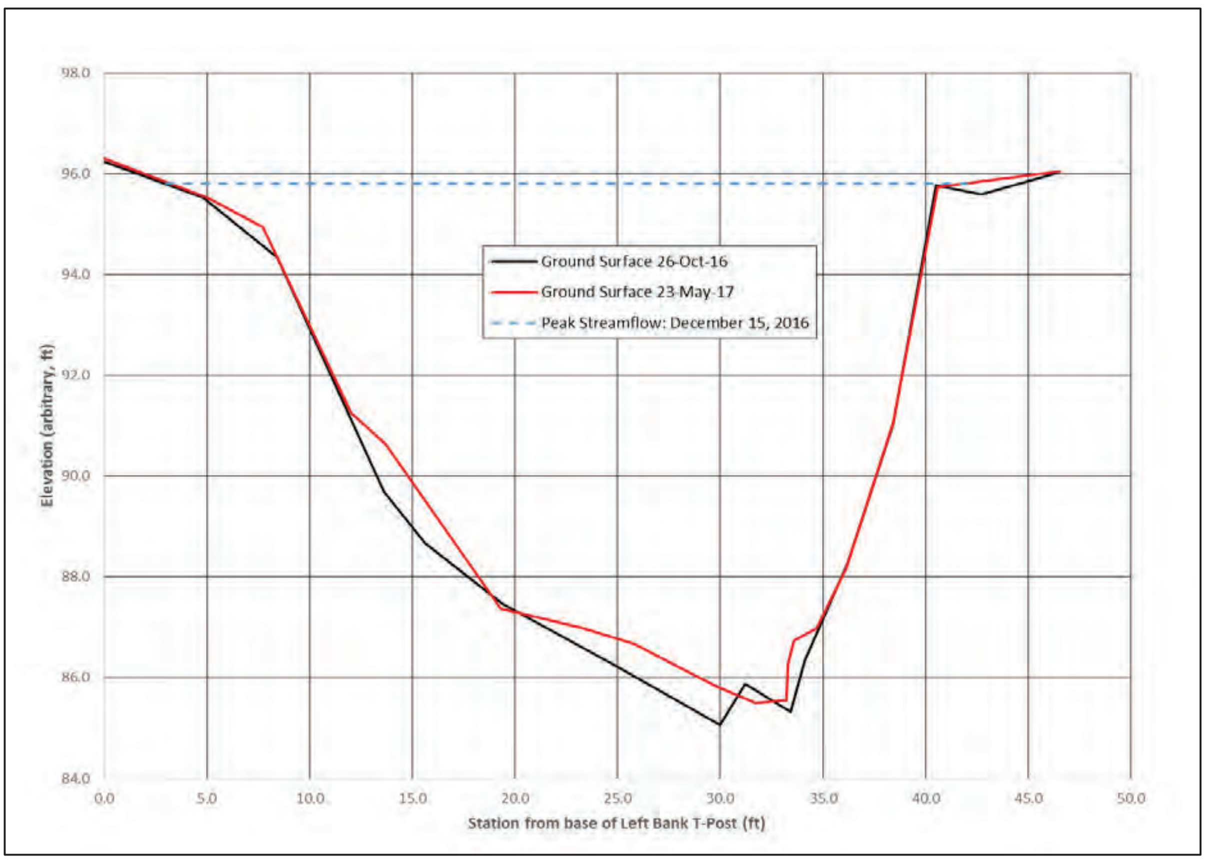

Figure 6. Sampling section at the Williams Creek gage: October 2017 and May 2017.

Suspended Sediment

Seven two-pass samples and 12 one-pass samples were collected during the water year (Table 2). Sampled concentrations ranged from 24 to 17,250 mg/l. Nineteen cross-sectional, depth-integrated samples were analyzed using a split at <0.063mm (Table 2). Sediment discharge compuations were completed for >0.063mm (fine) and ≥0.063mm (coarse) size classes. Of the nineteen samples, eight passes were also analyzed for a full particle size anlaysis and split at the following sizes; 0.063mm, 0.125mm, 0.25mm, 0.5mm, 1mm and 2mm (Table 3). No computations were performed with these size classes, they were analyzed to provide additional detail of the size distribution of suspended sediment.

Table 2. Williams Creek Water Year 2017 Suspended Sediment Sampling Summary.

Williams Creek near Ferndale, CA

Suspended Sediment Sampling Summary -- WY2017

Sample Number	Date & Mean Time	Average Discharge (cfs)	Average SSC <0.063mm (mg/l)	Average Coarse SSC >0.063mm (mg/l)	Average SSC Total (mg/l)	Average SSD Total (tons/day)
2017-01	11/18/2016 10:06	4.89	22	2	24	0
2017-02	11/21/2016 16:10	39.8	377	22	399	43
2017-03*	11/27/2016 8:37	146	2,170	600	2,770	1,090
2017-04*	11/29/2016 10:35	26.2	258	28	285	20
2017-05	12/9/2016 14:45	47.4	708	32	740	95
2017-06*	12/14/2016 11:17	213	3,920	1,120	5,045	2,900
2017-07	12/14/2016 14:41	166	2,390	606	3,000	1,350
2017-08	12/15/2016 8:41	467	9,270	2,700	12,000	15,100
2017-09	12/15/2016 10:31	299	7,400	2,290	9,690	7,820
2017-10	12/15/2016 13:54	204	5,060	1,500	6,550	3,610
2017-11	1/10/2017 12:45	402	9,780	2,480	12,300	13,400
2017-12	1/10/2017 13:12	416	8,460	2,400	10,900	12,200
2017-13*	1/10/2017 14:55	481	7,580	2,260	9,840	12,800
2017-14*	1/10/2017 16:46	383	7,840	1,910	9,750	10,100
2017-15*	2/9/2017 8:50	728	13,960	3,290	17,300	34,000
2017-16*	2/9/2017 14:28	337	5,120	1,980	7,100	6,460
2017-17	3/25/2017 10:44	48.5	594	123	717	94
2017-18	3/25/2017 12:24	44.9	565	90	654	79
2017-19	3/25/2017 13:46	42.5	562	91	653	75

* Averaged two pass sample

Values Rounded According to Porterfield (1972)

Table 3. Grain size analysis for eight of the nineteen suspended sediment passes.

Sample Number (ID-SSCTyear- #)	Date and Average Time Sampled (mm/dd/yy hh:mm)	<0.063 mm fine conc (ppm)	% <0.063 mm	% >0.063 - 0.125 mm	% >0.125-0.25 mm	% >0.250-0.5 mm	% >0.5-1 mm	% >1.0-2.0 mm	% >2.0 mm	Reported SSC Conc (mg/l)
2017-03	11/27/2016 8:37	2151	80%	15%	4%	0%	0%	0%	0%	2680
2017-06	12/14/2016 11:17	3720	77%	18%	4%	0%	0%	0%	0%	4830
2017-08	12/15/2016 8:41	9274	77%	18%	4%	0%	0%	0%	0%	11970
2017-09	12/15/2016 10:31	7401	76%	18%	5%	0%	0%	0%	0%	9690
2017-10	12/15/2016 13:54	5057	77%	17%	5%	1%	0%	0%	0%	6550
2017-12	1/10/2017 13:12	8460	78%	16%	5%	1%	0%	0%	0%	10860
2017-13a	1/10/2017 14:55	7528	77%	18%	5%	1%	0%	0%	0%	9820
2017-13b	1/10/2017 14:55	7621	77%	18%	5%	0%	0%	0%	0%	9850
		Average	**78%**	**17%**	**5%**	**0%**	**0%**	**0%**	**0%**	

Bedload

When conditions allowed, two passes were collected for each bedload sample, and an average of the passes was computed. If stage was rising or falling too rapidly or time did not allow for a second pass, a single pass was collected. Four two pass samples and three single pass samples were collected for a total of 7 samples (Table 4). Full particle size analysis was performed on all samples collected and these data are summarized in Table 5. Bedload Discharge ranged from 1.6 to 41 tons per day. Sample 2017-06, the highest transport sample, indicated that gravel transport begins to increase between 10-10.5 feet in stage. Transport rates shown by Sample 2017-06, taken shortly after, dropped by 75% with only a 1 foot of drop in gage height.

Table 4. Water Year 2017 Bedload Sampling Summary, Williams Creek near Ferndale.

Sample Number	Date & Mean Time	Water Discharge (cfs)	Total Bedload Discharge (tons/day)
WCNF-BLM2017-01	11/27/2016 09:41	135	1.6
WCNF-BLM2017-02	12/14/2016 12:19	196	2.4
WCNF-BLM2017-03	12/15/2017 11:06	278	1.8
WCNF-BLM2017-04	01/10/2017 13:15	420	9.4
WCNF-BLM2017-05	01/10/2017 16:01	493	9.4
WCNF-BLM2017-06	02/09/2017 10:38	722	41
WCNF-BLM2017-07	02/09/2017 13:32	468	11

Values Rounded According to Porterfield (1972)

Table 5. Grain size analysis for Water Year 2017 bedload samples, Williams Creek, CA.

Sample Number	Date and Average Time Sampled (mm/dd/yy hh:mm)	Discharge (cfs)	% <0.063 mm	% 0.125 mm	% 0.25mm	% 0.5mm	% 0.85mm	% 1mm	% 2mm	% 2.8 mm	% 4 mm	% 5.6 mm	% 8 mm	% 11.2 mm	% 16 mm	% 22.4 mm	% 31.5 mm	% 45 mm
2017-01	11/27/2016 9:41	135	1.2%	1.3%	1.4%	1.4%	3.5%	2.9%	34%	18%	14%	10%	7.3%	4.1%	0.8%	0.0%	0.0%	0.0%
2017-02	12/14/2016 12:19	196	2.2%	2.8%	2.5%	1.6%	4.0%	3.1%	39%	19%	13%	7%	4.0%	1.6%	0.5%	0.0%	0.0%	0.0%
2017-03	12/15/2017 11:06	278	7.4%	16.3%	17.5%	7.9%	8.0%	3.0%	16%	6%	6%	5%	3.3%	1.9%	0.0%	1.3%	0.0%	0.0%
2017-04	1/10/2017 13:15	420	6.8%	6.1%	7.2%	8.2%	12.8%	5.7%	24%	7%	6%	5%	2.9%	3.1%	2.1%	3.2%	0.0%	0.0%
2017-05	1/10/2017 16:01	493	6.9%	5.8%	5.0%	3.3%	7.1%	4.6%	31%	10%	9%	7%	4.4%	3.5%	2.0%	0.0%	0.0%	0.0%
2017-06	2/9/2017 10:38	722	1.9%	2.0%	2.6%	3.1%	5.6%	2.9%	22%	13%	13%	12%	12.1%	5.3%	4.1%	0.5%	0.1%	0.0%
2017-07	2/9/2017 13:32	468	2.7%	3.8%	4.0%	3.0%	6.5%	4.3%	30%	14%	12%	8%	6.8%	3.0%	1.1%	0.3%	0.2%	0.0%
Average			4.2%	5.4%	5.7%	4.1%	6.8%	3.8%	28%	13%	10%	8%	5.8%	3.2%	1.5%	0.7%	0.1%	0.0%

Bedload comprised a very small proportion of the load on Williams Creek (0.09%). Most samples collected during Water Year 2017 were mostly sand and organic matter. The total bedload was 83.4 tons for Water Year 2017 (Table 6). Turbidities and Suspended Sediment Concentrations were very high. Fine suspended sediment load was 75,590 tons, coarse suspended sediment load was 21,080 tons, for a total suspended sediment load of 96,670 tons.

Table 6. Water Year 2017 sediment load totals for Williams Creek near Ferndale, CA.

Suspended Sediment			Bedload
<0.063mm (tons)	≥0.063 mm (tons)	Total Suspended Sediment (tons)	Total Bedload (tons)
75,590	**21,080**	**96,670**	**83.4**

Values Rounded According to Porterfield (1972)

REFERENCES

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APPENDIX

A. STATION ANALYSIS FOR WILLIAMS CREEK NEAR FERNDALE, CALIFORNIA, WATER YEAR 2017

B. SEDIMENT TRANSPORT CURVES

1. **Turbidity vs <0.063mm Suspended Sediment Concentration**
2. **Turbidity vs ≥0.063mm Suspended Sediment Concentration**
3. **Water Discharge vs Bedload Discharge**

Williams Creek near Ferndale, California

STATION ANALYSIS

SURFACE WATER RECORD

WY 2017: (October 26 to April 30)

RECORDS – Water Discharge, Suspended Sediment Discharge and Bedload Discharge

EQUIPMENT – GMA Hydrology, Inc.(GMA) at the request of the Humboldt County Resource Conservation District (RCD), established this site in October 2016. Sampling equipment consists of a D-74 and DH-48 for suspended-sediment sampling, and a cable-deployed Elwha bedload sampler with a 1 mm mesh collection bag. The D-74 or DH-59 suspended-sediment sampler and the Elwha bedload sampler were deployed from a crane-mounted E-reel or B-Reel attached to a bridge crane or bridge board. Stage references (staff plates) were installed near the gaging station and were levelled to a temporary benchmark assigned an arbitrary elevation. A Design Analysis H-310 pressure transducer and Campbell Scientific CR850 data collection platform were installed on October 26, 2016 at 11:10 (times are 24 hr). A Forest Technology Systems DTS-12 turbiditimeter was installed as well. The maximum turbidity value for the DTS-12 was exceeded during the first few storm events. On December 5, 2016 at 11:30 the DTS-12 was removed and replaced with a Campbell Scientific OBS3+ turbidimeter, which has a higher maximum turbidity value. Photographs were taken with a digital camera.

Inside recording gage: Design Analysis H-310 (Accuracy to ± 0.007 ft)
Forest Technology Systems DTS-12 (Accuracy (0-499.99 NTU ± 2% +0.2 NTU), (500.00 to 1600 NTU ± 4%))
D&A Instrument Company OBS 3+ (Accuracy 2% of reading or 0.5 NTU), (Range: 0-4,000 FBU)
Outside staff gage: Three enameled sections (0.00 ft – 10.14 ft).

GAGE HEIGHT RECORDS – The gage was installed on October 26, 2016. The record is incomplete for the computational period. There are small gaps in the record on February 2, 2017 from 12:30 to 15:20, which occured during station maintenance. A steep drop in gage height occurs on February 12, 2017 at 16:40 for unknown reasons. The gage record is flagged as suspect from February 12 at13:20 until February 13, 2017 at 08:50. During the computational period the maximum gage height of 10.74 ft. occurred on December 15, 2016 at 03:50 hours. The minimum gage height for the computational period of 0.76 ft. occurred on November 15, 2016 at 01:40 hours.

Staff height readings were compared to recorded gage height values and the gage height was corrected when necessary.

DATUM CORRECTIONS – No correction necessary. A level survey was performed on October 26, 2016 and May 23, 2017.

CONTROL – The low water control at the site is a downstream riffle. The low water control appears to be prone to shifts. At high water, channel control dominates and was stable through the computational period.

RATING – Nineteen discharge measurements (1-19) were made during the computational period. Measurements were made with a Price AA meter or Pygmy meter and Aquacalc Pro attached to a wading rod or suspended from a reel cable attached to a bridge crane. Measured discharge for the period ranged from 2.81 cfs to 617 cfs. Computed instantaneous discharged ranged from 2.58 cfs to 788 cfs.

Rating 1.1 was developed using Measurements 1 (Fair) through 11 (Fair), taken from October 30, 2016 through January 10, 2017. Measurement 4 taken on December 5, 2016 was excluded from rating development due to an Aquacalc malfunction. Measurement 5 (Fair) was taken as a check measurement on the same day and was used in place of Measurement 4.

Rating 1.1 has a validated range between 1.04 ft (6.44 cfs) and 8.87 ft (332 cfs).

Measurement 14 (Fair) through 19 (Poor) indicated a negative shift to Rating 1.1, which was confirmed by the aggradation shown during the May 2017 cross section survey. Measurement 12 (Poor) showed a negative shift, however it was rated a Poor measurement due to Aquacalc malfunction during the flood measurement. Because Measurement 13 (Fair) fell within acceptable limits of Rating 1.1 the high end of Rating 1.1 was not shifted. Examination of the hydrograph indicated that the shift likely took place during the storm event on February 9, 2017. The stage variable shift was brought into full effect on the peak of that event at 09:10 and remained in effect for the rest of the computational period.

Additional low to mid range changes to the rating may have occurred earlier in the year, however, we did not have adequate resolution in our measurements to develop shifts.

DISCHARGE –Rating 1.1 is used as follows:

April 1 to Feb. 9 (09:00)	Rating 1.1
Feb. 9 to April 30 (23:45)	Direct to SV17-01 (2.29, -0.37; 3.01, -0.09; 4.96, 0.00)

SEDIMENT

Data summary for Partial WY 2017

Total number of samples:

Suspended sediment sets	7
Single pass suspended sediment samples	12
Box sample sets	0
Single box samples	0
Bedload sets	4
Single pass bedload samples	3

Three pass bedload samples	…………………………………………	0
Number of field turbidities measured	…………………………………………	0
Number of suspended sediment size analysis samples:		
Particle size analysis	…………………………………………	8
0.063mm break	…………………………………………	18
0.500mm break	…………………………………………	0
Number of bedload sediment size analysis samples:		
Particle size analysis	…………………………………………	11
Number of suspended sediment discharge measurements	………………………	19
Number of bedload discharge measurements	………………………………	7
Maximum flow sampled by:		
GMA technicians, ft^3/s	…………………………………………	728
Range of concentrations sampled by:		
GMA technicians, mg/l	…………………………………………	24-17,250
GMA technicians, ton/d	…………………………………………	1-74
Peak flow, ft^3/s	…………………………………………	788
Periods of faulty record	…………………………………………	

Turbidity

October 27, 2016 at 08:20 – October 27, 2016 at 14:00
October 30, 2016 at 14:40 – October 30, 2016 at 15:10
November 26, 2016 at 23:20 – November 27, 2016 at 02:30
December 9, 2016 at 21:50 – December 9, 2016 at 21:50
December 10, 2016 at 04:50 – December 10, 2016 at 16:20
December 14, 2016 at 05:10 – December 14, 2016 at 06:40
December 17, 2016 at 18:10 – December 23, 2016 at 16:20
December 25, 2016 at 22:40 – January 3, 2017 at 11:10
January 6, 2017 at 00:10 – January 7, 2017 at 08:50
January 11, 2017 at 10:20 – January 17, 2017 at 13:30

Coefficients.-- None used.

Continuous Turbidity.-- The turbidity record is incomplete for the computational period. A Forest Technology Systems DTS-12 turbiditimeter was installed on October 26, 2016. The maximum turbidity value for the DTS-12 was exceeded on October 27, October 30 and November 26, 2016. On December 5, 2016 at 11:30 the DTS-12 was removed and replaced with an OBS3+ turbidimeter, which has a higher maximum turbidity value.

During early December 2016 the site geometry changed and the turbidimeter was no longer submerged during several low flow periods from December 9, 2016 through January 17, 2017, when the probe housing was lowered.

Several turbidity spikes were removed. Turbidity spikes are defined as short periods of time, 15-minutes to several hours, during which the optics of the probe were presumably fouled.

During the computational period the maximum turbidity was 2,440 FBU on December 15 at 03:20, and the minimum turbidity was 2.25 FBU, which occurred on November 22, 2016 at 14:20.

Total suspended sediment-discharge computations. -- Total suspended-sediment discharge was computed by summing the partial suspended-sediment discharges.

Size analysis. – Nineteen cross-sectional, depth-integrated samples were analyzed using a split at <0.063mm. Sediment discharge compuations were completed for <0.063mm (fine) and ≥0.063mm (coarse) size classes. Of the nineteen samples, eight passes were also analyzed for a full particle size anlaysis and split at the following sizes; 0.063mm, 0.125mm, 0.25mm, 0.5mm, 1mm and 2mm. No computations were performed with these size classes, they were analyzed to provide additional information regarding the size distribution of suspended sediment.

Partial suspended sediment-discharge computations. – When conditions allowed, two passes were collected for each suspended sediment sample, and an average of the passes was computed. If stage was rising or falling rapidly or time did not allow for a second pass, a single pass was collected. Seven two pass samples and twelve single pass samples were collected for a total of 19 samples. No outliers were identified for either size class.

Turbidity versus SSC transport curves were analyzed for Water Year 2017.

For the <0.063mm size class, the turbidity versus SSC transport curve is defined by the following piecewise linear regression Eqn. (1) and Eqn. (2).

T < 1,558 FNU: $$SSC = 3.29 * Turbidity - 14.04, \qquad r^2 = 0.96 \qquad (1)$$

T≥ 1,558 FNU: $$SSC = 10.79 * Turbidity - 11{,}689, \qquad r^2 = 0.94 \qquad (2)$$

Eqn. (1) was developed using samples 1-7, 10, and 16-19. Eqn. (2) was developed using samples 8-9, and 11-16. Eqn. (1) and (2) are used for the entire Water Year 2017. Eqn. (1) has a validated range between 3.00 FNU and 2,323 FNU.

For the ≥0.063mm size class, the turbidity versus SSC transport curve is defined by Eqn. (3).

$$SSC = 1.35 * Turbidity - 198.8, \qquad r^2 = 0.98 \qquad (3)$$

Eqn. (3) was developed using all samples collected during Water Year 2017 and has a validated range between 3.00 FNU and 2,323 FNU.

The tranport curves were used to develop continuous concentration curves for the <0.063mm and the ≥0.063mm size classes. Suspended-sediment discharge was computed directly from the continuous concentration once the continuous concentration data had been checked and its accuracy verified.

Bed material.-- None.

Bedload measurement. -- When conditions allowed, two passes were collected for each bedload sample, and an average of the passes was computed. If stage was rising or falling too rapidly or time did not allow for a second pass, a single pass was collected. Four two pass samples and three single pass samples were collected for a total of 7 samples. Full particle size analysis was performed on all samples collected.

Bedload-discharge computations. – A sediment transport curve was developed for Total Bedload Discharge versus Water Discharge and is defined by Eqn. (4). No outliers were identified.

$$BLD = 9.95e - 005 * Discharge^{1.89}, \qquad r^2 = 0.93 \qquad (4)$$

Zero transport was estimated during transport curve development to be 40 cfs. Once the continuous bedload-discharge traces were developed using the above transport curve, they were evaluated to determine if it was necessary to adjust them so they would pass through the sample data. The trace passed within acceptable limits of all samples except Sample 6. The trace was adjusted up to Sample 6 for the storm event that occurred on February 6, 2017. Proportional fitting was used to smooth data between the start of the rising limb, the sample value, and the end of the falling limb. Proportional fitting calculates the ratio between two sequential sample values and then scales the appropriate time series (e.g. continuous SSC) by this ratio. When applied between sequential pairs of data, the ratio is decayed or increased linearly to match the end-points.

Partial bedload-discharge computations -- None

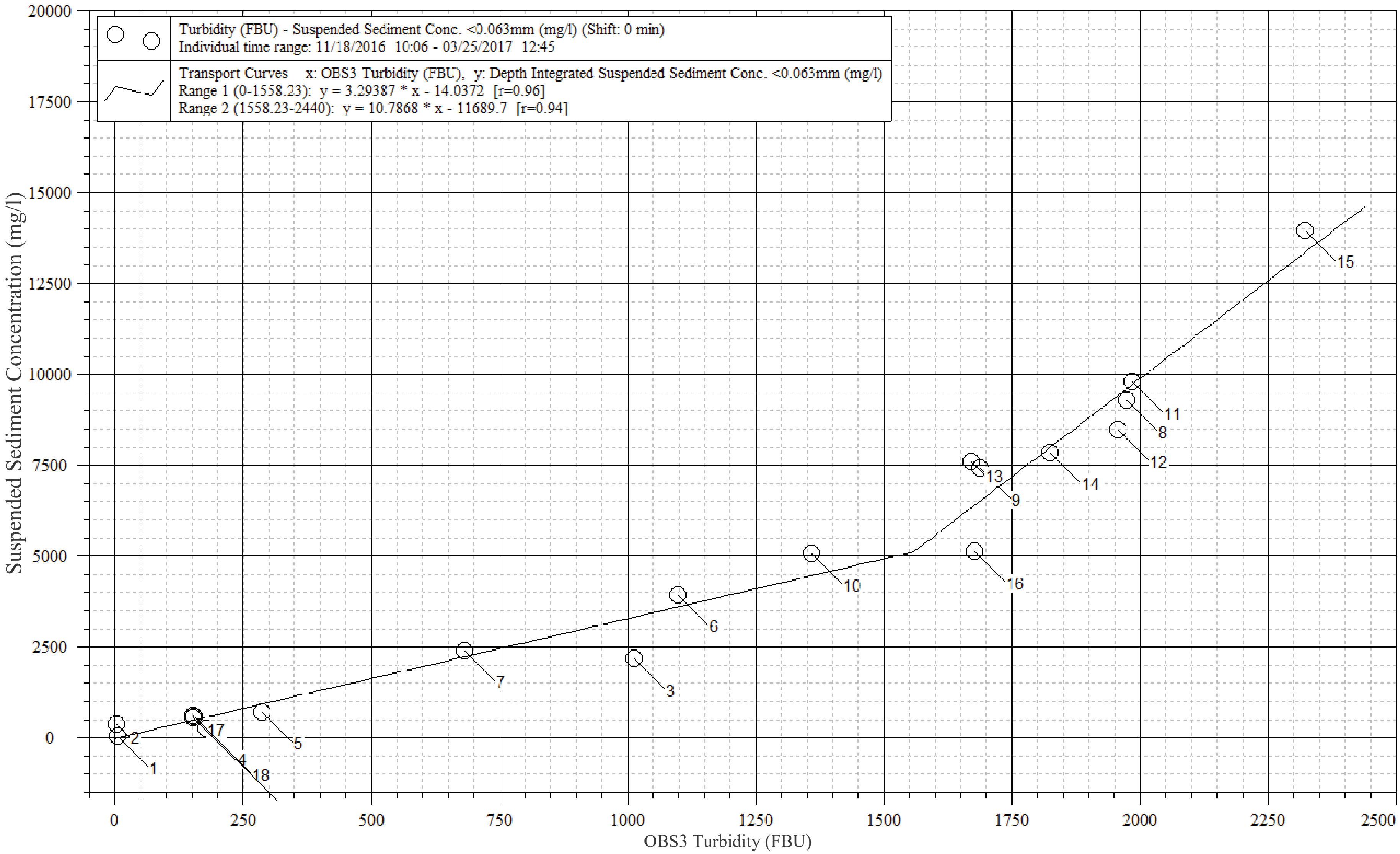
REMARKS – The record should be considered **Fair** for the computational period. The record should be considered estimated when the gage height is outside the validated range of Rating 1.1.

The sediment record rating follows the discharge record rating except during gaps in the turbidity record when continuous SSC was estimated using discharge or estimated zero transport. During those time period the sediment record should be considered **Estimated**.

Record Worked by: B. Pittman, June 2017
Proofed: S. Pittman, June 2017

WILLIAMS CREEK near FERNDALE

Turbidity (FBU) vs Suspended Sediment Concentration <0.063mm (mg/l)



PROJECT:

2017 WILLIAMS CREEK STREAMFLOW AND SEDIMENT MONITORING

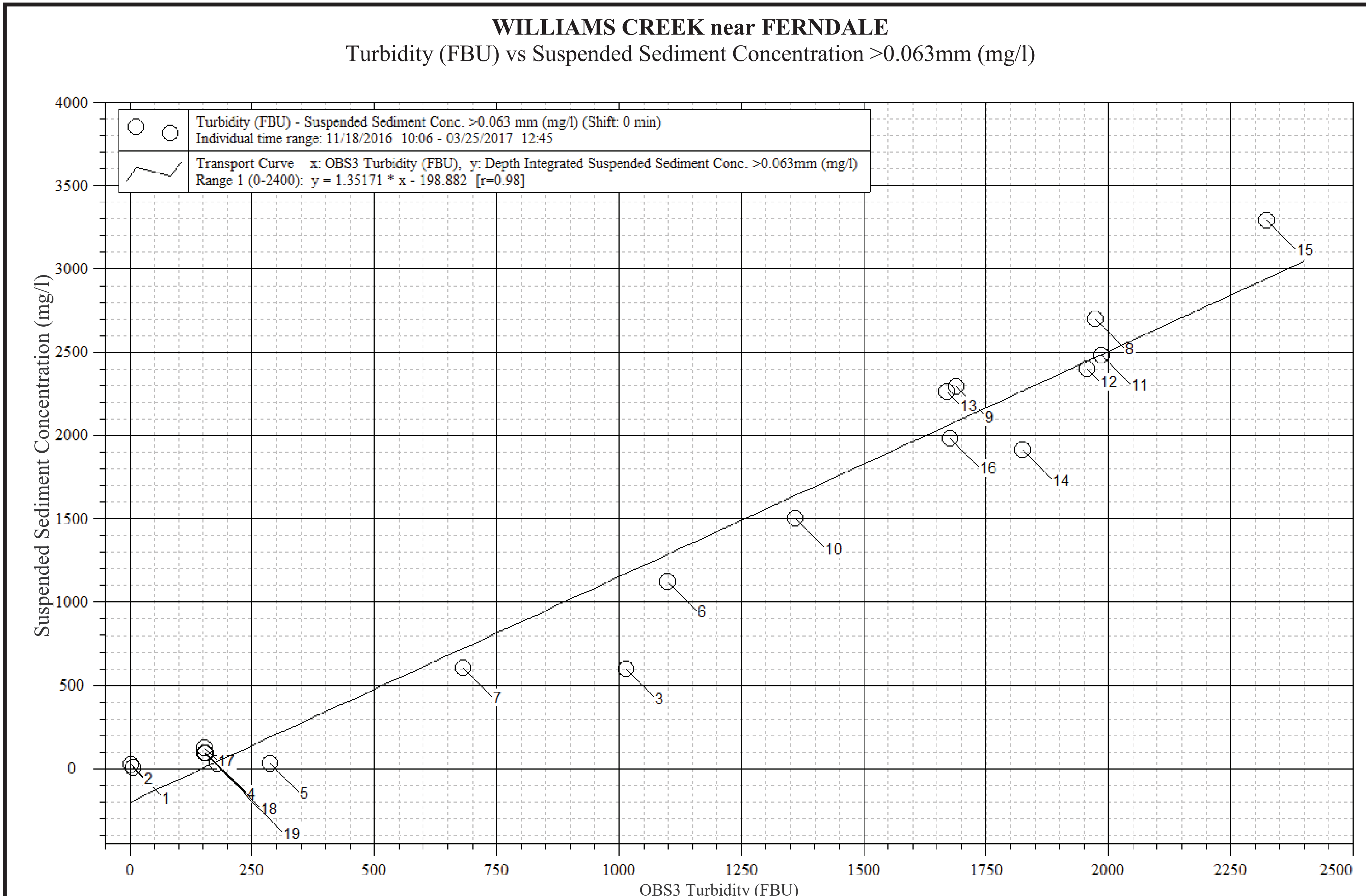
Humboldt County Resource Conservation District

GMA

Hydrology | Geomorphology | Stream Restoration

APPENDIX

B-1



PROJECT:

2017 WILLIAMS CREEK STREAMFLOW AND SEDIMENT MONITORING

Humboldt County Resource Conservation District

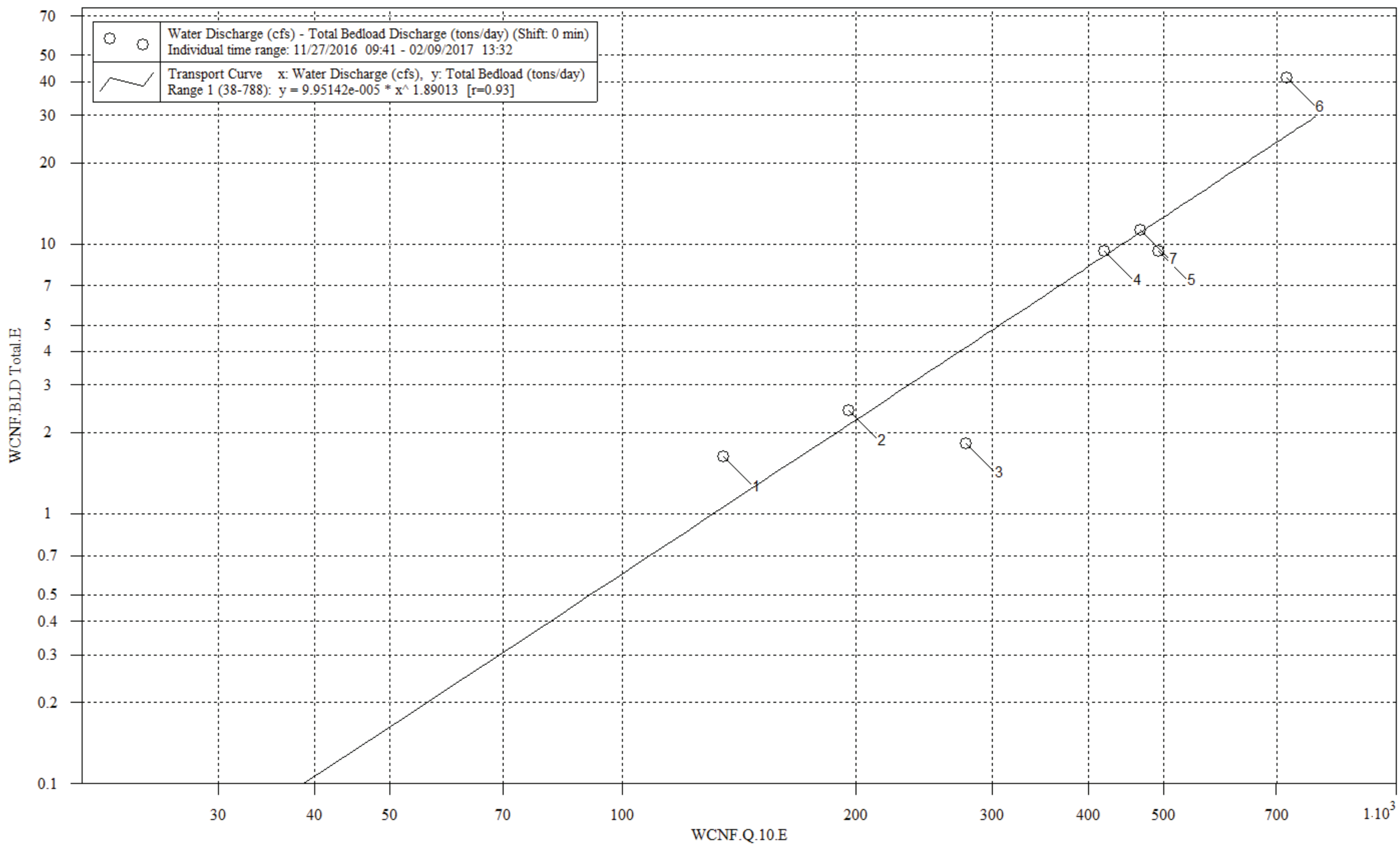
GMA
Hydrology | Geomorphology | Stream Restoration

APPENDIX

B-2

WILLIAMS CREEK near FERNDALE

Water Discharge (cfs) vs Total Bedload Discharge (tons/day)



PROJECT:

2017 WILLIAMS CREEK STREAMFLOW AND SEDIMENT MONITORING

Humboldt County Resource Conservation District

GMA

Hydrology | Geomorphology | Stream Restoration

APPENDIX

B-3

2018 WILLIAMS CREEK STREAMFLOW AND SEDIMENT TRANSPORT MONITORING REPORT

GHD Job No. 11151140
Purchase Order No. 38001450

Prepared for:

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Prepared by:

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June, 2018

Hydrology – Geomorphology – Stream Restoration
Land and Hydrographic Surveys

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Electronic Deliverables

INTRODUCTION

In the fall of 2016 GMA Hydrology, Inc. (GMA) installed a surface water monitoring station for the Humboldt County Resource Conservation District (HCRCD) on Williams Creek near Ferndale, CA (Figure 1) for operation during the wet season of water year 2017 (October-April). The purpose of the monitoring station was to produce continuous streamflow and sediment records. In June, 2017, GHD, Inc. (GHD) requested that GMA continue to operate the monitoring station with the assistance of the HCRCD for water year 2018 (October – April). Data collection included: continuous stage and turbidity, streamflow measurements, suspended sediment samples and bedload samples, during significant storm events. Objectives for the project included computation of streamflow, suspended sediment discharge, and bedload discharge. Objectives are more clearly described in the task descriptions below.

Figure 1. Location map for Williams Creek near Ferndale, CA. North is toward top of page.

Scope of Work Defined

Project Management

- Oversee and schedule gage maintenance and field data collection efforts;
- Coordinate with HCRCD staff; and
- Provide monthly progress reports and invoices to GHD.

Monitoring Station Re-occupation and Maintenance

- Re-install a data collection platform (Campbell CR850), Design Analysis H-310 pressure transducer, OBS3+ turbidimeter and cellular telemetry equipment;

- Conduct a site survey of: gage datum, reference marks, and sampling cross section and rebar pins.

Sediment Sampling and Streamflow Measurements

- GMA will collect data during an anticipated two high flow events;
- HCRCD staff will collect additional low to mid flow data as advised by GMA.

Streamflow, Bedload and Suspended Sediment Discharge Computations and Reporting

- Data entry and QA of streamflow and sediment sample data;
- Evaluation and correction of continuous stage and turbidity records;
- verify and update existing stage-discharge rating and develop shifts and new ratings when necessary;
- Develop suspended sediment and bedload rating curves;
- Compute continuous suspended and bedload discharge and sum into annual loads;
- Develop detailed station analyses for streamflow and sediment computations;
- Produce data summary report.

Laboratory Sediment Sample Analyses

- Suspended sediment and bedload samples will be analyzed in GMA's laboratories.

METHODS

Continuous Monitoring: Stage and Turbidity

The Williams Creek near Ferndale surface water monitoring station was re-occupied on October 18, 2017. Monitoring equipment included three staff plates, a Campbell Scientific (CS) CR850 data collection platform, a CS OBS3+ turbidimeter, a WaterLog H-310 pressure transducer and a Sierra Wireless AirLink RV50 cellular gateway (Figure 2). Devices are powered by a common 12 volt solar supported system. An FTS DTS-12 turbidimeter was used when the OBS3+ was removed due to equipment failure.

The site surveys were conducted using an auto level, following the methodologies outlined in Harrelson et. al. (1995).

Figure 2. Upstream view of sampling section, turbidimeter boom on cable, gage house and solar panel.

Streamflow Measurement

Streamflow measurements were generally collected according to standard USGS protocols and as described in the GMA Surface Water QA Plan (GMA 2002). Stream channel wading techniques for lower flows and bridge techniques for high flows were employed using Price Pygmy or AA current meters.

All discharge measurements were entered and catalogued using a modified USGS-type 9-207 discharge measurement summary form.

Sediment Data Collection

Low to mid-range suspended sediment data were collected by wading the stream channel using a US DH-48 handheld sampler. High flow data were collected from the land owner's bridge using a rope deployed DH-76 suspended sediment sampler. Bedload samples from water year 2017 indicated that significant bed mobility occurred above a stage of 9.4 feet. Therefore bedload samples for water year 2018 were to be collected when stage exceeded 9.4 feet. Sediment sampling protocols followed standard USGS procedures (Edwards and Glysson, 1999) for Equal Width Increment (EWI) sampling. Information recorded for each sample included: time, date, site, stage, bottle #, pass#, method, equipment used, etc. The GMA suspended and coarse sediment laboratories processed the sediment samples.

Computations

Streamflow

Stage-discharge relationships (rating curves) were developed and applied to the adjusted continuous-stage records to generate 10 minute streamflow records. streamflow records were computed in the WISKI software suite, a comprehensive hydrologic time-series database management system developed by Kisters AG. The WISKI Suite incorporates complete USGS standards for surface water streamflow computations which utilize methods according to WSP 2175, Measurement and Computation of Streamflow vols.1 and 2 (Rantz 1982).

Suspended Sediment

Turbidity was employed as a surrogate for suspended sediment concentration (SSC). In order to develop continuous suspended sediment concentration, suspended sediment-turbidity transport curves were developed for the <0.063mm and the ≥0.063mm size classes. SSC values for the transport curves were obtained from the depth-integrated suspended sediment samples whereas the turbidity values were pulled directly from the continuous turbidity record. SSC-turbidity transport curves were applied to the corrected continuous turbidity record in order to develop continuous SSC for each size class. Continuous SSC for each size class was transformed into continuous suspended sediment discharge (SSD) using the standard equation:

$$Q\ (\text{cfs}) * SSC\ (\text{mg/l}) * 0.002697 = SSD\ (\text{tons/day})$$

Continuous SSD was then summed over the computational period to compute the load for each size class. Total suspended sediment load was computed by summing the partial loads. For detailed information on suspended sediment discharge computations see the Station Analysis in Appendix A. Transport curves utilized in the computation of fine (<0.063mm) and coarse (≥0.063mm) suspended load are provided in Appendix B.

Bedload

Bedload transport curves were developed from discharge-bedload sample pairs from water year 2017 and continuous bedload discharge was estimated as a function of stream discharge for total bedload (no partial loads were computed as was done for suspended sediment).

RESULTS

Continuous Monitoring

The data collection platform and pressure transducer system functioned properly throughout the monitoring period. The OBS3+ turbidimeter experienced two equipment failures requiring the probe to be replaced with a DTS-12. The DTS-12 was installed for the periods: 12/21/2017 08:40 to 1/11/2018 10:30; and 4/4/18 11:00 to 5/2/2018 10:50. The upper range of the DTS-12 was exceeded during a few high flow events. Low flow turbidity data were removed when the probe was too close to the stream bed or when the probe was out of the water. Gaging details can be found in the Station Analysis (Appendix A).

Streamflow

The low water control at the site is a downstream riffle. The low water control is prone to shifts. At high water, channel control dominates and was stable through the computational period. Twenty four discharge measurements were collected during the computational period. Measured streamflow ranged from 0.34 to 249 cfs (Appendix C) and computed instantaneous discharged ranged from 0.32 cfs to 433 cfs (Appendix A). Rating 1.1, developed for use in water year 2017, was continue in use for the current computational period. Discharge measurement 20 taken on October 18, 2017, indicated that the low end of rating 1.1 needed to be extended. The low end of Rating 1.1 was extended and the rating was renamed Rating 1.1 to indicate the modification (Figure 3). Four stage variable shifts were identified in water 2018 which are detailed in Appendix A. The hydrograph and the continuous trace for turbidity are provided in Figure 4. Cross section surveys conducted at the sampling cross section are shown in Figure 5.

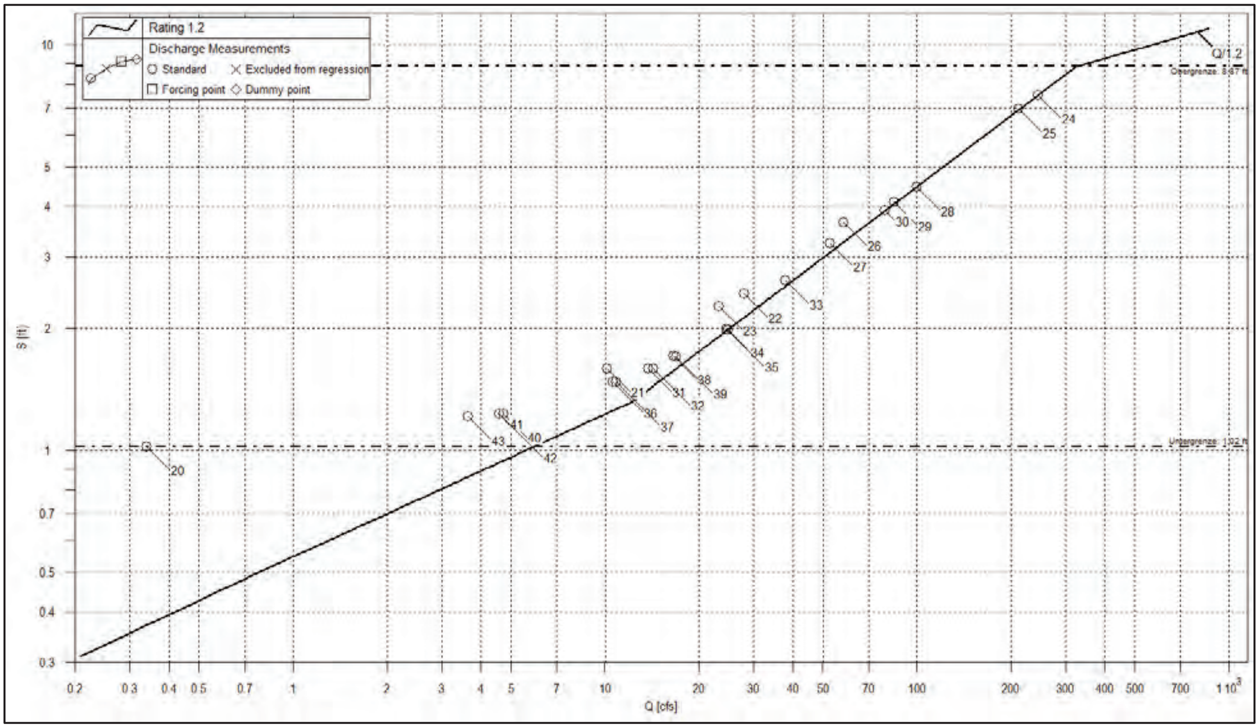


Figure 3. Rating 1.2 and streamflow measurements collected during the computation period for Williams Creek near Ferndale.

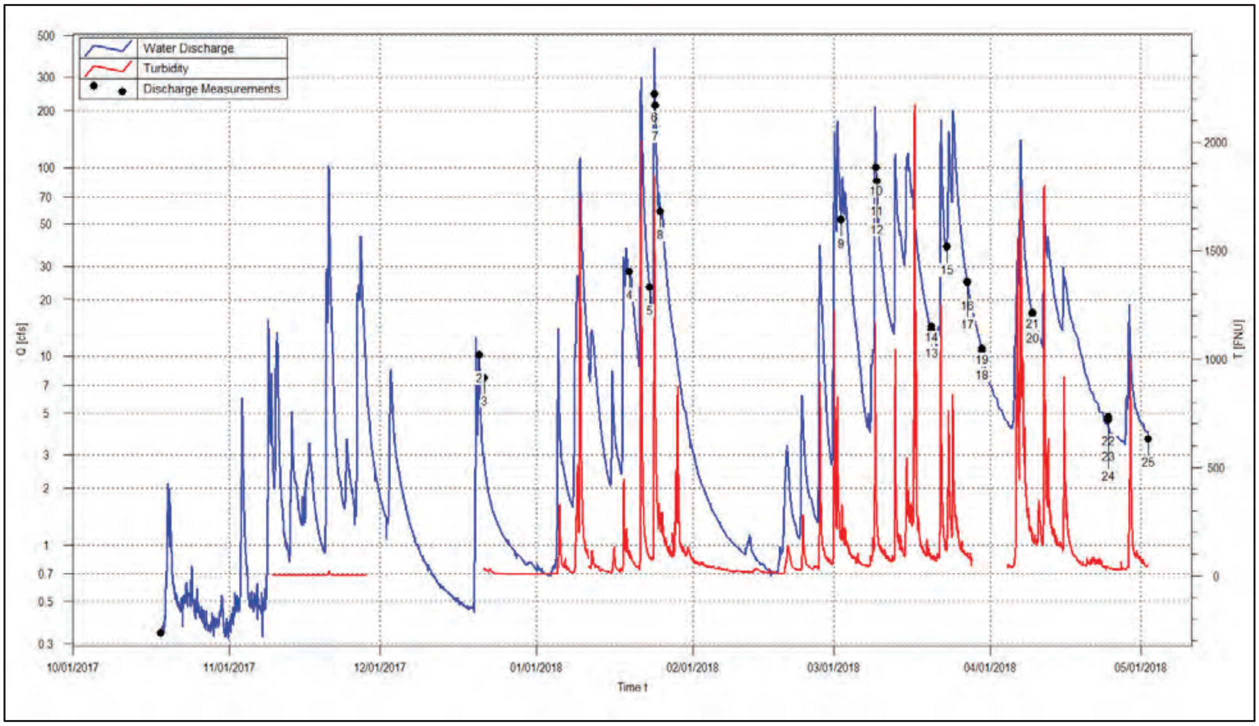


Figure 4. Computation period hydrograph and continuous turbidity for Williams Creek near Ferndale.

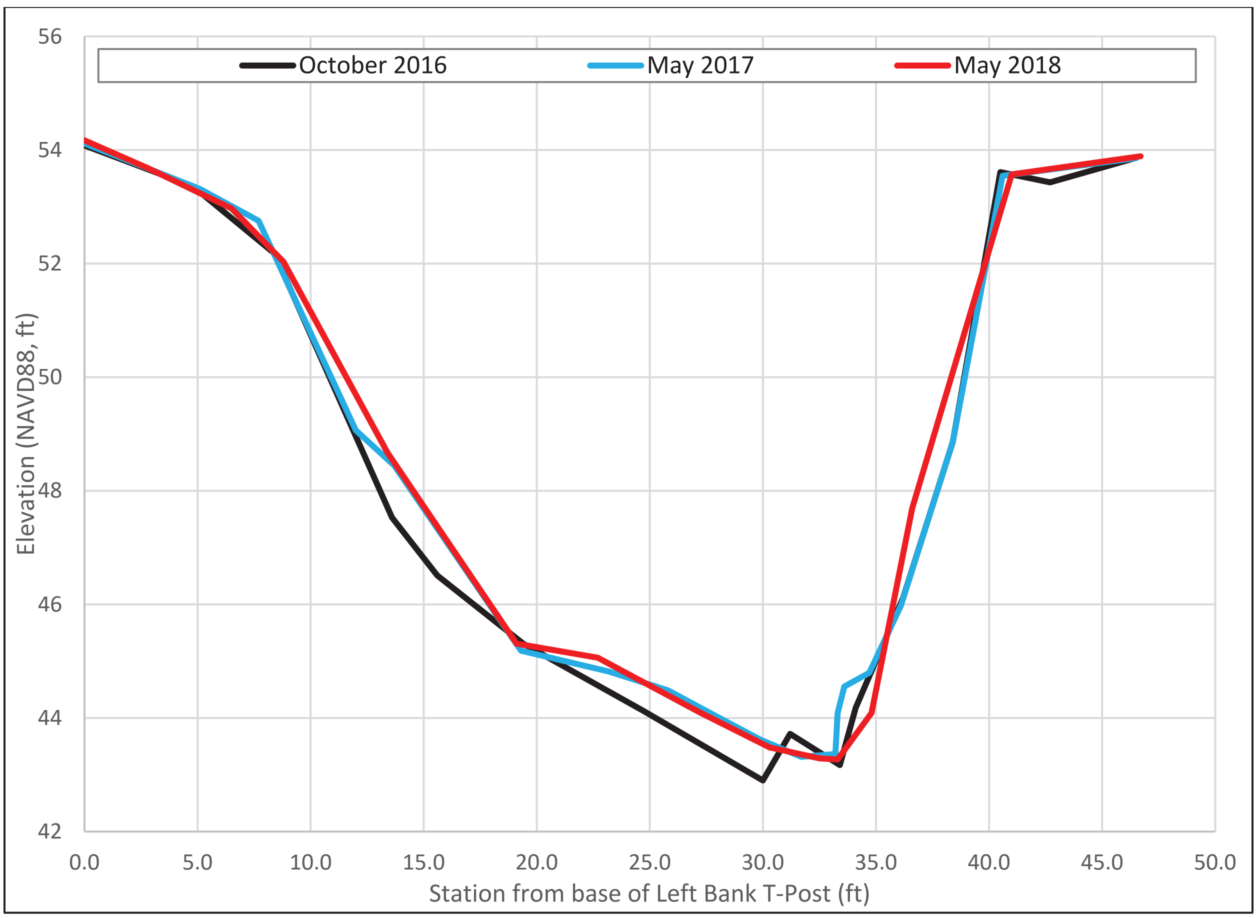


Figure 5. Cross section surveys of the sampling section at the Williams Creek near Ferndale.

Suspended Sediment Sampling

Twelve one-pass samples were collected during the computational period (Table 2). Sampled concentrations ranged from 133 to 8730 mg/l.

Table 1. Williams Creek Water Year 2018 Suspended Sediment Sampling Summary.

Williams Creek near Ferndale, CA

Suspended Sediment Sampling Summary -- WY2018

Sample Number	Date & Mean Time	Average Discharge (cfs)	Average SSC <0.063mm (mg/l)	Average SSC ≥0.063mm (mg/l)	Average SSC Total (mg/l)	Average SSD Total (tons/day)
2018-01	1/19/2018 12:34	28.5	150	9.3	160	12.3
2018-02	1/19/2018 12:50	28.9	126	7.3	133	10.4
2018-03	1/24/2018 11:27	390	6960	1000	7960	8300
2018-04	1/24/2018 14:20	225	3510	869	4380	2650
2018-05	1/24/2018 15:56	199	3100	927	4030	2140
2018-06	1/24/2018 16:19	190	2830	676	3500	1790
2018-07	3/9/2018 12:14	93.0	1700	335	2030	503
2018-08	3/9/2018 13:33	82.0	798	415	1210	266
2018-09	3/9/2018 14:33	76.4	1210	250	1460	297
2018-10	3/22/2018 8:01	177	7720	1000	8730	4180
2018-11	3/22/2018 10:11	141	4230	723	4960	1840
2018-12	3/22/2018 11:44	111	2710	582	3290	975

Values Rounded According to Porterfield (1972)

Bedload Sampling

No bedload samples were collected during the computation period. Bedload sampling was to be conducted over 9.4 feet and only 1 event, January 24, 2018 met this threshold (9.41 feet).

Sediment Loads

Table 2 shows the computed sediment loads for the computation period. Bedload comprised a very small proportion of the total load on Williams Creek (0.07%) during the computation period.

Table 2. Computational period sediment load totals for Williams Creek near Ferndale, CA.

Suspended Sediment			Bedload	Total Load
<0.063 mm (tons)	≥0.063 mm (tons)	Total Suspended Sediment (tons)	Total Bedload (tons)	Total (tons)
10,249	2,769	13,018	9.41	13,027

REFERENCES

Edwards, T.K., and Glysson, G.D., 1999. Field Methods for Measurement of Fluvial Sediment. U.S. Geological Survey Techniques of Water Resources Investigation, Book 3 Chapter C2, 89 p.

Graham Matthews & Associates, 2002. *Quality Assurance Project Plan for Surface Water, Sediment Transport, and Geomorphic Data Collection.*

Harrelson, C.C., Rawlins, C.L., and Potyondy, J.P., 1994, *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station RM-245.

Rantz, S.E. and others. 1982. *Volume 1: Measurement of stage and Discharge, and Volume 2: Measurement and Computation of Discharge.* United States Geological Survey, Water Supply Paper 2175.

Williams Creek near Ferndale, California

STATION ANALYSIS

SURFACE WATER RECORD

WY 2018: (October 18 to May 2)

RECORDS – Water Discharge, Suspended Sediment Discharge and Bedload Discharge

EQUIPMENT – GMA Hydrology, Inc.(GMA) at the request of Humboldt County Resource Conservation District (RCD), established this site in October 2016 and reoccupied the site in October 2017 as requested by GHD Inc. (GHD). Suspended sediment sampling equipment consists of a DH-76 and DH-48. Stage references (staff plates) were installed near the gaging station and were levelled to a temporary benchmark which received a known elevation during the Williams Creek, Upper Salt River topographic survey performed in the fall of 2017. A Design Analysis H-310 pressure transducer and Campbell Scientific CR850 data collection platform were re-installed on October 18, 2017 at 12:10 (times are 24 hr). A Campbell Scientific (CS) OBS3+ turbidimeter was installed as well. The OBS3+ malfunctioned on two occasions and had to be removed. A Forest Technology Systems (FTS) DTS-12 turbiditimeter replaced the OBS3+.

Inside recording gage: Design Analysis H-310 (Accuracy to ± 0.007 ft)
Campbell Scientific Inc. OBS 3+ (Accuracy 2% of reading or 0.5 NTU), (Range: 0-4,000 FBU)
Forest Technology Systems DTS-12 (Accuracy (0-499.99 FNU ± 2% +0.2 FNU), (500.00 to 1600 FNU ± 4%))

Outside staff gage: Three enameled sections (0.00 ft – 10.14 ft).

GAGE HEIGHT RECORDS – The gage was re-occupied on October 18, 2017. The record is incomplete for the computational period. There are two small gaps in the record on: December 21, 2017 from 09:10 to 14:00 and January 11, 2018 from 10:40 to 11:10, which occurred during station maintenance. During the computational period a maximum gage height of 9.41 ft. occurred on January 24, 2018 10:50. The minimum gage height for the computational period of 1.02 ft. occurred on October 18, 2017 13:10.

Staff height readings were compared to recorded gage height values and the gage height was corrected when necessary.

DATUM CORRECTIONS – No correction necessary. A level survey was performed on May 2, 2018.

CONTROL – The low water control at the site is a downstream riffle. The low water control is prone to shifts. At high water, channel control dominates and was stable through the computational period.

RATING – Twenty-four discharge measurements (20-43) were made during the computational period. Measurements were made with a Price AA meter or Pygmy meter and Aquacalc Pro attached to a wading rod or suspended from a sounding reel attached to a bridge board. Measured discharge for the period ranged from 0.34 cfs to 249 cfs. Computed instantaneous discharged ranged from 0.32 cfs to 433 cfs.

Discharge measurement 20 taken on October 18, 2017, indicated that the low end of rating 1.1 needed to be extended thus warranting the development of a new version of the rating which was named Rating 1.2.

Rating 1.2 has a validated range between 1.04 ft (6.44 cfs) and 8.87 ft (332 cfs).

Measurement 20 (Poor) through 23 (Fair) indicated a negative shift to Rating 1.2. Measurements 24 (Poor) and 25 (Fair) fell within acceptable limits of the high end of Rating 1.2. Stage variable shift (SV18-01) was brought into full effect at the beginning of the water year (October 1, 2017).

Measurement 26 (Good), taken on January 25, 2018, indicated an increased negative shift. Stage variable shift (SV18-02) was brought into full effect on January 24, 2018 at 15:00.

Measurement 27 (Fair), taken on March 2, 2018, indicated a positive shift. Stage variable shift (SV18-03) was brought into full effect on March 1, 2018 17:01.

Measurements 28 through 43 indicate a change to SV18-03. The stage variable shift (SV18-04) was prorated into effect on March 9, 2018 from 05:00 to 07:00 and was used for the rest of the computational period.

DISCHARGE –Rating 1.2 is used as follows:

Oct. 1 to Jan. 24 (14:00)	SV18-01 (1.02, -0.65; 1.59, -0.36; 6.96, 0.00)
Jan. 24 (15:00) to Mar. 1 (17:00)	SV18-02 (2.43, -0.66; 3.65, -0.39; 6.94, 0.00)
Mar. 1 (17:01) to Mar. 9 (05:00)	SV18-03 (1.02, -0.65; 3.24, -0.17; 3.90, 0.00)
Mar. 9 (07:00) to May 2	SV18-04 (1.21, -0.33; 1.47, -0.22; 2.00, 0.00)

SEDIMENT

Data summary for Partial WY 2018

Total number of samples:	
Suspended sediment sets	0
Single pass suspended sediment samples	12
Box sample sets	0
Single box samples	0
Bedload sets	0
Single pass bedload samples	0
Three pass bedload samples	0
Number of field turbidities measured	0
Number of suspended sediment size analysis samples:	
Particle size analysis	0
0.063mm break	12
0.500mm break	0
Number of bedload sediment size analysis samples:	
Particle size analysis	0
Number of suspended sediment discharge measurements	12
Number of bedload discharge measurements	0
Maximum flow sampled by:	
GMA technicians, ft^3/s	249
Range of concentrations sampled by:	
GMA technicians, mg/l	133-8730
GMA technicians, ton/d	0
Peak flow, ft^3/s	433
Periods of faulty record	

Turbidity

October 18, 2017 at 12:10 – November 9, 2017 at 15:50
November 28, 2017 at 09:40 – December 21, 2017 at 14:10
January 9, 2018 at 14:40 – January 9, 2018 at 18:20
January 11, 2018 at 10:30 – January 11, 2018 at 11:20
March 28, 2018 at 22:40 – April 4, 2018 at 11:00
April 7, 2018 at 00:10 – April 7, 2018 at 05:20
April 11, 2018 at 18:30 – April 11, 2018 at 20:50

Coefficients.-- None used.

Continuous Turbidity.-- The turbidity record is incomplete for the computational period. A CS OBS3+ turbiditimeter was installed on October 18, 2017. Due to excessively low flow conditions in October and November the turbidimeter was at the water surface or too close to the bed. Biofouling also occurred in December. On December 21, 2017 at 08:40 the OBS3+ was removed for repairs and replaced with a FTS DTS-12

The maximum turbidity value for the DTS-12 was exceeded on January 9, 2018 from 14:40 to 18:20.

On January 11, 2018 at 10:30 the OBS3+ turbidimeter was re-installed and the DTS-12 was removed.

On March 28, 2018 at 22:40 the OBS3+ failed. The OBS3+ was removed on April 4, 2018 at 11:00 and replaced with a DTS-12 turbidimeter.

The maximum turbidity value for the DTS-12 was exceeded on April 7, 2018 from 00:10 to 05:20 and on April 11, 2018 from 18:30 to 20:50.

Several turbidity spikes were removed. Turbidity spikes are defined as short periods of time, 10-minutes to several hours, during which the optics of the probe were presumably fouled or obstructed.

During the computational period the maximum turbidity was 2,170 FBU on March 17, 2018 at 02:40, and the minimum turbidity was 0.81 FBU, which occurred on November 19, 2018 at 03:30.

Total suspended sediment-discharge computations. -- Total suspended-sediment discharge was computed by summing the partial suspended-sediment discharges.

Size analysis. – Twelve cross-sectional, depth-integrated samples were analyzed using a split at <0.063mm. Sediment discharge compuations were completed for <0.063mm (fine) and ≥0.063mm (coarse) size classes.

Partial suspended sediment-discharge computations. – Twelve single pass suspended sediment samples were collected. No outliers were identified for either size class.

Turbidity versus SSC transport curves were analyzed for Water Year 2018 using the twelve SSC samples from water year 2018 in addition to the nineteen SSC samples from water year 2017. Linear regressions were used for the analysis and the equations were forced through a y-intercept of zero.

For the <0.063mm size class, the turbidity versus SSC transport curve is defined by Eqn. (1).

$$SSC = 3.76688 * Turbidity + 0, \qquad r = 0.96 \qquad (1)$$

Eqn. (1) was developed using samples 1-31 and has a validated range between 3.00 FBU and 2,323 FBU.

For the ≥0.063mm size class, the turbidity versus SSC transport curve is defined by Eqn. (2).

$$SSC = 1.01796 * Turbidity + 0, \qquad r = 0.98 \qquad (2)$$

Eqn. (2) was developed using all samples collected during Water Years 2017 & 2018 and has a validated range between 3.00 FBU and 2,323 FBU.

The tranport curves were used to develop continuous concentration curves for the <0.063mm and the ≥0.063mm size classes. Suspended-sediment discharge was computed directly from the continuous concentration once the continuous concentration data had been checked and its accuracy verified.

Bed material.-- None.

Bedload measurement. – No bedload samples were collected in water year 2018.

Bedload-discharge computations. – Using bedload samples collected in water year 2017, a sediment transport curve was developed for Total Bedload Discharge versus Water Discharge and is defined by Eqn. (3). No outliers were identified.

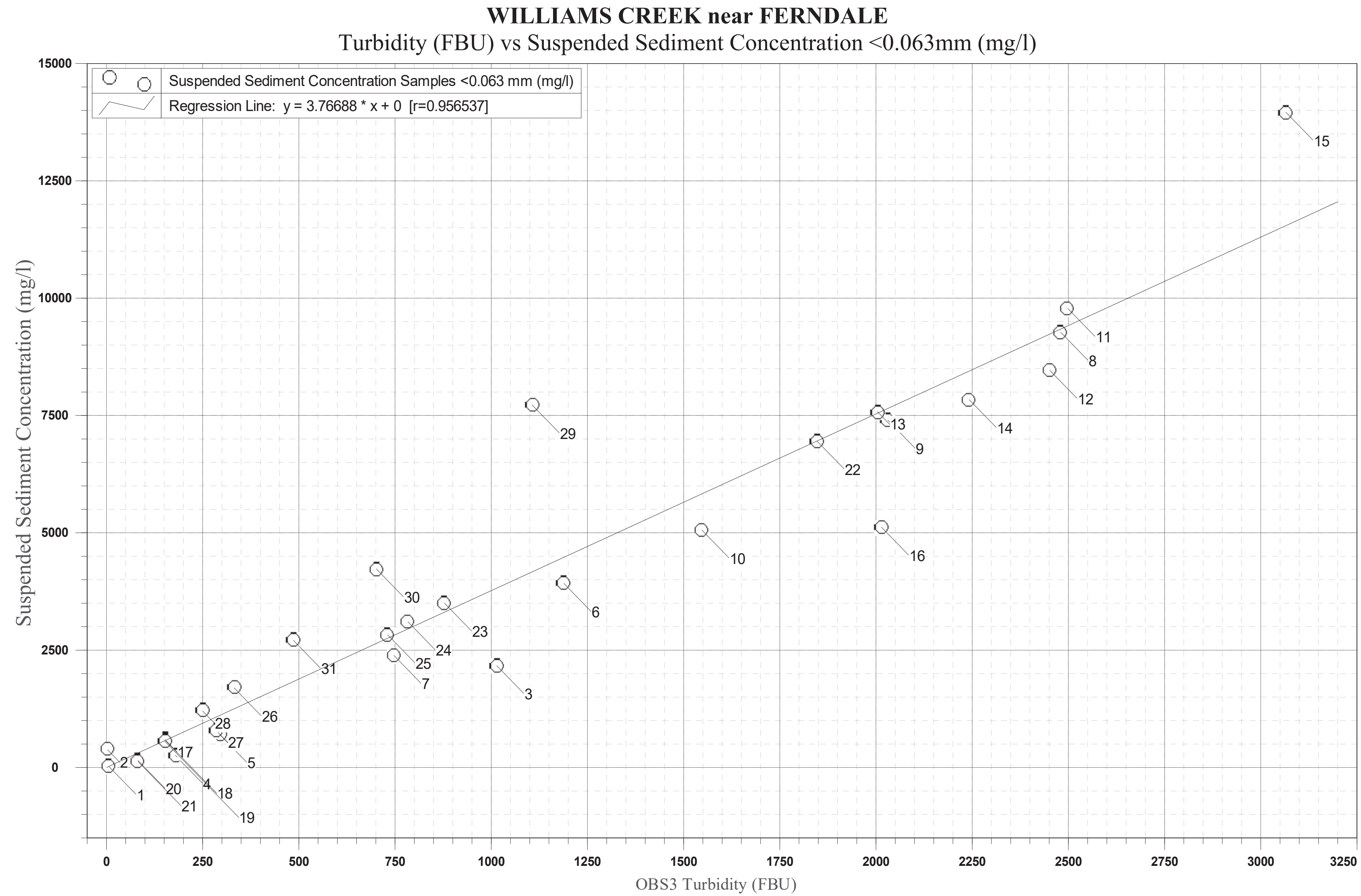
$$BLD = 9.95e-005 * Discharge^{1.89}, \qquad r = 0.93 \qquad (3)$$

Partial bedload-discharge computations -- None

REMARKS – The record should be considered **Fair** for the computational period. The record should be considered estimated when the gage height is outside the validated range of Rating 1.2.

The sediment record rating follows the discharge record rating except during gaps in the turbidity record when continuous SSC was estimated using discharge. During those time period the sediment record should be considered **Estimated**.

Record Worked by: T. Grey, June 2018
Record Reviewed by: C. Pryor, June 2018



PROJECT:

2018 WILLIAMS CREEK STREAMFLOW AND SEDIMENT TRANSPORT MONITORING

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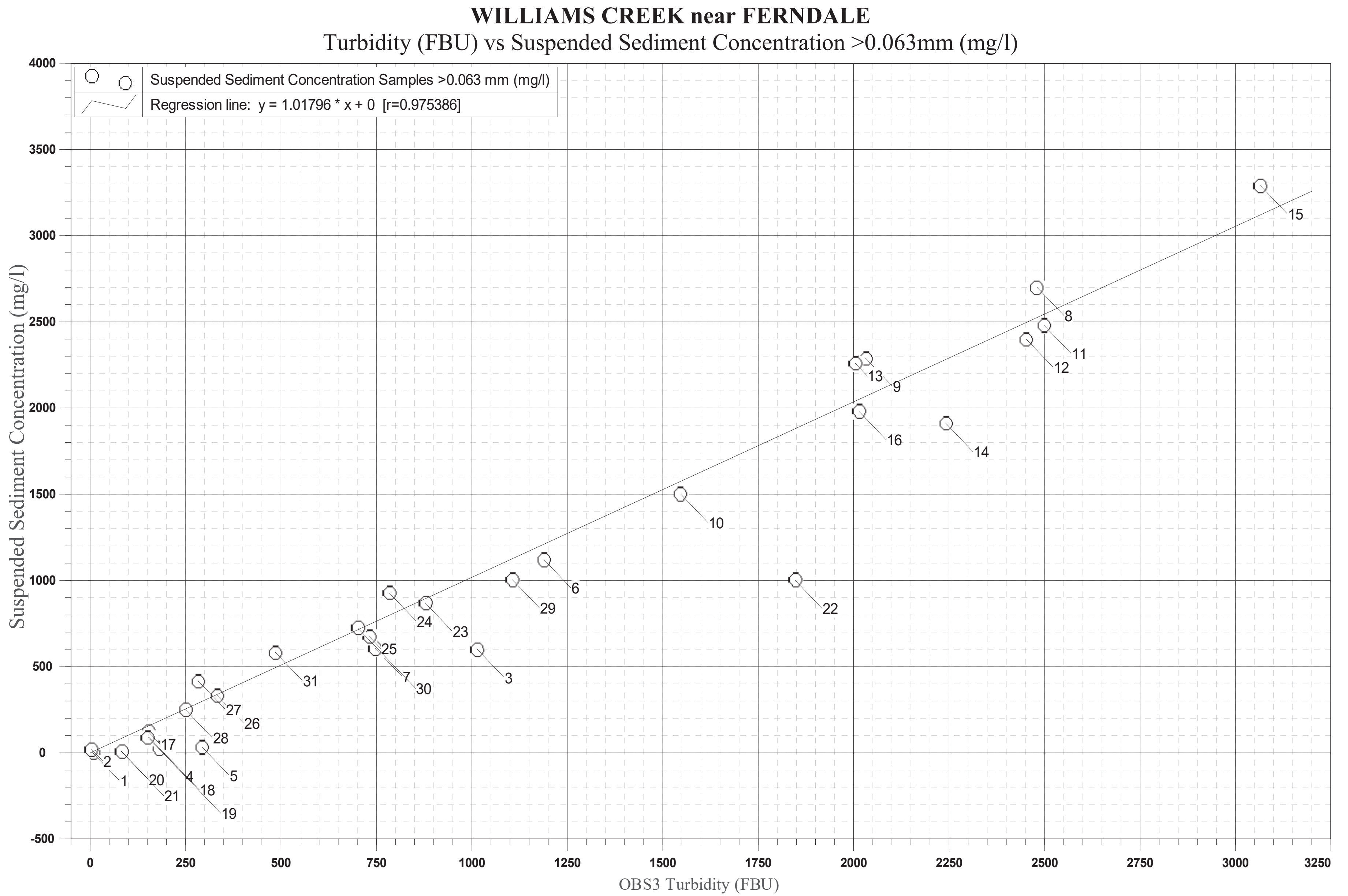
APPENDIX

B-1



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2018 WILLIAMS CREEK STREAMFLOW AND SEDIMENT TRANSPORT MONITORING

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APPENDIX

B-2

DISCHARGE SUMMARY SHEET

LOCATION: Williams Creek near Ferndale **WATER YEAR: 2018**

STATION NUMBER: 11479554

Measurement Number	WY Msmt #	Date	Made By	Width (feet)	Mean Depth (feet)	Area (ft2)	Mean Velocity (ft/sec)	Staff Height (feet)	Gage Height (feet)	Discharge (cfs)	Rating 1.2 SV18-01			Method	No. of Msmt sections	Begin Time (hours)	End Time (hours)	Msmt Rating	Notes
											Comp. Shift	Used Shift	Percent Diff.						
20	**2018-01**	10/18/2017	T. Grey	3.2	0.25	0.79	0.43	1.02	1.02	0.34	-0.80	-0.65	0	Wading	10	12:38	13:01	Poor	
21	**2018-02**	12/20/2017	S. Daugherty	8.0	0.71	5.68	1.35	1.61	1.59	10.2	-0.36	-0.36	2	Wading	14	14:22	15:25	Fair	
22	**2018-03**	01/19/2018	S. Daugherty	15.4	1.14	17.60	1.59	2.46	2.43	28.0	-0.33	-0.30	0	Wading	31	11:33	12:34	Fair	
23	**2018-04**	01/23/2018	S. Daugherty	14.8	1.00	14.74	1.57	2.27	2.26	23.2	-0.35	-0.31	-3	Wading	24	10:26	11:16	Fair	
24	**2018-05**	01/24/2018	D. Sheldon	30.0	4.33	129.80	1.89	7.78	7.52	249	-0.20	0.00	2	Bridge	26	12:15	14:15	Poor	Large change in Stage height from beginning of measurement to end. (Started 8.40' ended at 7.15')
25	**2018-06**	01/24/2018	D. Sheldon	27.0	4.06	109.65	1.93	6.95	6.94	212	-0.04	0.00	-1	Bridge	23	14:27	15:43	Fair	
											Rating 1.2 SV18-02								
26	**2018-07**	01/25/2018	S. Daugherty	18.7	2.05	38.25	1.52	>3.5	3.65	58.2	-0.39	-0.39	0	Wading	22	15:46	17:01	Good	
											Rating 1.2 SV18-03								
27	**2018-08**	03/02/2018	S. Daugherty	17.9	1.74	31.20	1.71	3.24	3.24	52.6	-0.17	-0.17	0	Wading	17	11:52	12:52	Fair	
											Rating 1.2 SV18-04								
28	**2018-09**	03/09/2018	D. Sheldon	16.6	2.88	47.79	2.09	4.52	4.46	100	0.01	0.00	0	Wading	24	10:58	11:59	Good	.2 and .8 measurements for 20 seconds
29	**2018-10**	03/09/2018	D. Sheldon	16.1	2.54	40.92	2.07	4.10	4.09	84.6	-0.04	0.00	-2	Wading	24	12:44	13:23	Good	.2 and .8 measurements for 20 seconds
30	**2018-11**	03/09/2018	D. Sheldon	15.5	2.53	39.28	2.01	3.90	3.90	78.9	-0.01	0.00	0	Wading	24	13:49	14:31	Good	.2 and .8 measurements for 20 seconds
31	**2018-12**	03/20/2018	S. Daugherty	9.6	0.75	7.22	1.91	1.62	1.59	13.8	-0.17	-0.17	-1	Wading	23	9:15	10:46	Fair	Need to correct aquacalc file time
32	**2018-13**	03/20/2018	S. Daugherty	11.8	0.65	7.63	1.88	1.62	1.59	14.3	-0.15	-0.17	3	Wading	23	9:51	10:16	Fair	Aquacalc file set to local time
33	**2018-14**	03/23/2018	S. Daugherty	16.6	1.20	19.98	1.9	2.64	2.62	38.0	-0.08	0.00	-5	Wading	28	12:01	12:44	Good	Aquacalc file set to local time
34	**2018-15**	03/27/2018	S. Daugherty	12.9	0.82	10.59	2.32	2.00	1.99	24.6	-0.01	0.00	-1	Wading	30	12:57	13:31	Fair	Aquacalc file set to local time
35	**2018-16**	03/27/2018	S. Daugherty	12.9	0.86	11.07	2.24	2.00	1.98	24.8	0.01	-0.01	1	Wading	31	13:36	14:20	Good	Aquacalc file set to local time
36	**2018-17**	03/30/2018	S. Daugherty	8.4	0.60	5.06	2.07	1.50	1.47	10.6	-0.22	-0.22	1	Wading	25	10:22	10:53	Good	Aquacalc file set to local time
37	**2018-18**	03/30/2018	S. Daugherty	8.4	0.63	5.29	2.05	1.50	1.47	10.9	-0.21	-0.22	4	Wading	22	10:58	11:20	Good	Aquacalc file set to local time
38	**2018-19**	04/09/2018	S. Daugherty	10.7	0.75	7.98	2.08	1.70	1.71	16.6	-0.13	-0.12	-2	Wading	28	11:10	11:42	Good	
39	**2018-20**	04/09/2018	S. Daugherty	10.7	0.76	8.12	2.08	1.70	1.70	16.9	-15.31	-0.12	2	Wading	25	11:44	12:10	Good	
40	**2018-21**	04/24/2018	S. Daugherty	7.5	0.39	2.93	1.615	1.23	1.23	4.73	-0.29	-0.32	12	Wading	14	12:35	12:51	Poor	
41	**2018-22**	04/24/2018	S. Daugherty	7.5	0.42	3.17	1.446	1.23	1.23	4.58	-0.30	-0.32	8	Wading	17	12:53	13:10	Poor	
42	**2018-23**	04/24/2018	S. Daugherty	7.5	0.43	3.24	1.419	1.23	1.23	4.59	-0.30	-0.32	8	Wading	14	13:11	13:25	Poor	
43	**2018-24**	05/02/2018	D. Sheldon	11.0	0.35	3.83	0.949	1.21	1.21	3.63	-0.35	-0.33	-6	Wading	20	9:51	10:32	Poor	

PROJECT:

2018 WILLIAMS CREEK STREAMFLOW AND SEDIMENT TRANSPORT MONITORING

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APPENDIX

C-1

Appendix C
Williams Creek Geomorphology and Existing Condition Hydraulics Technical Memorandum

Michael Love & Associates
Hydrologic Solutions
PO Box 4477 • Arcata, CA 95518 • (707) 822 -2411

Technical Memorandum

Date: February 2, 2020

To: Jeremy Svehla, Project Manager, GHD, Inc.

CC:

From: Rachel Shea, P.E. Engineering Geomorphologist, and Michael Love, P.E., Principal Engineer, Michael Love & Associates, Inc.

Subject: Technical Memorandum: Geomorphic Assessment, and Existing Condition Hydraulic Analysis of Williams Creek

1 INTRODUCTION

1.1 Purpose of Report

The purpose of this Technical Memorandum (TM) is to provide methodologies and results of a geomorphic analysis of Williams Creek, existing condition channel hydraulics, and sediment transport. It is meant to supplement an overall report addressing in-channel sedimentation and out-of-bank flooding along Williams Creek downstream of Grizzly Bluff Road.

1.2 Background

Williams Creek is a tributary to the Salt River in Ferndale, California. An aerial photograph of Williams Creek is shown on Figure 1. Downstream of Grizzly Bluff Road, Williams Creek has experienced chronic out-of-bank flooding for the past twenty years, inundating adjacent residents and pastures with both flow and sediment. Due in part to the excessive sediment load, Williams Creek currently splays across broad pastures at the historical connection with the Salt River, where it deposits sediment before slowly draining into the river downstream of Highway 211.

The Humboldt County Resource Conservation District (HCRCD) has been leading efforts to restore the Salt River, including re-connecting Williams Creek to the Salt River. However, the high sediment load in Williams Creek and chronic out-of-bank flooding and sedimentation that occurs along Williams Creek also necessitates rehabilitation of Williams Creek. Additionally, the rehabilitation of Williams Creek needs to address the sediment load that will be delivered to the Salt River after Williams Creek is re-connected. The Salt River has limited sediment transport capacity due to its low slope, and likely will not transport some or all of the sediment delivered from Williams Creek. Excess sediment delivered to the Salt River from Williams Creek would likely result in in-channel sedimentation, which would be detrimental to the restoration project as a whole.

The HCRCD retained the services of GHD, Inc. (GHD) and Michael Love & Associates, Inc. (MLA) to characterize the study area and identify potential actions to rehabilitate Williams Creek downstream of Grizzly Bluff Road. This TM summarizes the methodologies and results of a geomorphic analysis of Williams Creek and existing condition channel hydraulics and sediment transport capacity.

Horizontal Datum: NAD83 California State Plane Zone I

Figure 1
Williams Creek Vicinity Map

2 HYDROLOGY

Williams Creek has a contributing drainage area of 6.0 square miles at Bridge 3 off of Rose Avenue, about 3,000 feet downstream of Grizzly Bluff Road, where flow gaging and sediment transport sampling was performed for the project. Downstream of Bridge 3, Williams Creek's banks are perched above its floodplain; thus, the watershed size does not substantially increase downstream of Bridge 3. All flow computations are based on the contributing drainage area at Bridge 3.

The Williams Creek watershed upstream of Bridge 3 consists of a combination of ranches and forested hillslopes. Downstream of Grizzly Bluff Road the contributing watershed area is limited to the stream width, as the floodplain drains away from Williams Creek. The basin-average annual precipitation for the Williams Creek watershed is 50.7 inches (USGS StreamStats, 2019) and falls primarily as rainfall. Rainfall occurs primarily between October and May within the region. During late summer and early fall, the stream's flowrate become extremely low; less than 1 cfs.

StreamStats summaries of the Williams Creek watershed are shown in Attachment 1.

2.1 Peak Flows and Return Periods

Williams Creek streamflows have not historically been gaged; therefore, indirect methods were necessary to compute peak flow magnitude and associated return period in Williams Creek. For comparative purposes, peak flow return periods in Williams Creek at Bridge 3 were calculated using two different methods: (1) Log Pearson Type III probabilistic analyses of streamflows from a nearby USGS gage and (2) USGS regional regression equations (Gotvald et al, 2012).

Log Pearson Type III analyses were prepared using annual peak flow data from the USGS gage, Bull Creek near Weott (USGS No. 11476600), and applying methods in Bulletin 17B (USGS, 1982). Bull Creek was selected because it is the closest USGS gage with a relatively small watershed (27.6 square miles based on Gotvald et al., 2012), similar rainfall patterns as the Wildcat Range, and an extended period of continuous record (from 1961 through October 2018). The results of the analyses were normalized into units of cfs per square mile and then scaled linearly by the watershed area for Williams Creek at Bridge 3. Computed peak flows in Williams Creek and their associated return periods are provided in Table 1.

USGS regional regression equations from Gotvald et al. (2012) were also used to compute peak flow return periods for Williams Creek at Bridge 3 using StreamStats (Gotvald, et al, 2012), as given in Table 1.

The two methods predicted similar peak flows for Williams Creek. Flows computed by the USGS regional regression equation are slightly lower than those based on the Log Pearson Type III analyses. For consistency, the results of the Log Pearson Type III analyses were used to reference peak flow magnitudes and return periods in this TM.

Computations are presented in Attachment 1.

Table 1. Williams Creek at Bridge 3 estimated peak flows using two different methods. The contributing drainage area at Bridge 3 is 6.0 square miles.

Analysis Method	Peak Flow (cfs) for Indicated Return Period							
	1.01-Year	1.2-Year	1.5-Year	2-Year	5-Year	10-Year	50-Year	100-Year
LP III Bull Creek near Weott Scaled	107	299	440	584	971	1,239	1,837	2,089
USGS Regional Regression Equations	-	-	-	436	823	1,100	1,740	2,030

2.2 Water Level and Flow Gaging

GMA Hydrology, Inc. (GMA) established a water level and sediment sampling station at Bridge 3. They conducted flow and sediment sampling from October 26, 2016 through April 30, 2017, and from October 18, 2017 through May 2, 2018, representing water year (WY) 2017 and 2018. A water year extends from October 1 of the previous through September 30 of the named water year. The objective of the flow monitoring was to obtain continuous flow records for use in computing total annual bedload and suspended sediment load transported by Williams Creek at Bridge 3 for each water year.

Figure 2 shows a plot of gaged flows in Williams Creek during WY 2017 and WY 2018 (GMA, 2017, 2018). The 1.2-year flow is shown for reference. WY 2017 had numerous flow peaks well above a 2-year flow event. A peak flow of 788 cfs was recorded on December 15, 2016, which had a return period of between 3 and 4 years. WY 2018 had much lower peak flows, with only one event exceeding a 1.2-year return period magnitude.

GMA flow measurements and sediment sampling methods and results are presented in Section 7.

MLA installed and HCRCD downloaded five water level loggers along Williams Creek from November 11, 2017 through May 10, 2018. The locations of the water level loggers are shown in Figure 3 and Figure 5**.**

Water levels at these locations combined with water level and streamflow data at Bridge 3 were used to calibrate an existing condition hydraulic model of the project area (Section 6.1).

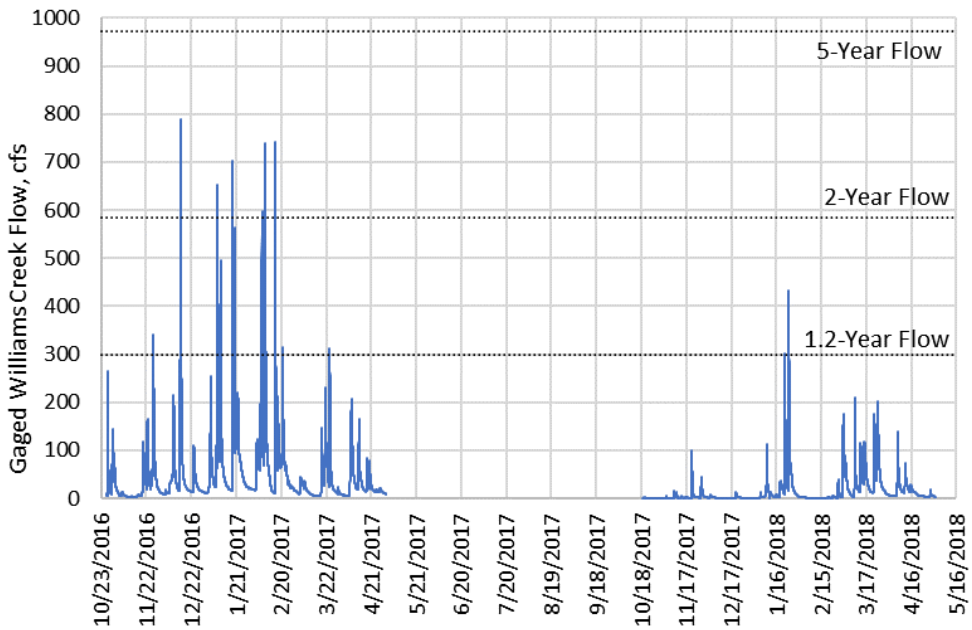


Figure 2. Gaged flows in Williams Creek during the 2017 and 2018 water years, with return periods indicated for reference.

3 WATERSHED GEOLOGY

Within the Wildcat Range, the Williams Creek watershed is underlain by several rock formations within the highly unstable Wildcat Group (Ogle, 1953). The unstable geology of the Williams Creek watershed is compounded by high rates of tectonic activities and high rainfall rates.

The Rio Dell formation comprises most of the upper watershed, and consists of massive mudstones, alternating thin sandstone and mudstone, siltstones, and very fine-grained sandstones. Weathering patterns in the mudstones formation are typically an intricate system of cross fracturing or onion-skin weathering. Numerous landslides are mapped within the Rio Dell Formation.

Northward of the Rio Dell formation, where the channel slope decreases and the stream valley begins to widen, the Scotia Bluffs sandstone comprise the valley walls. The Scotia Bluffs sandstones are massive sandstones, colloquially called "Ferndale Sandstones," and tend to form vertical cliff faces and ledges. The valley bottom is comprised of recent alluvium.

The Carlotta formation forms the north side of the Wildcats, consisting of resistant conglomerate made up of rounded material ranging from sand size to 8-inch boulders. The formation also contains sandstones and claystones that weather rapidly and form landslides. This formation typically forms tall vertical cliffs that undergo mass wasting with the erosion of the claystones and structural failure of the conglomerates and sandstones.

Where Williams Creek exits the Wildcats, it flows onto the Eel River floodplain, which is underlain by recent alluvium.

4 WILLIAMS CREEK GEOMORPHIC PROCESSES THROUGH HISTORY

The Salt River basin, including Williams Creek, was settled by Euro-Americans in the early 1850's. The watershed was cleared for timber and agriculture conversion destabilized already unstable soils in the Wildcat Range (Downie et al., 2005), increasing the sediment load to Williams Creek. An evaluation of historical maps found that, prior to Euro-Americans settlement, there were dense thickets of vegetation and an appropriately 700-acre freshwater wetland between lower Williams Creek and Coffee Creek to the east (Downie, et al., 2005,1993). The presence of this wetland was likely a result of an alluvial fan that formed where Williams Creek exits the Wildcat Range. The alluvial fan trapped sediments and delivered water (surface and ground) to the Eel River floodplain, where a vast wetland formed. The combination of sediment deposition across the alluvial fan and the large receiving wetland likely minimized the delivery of all but the finest sediment to the Salt River (Downie, et al., 2005,1993).

The freshwater wetland was ditched and drained around 1884 (Downie, et al., 2005), requiring the excavation through the natural high ground ("levee") running along the south bank of the Salt River. Most of the drainage network still exists and is in use today. Landowners also constructed makeshift berms along Williams Creek to reduce overbank flooding. This berming and ditching resulted in the delivery direct and rapid delivery of flow and sediment from Williams Creek into the Salt River.

Prior to1967, the Salt River served as an active side-channel of the Eel River. During higher flows in the river, waters would spill into the head of the Salt River channel across from the City of Fortuna and then flow back into the river near the mouth, scouring accumulated sediment from the Salt River. In 1967 the Leonardo Levee was constructed to prevent overflows from the Eel River from entering the Salt River (Downie et al., 2005), thus eliminating this aspect of the Salt River hydrology and geomorphology.

In 1998, sediment accumulation at the confluence of William Creek and the Salt River created a sediment plug isolating the Upper Salt River and its tributaries (Downie, et al., 2005). Shortly after, a ditch and berm system was constructed that directed Williams Creek into the Upper Salt River, resulting in elevated water levels in existing slough channels east of Williams Creek. These ponded waters would drain into the Eel River during wet periods by flowing out Old River.

In 2016, flows overtopped and breached a portion of the berm at the Williams Creek confluence, causing Williams Creek to once again flow into the lower Salt River. Currently, flows from Williams Creek are conveyed to the northwest in a large sediment splay across low pasture before flowing under Highway 211 and joining the Salt River. The current flow pattern is evident on Figure 1, and is labeled as "Williams Creek Sediment Splay".

According to local landowners, flow conveyance in Lower Williams Creek was maintained by clearing sediment and removing low-hanging vegetation and debris jams that blocked the channel. With changes in the regulatory environment, in-part associated with the listing of Coho Salmon in 1997 under the Federal Endangered Species Act, clearing of woody debris from the channel and riparian corridor was curtailed. Wood jams comprised of smaller woody debris have since accumulated in many reaches of the channel, causing local aggradation, decreased channel capacity, and increased frequency and extents of overbank flooding.

Since 2011, in an effort to reduce sedimentation to Williams Creek, the Natural Resource Conservation Service (NRCS) and the HCRCD have been implementing upslope sediment reduction projects, including streambank stabilization, hillslope stabilization, roadway improvements, and cattle exclusion fencing along upper Williams Creek watershed.

5 GEOMORPHIC SETTING

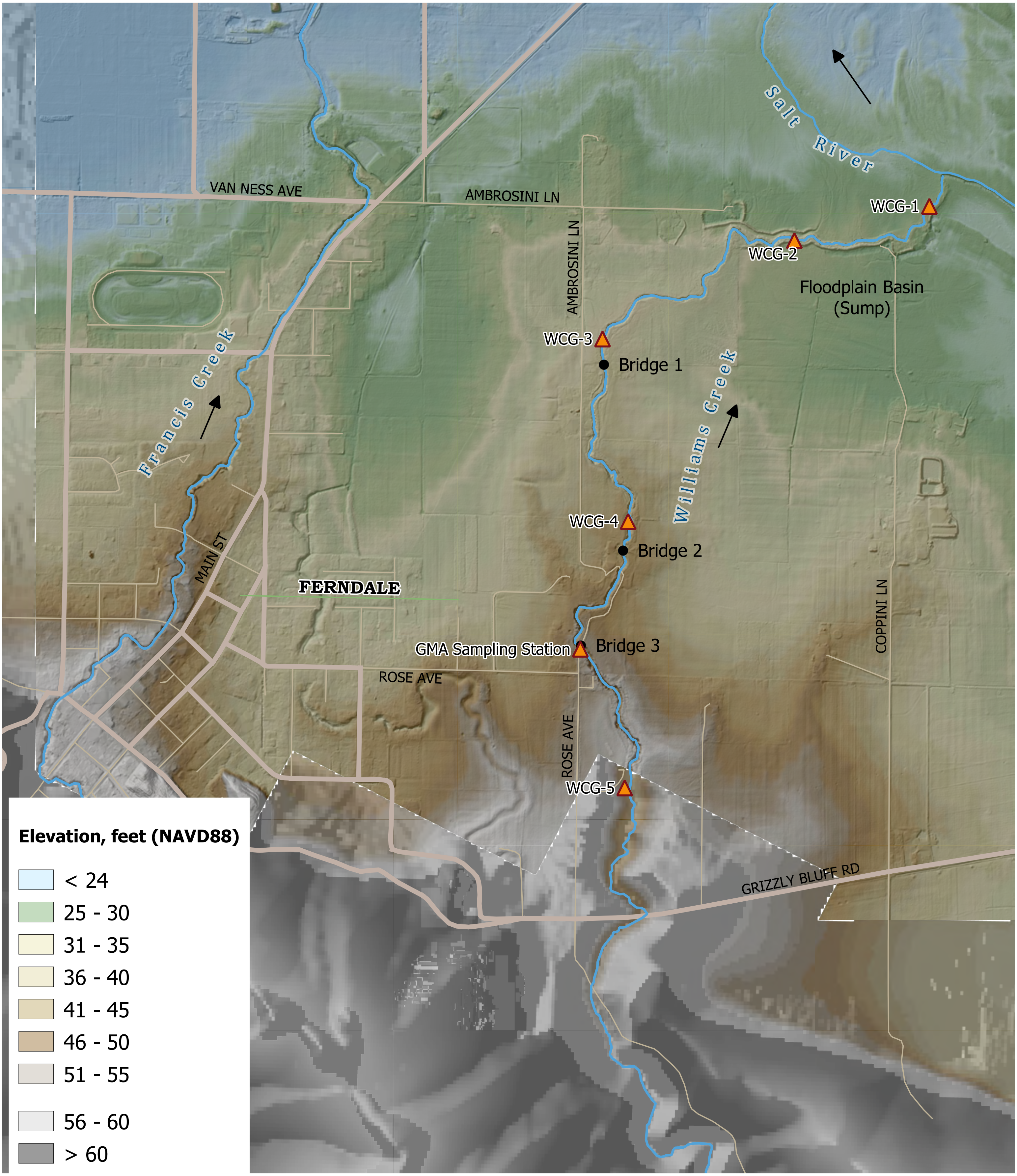
Upstream of Grizzly Bluff Road, Upper Williams Creek flows through a steep and confined stream valley in the Wildcat Range and delivers sediment from the watershed to the lower reaches of Williams Creek. Just upstream of the Grizzly Bluff Road crossing, Williams Creek exits the Wildcats, the stream valley widens and the channel slope decreases, and an alluvial fan has formed. Downstream of Grizzly Bluff Road, the creek flows about 2 miles across an alluvial fan formed on the Eel River floodplain, until reaching the confluence with the Salt River.

To understand the watershed condition, channel geomorphology, and potential sediment sources and sinks, the watershed geology was reviewed and a geomorphic assessment was conducted along Williams Creek. The results of the geomorphic assessment were used to identify a stable channel geometry for Williams Creek that could be used as part of the creek rehabilitation.

The geomorphic assessment included evaluation of both current and historical mapping and photographs to assess changes in the alignment of Williams Creek. A rapid geomorphic assessment was performed for upper Williams Creek upstream of Grizzly Bluff Road. A more detailed geomorphic assessment was performed for lower Williams Creek downstream of Grizzly Bluff Road. The role of channel hydraulics and sediment transport capacity were also evaluated as part of the geomorphic processes occurring in Williams Creek, and are discussed in Sections 6 and 7.

An elevation map of Williams Creek from where it exits the Wildcat Range to where it currently flows to the Salt River is show on Figure 3, where whites and browns represent higher elevations than greens and blues. Figure 4 shows topography of most of the Williams Creek mainstem.

Channel thalweg profiles of Williams Creek downstream and upstream of Grizzly Bluff Road are shown on Figure 5 and Figure 6, respectively. The channel thalweg downstream of Grizzly Bluff Road is based on the 2017 GMA survey. About 2,050 feet of thalweg survey obtained from Humboldt County is shown extending from downstream of Grizzly Bluff Road to upstream of the Williams Creek Road (Crossing 1).Upstream of the County survey, the channel profile shown on Figure 5 and Figure 6 were derived from a 1957 USGS topographic map, which has a much lower resolution (30 meter) than the LiDAR generated topography, and may have changed substantially since 1957.



Horizontal Datum: NAD83 California State Plane Zone I

Legend

Stream Gages

Figure 3
Colorized topographic map of Williams Creek

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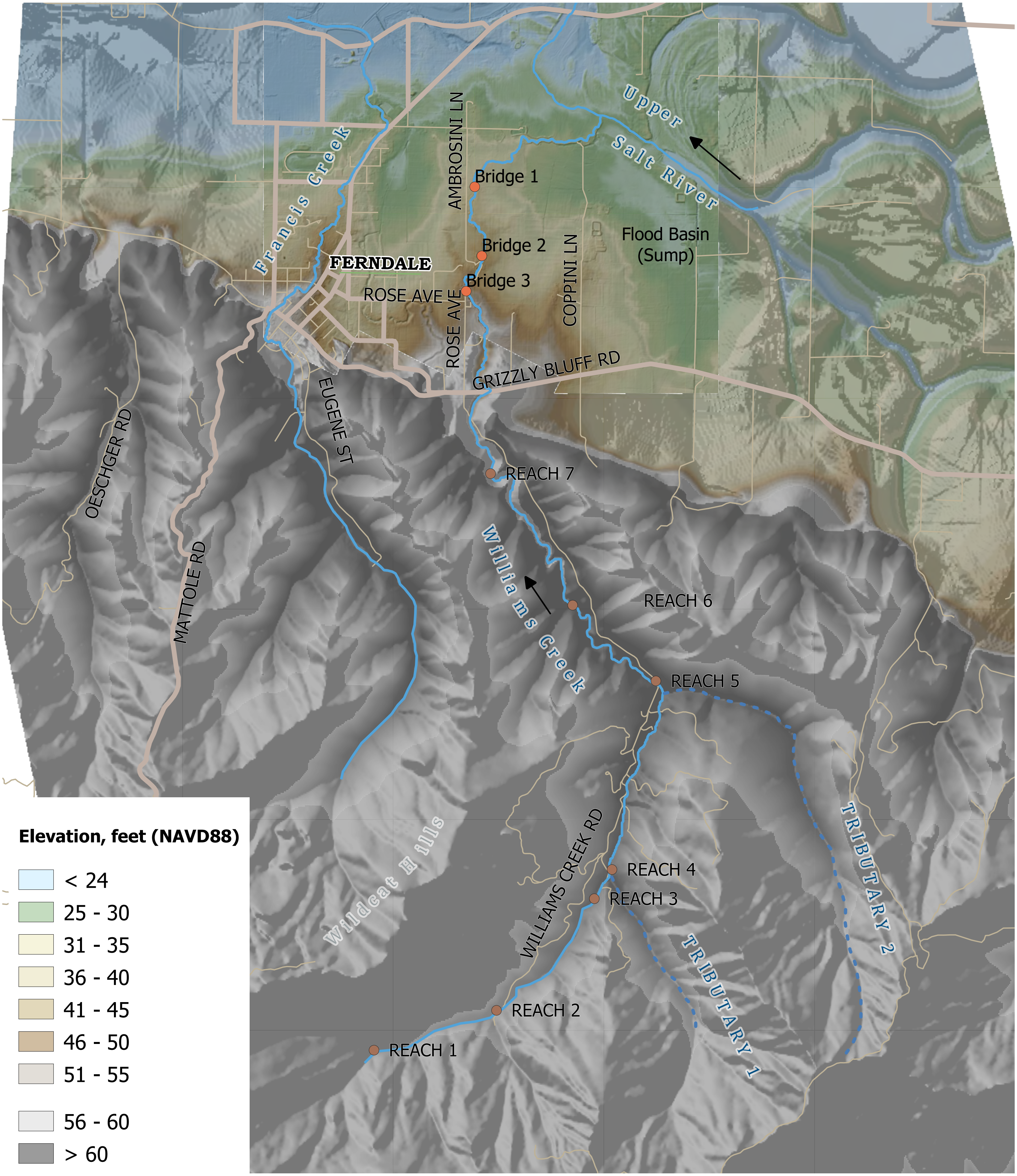
Michael Love & Associates, Inc. P.O. Box 4477, Arcata, CA 95521 (707) 822-2411



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Rapid Geomorphic Assessment Reach

Figure 4
Geomorphic Map of Williams Creek Watershed

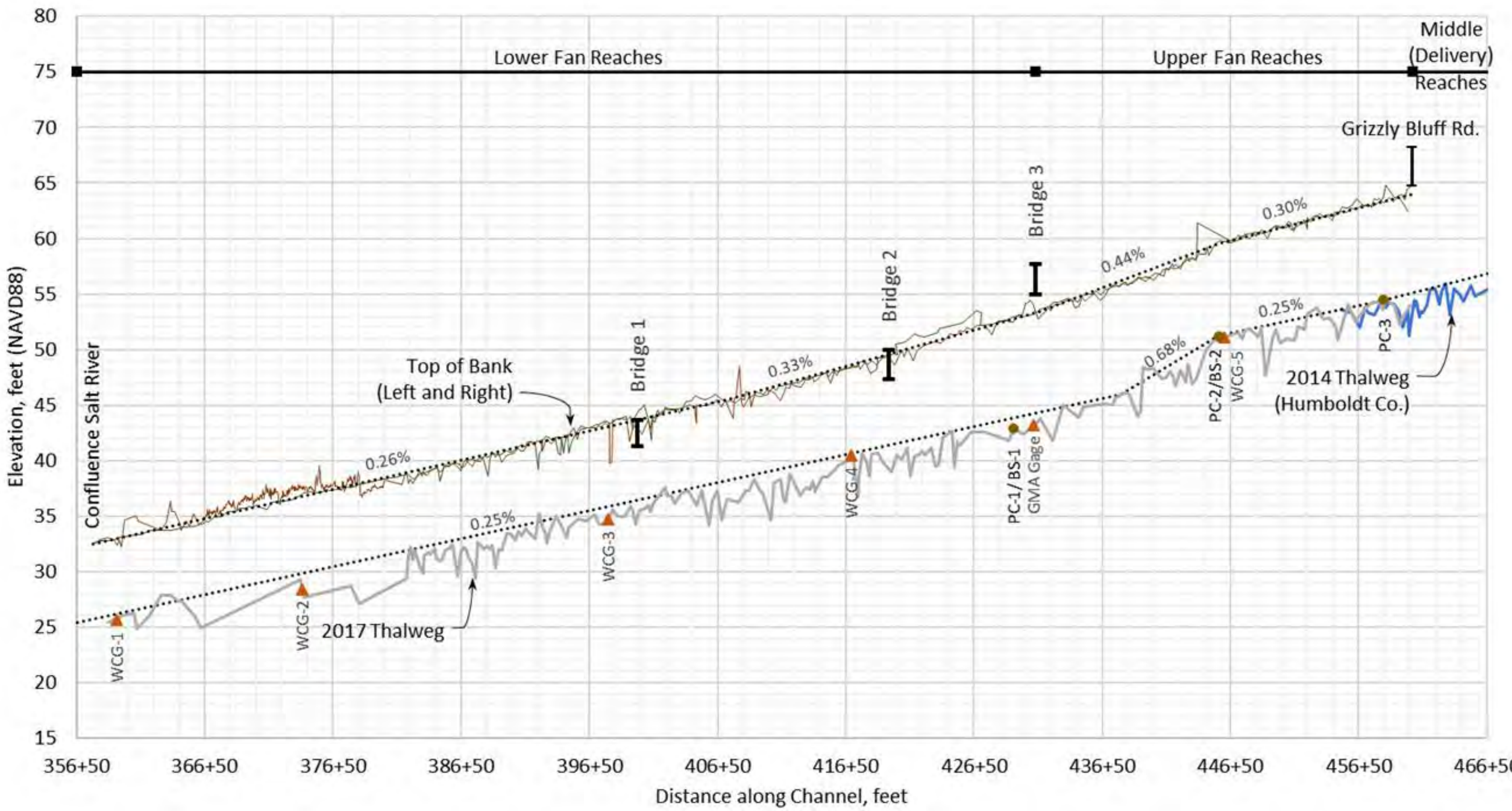


Figure 5. Longitudinal profile of the Williams Creek channel bottom (thalweg) and top-of-banks from the confluence of the Salt River to Grizzly Bluff Road. The dotted lines reflect overall slopes of the channel bottom and top-of-banks. Water level monitoring locations are shown as triangles. Pebble count (PC) and bulk sample (BS) locations are shown as circles.

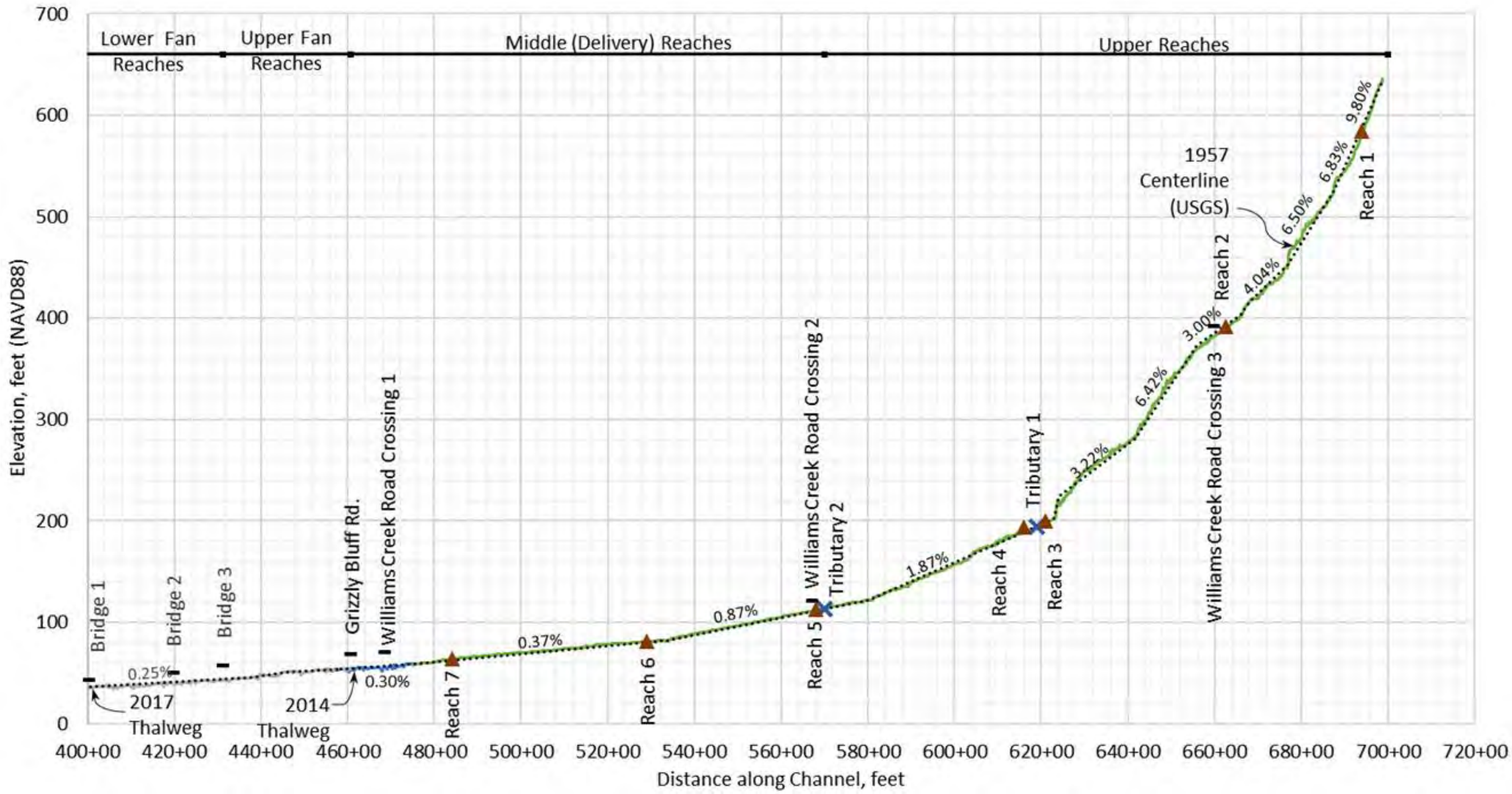


Figure 6. Stream centerline profile for the upper reaches of Williams Creek. The profile upstream of the Williams Creek Road Crossing 1 was derived from 1957 USGS mapping and may have changed substantially since then. Locations where rapid geomorphic assessments were performed are shown as triangles.

5.1 Geomorphic Assessment of Upper Williams Creek

A rapid geomorphic assessment of Williams Creek upstream of Grizzly Bluff Road conducted in August, 2018. Seven stream reaches were assessed, extending from Grizzly Bluff Road to the headwater channels located about 25,000 feet upstream Figure 4. GPS was used to locate each reach, as shown on Figure 4.

The rapid geomorphic assessment was conducted by a team of MLA/HCRCD staff walking the reaches and filling out a Rapid Geomorphic Assessment Form adapted from Vermont (2012) and AUSRivAS (2001). A blank version in the form is provided in Attachment 2. The rapid geomorphic assessment focused on assessing channel and valley geometry, channel stability, channel and upslope sources and sinks of sediment, and riparian characteristics. A full summary of the data recorded for each reach can be found in Attachment 2.

The rapid geomorphic assessment did not include any survey, hydraulic, or sediment transport analyses.

5.1.1 Upper Reaches of Williams Creek

The Upper Reaches of Williams Creek (reaches 1-4) extend from the headwaters to the confluence with Tributary 2. Photographs of the these reaches are shown in Figure 7 and Figure 8. Based on USGS mapping, channel slopes in this reach range from 1.9 % to 9.8% (Figure 6).

In the headwater reach, Williams Creek flows through a steep and confined stream valley. The bottom width of the channel averages about 17 feet and depths average over 15 feet. The channel bottom is comprised of a mix of bedrock and alluvial materials. In most locations, the valley walls are comprised of bands of more competent sandstones layered with thick deposits of highly erosive mudstones. Typically, the sandstones are relatively stable and the mudstones friable and very erosive. Areas of more competent sandstone appear to be the sources of the streambed material, which visually had a median diameter ranging from 30 to 90 mm, with the largest materials up to 700 mm. Where the streambanks are not bedrock, they consist of silts that varied in stability from stable and vegetated to eroding.

The eroding mudstones in the upper reaches of Williams Creek deliver a substantial amount of sediment to the channel, primarily as finer grained materials. Sand and silt deposits are evident throughout the channel, and are quite thick in localized areas.

The upper reaches are Williams Creek mostly forested, but pockets of grassland that appear grazed. Roads and land-use appear to contribute a small fraction of sediment compared to the unstable geology that provides the high volume of sediment to Williams Creek.

Tributary 2 appeared to be contributing a moderate load of clean cobbles, however, the tributary was not assessed in detail.

Figure 7. Confined upper reaches of the Williams Creek channel where the valley walls and some of the stream bottom are formed of sandstone and highly erosion mudstone. The channel margins and pools are filled with silt deposition from erosion of the surrounding bedrock.

Figure 8. Confined channel in the upper reaches of Williams Creek. Thick silt deposition overlays coarse alluvial materials formed of sandstone.

5.1.2 Middle (Sediment Delivery) Reaches

For the rapid geomorphic assessment, the middle reaches of Williams Creek (reaches 5-7) are defined as between Tributary 2 and Grizzly Bluff Road (See Figure 4 and Figure 6). The channel slope decreases to 0.87% at the Tributary 2 confluence (Figure 6), the stream valley widens, and the channel is typified by unconfined meanders with alluvial floodplains on both sides of the channel. The changes in the stream valley appears to be associated with a change in underlying geology from the erosive Rio Dell formation to more competent Scotia Bluff sandstones. The slope of the channel continues to decrease to 0.37% between reaches 6 and 7 upstream of Grizzly Bluff Road. Photographs of the middle reaches are shown on Figure 9.

The bottom width of the channel ranges from 13 to 21 feet, slightly wider than the upstream reaches. The channel depth averages about 6.3 feet before flowing onto its adjoining floodplain. There are more in-channel debris jams than upstream.

The floodplains are typically grazed, leaving a thin, discontinuous riparian corridor along the stream. Streambank erosion contributes silts to gravel size sediment to the channel. The channel banks along this reach are typically unstable, resulting from stock access and minimal riparian vegetation. Landowners living in the middle reach since childhood have indicated that the stream channel has gotten about 10 feet wider, deepened, and the pools filled with sediment.

The sediment size in-transport in the middle reaches decreases substantially from the upstream reaches, with median grain sizes ranging from 60 to 80 mm, and larger particle up 190 mm in the upper-middle reach, decreasing to a median grain size of 4 to 15 mm, with larger particles up to 90 mm in the lower part of the middle reach. In-channel deposition of larger particles indicate that the middle reach is a sink for larger size particles, while delivering to the lower reaches finer materials, including sands and gravels. Silt deposition on the channel margins and upstream of obstructions is pervasive. Comparison of surveyed channel elevations at Grizzly Bluff Road as part of a 1993 survey for the FEMA Flood Insurance Study (FEMA, 2016) and a 2017 topographic survey conducted for the current project indicates the channel has aggraded about 1 foot between 1993 and 2017. Avila & Associates (2016) compared cross sections surveyed as part of bridge inspection reports for the Grizzly Bluff Road Bridge. They found the channel at the bridge aggraded about 2 feet between 1971 and 2007, but then dropped about a foot in elevation in 2014.

The lower part of the middle reaches, between Grizzly Bluff Road and Reach 6 was characterized as a s*ediment delivery reach* to the downstream reaches of Williams Creek. As shown on Figure 6, in the lower part of this reach, the channel maintains a slope of 0.37% for about 4,500 feet. Though some sedimentation occurs within the channel, a lack of pervasive sedimentation features, such as mid-channel bars, and minimal amount of observed sediment aggradation over the years, suggests this reach generally has the capacity to transport the supplied sediment load. Therefore, a channel with a slope of about 0.37%, a bottom width of about 18 feet, and depth of about 6 feet can be assumed to have the capacity to transport the supplied sediment load.


a.


b.

Figure 9. Unconfined channel in the middle reaches of Williams Creek where the valley is less confined. Streambed materials are smaller than upstream, but silt deposition remains pervasive and bank erosion is common.

5.2 Geomorphology of Lower Williams Creek

5.2.1 Alluvial Fan Morphology of Lower Williams Creek

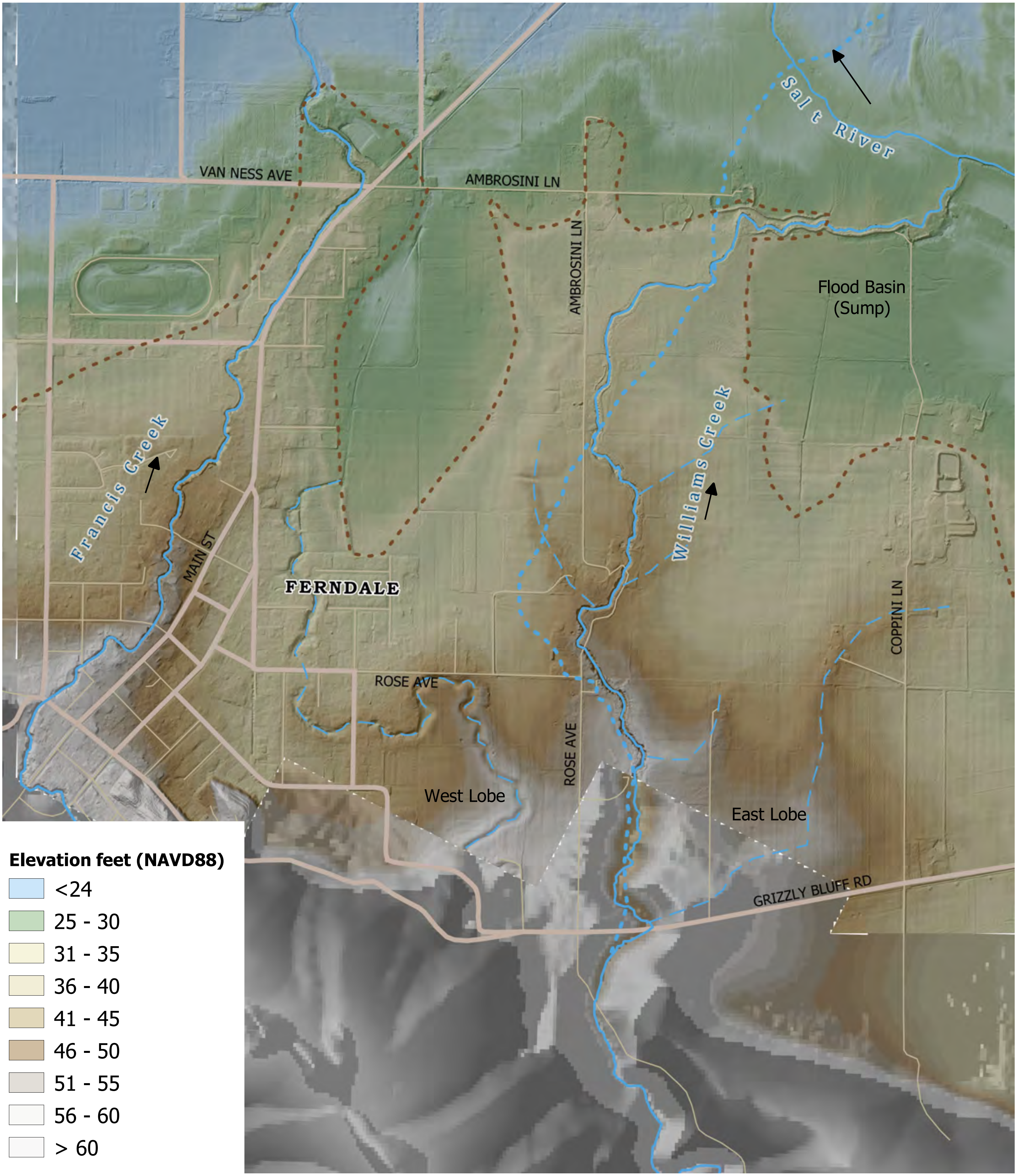
Just upstream of the Grizzly Bluff Road crossing, Williams Creek exits the Wildcats and the stream becomes unconfined, the channel slope decreases, and the channel flows across an alluvial fan. Alluvial fans serve as the transition from steeper confined channels within the hills to an unconfined low-gradient floodplain. The loss of channel confinement and a decrease in channel slope leads to decrease sediment transport capacity and in-channel and overbank sediment deposition.

Figure 10 shows an annotated elevation map highlighting the alluvial fan built by Williams Creek on top of the Eel River floodplain. The extents of the fan are approximated as a dotted line. The current alignment of Williams Creek and the approximate 1916 alignment are shown for reference. An alluvial fan built by Francis Creek is evident on the west side of the figure, overlapping with the Williams Creek alluvial fan. There are three primary lobes forming the Williams Creek alluvial fan, with lower ground (geomorphically referred to as "flood basins") between the lobes.

The current alignment of Williams Creek forms the center lobe of the fan. Rose Avenue and Ambrosini Lane are located on the ridgeline formed by this lobe. Historic maps indicate that Williams Creek has been confined to its current alignment since the late 1800's, with some differences in the location of the downstream-most portion of the stream. As shown on Figure 10, the 1916 alignment of Williams Creek was located to the west between Rose Avenue and Ambrosini Lane. This reach of channel shifted or was moved to its current alignment between 1916 and 1921. The downstream reaches of the 1916 channel flowed northward, and connected to Salt River further downstream than the existing confluence. Between 1916 and 1921, the lower reaches of the channel appear to have moved into its current alignment.

The other two fan lobes were formed prior to mapping of the area, thus are much older than the center lobe. The eastern lobe of the alluvial fan is located on the east side of Williams Creek, just west of Coppini Lane. Ranch buildings are located on slightly elevated ground at the downstream end of this lobe. West of Williams Creek is a fan lobe with a well-defined abandoned channel that flowed through what is now the town of Ferndale. This channel flowed to the west of Rose Avenue and into the low-lying fields that functioned as a "flood basin" for Williams Creek and possibly Francis Creek. Accumulated waters within this flood basin appeared to have flowed into Salt River through a water course called "Shaw's" Creek in the 1854 plat map.

The active fan lobe that Williams Creek is currently building is much longer than the other two lobes, and the stream channel is located on a self-formed ridge over 10 feet higher than the adjacent valley bottom to the east and west. This suggests that Williams Creek is being artificially maintained along its current alignment, and historical manipulations of the channel and banks have prevented it from jumping (avulsing) and migrating to a new location. The longer the time that a channel on an alluvial fan is maintained in one location, the active lobe will increase in both length and elevation, with channel deposition progressing in both the downstream and upstream directions.



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Horizontal Datum: NAD83 California State Plane Zone I

LEGEND

Alluvial fan boundary

Williams Cr. (1916)

Undated historical alignments

Figure 10
Williams Creek alluvial fan and historical stream locations

5.2.2 Geomorphic Characterization of Lower Williams Creek

A more detailed geomorphic assessment was performed in May 2018 for lower Williams Creek, downstream of Grizzly Bluff Road. The geomorphic assessment included field assessments of the stream channel, viewing out-of-bank flooding and sedimentation patterns, evaluation of the channel thalweg profile, and collection of pebble counts and bulk samples of streambed material.

As shown on Figure 5, the channel bottom slope decreases from a slope of 0.37% upstream of the Grizzly Bluff Road bridge to a slope of 0.25% downstream of Grizzly Bluff Road, with the exception of one short reach of higher sloped channel downstream of WCG-5.The top-of-bank slopes, representing the surface of the alluvial fan, are slightly steeper than the channel slopes, ranging from 0.30% to 0.44% just downstream of Grizzly Bluff Road, and decreasing to 0.26% downstream of Bridge 1.

Lower Williams Creek was broken into two reaches. Between Grizzly Bluff Road to Bridge 3, the channel is generally deeper, has less sediment deposition than downstream, and conveys more flow, with overbank spilling occurring only during large flow events. Downstream of Bridge 3, the channel becomes progressively narrower and shallower, depositional features are more evident, and out-of-bank flows increase in frequency in the downstream direction.

Upper Alluvial Fan Reach (Grizzly Bluff Road to Bridge 3)

Description

The upper alluvial fan reach of Williams Creek is located between the fan apex, just upstream of Grizzly Bluff Road, to Bridge 3. The upper fan reach originates at the apex of the alluvial fan and flows as an incised channel. It is characterized as a delivery reach, efficiently transporting sediment from the upper watershed to the next reach downstream. There is some localized evidence of in-stream sedimentation, mostly consisting of small gravel deposition upstream of debris jams. Fine sediment deposits on the channel margins is not as pervasive as upstream, but is common on the channel banks.

Figure 11 shows a photograph of Williams Creek looking downstream from the Grizzly Bluff Road Bridge. At this location, the channel is trapezoidal in shape with an approximate13-foot bottom width and about 8 feet deep. The bridge in the photograph, replaced in 2019, is skewed to the channel and located on a meander bend. A point bar comprised of fine-grained materials has built to bankfull elevation under the bridge. Gravel riffles are present upstream and downstream of the bridge, with some deposition of smaller grained materials on the channel margins.

Most of this reach downstream of Grizzly Bluff Road has a channel slope of 0.25%, except for a short reach just downstream of WCG-5, where the channel has a slope of 0.68% (Figure 5). Inspection of the reach upstream of WCG-5 indicated that it is choked with debris jams that appear to be maintaining the channel grade, as shown in Figure 12. The streambanks in this reach have a gentler slope and are thickly covered with a riparian area. Landowners adjacent to this reach indicate that overbank flooding does not occur as frequently as downstream, but does occur. Sandbag berms have been constructed around the property to the west of where the WCG-5 gage is located.

Between WCG-5 and Bridge 3, the channel becomes more trapezoidal in shape with alternating riffles and pools. Figure 13 shows a photograph of a portion of this reach. A channel cross section at Bridge 3 indicated that the Williams Creek has narrowed from upstream, and has about a 10-foot wide bottom width and is about 9 feet deep.

There are a few debris jams in this reach, and the alder riparian area hangs over the channel in numerous locations. The channel planform is characterized by frequent tight, or tortuous, meander bends. The combination of debris jams and tortuous meander bends create high channel roughness (flow resistance) that elevates water levels.

Because of minimal observed sediment deposition in this reach, it can be considered as a sediment delivery reach to the downstream portion of the alluvial fan. Because this reach of channel is incised into the fan, out-of-bank flows occur more rarely, and the in-channel flows appear to have the capacity to transport the bulk of the delivered sediment. See Section 7 for a sediment transport analysis of this reach.

As shown in Figure 5, the slope of the alluvial fan in this reach, represented by the top-of-bank of the channel, ranges from 0.30% to 0.44%, with an overall slope of 0.35%.

Figure 11. Williams Creek looking upstream from the Grizzly Bluff Road Bridge.

Figure 12. The reaches of Williams Creek between Grizzly Bluff Road and the WCG-5 monitoring location are choked with debris jams. Bank slopes are gentler in this portion of the reach.

Figure 13. Williams Creek from Bridge 3. The channel shape becomes more trapezoidal in this portion of the reach.

Streambed Substrate Characterization

Sediment substrate characterization was performed to assess the sediment sizes forming the streambed in the upper fan reach of Williams Creek, and for use in the hydraulic and sediment transport analyses. Streambed surface gradations were characterized by conducting three surface pebble counts in riffles and subsurface bulk samples at two of the pebble count locations.

The pebble counts and bulk samples were collected in accordance with Bundt and Abt (2001). Grain sizes in the pebble counts were measured down to 1 mm. The bulk samples were sieved in accordance with ASTM C-136, and included grain sizes down to 0.0625 mm. Grains smaller than 0.0625 mm were considered washload (Biedenharn, et al., 2000) and their gradation were not further characterized.

The results of the pebble counts and surface sediment sampling are presented in Figure 14 and Attachment 3. The grain sizes measured in the surface pebble counts decreased in the downstream direction. The sub-surface bulk samples collected at PC-1 and PC-2 had finer gradations than the pebble counts at the same location. The difference in medina grain sizes in the surface and subsurface layers indicates that a weak surficial armoring is forming.

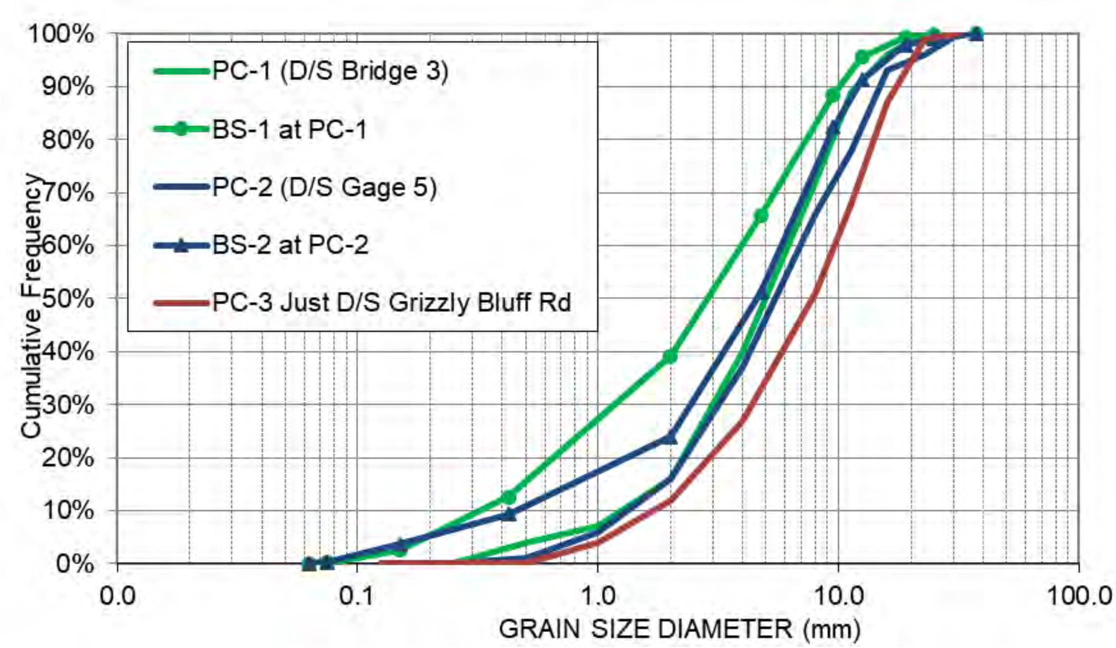


Figure 14. Results of pebble count (PC) and sub-surface bulk sampling (BS) for Williams Creek.

Lower Fan Reach (Bridge 3 to Salt River)

Downstream of Bridge 3 the channel becomes shallower in the downstream direction. As the channel shallows, the bottom width also decreases, resulting in a drastic reduction of channel flow capacity. In the FEMA Flood Insurance Study (FEMA, 2016) FIS Flood Profiles (Panels 64P65P), the channel bottom elevation of Williams Creek at the confluence with the Salt River was surveyed in 1993 to be 21.5 feet (NAVD88). Currently, the channel elevation of Williams Creek at the confluence is 25.4 feet, indicating the channel has filled in about 3 feet in the downstream reaches since 1993. Though there are no measurements, it is assumed that substantial aggradation occurred in Williams Creek before 1993 due to aggradation in the Salt River.

The Salt River channel bottom elevation of approximately 9 feet was noted on Caltran's 1968 Highway 211 bridge replacement plans. Currently, the Salt River channel elevation at the Highway 211 bridge is approximately 22 feet, indicating the Salt River channel at the Highway 211 bridge has aggraded approximately 13 feet since 1968. This aggradation would propagate up to the confluence with Williams Creek, and then extend up Williams Creek.

The channel planform is characterized by frequent tortuous meander bends. The channel bed material in this reach is finer than upstream; comprised of mostly fine-grained sediments with some pea gravels. Where the riparian area is present, overhanging trees block the channel and form debris jams as shown in Figure 15. Debris jams are relatively common along the lower reach of Williams Creek, though they tend to be transient and frequently shift locations. The combination of debris jams and tortuous meander bends create high channel roughness that elevates water levels and forces out-of-bank flows. Residents living adjacent to Williams Creek have indicated that the channel has shallowed and out-of-bank flooding has become more frequent since the late 1990's.

A combination of discontinuous earthen berms and natural alluvial berms along most of the channel in this reach serve to increase channel depth, help confine flows, and maintain in-channel sediment transport. However, the decrease in channel size and the high flow resistance of the debris jams and channel meanders result in frequent overtopping of the streambanks. Residents living adjacent to the stream indicate that the location of frequent overtopping shifts from year to year. Because the channel is located on a ridge above lower-elevation lands, overbank flow cannot return to channel, resulting in flooding and sediment deposition on the adjacent properties.

Depending on the flow event, the out-of-bank flooding and sediment deposition can be substantial. Occasionally, a berm is breached, resulting in a more catastrophic flood event, such as the berm breach in winter of 2019 that resulted substantial flooding and sedimentation along Ambrosini Lane.

Overbank flows occur to both the east and west of the channel. Where overbank flows spill to the west and northwest, they inundate the roadway, residences and outbuildings on Ambrosini Lane, as well as pastures to the northwest. Figure 16 shows a photograph of Ambrosini Lane, where overbank flows from Williams Creek flowed northward down the lane. Due to removal of deposited sediments around houses and on the road following flood events, the ground along Ambrosini Lane has not aggraded, while the eastern banks have aggraded in recent years. This results in preferential overbank flooding to the west and necessitates construction of extensive berms to protect residential properties.

Where overbank flows spill to the east, they flow down the gently-sloped fields between the lobes of the alluvial fan, and become trapped in a low sump south of the upper Salt River, between Williams Creek and Coffee Creek. Sedimentation and natural alluvial levees along the Salt River prevent the ponded surface water from flowing into the Salt River or returning to Williams Creek. Figure 17 shows flooding patterns in April 2011.

The downstream-most reaches of Williams Creek, just upstream of the confluence with the Salt River, show evidence of substantial aggradation associated with the period when Williams Creek was diverted into the upper Salt River. Following the breach of the berm at the Salt River confluence circa 2016 and forming the Williams Creek Sediment Splay (Figure 1), the channel has since down-cut through some of these deposited sediments, as evident in the reach immediately downstream of Bridge 1 (Figure 18).

Figure 19 shows a partially-buried outbuilding located in the bermed area to the south of the channel just upstream of the Salt River confluence. The berms in this area were constructed in 1999 (Downie et al., 2005). The combination of the berms, the ponding resulting from routing Williams Creek flows into the upper Salt River, and high sediment load in the channel resulted in extensive deposition that rapidly buried this building.

The channel aggradation, berm overtopping, overbank flows, and overbank sediment deposition occurring in the lower fan reach of Williams Creek are typical of processes found in the lower portions of alluvial fans. Aggradation that is presently occurring within the sediment splay downstream of the Salt River confluence will continue to raise the base level, decreasing channel slope in the lower fan and further reducing channel and sediment transport capacity. Over time, the effects of the rising base-level will propagate upstream, causing increases in channel bed and overbank elevations. This process is cyclic and creates a negative feedback loop of in-channel deposition and overbank flooding that typically leads to a channel avulsion to a lower portion of the fan.

Figure 15. Overhanging trees and debris jam between Bridge 2 and Bridge 1 on Williams Creek causing sedimentation on the channel bed, banks, and overbanks.

Figure 16. Overbank flows from Williams Creek flowing northward along Ambrosini Lane. Residents have installed various measures for flood protection (Svelha, December, 2015).

Figure 17. April 8, 2011 aerial view of Lower Williams Creek overbank flooding looking northeast (Photo by D. Tuttle).

Figure 18. Incision through recent in-channel sediment deposited associated with breaching of the berm that diverted Williams Creek into Old Salt River between 1998 and 2015.

Figure 19. Buried outbuilding on south side of Williams Creek upstream of WCG-1.

6 EXISTING CONDITIONS HYDRAULICS

Both 1-dimensional and 2-dimensional hydraulic models were used to evaluate existing conditions. The 1-dimensional (1-D) module of HEC-RAS 5.0.7 (USACE, 2016 a, c), was used to create a calibrated model of existing conditions of Williams Creek. The 1-D module of HEC-RAS only yields information on a cross sectional basis, and does not provide details regarding complex channel and overbank flow interaction that occur along Williams Creek.

The calibrated 1-D HEC-RAS model was then used to create a combination 1-D in-channel and 2-dimensional (2-D) overbank model of Williams Creek using HEC-RAS 5.0.7 (USACE, a-c). The 2-D model was used to evaluate the magnitude and frequency of out-of-bank flows along Williams Creek and resulting flow patterns on the overbanks.

The following sections present model development and results for both 1-D and 2-D hydraulic analyses.

6.1 1-Dimensional Hydraulic Model

6.1.1 1-D Model Setup

A calibrated 1-D HEC-RAS model was prepared to determine appropriate hydraulic loss coefficients for the channel. An unsteady HEC-RAS model was prepared for 10,080 feet of Williams Creek, between Grizzly Bluff Road and the confluence of the Salt River. Cross sections were derived from a digital terrain model (DTM) created by merging California Ocean Protection Council LIDAR and a 2017 topographic survey of the Williams Creek channel. Cross sections were spaced on average approximate every 120 feet, with closer spacing at stream crossings and to define stream features such as riffles and pools. Bridges 1, 2 and 3 were included in the model based on surveyed dimensions and elevations.

Lateral structures were used to simulate flow loss from the channel when water levels exceed the top-of-bank elevations and spill onto adjacent overbanks. Lateral structure elevations were defined by visually identifying on the DTM the highest elevation points separating the stream from the overbank. The point spacing on the lateral structures was substantially closer than the spacing of the cross sections to accurately define the top-of bank geometry. Lateral structures were defined continuously on both the left and right banks from Grizzly Bluff Road to the confluence of Williams Creek and the Salt River. Because the channel banks are perched the adjacent floodplain within most of the model domain, once flows leave the channel via the lateral structures, it was considered "out of the system" and was not returned to the channel.

The HEC-RAS model was calibrated using data from three high flow events collected as part of the GMA/HCRCD flow and water level monitoring conducted during WY 2017/18 (Section 2). The selected flows represent a flow event with about a 1.01-year return of 113 cfs (flows were fully contained within Williams Creek), about a 1.4-year flow event of 433 cfs (flows spilled out-of-bank along the lower reaches of the channel), and an approximate 3-year event of 722 cfs (highest flow in WY2017, causing flows to spill out-of-bank in multiple locations downstream of Bridge 3). Water surface elevations measured at the six gages, and flows measured by GMA at Bridge 3 were used for the calibration for the lower two calibration event. The 722 cfs event occurred during WY 2017, and only water level data was available at Bridge 3.

For all calibration runs, the steady-state HEC-RAS model was executed in mixed flow, using a normal depth slope of 0.24% at the downstream end of the model based on the existing thalweg slope. Expansion and contraction coefficients were set at 0.3 and 0.5 respectively, to reflect moderately abrupt flow transitions between cross sections due to the variable nature of the channel cross sectional area (USACE, 2016b).

To calibrate the HEC-RAS model, channel roughness values (flow resistance) were adjusted so that the model-predicted water surface elevations (WSE) matched the observed water surfaces within a few tenths of a foot, where possible. Overbank roughness values were set at 0.1 to simulate underbrush and trees comprising the overbank riparian area.

6.1.2 1-D Model Existing Conditions Results

Model-predicted WSE's compared to the gaged WSE's for the calibration flow events are shown on Figure 20. Figure 21 shows the model-predicted flows remaining in Williams Creek after losses from overbank floss. Results of the 1-D HEC-RAS modeling are shown in Attachment 4.

The model calibration yielded a channel Manning's roughness coefficient of 0.09. Though substantially higher than typical channel roughness (Chow 1959), the calibrated roughness values was not unexpected given that large portions of Williams Creek are controlled by debris jams, overhanging riparian vegetation, and tight meander bends. These factors act together to increase flow resistance and reduce channel capacity. The substructures of

Bridges 2 and 3 also obstruct flows for all but the lowest flows, resulting in artificially increased water levels upstream of these bridges.

As shown on Figure 20, the model-predicted and gaged water levels are similar in most locations along the channel. The differences between measured and modeled water levels are likely a result of localized difference in the number of debris jams, density of the overhanging riparian area, or tight bends in the channel planform. Additionally, ground elevations at the channel top-of-bank, where flows spill out of the channel, were not surveyed in detail, potentially leading to differences between model verses actual amount of flow that spills out-of-bank. However, as show on Figure 20, the differences between modeled and actual water levels are minor, and the calibrated model is suitable for a planning-level study.

Figure 20 also shows the water surface slope upstream of Bridge 3 is about 0.36%, dropping to 0.27% between Bridge 3 to downstream of Bridge 1, then dropping to 0.2% to the confluence with the Salt River. The steeper water surface slope upstream of Bridge 3 is probably a result of the steeper segment of channel just downstream of WCG-5 creating a flow drawdown. As will be shown in 7, this steeper water surface slope substantially improves sediment transport in the Upper Fan Reach.

Figure 21 shows total flow remaining within the Williams Creek channel from upstream to downstream, with the decrease associated with losses from overbank flooding. At the Williams Creek confluence with the Salt River, the channel is conveying only 147 cfs, regardless if incoming flows from upstream is greater. The remainder of flow has spilled out of the channel banks and does not return to William Creek. This occurrence is also illustrated on Figure 20, where the water surface elevation (WSE) profiles for 433 cfs and 722 cfs overlap in the downstream reach because only 147 cfs is remaining within the channel.

A flow of 147 cfs has a return period between 1.01- and 1.1-years. Therefore, out-of-bank flows can be expected to occur a minimum of once per year, and typically more frequently under existing conditions. This overbank flooding frequency is similar to what residents living adjacent to the channel have observed.

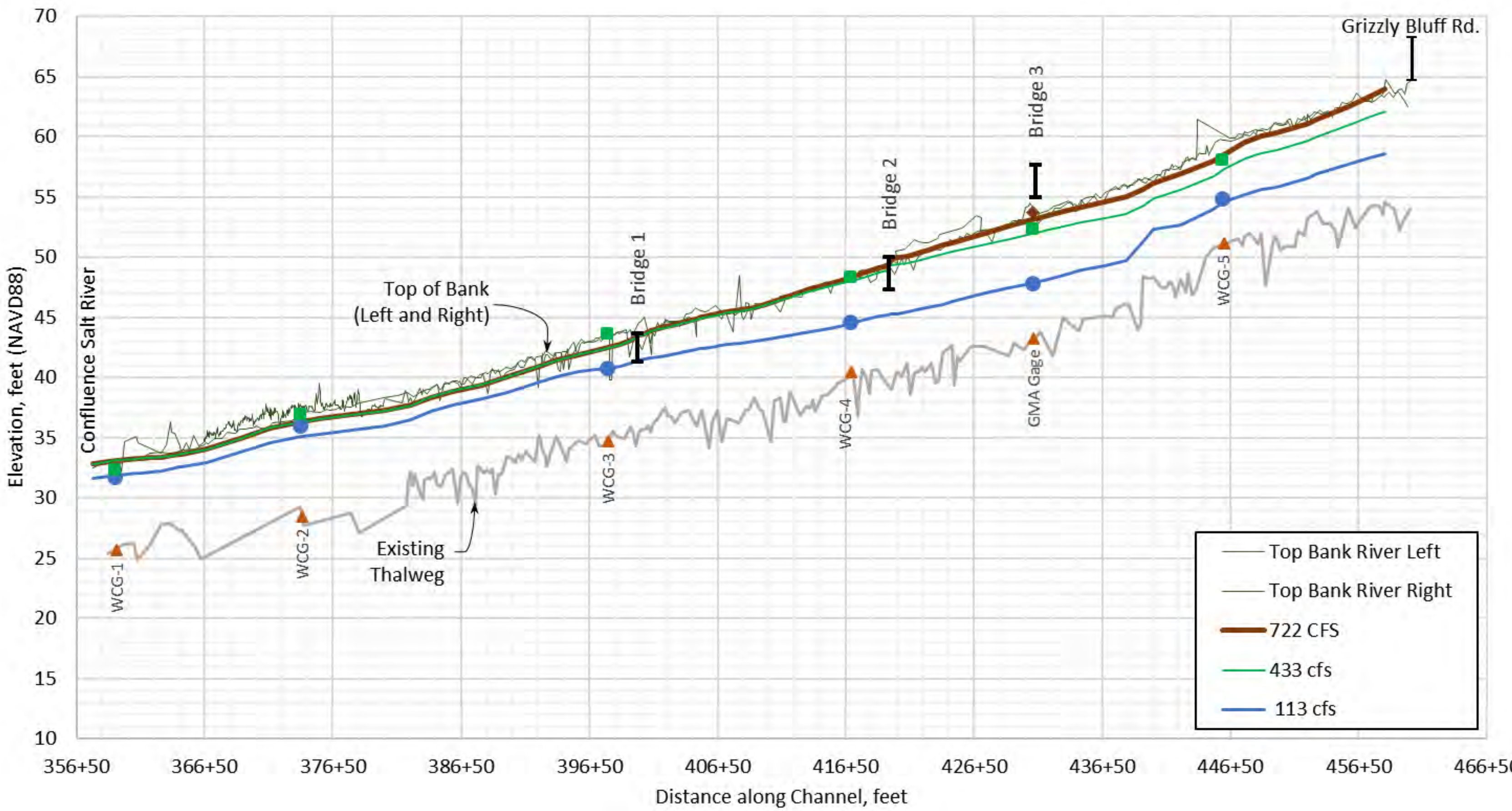


Figure 20. Williams Creek HEC-RAS model-predicted water surface profiles for 113 cfs (1.01-year return period), 433 cfs (1.5-year return period) and 722 cfs (3-year return period). The circle, triangles, and squares represent measured water levels. The lighter weight red and green lines represent the top of channel banks where flows begin to spill out-of-bank.

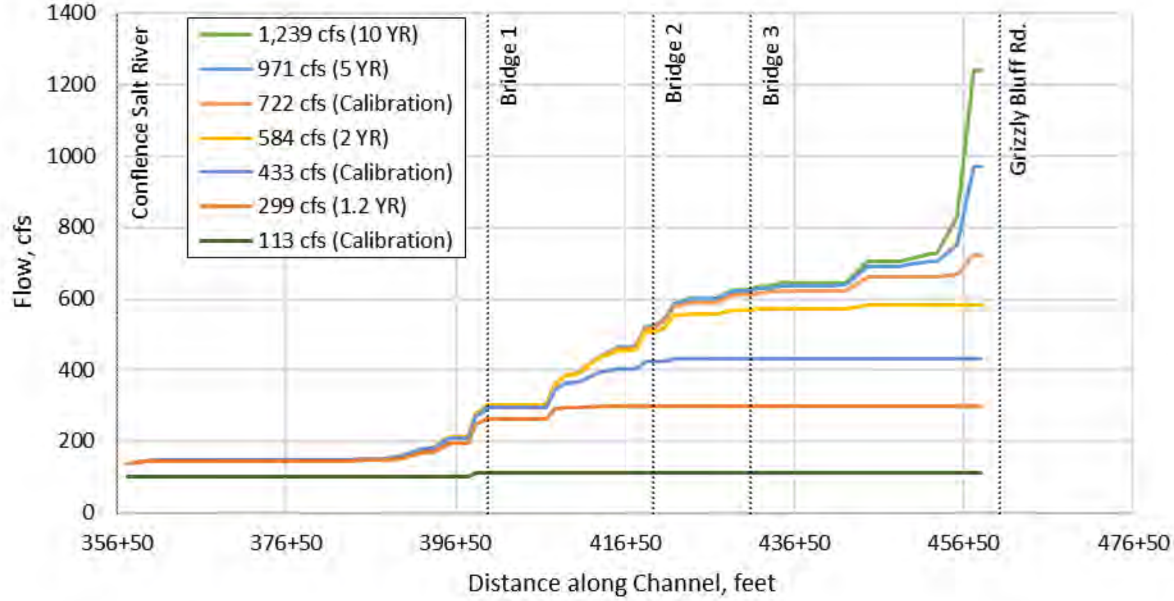


Figure 21. HEC-RAS model-predicted flows in Williams Creek for a range of flows. Flows decline in the downstream direction as water overtops and spill out of the channel banks and does not reenter the channel. The maximum capacity of the channel at the confluence with the Salt River is 147 cfs.

6.2 2-Dimensional Hydraulic Model

6.2.1 <u>2-D Model Setup</u>

A combined 1-D/2-D model was developed using HEC-RAS 5.0.7 (USACE, 2016 a-c) to characterize the frequency, extent, and patterns of Williams Creek flow onto the adjoining overbank areas. The combined model was developed by connecting the in-channel portion of the calibrated 1-D model to 2-D flow areas on the overbank using the lateral structures from the 1-D model that represent the top of bank.

The model domain encompassed about 640 acres of overbank areas adjacent to Williams Creek. The 2-D flow area to the west of the channel encompassed 230 acres of overbank, including Rose Avenue, Ambrosini Lane, and the lower areas to the west of these neighborhoods. The 2-D flow area to the east included about 410 acres, where overbank flows are conveyed downslope through pastures before pooling in a dead-end basin/sump to the south of the upper Salt River channel.

The 2-D flow areas were created in RAS Mapper based on the DTM created for the project area. A DTM of a 60-acre portion of USGS quad-sheet topography (1957) was used for the terrain along the upstream-most 1,000 feet of overbank area downstream of Grizzly Bluff Road. Because the USGS topography was fairly different than the LiDAR DTM, it was used sparingly to transition overbank flows from the upper portion of Williams Creek to the lower reaches with current detailed LiDAR mapping of the overbanks.

The overbank surface along Williams Creek was exported from AutoCAD Civil 3D as a 1 meter average grid digital elevation model (DEM). In HEC-RAS, the 2-D flow mesh was created from the DEM terrain using 40-foot by 40-foot grid spacing on average. Larger grid sizes reduce the number of computations and therefore run time of a model. However, the grid cells still accurately represent the underlying terrain by creating volume/area relationships to each grid cell and a detailed profile to each cell face, which are used for the computations and plotting of data results.

Smaller grid cells (about 15-foot by 15-foot) were used along the edges of the terrain that were connected to the lateral structures and at breaklines along higher elevation features (such as roads).

Boundary conditions to the 2-D area were set along the full edge of the model along both overbanks using normal depth friction slopes estimated from the topography. Downstream boundary conditions in the 1-D portion of the model were set at constant stage of 30 feet to represent the approximate top-of-bank elevation of the Salt River. The modeling was executed in unsteady for the 2-, 5-, and 10-year peak flow events using the setting that adjust the model time step to optimize the courant number. Modeling was run for the period of time it took for flows to stabilize throughout the extents of the model domain.

6.2.2 2-D Model Existing Conditions Results

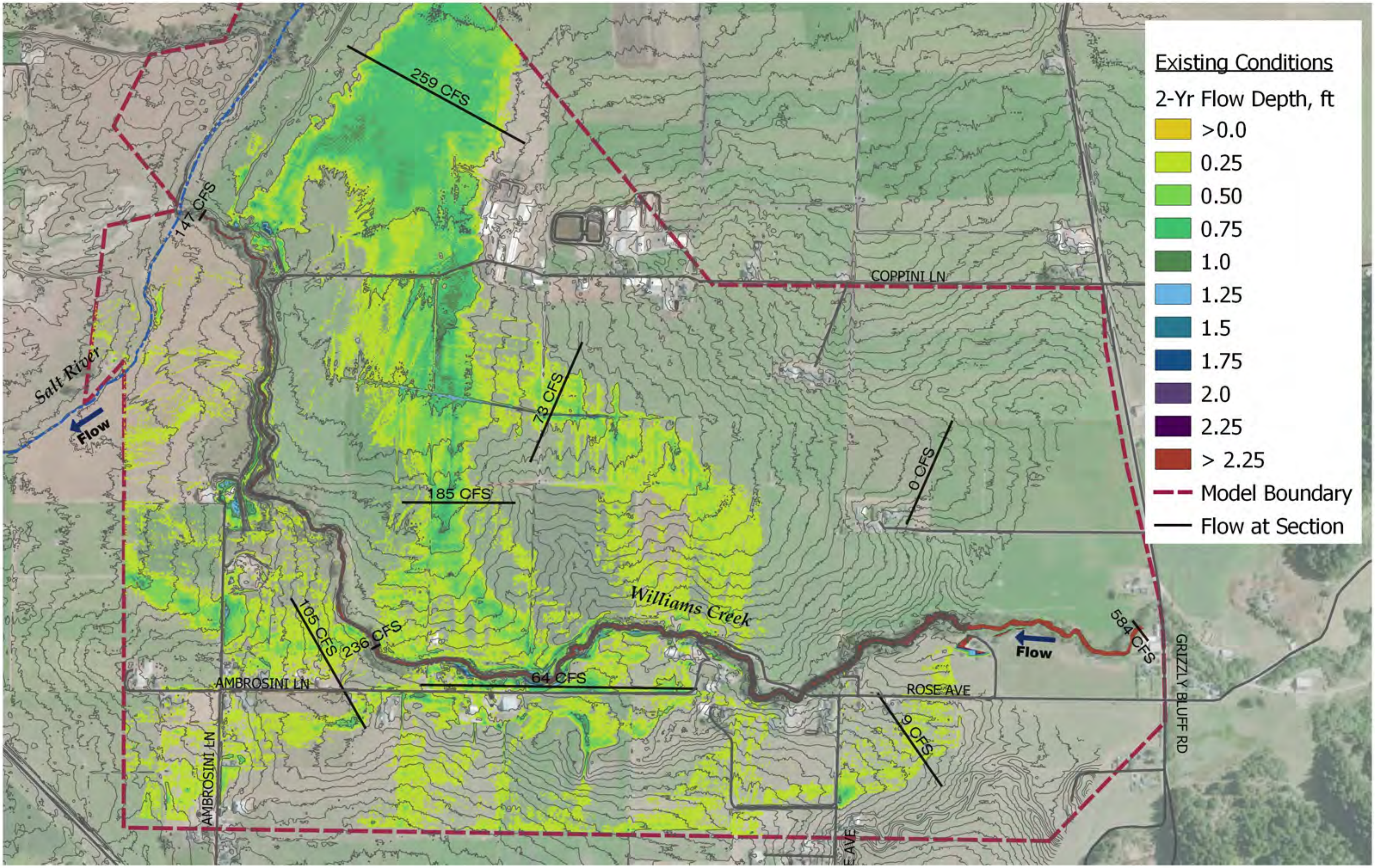
Figure 22 through Figure 24 present typical results of the 2-D modeling. HEC-RAS 2-D modeling results for flow depths, velocities, and shear stresses for the 2, 5, and 10-year flow events are provided in Attachment 5. Note that the modeling was based on a channel topography survey performed in 2017 and overbank LiDAR data from 2009-11. Therefore, the locations where out-of-bank flow is shown in the modeling may be different than current conditions.

Figure 22 shows the results of 2-D model predicted flow depths for a 2-year peak flow (584 cfs) on Williams Creek. In-channel and overbank flows are labeled at various locations. During a 2-year flow event, 584 cfs is conveyed within the channel just downstream of Grizzly Bluff road. About 9 cfs is spilled out of the channel to the west near Rose Avenue and flows down a wide swale to the west of Ambrosini lane. An additional 64 cfs spills out of the channel between Rose Avenue and along Ambrosini Lane, flooding Ambrosini Lane and the low-lying properties on both sides of the land. An additional 105 cfs spills out of the channel to the northwest downstream of Ambrosini Lane and flows towards Highway 211 and the Scalvini swale. On the east side, about 259 cfs spills of the channel, mostly opposite Ambrosini Lane, then flows down broad swales to a low sump area to the south of the Williams Creek and the upper Salt River channel, where the landowner has indicated that flows pond. At the downstream end of Williams Creek, a total of 147 cfs remains within the channel, and 437 cfs has flown out-of-bank to the east and west.

Figure 23 shows the results of 2-D model predicted flow depths for a 5-year peak flow (971 cfs) on Williams Creek. In-channel and overbank flows are labeled at various locations. The number of areas along both channel banks where flows exceed the top-of-banks increase from the 2-year event. Out-of-bank flows to the west increase to about 284 cfs, with increased depth of flow on Ambrosini Lane. Low channel banks on the east side of Williams Creek allow about 540 cfs to spill out-of-bank opposite Rose Avenue. At the downstream end of Williams Creek, a total of 147 cfs remains within the channel, and 824 cfs has left the channel.

A 10-year flow was selected to evaluate the susceptibility of the Williams Creek overbank areas to rilling or erosion. Silt erosion begins to occur at a shear stress of about 0.05 pounds/square foot (Fischenich, 2001). Silt erosion could occur on the Williams Creek overbanks when there is recently tilled ground where a cover crop has not yet established. Short grazed pasture grasses are expected to begin to erode when flow shear stresses are about 0.6 pounds/square foot, and longer, un-grazed pasture grasses would be expected to begin to erode when flow shear stresses are about 1 pounds/square foot (Fischenich, 2001).

Model-predicted shear stresses shown in Figure 24 indicate that erosion of areas of grazed short grasses may occur within portions of the existing overbank drainage swales during a 10-year flow event, and silt erosion may occur in most bare-earth fields, except the sump area. The modeling predicts that ground erosion would not occur in areas with grasses. The rancher has indicated that when overbank flows occur, rilling has occurred within recently tilled pastures where the cover crop had not yet become established for the winter, but areas with established grasses have been stable.



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Hydrologic Solutions

Figure 22

2-D Existing Condition Model Predicted Flow Depths for a 2-Year Peak Flow (584 cfs)

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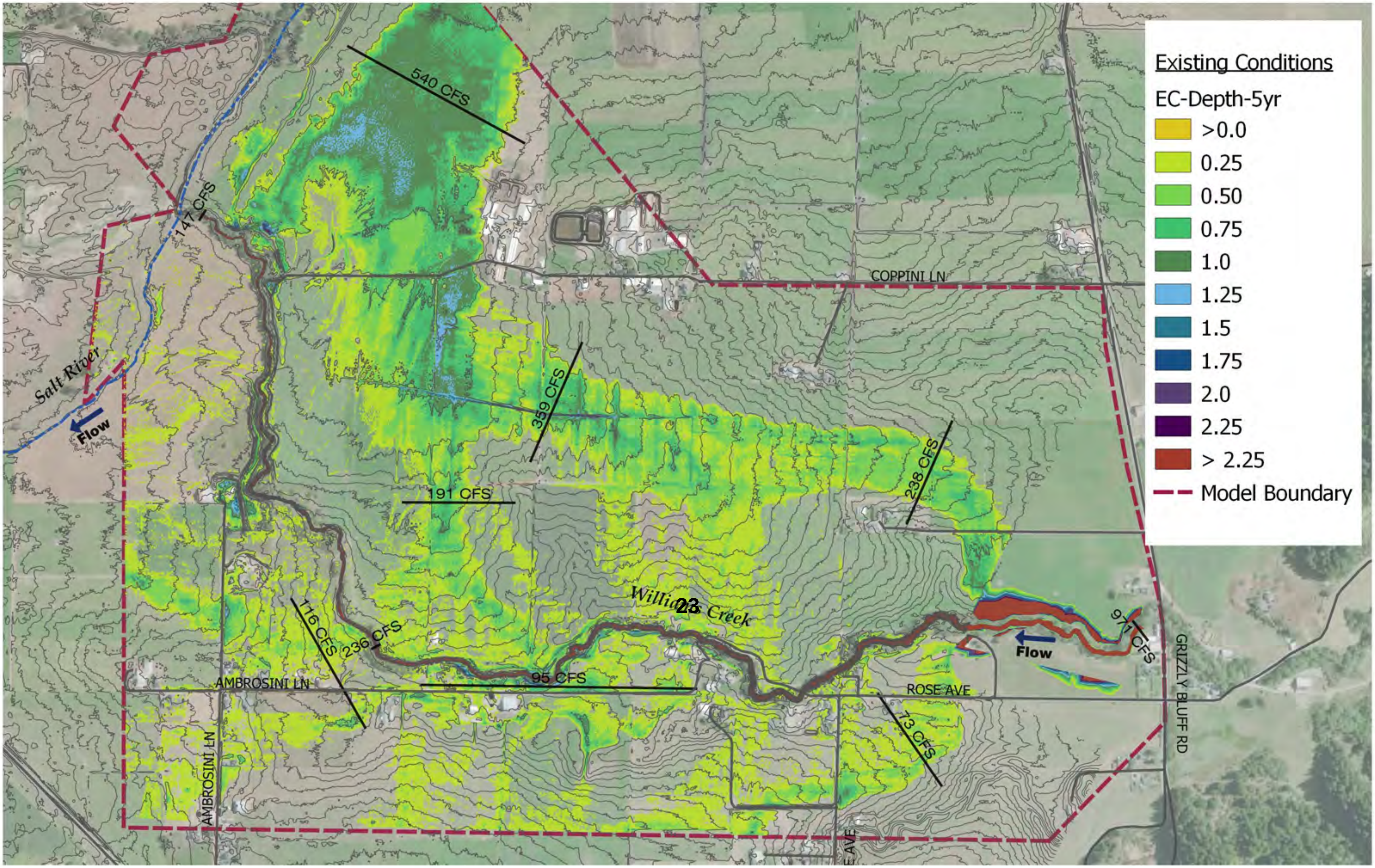

0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

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Hydrologic Solutions

Figure 23

2-D Existing Condition Model Predicted Flow Depths for a 5-Year Peak Flow (971 cfs)

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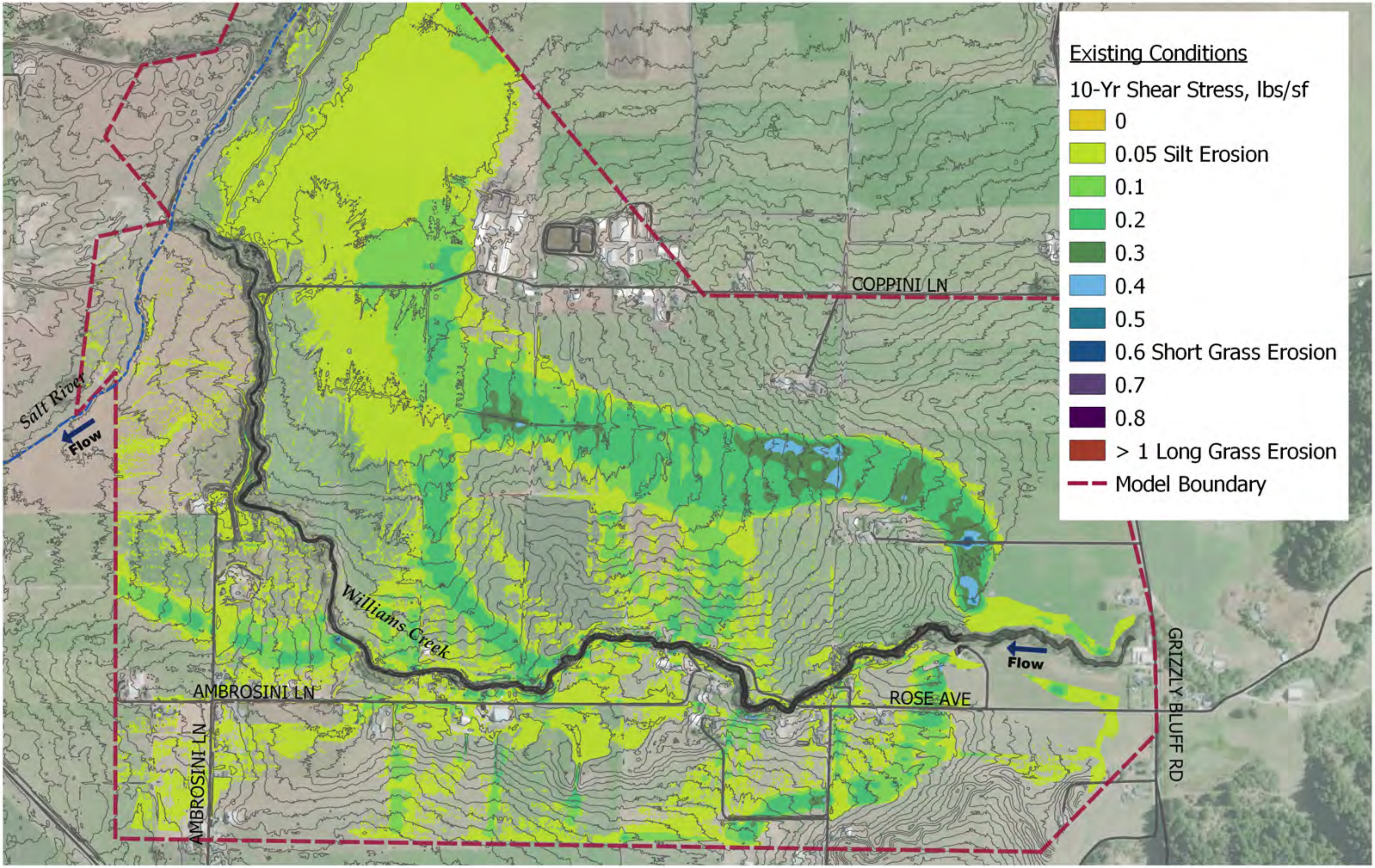

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Figure 24

2-D Existing Condition Model Predicted Shear Stress for a 10-Year Peak Flow (1,239 cfs)

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7 SEDIMENT TRANSPORT SAMPLING AND ANALYSIS

Sediment transport sampling was conducted to obtain estimates of bedload and suspended load sediment volumes and gradations delivered to Williams Creek downstream of Grizzly Bluff Road. This information was necessary to evaluate existing condition sediment transport and deposition patterns in Williams Creek and to assess the ability of the Salt River to transport received sediment from Williams Creek.

7.1 Sediment Sampling

GMA Hydrology, Inc. performed flow gaging and sediment transport sampling for WY 2017 and 2018 and computed the total bedload and suspended sediment load transported in Williams Creek for each water year (GMA, 2017, 2018). All sampling and flow gaging was performed at Bridge 3.

During WY 2017, GMA collected a total of 19 suspended sediment samples during flows ranging from 4.9 cfs to 728 cfs. Gradation analyses were performed for 8 of the 19 samples. GMA also collected 7 bedload samples during flows ranging from 135 to 722 cfs. Gradation analyses were performed for each sample. During the sampling, GMA observed that the bed did not fully mobilize until flows reached about 722 cfs, and zero transport was estimated to occur at 40 cfs.

Table 2 summarizes the results of the sediment sampling for WY 2017 by tonnage and cubic yards (CY) for a range of grain sizes. Tonnage can be converted to grain size by dividing tonnage by 1.3. Of the total 96,753 tons of sediment transported in Williams Creek during WY 2017, suspended load comprised 96,670 tons and bedload comprised 83.4 tons, or 0.09% of the total load.

Of the amount of sediment transported, about 22% or 21,349 tons was greater than 0.0625 mm. Grains smaller than 0.0625 mm are considered to be washload, consisting of silts and clays (Biedenharn, et al., 2000). These grain sizes are in near-permanent suspension and, therefore, transported through the stream without deposition, thus are excluded from many sediment transport analyses. Therefore, the total sediment load (bedload + coarse suspended load, excluding washload) transported in Williams Creek during WY 2017 was 21,349 tons (16,422 cubic yards assuming 1.3 tons per cubic yard).

During WY 2018, GMA collected 12 suspended load samples during flows ranging from 28.5 to 390 cfs. No bedload samples were collected, but bedload transport was estimated using data from WY 2017. A total sediment load of 13,027 tons, comprised of 13,018 tons of suspended load and 9.41 tons of bedload was transported during WY 2018. Grain sizes greater than 0.0625 mm consisted of 21% of the sediment load. Therefore, the total sediment load (excluding washload) transported in Williams Creek in WY 2018 was 2,735 tons or 2,104 cubic yards.

Table 2. Estimate of sediment load transported by Williams Creek during WY 2017, including washload. Of the total load, suspended load comprised 96,670 tons and bedload comprised 83.4 tons.

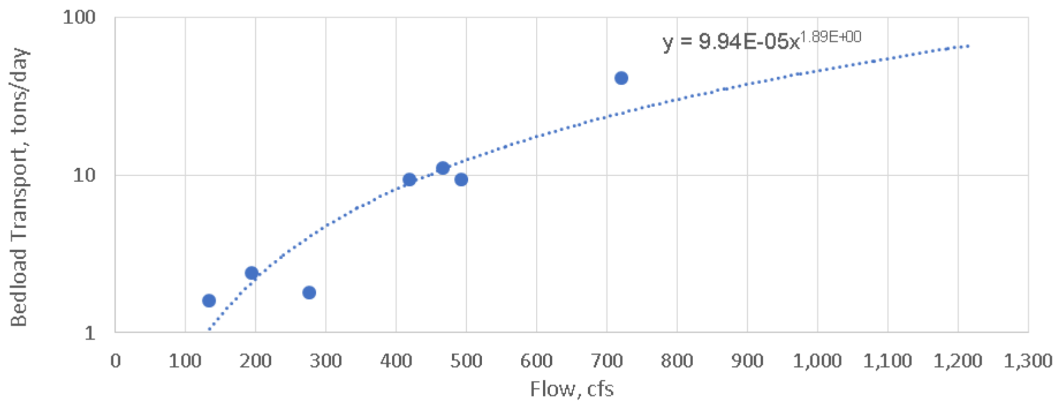
Grain Size (mm)	Name	Tonnage	Cubic Yards[1]	Percent of Load
<.0625	Silts and Clays	75,404	58,003	78%
0.0625-0.125	Very Fine Sand	16,436	12,643	17%
0.125-0.5	Medium Sand	4,838	3,722	5%
0.5 to 2.0	Coarse to Very Coarse Sand	25	20	0.03%
2.0 to 8.0 mm	Very Fine to Fine Gravel	32	24	0.03%
8.0 to 22.4 mm	Medium to Coarse Gravel	18	14	0.02%
	Total Load	**96,753**	**74,426**	**100.00%**

[1] *Assumes 1.3 tons per cubic yard*

7.2 Sediment Transports Rating Curves

To compute the total sediment load for WY 2017 and 2018, GMA developed sediment transport rating curves for bedload and both total and coarse suspended load (excluding washload).

GMA used a power function to predict bedload sediment transport, as shown on Figure 25a. GMA based both the total and coarse suspended load rating curves on measured turbidity. For this study, a coarse suspended sediment rating curve (excluding washload) was created by fitting a polynomial function to the 2017 coarse suspended sediment data. A polynomial function was used, as shown on Figure 25b, rather than a power function because the power function substantially over-predicted sediment load at higher flows. The combined total sediment load (bedload + coarse suspended load, excluding washload) for Williams Creek was estimated by using the bedload and suspended load rating curves to compute sediment loads for each flow, then adding them together.



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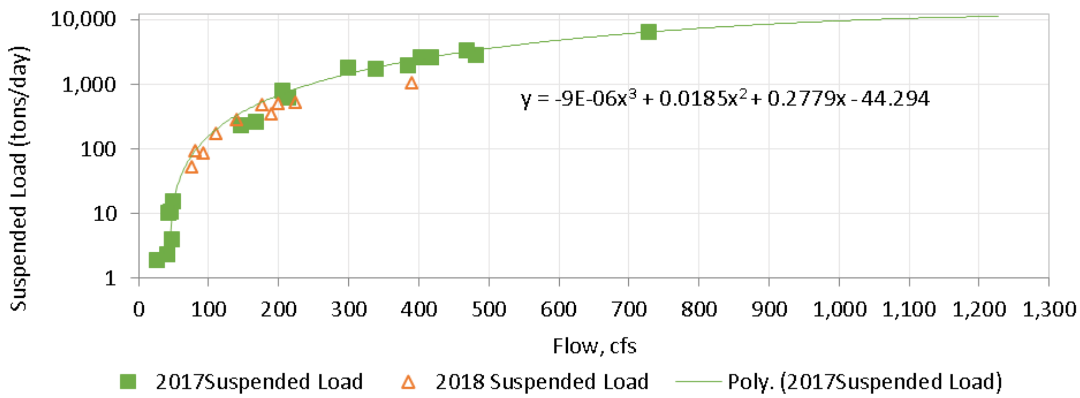

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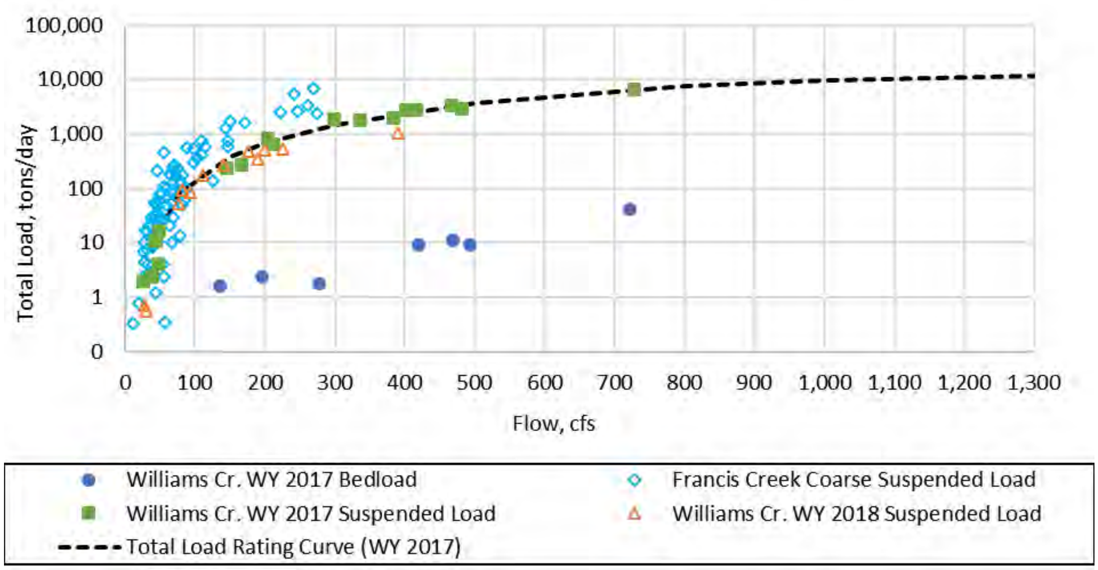

c.

Figure 25. Williams Creek (a) 2017 bedload data and bedload rating curve (GMA, 2017), (b) 2017 and 2018 coarse suspended load data (GMA, 2017, 2018) and rating curve, and (c) coarse suspended and bed load data with dotted line representing total load. Coarse suspendered loads sampled in Francis Creek (c) by Fenton (2007, 2017, and 2018) are also shown.

7.3 Long-Term Annual Sediment Load

Sediment sampling was conducted for only 2 years at Williams Creek. WY 2017 was an exceptionally wet year and WY 2018 was an exceptionally dry year. Understanding the Williams Creek sediment load in a longer-term context would be useful for design and planning for maintenance of in-channel sediment.

The total annual suspended sediment load (excluding washload) collected by Fenton (2007-2018) on adjacent Francis Creek between 2007 through 2018 was used to estimate long-term sediment delivery rates for Williams Creek. Francis Creek is the drainage directly to the west of Williams Creek and has a drainage area of 3.2 square miles. The geology and land use within the Francis Creek and Williams Creek watersheds are similar, thus the sediment yields for a given flow are likely comparable, and the data can be used to predict sediment loads in Williams Creek for the years that Francis Creek was sampled.

The sediment sampling for Francis Creek consisted only of suspended sediment, including washload. The sediment sampling in Williams Creek indicated that bedload comprises a very small fraction of the total sediment load, thus using the coarse fraction of the Francis Creek sediment data to evaluate long-term sediment loads in Williams Creek appears appropriate.

The coarse fraction of the total suspended load at higher flows in Francis Creek appears to be similar to Williams Creek based on 2007, 2017 and 2018 data (21-25%, Fenton, 2018). Therefore, the total coarse suspended sediment load per water year were predicted for Williams Creek using data from Francis Creek by multiplying the Francis Creek total load for each year by 22%. These results were then scaled by drainage area to achieve an estimate of the total annual sediment load in Williams Creek.

Table 3 shows the predicted sediment load (bedload + coarse suspended load) in Williams Creek based on Francis Creek data, and the actual loads measured for Williams Creek in WY 2017 and WY 2018. The difference between actual and predicted annual sediment transport rates ranges about ±34%. This difference is not unexpected, given that each watershed has highly unstable geology prone to landslides. A landslide in one watershed and not the other results in substantially different watershed sediment yields until the landslide material is processed by the stream. A large landslide occurred in the Francis Creek watershed in 2011, as documented by Fenton, resulting in high sediment loads in 2012 and 2013, despite the annual water yields in those years as being below average. The sediment from this landslide may still be working through the system.

Table 3 shows the predicted total sediment load in Williams Creek, including and excluding washload, and the actual loads measured for Williams Creek in WY 2017 and WY 2018. The difference between actual and predicted annual sediment transport rates ranges about ±34%. This difference is not unexpected given that the Francis Creek sediment load appeared to be slightly higher than Williams, and each watershed has highly unstable geology prone to landslides. A landslide in one watershed and not the other could result in substantially different watershed sediment yields until the landslide material is processed by the stream. A landslide occurred in the Francis Creek watershed in 2011, resulting in high sediment loads in 2012 and 2013, despite the fact the annual water yields in those years were below average. The sediment from this landslide may still be working through the system.

For planning purposes, it was assumed that long-term sediment transport rates measured in Francis Creek are similar to Williams Creek, and that the Francis Creek sediment data can be used as surrogate data for Williams Creek during years when sediment was not measured in Williams Creek. Therefore, for WY 2016, an average water year, the total annual coarse sediment load (excluding washload) in Williams Creek would be about 12,000 cubic yards. For a wet year, the total annual coarse sediment load in Williams Creek would be about 16,500 cubic yards, the actual measured load.

Table 3. Estimated sediment loads in Williams Creek (excluding wash load) based measured suspended sediment loads in Francis Creek from WY 2007 – WY 2017, compared to actual sediment loads sampled in Williams Creek.

Water Year	Total Annual Load [Excluding Washload]		Percent Difference
	Williams Creek Load based on Scaled Francis Creek Load (CY)	Sampled Williams Creek Load (CY)	
2007	3,580	-	-
2008	6,291	-	-
2009	1,896	-	-
2010	5,877	-	-
2011	10,605	-	-
2012	9,929	-	-
2013	21,004	-	-
2014	365	-	-
2015	12,732	-	-
2016 (Average Year)	**11,628**	-	-
2017 (Wet Year)	22,117	**16,422**	-34.7%
2018	1,473	2,865	33.2%

7.4 Evaluation of Existing Sediment Transport Rates in Williams Creek

7.4.1 Methods

The existing condition calibrated 1-D HEC-RAS model was used to provide insights into changes in sediment transport along the length of the Williams Creek channel downstream of Grizzly Bluff Road. Sediment transport modeling was conducted using the Laursen/Copeland equations (USACE, 2016c), which were developed to compute total sediment transport load for materials ranging from 0.011 mm to 29 mm. Washload particles smaller than 0.0625 mm were excluded from the computations.

The sediment transport analysis was performed for a constant flow of 722 cfs lasting 6 hours. During sediment sampling, GMA observed that the entire stream bed was mobilized during this flow, unlike smaller flows. They also noted that water levels were near the top-of-bank at Bridge 3, and began flowing out-of-bank downstream of the bridge.

The sediment gradation for the analysis represented the combination of bedload and coarse suspended load gradations sampled during the 722 cfs flow. The combined gradation was derived based on the relative proportion of coarse suspended load and bedload comprising the total coarse load. For a 722 cfs flow event, the coarse suspended load represented 99.6% of the total load. Of the total combined coarse load, 76% of the load was between 0.0625 mm and 0.125 mm and 24% of the load was greater than 0.125 mm.

The sediment transport analysis was conducted by allowing HEC-RAS to compute the equilibrium sediment transport load at Grizzly Bluff Road, then routing this load through the project area to the confluence with the Salt River. Channel erosion would result in an increase in the load, and channel deposition would result in a decrease in the load. The modeling was set to allow a proportional amount of sediment to leave the channel with overbank flows. Sediment deposition on the overbanks was not modeled.

The sediment transport analyses were calibrated using measured sediment transport data at Bridge 3 from GMA (2017), resulting in a value of 1 (unscaled) for the transport function scaling factor. The model was executed for 6 hours, which would be a substantially longer time than this peak flow would typically occur.

7.4.2 Results

Figure 26 shows the HEC-RAS model-predicted sediment transport rate along Williams Creek for a 722 cfs flow event lasting 6 hours. The modeling predicted that the sediment transport rate declines by about 98% through Williams Creek between Grizzly Bluff Road and the Salt River. The decrease in transport rate is a combination of the decrease in channel slope, width, and depth in the downstream direction, and resulting loss of sediment to out-of-bank flows.

Figure 27 shows the model-predicted changes in the channel bed elevation during a 722 cfs flow event after 6 hours. Sediment transport modeling predicted that some pools would locally scour, but up to1 foot of sediment accumulation could occur in the channel, with most aggradation occurring in the middle reaches where flows are spilling out of the channel on both sides. Though not modeled explicitly, the sediment that leaves the channel with overbank flows can be expected to deposit on the channel overbanks as depths become shallower and the high roughness of riparian and pasture vegetation decrease overbank transport capacity.

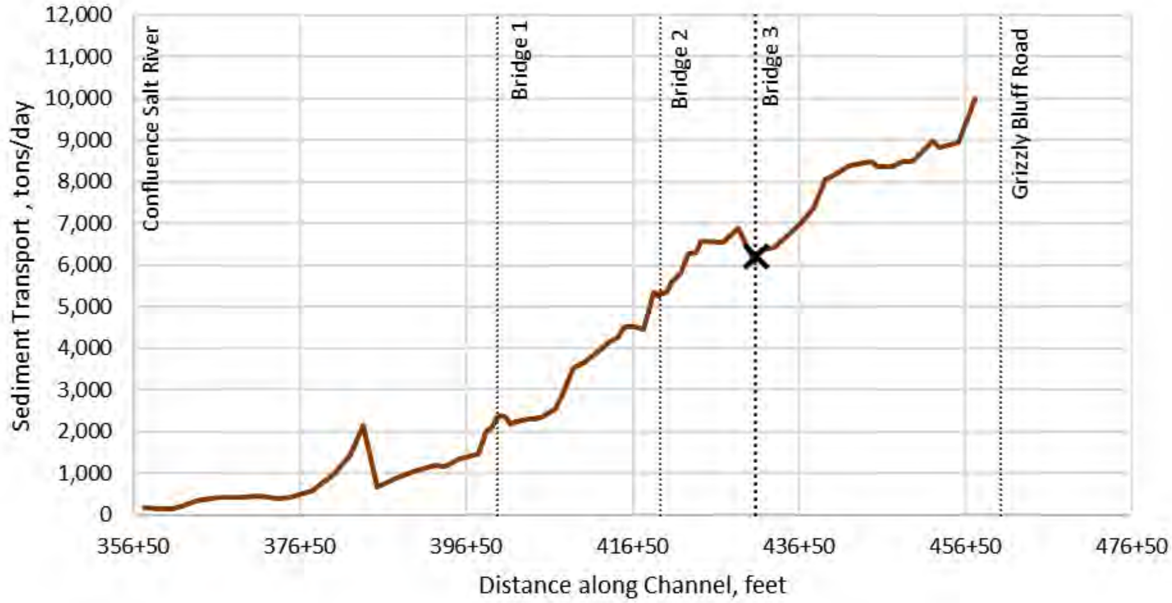

Figure 26. HEC-RAS model predicted sediment transport in Williams Creek during a constant 722 cfs flow event lasting 6 hours (~3-year return period). The actual measured transport rate at Bridge 3 is shown as an X.

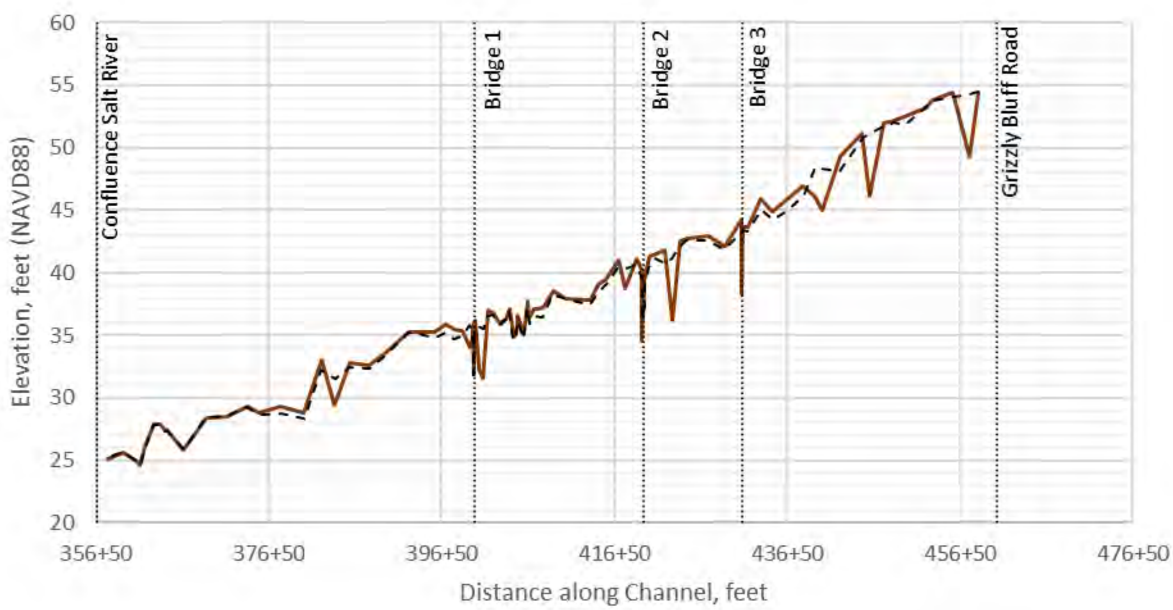

Figure 27. HEC-RAS model predicted changes to the channel bed of Williams Creek during a 722 cfs event lasting 6 hours. The dashed line indicates the bed elevation prior to the flow event, and the solid line represents the model-predicted bed after the flow event.

About 76% of the total combined sediment load gradation is between 0.0625 mm and 0.125 mm, and appears to remain suspended relatively uniformly throughout the water column based on sampling. The coarser sediments larger than 0.125 are more likely to be transported lower in the water column. As shown on Figure 21, the channel flow conveyance capacity for a 722 cfs event decreases about 80% from Grizzly Bluff Road downstream to the confluence with Williams Creek. If the out-of-bank flows transport about 80% of the sediment load out of the channel, the sediments would likely be the finer grained sediments because they are carried higher in the water column. The remaining 20% of the sediment load remaining in the channel would be the coarser fraction. The presence of pea gravel deposition in the Williams Creek Sediment Splay (Figure 1) suggests that the Lower Fan Reach of Williams Creek retains the capacity to transport pea gravels.

7.5 Salt River Sediment Transport Capacity

As discussed in Section 4, the Williams Creek alluvial fan and a large wetland area on the Salt River floodplain historically minimized the amount of sediment delivered to the Salt River from Williams Creek. However, over the past 150 years manipulations of Williams Creek has routed the stream's flow and sediment directly into the Salt River, overloading the river's ability to process received sediments. As part of the overall restoration of the Salt River, Williams Creek will be re-connected to the Salt River. The restored Salt River channel slope will be three times less than the slope of Williams Creek. The low slope of the Salt River provides limited sediment transport capacity, especially for larger grain size materials.

Before identifying a rehabilitation approach for Williams Creek, it was necessary to determine if the restored Salt River will have the capacity to transport some or all of the sediment delivered from Williams Creek. The appropriate rehabilitation approach for Williams Creek depends on these findings.

As part of the Salt River design process, a sediment transport rating curve was constructed by the U.S. Fish and Wildlife Service for various reaches of the Salt River, including the reach at the confluence with Williams Creek. The Ackers-White Total Load sediment transport equations were used (Ackers and White, 1973), with modifications proposed by Wallingford (1990). A median grain size (D_{50}) of 0.09 mm was used for the analysis, based on grain size distributions in the Salt River and Francis Creek.

To evaluate if the Salt River has the capacity to transport the sediment load delivered from Williams Creek, the sediment transport capacity of the Salt River was assessed for a range of flows using the Ackers-White equations. The analysis was conducted assuming the total sediment load transported by Williams Creek would be delivered to the Salt River. Washload was not included in the computations, under the assumption that the Salt River has the capacity to carry the washload. A D_{50} of 0.18 mm was used for the analysis, which represents the intermediate particle diameter (D_{50}) of the combined load sediment gradation in Williams Creek (based on gradation categories used by Ackers-White). The assessment was performed using a cross section for the restored Salt River near Fulmor Road Bridge.

Figure 28 shows the predicted sediment transport capacity rating curve for the Salt River assuming that Williams Creek is delivering its full sediment load and complement of grain sizes. The analysis suggests that the Salt River may not have the capacity to transport the higher volume and coarser sediment load delivered from Williams Creek, and deposition would occur.

The transport capacity was then analyzed assuming the gravels and coarser sands (>0.125 mm) are trapped before reaching the Salt River. This results in a decrease in the D50 from 0.18 mm to 0.09mm. The decrease in sediment size delivered to the Salt River dramatically increases its sediment transport efficiency. Figure 29 shows the Salt River sediment transport capacity exceeds the delivered load from Williams Creek if these coarser sediments are trapped rather than being delivered to the Salt River.

This analysis indicates that it is necessary to prevent coarser sands and gravels from being delivered to the Salt River from Williams Creek, and any rehabilitation alternative considered for Williams Creek must provide a mechanism to accomplish this.

Computations are shown in Attachment 6.

Figure 28. Comparison of Salt River and Williams Creek sediment transport capacities if all of the Williams Creek sediment is delivered to the Salt River (D_{50} = 0.18 mm).

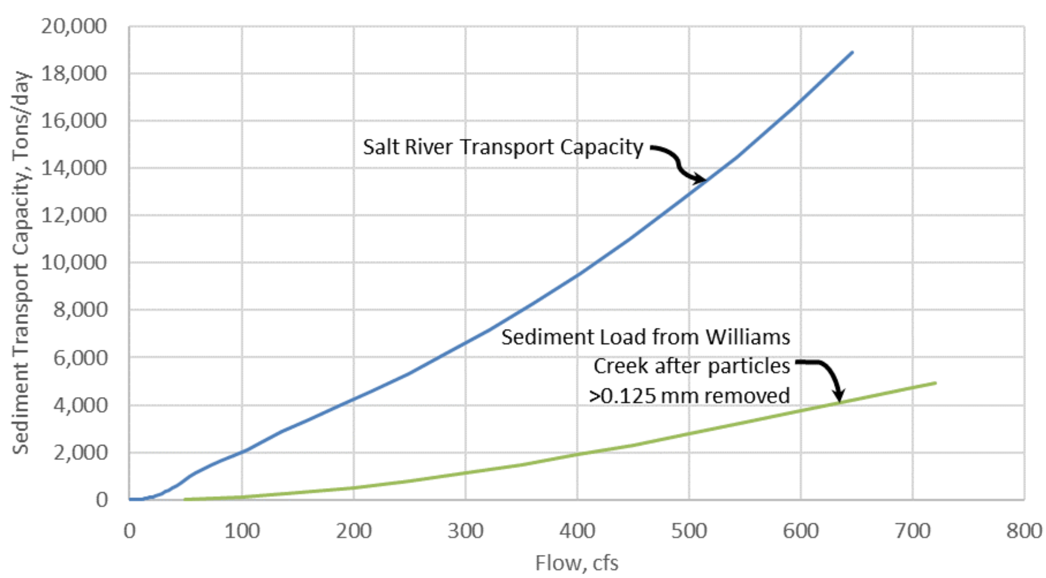

Figure 29. Comparison of Salt River and Williams Creek sediment transport capacities if the larger particles (>0.125 mm) in the Williams Creek sediment load were not delivered to the Salt River, resulting in a D_{50} = 0.09 mm of the sediment load.

8 RECOMMENDATIONS FOR PRELIMINARY DESIGN OF WILLIAMS CREEK CHANNEL AND SEDIMENT STORAGE AREAS

Findings from the existing geomorphic and sediment transport analyses show that limited channel capacity and flooding issues along Williams Creek downstream of Grizzly Bluff Road are primarily driven by a watershed with a naturally high sediment load and its location on an alluvial fan. The alluvial fan processes are out of equilibrium due to land-use activities since the mid to late 1800's that have prevented the channel from avulsing (jumping) into a new alignment. It is necessary to address these alluvial fan processes to address the flooding issues. Generally, there are three approaches to integrating alluvial fan processes on an occupied landscape (Davies and McSaveney, 2008):

- Approach 1: Allowing natural fan processes to occur within a controlled area
- Approach 2: Constructing and maintaining a designated sediment storage area for collection and removal of excess sediment
- Approach 3: Creating a sediment delivery channel to transport all sediment from the upper fan directly to the receiving river

The sediment transport analyses discussed in Section 7.5 indicated that the restored channel of the Salt River does not have the capacity to transport the full sediment load and larger grain sizes delivered from Williams Creek. Therefore, Approach 3 is not a feasible option for Williams Creek and is not recommended.

8.1 Recommended Channel Geometry

If Approach 2 or 3 were implemented to address the flooding and channel capacity issues along Williams Creek, it will be necessary to design a channel that has the capacity to transport the supplied sediment load to a designated sediment storage area.

The geomorphic analysis (Section 5) identified that the approximate 4,500 feet of the channel reach extending upstream of Grizzly Bluff road appears to have the capacity to transport the delivered sediment load without substantial aggradation. This channel, called the "delivery reach," has a slope of 0.37%, and a trapezoidal channel with bottom width of about 8 feet and a depth of about 6 feet.

The geomorphic analysis also identified that the Upper Fan Reach of Williams Creek, between Grizzly Bluff Road and Bridge 3 (Figure 5) appears to have the capacity to transport the supplied sediment load, and can also be considered a "delivery reach" (Section 7). This reach is characterized by a trapezoidal channel with bottom width of 10 feet and is about 9 feet deep. Though this reach has a bottom slope of 0.25%, the water-surface slope through this reach is about 0.36% due to localized area of steep channel within this reach.

Therefore, for preliminary design, it is recommended that any channel designed to transport the full sediment load delivered from upstream should have a slope between 0.25% and 0.37%. For analysis purposes, a slope of 0.35% could be used. The channel should be trapezoidal in shape with a bottom width ranging from 10-18 feet, with a minimum depth of 6-9 feet.

Before final design, to refine design channel slopes and dimensions, it is recommended that the channel reach upstream of Grizzly Bluff road be surveyed and a more detailed sediment transport analysis performed in this reach.

8.2 Recommended Parameters for Sizing Sediment Storage Areas

The analyses in Section 7.5 showed that the restored channel of the Salt River does not have the capacity to transport the full sediment load from Williams Creek without removing materials coarser than 0.125 mm. Therefore, sediment storage area designs should focus on trapping these coarser sized materials while allowing finer material to continue downstream to the Salt River. This may be achieved by allowing alluvial fan processes to occur naturally in one of the existing flood basins on the fan, or constructing a sediment storage area. The sediment storage could be similar to what is descried in Piton and Recking (2015) that incorporates a "guide channel" similar to what is as described by Schwindt, et al (2018).

To minimize the footprint of a sediment storage area, it is recommended that it be cleaned out annually, and should be designed to provide sediment storage for a sediment load that could be delivered during a wet year, such as WY2017. As shown in Table 2, the total volume of materials sampled by GMA during the wet 2017 WY coarser than 0.125 mm was about 4,000 cy. Therefore, a sediment storage area should be sized to trap a minimum of 4,000 cy of material, and also maintain a geometry to minimize trapping of finer materials.

For sizing purposed, it should be assumed that the slope of sediment deposition in the basin will be similar to the slope of the coarser grained sediment deposited on the overbank areas in the upper reaches of the alluvial fan. As shown in Figure 5, the slope of the Upper Alluvial Fan Reach, represented by the top-of-bank of the channel, ranges from 0.30% to 0.44%, with an overall slope of 0.35%. Therefore, the stored sediment elevation slope in the basin when "full" would be about 0.35%, and the length and depth of the storage area should be sufficient to accommodate the full sediment volume at this slope without causing channel aggradation upstream.

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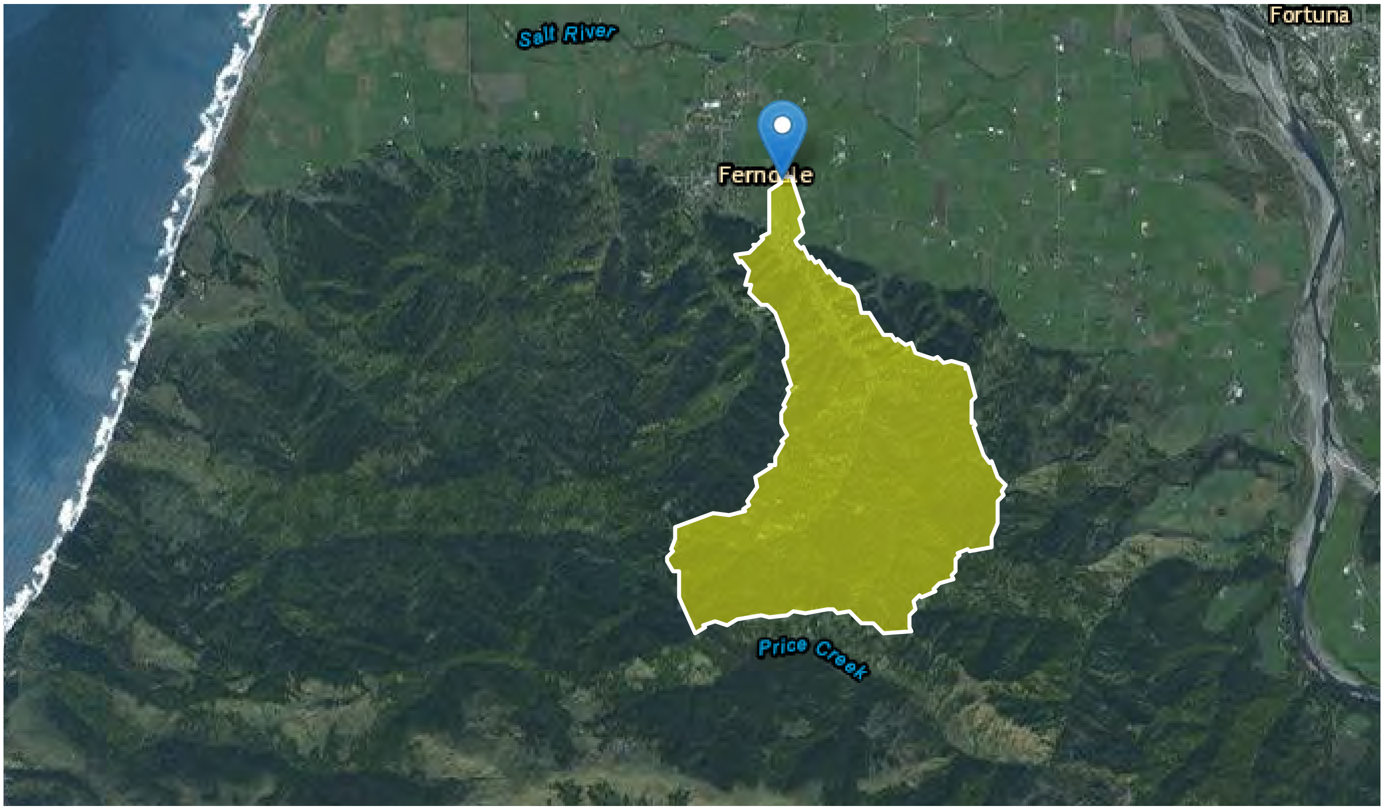
Attachment 1

Hydrology

Williams Creek at Bridge 3

StreamStats Report

Region ID:
CA
Workspace ID:
CA20170721192620462000
Clicked Point (Latitude, Longitude):
40.57770, -124.24996
Time:
2017-07-21 16:27:02 -0700



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	6	square miles
PRECIP	Mean Annual Precipitation	50.7	inches
BASINPERIM	Perimeter of the drainage basin as defined in SIR 2004-5262	16.7	
BSLDEM30M	Mean basin slope computed from 30 m DEM	33	percent
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	-2336895.4	

Parameter Code	Parameter Description	Value	Unit
CENTROIDY	Basin centroid vertical (y) location in state plane units	2297341.8	
EL6000	Percent of area above 6000 ft	0	percent
ELEV	Mean Basin Elevation	660	feet
ELEVMAX	Maximum basin elevation	1757	feet
FOREST	Percentage of area covered by forest	67.4	percent
JANMAXTMP	Mean Maximum January Temperature	54.39	degrees F
JANMINTMP	Mean Minimum January Temperature	38.73	degrees F
LAKEAREA	Percentage of Lakes and Ponds	0	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	2.4	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.1	percent
LFPLENGTH	Length of longest flow path	6	miles
MINBELEV	Minimum basin elevation	39	feet
OUTLETELEV	Elevation of the stream outlet in thousands of feet above NAVD88.	39	feet
RELIEF	Maximum - minimum elevation	1718	feet
RELRELF	Basin relief divided by basin perimeter	103	feet per mi

Peak-Flow Statistics Parameters [100 Percent (6.03 square miles) 2012 5113 Region 1 North Coast]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	6	square miles	0.04	3200
PRECIP	Mean Annual Precipitation	50.7	inches	20	125

Peak-Flow Statistics Flow Report [100 Percent (6.03 square miles) 2012 5113 Region 1 North Coast]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SEp
2 Year Peak Flood	436	ft^3/s	179	1060	58.6

Statistic	Value	Unit	PIl	PIu	SEp
5 Year Peak Flood	823	ft^3/s	394	1720	47.4
10 Year Peak Flood	1100	ft^3/s	547	2220	44.2
25 Year Peak Flood	1460	ft^3/s	751	2860	42.7
50 Year Peak Flood	1740	ft^3/s	891	3410	42.7
100 Year Peak Flood	2030	ft^3/s	1010	4070	44.3
200 Year Peak Flood	2300	ft^3/s	1150	4620	44.4
500 Year Peak Flood	2670	ft^3/s	1300	5480	46

Peak-Flow Statistics Citations

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl. (http://pubs.usgs.gov/sir/2012/5113/)

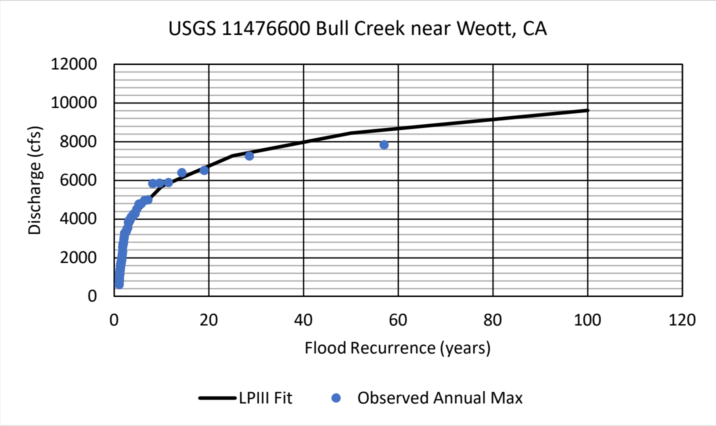
Log Pearson Type III Probabilistic Analysis
Williams Creek

Peak flows were estimated using a Log-Pearson type III distribution as described in Bulletin 17B (Guidelines for Determining Flood Flow Frequency, 1982).

Stream Name	Location	Drainage Area (mi^2)	Recurrence Interval of Peak Flows 1.01 yr (cfs/mi^2)	1.01 YR (cfs/mi^2)	1.2 yr (cfs/mi^2)	1.5-yr (cfs/mi^2)	2-yr (cfs/mi^2)	5-yr (cfs/mi^2)	10-yr (cfs/mi^2)	25-yr (cfs/mi^2)	50-yr (cfs/mi^2)	100-yr (cfs) (cfs/mi^2)
Bull Creek	Weott, CA	27.6	17.78	37.14	49.86	73.30	97.39	161.81	206.50	263.65	306.14	348.24

Williams Creek

Drainage Area (mi^2)	Q 1.01-yr (cfs)	Q 1.1-yr (cfs)	Q 1.2-yr (cfs)	Q 1.5-yr (cfs)	Q 2-yr (cfs)	Q 5-yr (cfs)	Q 10-yr (cfs)	Q 25-yr (cfs)	Q 50-yr (cfs)	Q 100-yr (cfs)
6.0	107	223	299	440	584	971	1,239	1,582	1,837	2,089



Flood Frequency based on Annual Maximum Series

USGS 11476600 Bull Creek near Weott, CA

Station #: 11476600

Drainage Area (sq. miles) 27.6

Maximum Daily Average Discharge

Water Year	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Annual Exceedance Probability	Water Year	Discharge (cfs)	Discharge (cms)	Log-Discharge (cfs)
1961	2/10/1961	3400	1	57.00	0.02	1997	7830	221.72	3.89
1962	2/9/1962	1380	2	28.50	0.04	2013	7260	205.58	3.86
1963	1/31/1963	4120	3	19.00	0.05	1965	6520	184.63	3.81
1964	1/20/1964	1930	4	14.25	0.07	1995	6400	181.23	3.81
1965	12/22/1964	6520	5	11.40	0.09	1983	5880	166.50	3.77
1966	1/4/1966	5000	6	9.50	0.11	2003	5860	165.94	3.77
1967	12/5/1966	4800	7	8.14	0.12	1974	5830	165.09	3.77
1968	1/14/1968	2710	8	7.13	0.14	1966	5000	141.59	3.70
1969	12/24/1968	3550	9	6.33	0.16	2015	4960	140.45	3.70
1970	1/26/1970	4280	10	5.70	0.18	1967	4800	135.92	3.68
1971	12/3/1970	2970	11	5.18	0.19	1986	4780	135.36	3.68
1972	1/22/1972	4000	12	4.75	0.21	2017	4520	127.99	3.66
1973	1/16/1973	1370	13	4.38	0.23	1970	4280	121.20	3.63
1974	1/16/1974	5830	14	4.07	0.25	1978	4260	120.63	3.63
1975	3/18/1975	3290	15	3.80	0.26	2006	4130	116.95	3.62
1976	2/26/1976	1590	16	3.56	0.28	1963	4120	116.67	3.61
1977	9/19/1977	173	17	3.35	0.30	1972	4000	113.27	3.60
1978	12/14/1977	4260	18	3.17	0.32	2004	3950	111.85	3.60
1979	1/11/1979	878	19	3.00	0.33	1982	3840	108.74	3.58
1980	1/14/1980	2540	20	2.85	0.35	1969	3550	100.53	3.55
1981	1/27/1981	1770	21	2.71	0.37	1985	3500	99.11	3.54
1982	11/16/1981	3840	22	2.59	0.39	1961	3400	96.28	3.53
1983	12/16/1982	5880	23	2.48	0.40	1996	3370	95.43	3.53
1984	11/10/1983	2810	24	2.38	0.42	1993	3300	93.45	3.52
1985	11/12/1984	3500	25	2.28	0.44	1975	3290	93.16	3.52
1986	2/17/1986	4780	26	2.19	0.46	2016	3270	92.60	3.51
1987	3/5/1987	1460	27	2.11	0.47	2008	3070	86.93	3.49
1988	12/6/1987	2310	28	2.04	0.49	1971	2970	84.10	3.47

Generalized Skew=	-0.4	A=	-0.301271246
Station Skewness (log Q)=	-0.36	B=	0.846631549
Station Mean (log Q)=	3.41	(station skew)	
Station Median (log Q)=	3.46	=	0.11622
Station Std Dev (log Q)=	0.28		
Weighted Skewness (G_W)=	-0.37		

Log Pearson Type III Distribution

Return Period (years)	Exceedence Probability	Log-Pearson K	Est. Discharge [mean] (cfs)	Est. Discharge [median] (cfs)
1.01	0.990	-2.59437	490.69	548.57
1.1	0.909	-1.44382	1025.12	1146.06
1.2	0.833	-0.98389	1376.20	1538.55
1.5	0.667	-0.38222	2023.05	2261.71
2.0	0.500	0.06161	2688.05	3005.15
2.33	0.429	0.23581	3005.25	3359.77
2.4	0.417	0.26960	3070.98	3433.26
2.6	0.385	0.35611	3245.91	3628.82
2.8	0.357	0.43026	3403.76	3805.29
5.0	0.200	0.85442	4465.98	4992.82
10	0.100	1.23528	5699.46	6371.81
25	0.040	1.61683	7276.83	8135.26
50	0.020	1.85014	8449.41	9446.16
100	0.010	2.05136	9611.38	10745.21

Flood Frequency based on Annual Maximum Series

USGS 11476600 Bull Creek near Weott, CA

Station #: 11476600

Drainage Area (sq. miles) 27.6

Maximum Daily Average Discharge

Water Year	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Annual Exceedance Probability	Water Year	Discharge (cfs)	Discharge (cms)	Log-Discharge (cfs)
1989	11/22/1988	1150	29	1.97	0.51	1984	2810	79.57	3.45
1990	1/8/1990	806	30	1.90	0.53	1968	2710	76.74	3.43
1991	3/4/1991	2040	31	1.84	0.54	2000	2700	76.46	3.43
1992	2/16/1992	635	32	1.78	0.56	1980	2540	71.93	3.40
1993	1/20/1993	3300	33	1.73	0.58	1988	2310	65.41	3.36
1994	1/23/1994	1110	34	1.68	0.60	2010	2180	61.73	3.34
1995	1/9/1995	6400	35	1.63	0.61	1991	2040	57.77	3.31
1996	12/12/1995	3370	36	1.58	0.63	1964	1930	54.65	3.29
1997	12/31/1996	7830	37	1.54	0.65	2007	1870	52.95	3.27
1998	3/23/1998	1690	38	1.50	0.67	2009	1830	51.82	3.26
1999	11/30/1998	1430	39	1.46	0.68	2012	1790	50.69	3.25
2000	2/14/2000	2700	40	1.43	0.70	1981	1770	50.12	3.25
2001	2/22/2001	970	41	1.39	0.72	1998	1690	47.86	3.23
2002	1/6/2002	1680	42	1.36	0.74	2002	1680	47.57	3.23
2003	12/16/2002	5860	43	1.33	0.75	1976	1590	45.02	3.20
2004	2/17/2004	3950	44	1.30	0.77	1987	1460	41.34	3.16
2005	12/8/2004	1270	45	1.27	0.79	1999	1430	40.49	3.16
2006	12/30/2005	4130	46	1.24	0.81	1962	1380	39.08	3.14
2007	12/26/2006	1870	47	1.21	0.82	1973	1370	38.79	3.14
2008	1/4/2008	3070	48	1.19	0.84	2011	1330	37.66	3.12
2009	2/23/2009	1830	49	1.16	0.86	2005	1270	35.96	3.10
2010	1/19/2010	2180	50	1.14	0.88	1989	1150	32.56	3.06
2011	12/21/2010	1330	51	1.12	0.89	1994	1110	31.43	3.05
2012	3/27/2012	1790	52	1.10	0.91	2001	970	27.47	2.99
2013	12/2/2012	7260	53	1.08	0.93	1979	878	24.86	2.94
2014	3/29/2014	614	54	1.06	0.95	1990	806	22.82	2.91
2015	2/6/2015	4960	55	1.04	0.96	1992	635	17.98	2.80
2016	1/17/2016	3270	56	1.02	0.98	2014	614	17.39	2.79

Values From K-Table for Linear interpolation

Weighted Skewness =	-0.40	-0.30	-0.37
P	K	K	K
0.99	-2.61539	-2.54421	-2.59437
0.9	-1.31671	-1.30936	-1.31454
0.8	-0.81638	-0.82377	-0.81856
0.7	-0.47228	-0.48600	-0.47633
0.6	-0.18916	-0.20552	-0.19399
0.500	0.06651	0.04993	0.06161
0.429	0.24037	0.22492	0.23581
0.200	0.85508	0.85285	0.85442
0.100	1.23114	1.24516	1.23528
0.040	1.60574	1.64329	1.61683
0.020	1.83361	1.88959	1.85014
0.010	2.02933	2.10394	2.05136

Sample Size, n =	56		
Skewness =	0.70	0.70	-0.36
Mean=	3103.27	87.88	3.41
Median=	2890.00	81.84	3.46
Std Dev=	1797.29	50.89	0.28
Outliers			
Kn=		2.811	
Q_{LOW}		427.13 cfs	
Q_{HIGH}		15632.98 cfs	

Attachment 2

Rapid Geomorphic Assessment Forms and Summary of Results

Summary of Rapid Geomorphic Assessment of Williams Creek Upstream of Grizzly Bluff Road 08/15/2018) (MLA/HCRCD/NRCS)

Location	USGS Channel slope	Measured channel slope	ACW	BFW	BFD	Low TB Depth	TB width	Entr. Ratio (TBW/BFW)	Incision ratio (TBD/BFD)	Planform	Channel Shape	Bank shape	Bank materials/stability	Bedform features	Bed material	Max size in transport	Factors affecting bank stability	Bedrock?	Valley Shape	Forest cover	Channel Evolution	Channel stability	Notes
Reach 1	9.80%	-	-	-	-	-	-	-	-	sinuous, valley controlled	mod. Depth trapezoid	vertical to convex	stable silt floodplains, vert eroding mudstone	unorganized cascade	D50 45-80 mm, D max 260-630 mm(Colluvium?) mm, cobble, boulders, silt deposition on edges, tightly packed bed, matrix filled to framework dilated	260 mm	loose mudstone, planform erosion, no roots, debris, falling trees	Mudstone/sandstone	asymmetrical floodplain, alternating sides with meandering into hillslopes	semi to continuous 4-10" alders, hemlock, spruce, cedar	stable inset	moderately unstable	soft mudstone on channel bottom and banks, some more competence sandstone, lots of mudstone erosion on banks, high source sediment from mudstone erosion
Reach 2-1	6.50%	7.00%	13.8	17.9	3.8	4.0	22.0	1.2	1.0	straight, valley controlled	deep, wide box	vert to stepped	vegetated, stable. Vert banks eroding silt	plane bed, with boulder forcing features	silt storage, little mid channel storage	D50 32, Dmax 290 mm	290 mm	mudstone/sandstone	asymmetrical floodplain	semi-continuous, alder, spruce fir, elderberry, grazing	stable inset	moderately unstable	straight riffle, pool with sedimentation, higher flows have access to floodplain
Reach 2-2			13.0	17.8	4.0	10.0	-	-	2.5														
Reach 3-1	1.90%	2.50%	12.4	24.5	3.0	20.0	60.0	2.4	6.7	straight, valley controlled	Deep U shape	convex, steep, toe cutting	earthen, crumbling mudstone	rifles, with drop and pool	D50 65-90 mm, D max 700 mm, strongly imbricated, 40% filled with fines, unvegetated side/point bar	420-700 mm	planform erosion, loose bank material, no roots, falling trees, stock access	mudstone	steep canyon	mature alder, spruce, elderberry, understory, maples	inset deposition	moderately unstable	measured slopes at riffles, silt depo on sides of reach, lower in reach more depo, trib downstream bedrock, delivering clean gravels
Reach 3-2		2.00%	20.0	24.6	3.5	25.0	60.0	2.4	7.1														
Reach 4-1	1.87%	1.00%	18.2	25.3	4.0	15.0	60.0	2.4	3.8	straight valley controllled	flat U shape	convex to stepped	vegetated and stable bedrock and soils	plane bed, berdrock, boulders, debris jams, imbricated matrix filled, coarse sand and pea gravel in center of channel	D50 30-75 mm, Dmax 290-310 mm	310 mm	2 debris jams, falling trees	sand/mudstone	mod steep to steep valley	continuos forest, 6-8" aders, maples, redwood, dense understory	stable	modetately-very stable	inbricated channel bed, fairly stable banks, most upstream mid-channel aggradation at debris jam
Reach 4-2		1.50%	24.4	32.0	2.0	20.0	60.0	1.9	10.0														
Reach 5-1	0.87%	0.50%	20.0	24.3	3.0	4.0	35.0	1.4	1.3	meandering (not valley controled)	flat U shape	stepped, with some undercuts	silty banks, some areas w cobbles	riffle/pool overwidened and aggrading	D50 25-40 mm, D max 140-190 mm, loose cobble, cemented underneath	190 mm	lot of shallow bank failures, loose material, planform erosion, stock, fallen trees, debris jams, mimimal riparian	no	mod steep valley	occasional clumps 12" alders, occasional willows	inset deposition	moderately unstable	sinuous chanel in unconfiled valley. Bed fully choked with silt under loose cobbles. Poo WQ. Trib DS contributing clean cobbles. Whole reach has cattle access.
Reach 5-2			17.3	24.0	2.8	6.0	45.0	1.9	2.1						60 to 80 mm	140 mm							
Reach 5-3			15.75	32	2	-	-	-	-							-							
Reach 6-1	0.36%	-	21.0	22.5	3.0	5.0	45.0	2.0	1.7	meandering-highly meandering	shallow overwidened in loaces	stepped, moderate bank angles	-	riffle pools-partially aggraded, lots of debris jams/storage	D50 10-15 mm, dmax 55-60 mmcobbles in silt, framework dialeted, cobbbles tightly embedded in silt	-	stock, undersized crossing, lots of planform erosion,soft bank materials, no roots, moderate debris jams	no	shallow valley	narrow buffer, 6-8" alders, lots of tree falls, semi-continuous to isolated	inset deposition	moderately unstable	Landowner says channel has widened about 10 feet since kid, deep pools filled in. channel downcut since kid
Reach 6-2			13.0	14.5	1.5	5.0	50.0	-	-														
Reach 7-1	0.36%	0.50%	18.4	25.0	3.0	8.0	35.0	1.4	2.7	meandering (not valley controled)	shallow overwidened	stepped, low to moderate bank angles	loose silty clay clumps	riffle pools-partially aggraded, lots of debris jams	D50 4-15 mm , D max 30-90 mm, framework dialated	-	stock, planform erosion, looose bank material, no roots, debris jams, falling trees	no	shallow valley	12-22" alders, semi continuoius, thin buffer	inset deposition	moderately unstable	in backwater from downstream debris jams. Sumer says creek downcutting here since levee breach doewnstream. Lots of pebbles and gravels. Many sedimetn storage bars.
Reach 7-2		0.50%	18.0	31.0	2.5	7.0	50.0	1.6	2.8														

Williams Creek Rapid Geomorphic Assessment Form

Adapted from Vermont Stream Geomprhic Asssessment (2012) and AUSRivAS Physical Assessment Protocol (2002)

Date ______________

Location (station Limits) ______________

Field Crew ______________

General Notes

Summary of Findings

Reach Type (Circle 1)

Source

Delivery

Storage

Description of Stability (Circle 1)

Substantially Unstable

Moderately Unstable

Moderately Stable

Very Stable

Channel Evolution (Circle 1)

Stable

Incision

Widening

Inset Deposition

Stable Inset

1.0 Planform Geometry (Circle)

Straight (Sinuosity 1-1.05) | Sinuous (1.05-1.25) | Meandering (1.25-2.0) | Highly Meandering (>2.0)

2.0 Channel Hydraulic Geometry

Channel Slope

	Value	Notes
1		
2		
3		
4		
5		

Active Channel Width (ft)

	Value	Notes
1		
2		
3		
4		
5		

Bankfull Width (ft)

	Value	Notes
1		
2		
3		
4		
5		

Bankfull Depth (ft) (BFD)

	Value	Notes
1		
2		
3		
4		
5		

Entrenchment Ration (TBW/BFW)

	Value	Notes
1		
2		
3		
4		
5		

Top of Bank Depth (ft) (TBD)

	Value	Notes
1		
2		
3		
4		
5		

Top of Bank Width (ft) (TBW)

	Value	Notes
1		
2		
3		
4		
5		

Incision Ratio (TBD /BFD)

	Value	Notes
1		
2		
3		
4		
5		

Notes

3.0 Valley Shape

Left (Note rough valley width)

Valley shape
Choose one category only

 ☐	Steep valley
 ☐	Shallow valley
 ☐	Broad valley
 ☐	Entrenched / incised
 ☐	Symmetrical floodplain
 ☐	Asymmetrical floodplain

☐ Perched Channel

Right (Note rough valley width)

Valley shape
Choose one category only

 ☐	Steep valley
 ☐	Shallow valley
 ☐	Broad valley
 ☐	Entrenched / incised
 ☐	Symmetrical floodplain
 ☐	Asymmetrical floodplain

☐ Perched Channel

Notes

4.0 Channel Attributes

Channel Shape

Note Left and Right Side

Channel shape Choose one category only

U shaped ☐	Flat U shaped ☐	e	Widened ☐ (handwritten: Shallow / over-)		
Box ☐ (handwritten: Deep/narrow)	Wide box ☐ (handwritten: Deep/wide)	V shaped ☐	Trapezoid ☐ (handwritten: moderate Depth)	Concrete ☐ (handwritten: manmade)	Pipe or culvert ☐

Bank Shape and slope

Bank shape
Choose one category for each bank

Bank shape	Left bank	Right bank
Concave	☐	☐
Convex	☐	☐
Stepped	☐	☐
Wide lower bench	☐	☐
Undercut	☐	☐

Bank slope
Choose one category for each bank

Bank slope	Left bank	Right bank
Vertical 80 - 90°	☐	☐
Steep 60 - 80°	☐	☐
Moderate 30 - 60°	☐	☐
Low 10 - 30°	☐	☐
Flat <10°	☐	☐

Channel Bank Materials/Extent Instabilities/Mass Wasting

LEFT
Right

5.0 Channel Modifications

Left

Channel modifications Choose one or more categories

	No modifications ☐		Reinforced / RSP Ret. Wall ☐
	Desnagged ☐		Revegetated ☐
	Dams and diversions ☐		Infilled / Confined ☐
	Resectioned / Gullied ☐		Berms or embankments ☐
	Straightened ☐		☐

Right

Channel modifications Choose one or more categories

	No modifications ☐		Reinforced / RSP Ret. Wall ☐
	Desnagged ☐		Revegetated ☐
	Dams and diversions ☐		Infilled / Confined ☐
	Resectioned / Gullied ☐		Berms or embankments ☐
	Straightened ☐		☐

Notes	Notes

6.0 Instream instabilities/ Sediment Sources

Crossings (Circle)

Width < BFW
Width > BFW
Obstructing Channel Flow
Perched at Outlet
Aggrading
Failure potential

Factors affecting bank stability
Choose one or more categories

- ☐ None
- ☐ Mining
- ☐ Runoff
- ☐ Stock access
- ☐ Human access
- ☐ Ford, culvert or bridge
- ☐ Feral animals
- ☐ Other
- ☐ Cleared vegetation
- ☐ Irrigation draw-down
- ☐ Reservoir releases
- ☐ Seepage
- ☐ Flow and waves
- ☐ Drainpipes

- ☐ Planform erosion
- ☐ Undercut bank
- ☐ Loose Bank material
- ☐ Roots
- ☐ No Roots
- ☐ Bedrock
- ☐ Debris Jams
- ☐ Encroachments
- ☐ Garden Waste
- ☐ Dredging
- ☐ Falling Trees

Notes, Source Severity (H,M,L)
Notes

7.0 Channel Bed Characteristics/Sediment Storage Potential

Extent of bedform features

Total % composition for all features must equal 100%

Step-Pool: ______ % of Reach
Stable/Unstable
Aggrading/Degrading
Forcing Feature:

Cascade (Unorganized): ______ % of Reach
Stable/Unstable
Aggrading/Degrading
Forcing Feature:

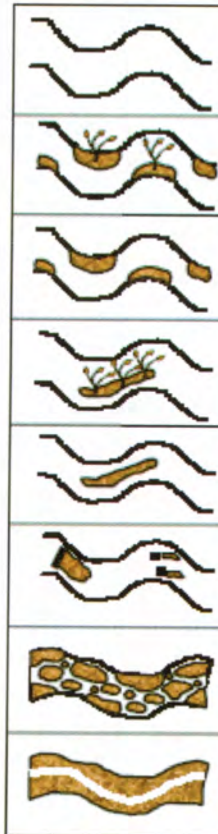
Steep Plane Bed: ______ % of Reach
Stable/Unstable
Aggrading/Degrading
Forcing Feature:

Riffle/Pool: ______ % of Reach
Stable/Unstable
Aggrading/Degrading
Forcing Feature:

Low Slope Plane Bed ____________% of Reach
Stable/Unstable
Aggrading/Degrading
Forcing Feature:

Type of bars

Choose one or more categories

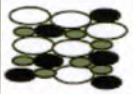
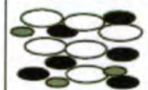


Type	Check
Bars absent min. Storage	☐
Side/point bars VEGETATED Low Storage	☐
Side/point bars UNVEGETATED Low-mid. Storage	☐
Mid-channel bars VEGETATED Lo-mid Storage	☐
Mid-channel bars UNVEGETATED mid. Storage	☐
Bars around obstructions mid Storage	☐
PARtiALLY Aggraded High Storage	☐
Highly Aggraded High Storage	☐

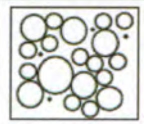
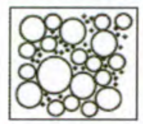
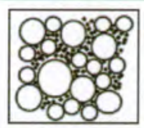
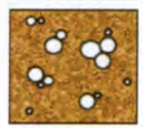
Knickpoints	height (ft)	Notes
Stable	________	____________
Unstable	________	____________

Debris jams (Circle)
Full Spanning (High)
Full Spanning (Low)
Partial Spanning (High)
Aggradation Upstream
Creating Knickpoint
Stable/Temporary

Bed compaction
Choose one category only

	Tightly packed, armoured Array of sediment sizes, overlapping, tightly packed and very hard to dislodge ☐
	Packed, unarmoured Array of sediment sizes, overlapping, tightly packed but can be dislodged with moderate ☐
	Moderate compaction Array of sediment sizes, little overlapping, some packing but can be dislodged with moderate ☐
	Low compaction (1) Limited range of sediment sizes, little overlapping, some packing and structure but can be dislodged very easily ☐
	Low compaction (2) Loose array of fine sediments, no overlapping, no packing and structure and can be dislodged very easily ☐

Sediment matrix
Choose one category only

	Bedrock ☐
	Open framework 0-5% fine sediment, high availability of interstitial spaces ☐
	Matrix filled contact framework 5-32% fine sediment, moderate availability of interstitial spaces ☐
	Framework dilated 32-60% fine sediment, low availability of interstitial spaces ☐
	Matrix dominated >60% fine sediment, interstitial spaces virtually absent ☐

Bed stability rating Choose one category only

Unstable - eroding ◀——— **Stable** ———▶ **Unstable - depositing**

Severe erosion	Moderate erosion	Bed stable	Moderate deposition	Severe deposition
Streambed scoured of fine sediments. Signs of channel deepening. Bare, severely eroded banks. Erosion heads. Steep streambed caused by erosion. ☐	Little fine sediment present. Signs of channel deepening. Eroded banks. Streambed deep and narrow. Steep streambed comprised of unconsolidated (loosely arranged and unpacked) material ☐	A range of sediment sizes present in the streambed. Channel is in a 'relatively natural' state (not deepened or infilled). Bed and bar sediments are roughly the same size. Banks stable. Streambed comprised of consolidated (tightly arranged and packed) material. ☐	Moderate build-up of fine sediments at obstructions and bars. Streambed flat and uniform. Channel wide and shallow. ☐	Extensive build up of fine sediments to form a flat bed. Channel blocked, but wide and shallow. Bars large and covering most of the bed or banks. Streambed comprised of unconsolidated (loosely arranged and unpacked) material. ☐

Particle Sizes (Visual Estimate)

D_{50} (mm) ____________ D_{max} (mm) ________________ Bedrock ______________________

Sizes in transport/lag ____________________________

8. Upslope Sediment Sources

Sediment Sources (Circle)

Unstable geology
Gullying
Shallow slide
Deep slide
Historical mass wasting
Oversteepened slopes
Road embankment
Road drainage
Roadway instabilities
Concentrated runoff
Livestock
Agricuttural
Construction
Mining

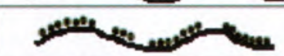
Source Severity (H,M,L)
Delivery Ratio to Stream (H,M,L)

Notes

9.0 Riparian Characteristics

Longitudinal extent of riparian vegetation

Choose one category for each bank. Do not include ground layer except where site is in native grassland.

		Left bank	Right bank
None		☐	☐
Isolated / scattered		☐	☐
Regularly spaced		☐	☐
Occasional clumps		☐	☐
Semi-continuous		☐	☐
Continuous		☐	☐

Local landuse

Choose one category for each bank

Left	Right	
☐	☐	Native forest
☐	☐	Native grassland (not grazed)
☐	☐	Grazing (native or non-native pasture)
☐	☐	Exotic grassland (lawns etc., no grazing)
☐	☐	Forestry Native [ ][ ] Pine [ ][ ]
☐	☐	Cropped Rainfed [ ][ ] Irrigated [ ][ ]
☐	☐	Urban residential
☐	☐	Commercial
☐	☐	Industrial or intensive agricultural
☐	☐	Recreation
☐	☐	Other ____________________

Riparian Canopy/Subcanopy species, size classes, Invasives

Left

Buffer width (Ft):

Riparian Canopy/Subcanopy species, size classes, Invasives

Right

Buffer width (Ft):

Michael Love & Associates
Hydrologic Solutions
PO Box 4477 • Arcata, CA 95518 • (707) 822 -2411

Attachment 3

Results of Streambed Substrate Characterization

CONSULTING ENGINEERS & GEOLOGISTS, INC.
812 W. Wabash Eureka, CA 95501-2138 Tel: 707/441-8855 FAX: 707/441-8877 E-mail: shninfo@shn-engr.com

SIEVE ANALYSIS WORKSHEET ASTM C136

JOB NAME:	**Michael Love Assoc.**	JOB NUMBER:	**017148**	DATE:	**5/23/2018**
PROJECT MANAGER:	**DJG**	PERFORMED BY:	**JMA**	CHECKED BY:	5/25/2018
SAMPLE I.D.:	**Williams Creek - WC-1**			LAB SAMPLE NO:	18-352

TOTAL SAMPLE WEIGHT BEFORE WASH: 8058.0 SAMPLE WEIGHT AFTER WASH: 7748.1

PERCENT LOST= **-0.19** MUST BE 0.3% OR LESS TO COMPLY W/ ASTM C136-01 AND AASHTO T 27-93

SIEVE #	WEIGHT RETAINED SCREEN	WEIGHT RETAINED TOTAL	% PASSED
1 1/2" (37.5mm)	0	0	**100**
1" (25mm)	28	28	**100**
3/4" (19mm)	21	49	**99**
1/2" (12.5mm)	294	343	**96**
3/8" (9.5mm)	546	889	**89**
#4 (4.75mm)	1771	2660	**67**
Pan	5088	7748.3	

FINE FRACTION GRADING WEIGHT 309.5

	WEIGHT RETAINED			
	REDUCED PORTION	SCREEN	TOTAL	%PASSED
#10 (2mm)	124.1	2040	4700	**42**
#40 (425um)	125.2	2058.3	6758.6	**16**
#100 (150um)	47	772.7	7531.3	**7**
#200 (75um)	11.5	189.1	7720.4	**4.2**
PAN	0.8	13	7733.5	

CONSULTING ENGINEERS & GEOLOGISTS, INC.
812 W. Wabash Eureka, CA 95501-2138 Tel: 707/441-8855 FAX: 707/441-8877 E-mail: shninfo@shn-engr.com

SIEVE ANALYSIS WORKSHEET ASTM C136

JOB NAME:	**Michael Love Assoc.**	JOB NUMBER:	**017148**	DATE:	**5/23/2018**
PROJECT MANAGER:	**DJG**	PERFORMED BY:	**JMA**	CHECKED BY:	**5/25/2018**
SAMPLE I.D.:	**Williams Creek - WC-2**			LAB SAMPLE NO:	**18-353**

TOTAL SAMPLE WEIGHT BEFORE WASH: 8612.7 SAMPLE WEIGHT AFTER WASH: 8049.6

PERCENT LOST= **-0.01** MUST BE 0.3% OR LESS TO COMPLY W/ ASTM C136-01 AND AASHTO T 27-93

SIEVE #	WEIGHT RETAINED SCREEN	WEIGHT RETAINED TOTAL	% PASSED
1 1/2" (37.5mm)	0	0	**100**
1" (25mm)	80	80	**99**
3/4" (19mm)	86	166	**98**
1/2" (12.5mm)	543	709	**92**
3/8" (9.5mm)	715	1423	**83**
#4 (4.75mm)	2505	3929	**54**
Pan	4125	8053.7	

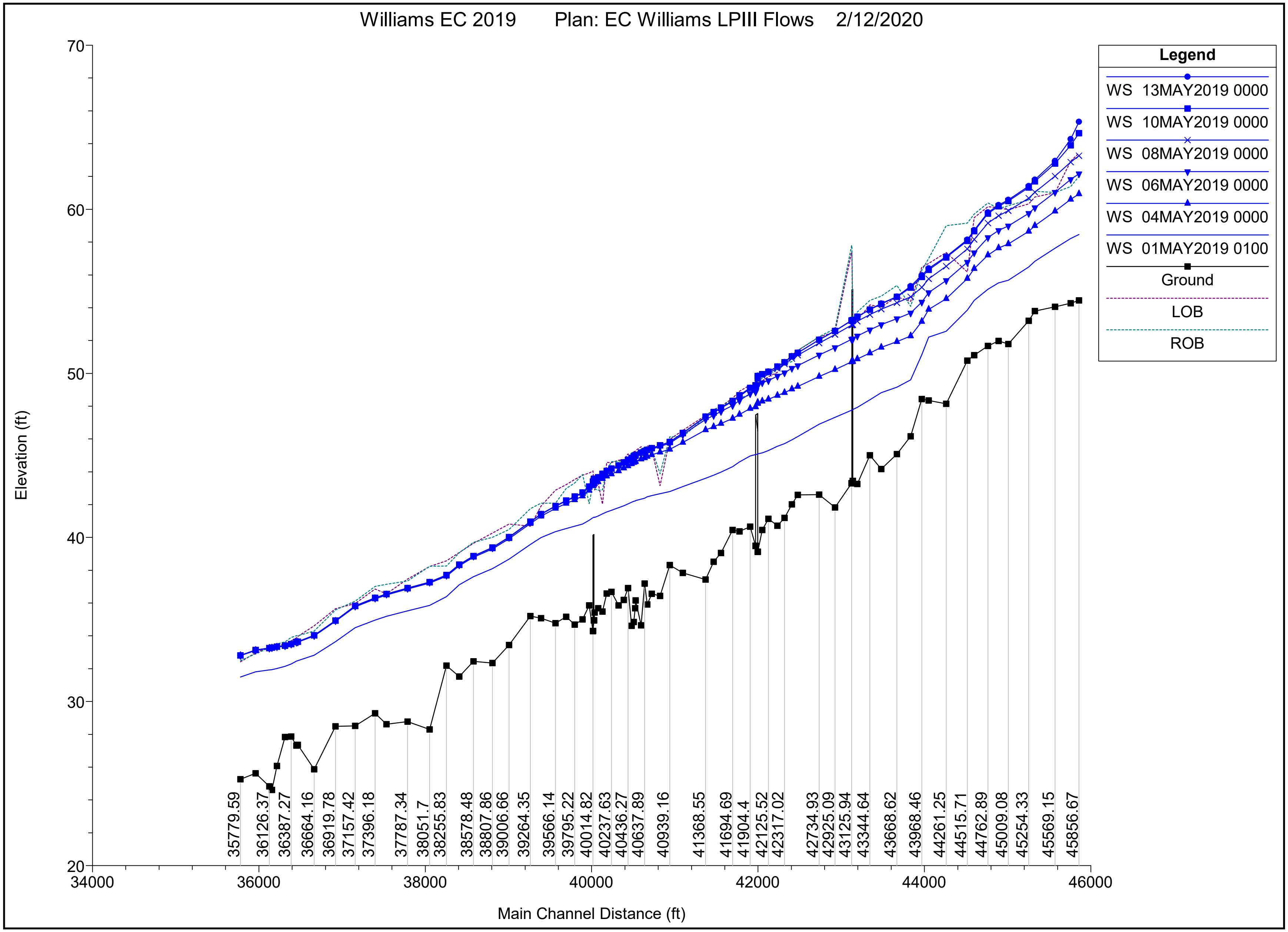
FINE FRACTION GRADING WEIGHT 406.1

	WEIGHT RETAINED			
	REDUCED PORTION	SCREEN	TOTAL	%PASSED
#10 (2mm)	216	2194	6123	**29**
#40 (425um)	115.2	1170.2	7292.9	**15**
#100 (150um)	45.1	458.1	7751.0	**10**
#200 (75um)	27.4	278.3	8029.3	**6.8**
PAN	1.9	19	8048.6	

Michael Love & Associates
Hydrologic Solutions
PO Box 4477 • Arcata, CA 95518 • (707) 822 -2411

Attachment 4

Existing Condition 1-Dimensional HEC-RAS Hydraulic Modeling Results


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
LOB
ROB
Elevation (ft)
Main Channel Distance (ft)
70
60
50
40
30
20
34000
36000
38000
40000
42000
44000
46000
35779.59
36126.37
36387.27
36664.16
36919.78
37157.42
37396.18
37787.34
38051.7
38255.83
38578.48
38807.86
39006.66
39264.35
39566.14
39795.22
40014.82
40237.63
40436.27
40637.89
40939.16
41368.55
41694.69
41904.4
42125.52
42317.02
42734.93
42925.09
43125.94
43344.64
43668.62
43968.46
44261.25
44515.71
44762.89
45009.08
45254.33
45569.15
45856.67

HEC-RAS Plan: US EC Williams LPIII River: Will-Barbata Reach: Williams_E-TH-SA

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)	
Williams_E-TH-SA	45856.67	01MAY2019 0100	107.00	54.44	58.47		58.50	0.001825	1.36	78.58	26.77	0.14
Williams_E-TH-SA	45856.67	04MAY2019 0000	299.00	54.44	60.93		60.99	0.002171	1.97	151.65	32.63	0.16
Williams_E-TH-SA	45856.67	06MAY2019 0000	440.00	54.44	62.17		62.25	0.002355	2.27	193.97	35.36	0.17
Williams_E-TH-SA	45856.67	08MAY2019 0000	584.00	54.44	63.26		63.36	0.002446	2.51	233.13	36.51	0.17
Williams_E-TH-SA	45856.67	10MAY2019 0000	971.00	54.44	64.64		64.82	0.003830	3.42	283.55	36.69	0.22
Williams_E-TH-SA	45856.67	13MAY2019 0000	1239.00	54.44	65.33		65.58	0.004875	4.01	308.92	36.69	0.24
Williams_E-TH-SA	45758.48	01MAY2019 0100	107.00	54.28	58.22		58.27	0.002911	1.69	63.17	21.45	0.17
Williams_E-TH-SA	45758.48	04MAY2019 0000	299.00	54.28	60.61		60.70	0.003718	2.47	121.15	27.18	0.21
Williams_E-TH-SA	45758.48	06MAY2019 0000	440.00	54.28	61.81		61.94	0.004039	2.83	155.59	29.64	0.22
Williams_E-TH-SA	45758.48	08MAY2019 0000	584.00	54.28	62.88		63.03	0.004261	3.11	187.85	31.42	0.22
Williams_E-TH-SA	45758.48	10MAY2019 0000	971.00	54.28	63.90		64.20	0.007570	4.39	221.15	32.46	0.30
Williams_E-TH-SA	45758.48	13MAY2019 0000	1239.00	54.28	64.27		64.71	0.010597	5.32	233.03	32.46	0.35
Williams_E-TH-SA	45751.51		Lat Struct									
Williams_E-TH-SA	45748.78		Lat Struct									
Williams_E-TH-SA	45569.15	01MAY2019 0100	107.00	54.06	57.63		57.68	0.003362	1.72	62.10	23.49	0.19
Williams_E-TH-SA	45569.15	04MAY2019 0000	299.00	54.06	59.89		59.98	0.003921	2.47	120.94	28.82	0.21
Williams_E-TH-SA	45569.15	06MAY2019 0000	440.00	54.06	61.03		61.16	0.004217	2.83	155.60	31.61	0.22
Williams_E-TH-SA	45569.15	08MAY2019 0000	584.00	54.06	62.03		62.18	0.004323	3.12	186.99	31.61	0.23
Williams_E-TH-SA	45569.15	10MAY2019 0000	750.44	54.06	62.79		62.99	0.005009	3.55	211.24	31.61	0.24
Williams_E-TH-SA	45569.15	13MAY2019 0000	829.01	54.06	62.95		63.18	0.005715	3.83	216.23	31.61	0.26
Williams_E-TH-SA	45327.73	01MAY2019 0100	107.00	53.79	56.83		56.87	0.003320	1.64	65.36	27.13	0.19
Williams_E-TH-SA	45327.73	04MAY2019 0000	299.00	53.79	59.01		59.09	0.003502	2.27	131.55	33.89	0.20
Williams_E-TH-SA	45327.73	06MAY2019 0000	440.00	53.79	60.10		60.20	0.003677	2.58	170.55	37.38	0.21
Williams_E-TH-SA	45327.73	08MAY2019 0000	584.00	53.79	61.03		61.16	0.003786	2.82	206.83	40.04	0.22
Williams_E-TH-SA	45327.73	10MAY2019 0000	703.13	53.79	61.70		61.84	0.003815	3.01	233.53	40.15	0.22
Williams_E-TH-SA	45327.73	13MAY2019 0000	726.48	53.79	61.80		61.94	0.003875	3.06	237.44	40.15	0.22
Williams_E-TH-SA	45254.33	01MAY2019 0100	107.00	53.20	56.48		56.54	0.005692	2.04	52.57	23.67	0.24
Williams_E-TH-SA	45254.33	04MAY2019 0000	299.00	53.20	58.66		58.76	0.005305	2.60	114.80	33.48	0.25
Williams_E-TH-SA	45254.33	06MAY2019 0000	440.00	53.20	59.75		59.88	0.005195	2.86	154.10	38.40	0.25
Williams_E-TH-SA	45254.33	08MAY2019 0000	584.00	53.20	60.68		60.83	0.004974	3.05	191.57	41.35	0.25
Williams_E-TH-SA	45254.33	10MAY2019 0000	703.13	53.20	61.33		61.49	0.004849	3.22	218.22	41.35	0.25
Williams_E-TH-SA	45254.33	13MAY2019 0000	726.45	53.20	61.41		61.58	0.004924	3.27	221.85	41.35	0.25
Williams_E-TH-SA	45009.08	01MAY2019 0100	107.00	51.79	55.68		55.70	0.001191	1.08	98.80	35.64	0.11
Williams_E-TH-SA	45009.08	04MAY2019 0000	299.00	51.79	57.88		57.92	0.001536	1.59	188.64	45.78	0.14
Williams_E-TH-SA	45009.08	06MAY2019 0000	440.00	51.79	58.98		59.04	0.001647	1.83	241.08	49.46	0.15
Williams_E-TH-SA	45009.08	08MAY2019 0000	584.00	51.79	59.91		59.97	0.001752	2.03	288.12	52.55	0.15
Williams_E-TH-SA	45009.08	10MAY2019 0000	696.46	51.79	60.51		60.58	0.001813	2.18	319.99	52.95	0.16
Williams_E-TH-SA	45009.08	13MAY2019 0000	712.91	51.79	60.58		60.66	0.001832	2.20	323.81	52.95	0.16
Williams_E-TH-SA	44890.09	01MAY2019 0100	107.00	51.97	55.51		55.53	0.001600	1.27	84.35	29.84	0.13
Williams_E-TH-SA	44890.09	04MAY2019 0000	299.00	51.97	57.64		57.70	0.002209	1.93	155.27	36.65	0.16
Williams_E-TH-SA	44890.09	06MAY2019 0000	440.00	51.97	58.71		58.79	0.002490	2.24	196.33	40.07	0.18
Williams_E-TH-SA	44890.09	08MAY2019 0000	584.00	51.97	59.61		59.71	0.002718	2.50	233.48	42.92	0.19
Williams_E-TH-SA	44890.09	10MAY2019 0000	691.46	51.97	60.19		60.30	0.002853	2.67	258.94	44.44	0.20
Williams_E-TH-SA	44890.09	13MAY2019 0000	704.87	51.97	60.26		60.37	0.002861	2.69	262.03	44.44	0.20
Williams_E-TH-SA	44762.89	01MAY2019 0100	107.00	51.67	55.12		55.17	0.004209	1.76	60.71	27.37	0.21
Williams_E-TH-SA	44762.89	04MAY2019 0000	299.00	51.67	57.21		57.30	0.004176	2.29	130.45	39.21	0.22
Williams_E-TH-SA	44762.89	06MAY2019 0000	440.00	51.67	58.27		58.37	0.004099	2.51	175.22	45.20	0.22
Williams_E-TH-SA	44762.89	08MAY2019 0000	584.00	51.67	59.16		59.28	0.004039	2.68	217.67	50.22	0.23
Williams_E-TH-SA	44762.89	10MAY2019 0000	691.46	51.67	59.74		59.86	0.004015	2.79	247.51	53.48	0.23
Williams_E-TH-SA	44762.89	13MAY2019 0000	704.87	51.67	59.81		59.93	0.004009	2.81	251.22	53.87	0.23
Williams_E-TH-SA	44597.17	01MAY2019 0100	107.00	51.11	54.44		54.49	0.003952	1.83	58.52	22.91	0.20
Williams_E-TH-SA	44597.17	04MAY2019 0000	299.00	51.11	56.38		56.50	0.005441	2.80	106.93	27.06	0.25
Williams_E-TH-SA	44597.17	06MAY2019 0000	440.00	51.11	57.36		57.52	0.006201	3.28	134.34	29.15	0.27
Williams_E-TH-SA	44597.17	08MAY2019 0000	584.00	51.11	58.16		58.37	0.006885	3.68	158.56	30.88	0.29
Williams_E-TH-SA	44597.17	10MAY2019 0000	691.46	51.11	58.67		58.91	0.007513	3.96	174.57	32.49	0.30
Williams_E-TH-SA	44597.17	13MAY2019 0000	704.87	51.11	58.73		58.98	0.007582	3.99	176.57	32.70	0.30
Williams_E-TH-SA	44515.71	01MAY2019 0100	107.00	50.78	53.85		53.95	0.009732	2.42	44.21	22.86	0.31
Williams_E-TH-SA	44515.71	04MAY2019 0000	299.00	50.78	55.78		55.93	0.008798	3.08	97.18	32.11	0.31
Williams_E-TH-SA	44515.71	06MAY2019 0000	440.00	50.78	56.78		56.95	0.007811	3.36	131.57	37.25	0.30
Williams_E-TH-SA	44515.71	08MAY2019 0000	584.00	50.78	57.59		57.79	0.007369	3.65	163.80	42.17	0.30
Williams_E-TH-SA	44515.71	10MAY2019 0000	691.46	50.78	58.08		58.31	0.007376	3.86	185.24	45.15	0.31
Williams_E-TH-SA	44515.71	13MAY2019 0000	704.87	50.78	58.14		58.37	0.007369	3.89	187.95	45.51	0.31
Williams_E-TH-SA	44269.18		Lat Struct									
Williams_E-TH-SA	44261.25	01MAY2019 0100	107.00	48.15	52.56		52.58	0.001070	1.06	100.61	34.65	0.11
Williams_E-TH-SA	44261.25	04MAY2019 0000	299.00	48.15	54.55		54.60	0.001658	1.72	174.22	39.40	0.14
Williams_E-TH-SA	44261.25	06MAY2019 0000	440.00	48.15	55.66		55.72	0.001852	2.01	219.31	42.05	0.15
Williams_E-TH-SA	44261.25	08MAY2019 0000	570.17	48.15	56.53		56.60	0.001985	2.22	256.82	44.14	0.16
Williams_E-TH-SA	44261.25	10MAY2019 0000	637.83	48.15	57.06		57.14	0.001935	2.27	281.25	51.97	0.16
Williams_E-TH-SA	44261.25	13MAY2019 0000	643.68	48.15	57.13		57.21	0.001909	2.27	284.94	54.80	0.16

HEC-RAS Plan: US EC Williams LPIII River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	44260.8		Lat Struct									
Williams_E-TH-SA	44050.21	01MAY2019 0100	107.00	48.35	52.21		52.24	0.002137	1.45	73.60	25.92	0.15
Williams_E-TH-SA	44050.21	04MAY2019 0000	299.00	48.35	53.90		54.00	0.004047	2.46	121.66	30.86	0.22
Williams_E-TH-SA	44050.21	06MAY2019 0000	440.00	48.35	54.93		55.05	0.004487	2.84	154.89	33.86	0.23
Williams_E-TH-SA	44050.21	08MAY2019 0000	570.17	48.35	55.76		55.90	0.004701	3.10	184.61	47.36	0.24
Williams_E-TH-SA	44050.21	10MAY2019 0000	637.80	48.35	56.31		56.46	0.004299	3.08	217.20	66.70	0.23
Williams_E-TH-SA	44050.21	13MAY2019 0000	643.32	48.35	56.39		56.54	0.004452	3.05	222.97	77.12	0.24
Williams_E-TH-SA	43968.46	01MAY2019 0100	107.00	48.44	51.14		51.30	0.021679	3.22	33.28	21.02	0.45
Williams_E-TH-SA	43968.46	04MAY2019 0000	299.00	48.44	53.16		53.33	0.012295	3.36	88.87	34.16	0.37
Williams_E-TH-SA	43968.46	06MAY2019 0000	440.00	48.44	54.34		54.51	0.008943	3.29	133.78	41.87	0.32
Williams_E-TH-SA	43968.46	08MAY2019 0000	570.17	48.44	55.24		55.41	0.007412	3.27	174.35	47.77	0.30
Williams_E-TH-SA	43968.46	10MAY2019 0000	637.76	48.44	55.88		56.03	0.005894	3.08	212.05	88.19	0.27
Williams_E-TH-SA	43968.46	13MAY2019 0000	643.11	48.44	55.98		56.13	0.005558	3.02	221.19	90.55	0.27
Williams_E-TH-SA	43833.6	01MAY2019 0100	107.00	46.16	49.60		49.64	0.003184	1.60	66.81	27.52	0.18
Williams_E-TH-SA	43833.6	04MAY2019 0000	299.00	46.16	52.28		52.34	0.002382	1.99	150.61	34.98	0.17
Williams_E-TH-SA	43833.6	06MAY2019 0000	440.00	46.16	53.68		53.75	0.002260	2.18	202.16	38.87	0.17
Williams_E-TH-SA	43833.6	08MAY2019 0000	570.17	46.16	54.67		54.75	0.002305	2.36	241.98	41.62	0.17
Williams_E-TH-SA	43833.6	10MAY2019 0000	637.76	46.16	55.23		55.32	0.004960	2.33	273.17	89.95	0.24
Williams_E-TH-SA	43833.6	13MAY2019 0000	643.11	46.16	55.31		55.39	0.005313	2.29	280.67	100.70	0.24
Williams_E-TH-SA	43668.62	01MAY2019 0100	107.00	45.08	49.16		49.19	0.002284	1.47	72.89	26.87	0.16
Williams_E-TH-SA	43668.62	04MAY2019 0000	299.00	45.08	51.93		51.98	0.001977	1.89	158.30	34.74	0.16
Williams_E-TH-SA	43668.62	06MAY2019 0000	440.00	45.08	53.33		53.40	0.001964	2.09	210.05	38.88	0.16
Williams_E-TH-SA	43668.62	08MAY2019 0000	570.17	45.08	54.31		54.39	0.002062	2.29	251.07	51.33	0.16
Williams_E-TH-SA	43668.62	10MAY2019 0000	637.76	45.08	54.66		54.75	0.002192	2.41	270.72	64.47	0.17
Williams_E-TH-SA	43668.62	13MAY2019 0000	643.11	45.08	54.68		54.77	0.002203	2.42	272.23	68.60	0.17
Williams_E-TH-SA	43481.48	01MAY2019 0100	107.00	44.17	48.82		48.85	0.001391	1.28	83.58	24.56	0.12
Williams_E-TH-SA	43481.48	04MAY2019 0000	299.00	44.17	51.58		51.63	0.001767	1.85	161.65	32.01	0.15
Williams_E-TH-SA	43481.48	06MAY2019 0000	440.00	44.17	52.97		53.04	0.001906	2.11	208.78	35.67	0.15
Williams_E-TH-SA	43481.48	08MAY2019 0000	570.17	44.17	53.92		54.00	0.002102	2.34	243.58	38.05	0.16
Williams_E-TH-SA	43481.48	10MAY2019 0000	637.17	44.17	54.24		54.33	0.002268	2.49	259.87	68.18	0.17
Williams_E-TH-SA	43481.48	13MAY2019 0000	642.26	44.17	54.26		54.35	0.002282	2.50	261.25	68.20	0.17
Williams_E-TH-SA	43344.64	01MAY2019 0100	107.00	45.01	48.38		48.44	0.004619	1.89	56.53	24.08	0.22
Williams_E-TH-SA	43344.64	04MAY2019 0000	299.00	45.01	51.24		51.31	0.002907	2.13	140.67	34.74	0.19
Williams_E-TH-SA	43344.64	06MAY2019 0000	440.00	45.01	52.65		52.73	0.002665	2.28	193.09	39.96	0.18
Williams_E-TH-SA	43344.64	08MAY2019 0000	570.08	45.01	53.58		53.67	0.002728	2.46	231.82	43.38	0.19
Williams_E-TH-SA	43344.64	10MAY2019 0000	630.30	45.01	53.88		53.98	0.002867	2.57	245.18	44.50	0.19
Williams_E-TH-SA	43344.64	13MAY2019 0000	634.69	45.01	53.90		54.00	0.002880	2.58	246.02	44.57	0.19
Williams_E-TH-SA	43191.84	01MAY2019 0100	107.00	43.26	47.92		47.96	0.001747	1.41	75.70	22.51	0.14
Williams_E-TH-SA	43191.84	04MAY2019 0000	299.00	43.26	50.88		50.94	0.001975	1.97	152.10	29.10	0.15
Williams_E-TH-SA	43191.84	06MAY2019 0000	440.00	43.26	52.28		52.36	0.002181	2.26	195.02	32.32	0.16
Williams_E-TH-SA	43191.84	08MAY2019 0000	570.08	43.26	53.17		53.27	0.002494	2.54	224.81	34.39	0.17
Williams_E-TH-SA	43191.84	10MAY2019 0000	629.00	43.26	53.45		53.56	0.002680	2.68	236.88	55.93	0.18
Williams_E-TH-SA	43191.84	13MAY2019 0000	633.13	43.26	53.47		53.58	0.002694	2.69	237.83	56.67	0.18
Williams_E-TH-SA	43139.97	01MAY2019 0100	107.00	43.44	47.80	45.08	47.84	0.002701	1.71	62.73	18.97	0.17
Williams_E-TH-SA	43139.97	04MAY2019 0000	299.00	43.44	50.72	46.29	50.81	0.003108	2.39	125.04	23.61	0.18
Williams_E-TH-SA	43139.97	06MAY2019 0000	440.00	43.44	52.09	46.95	52.21	0.003511	2.77	158.89	25.79	0.20
Williams_E-TH-SA	43139.97	08MAY2019 0000	568.99	43.44	52.95	47.49	53.10	0.004067	3.13	181.64	27.42	0.21
Williams_E-TH-SA	43139.97	10MAY2019 0000	622.53	43.44	53.22	47.70	53.39	0.004329	3.30	189.05	28.38	0.22
Williams_E-TH-SA	43139.97	13MAY2019 0000	626.21	43.44	53.23	47.72	53.40	0.004350	3.31	189.50	28.45	0.22
Williams_E-TH-SA	43130		Bridge									
Williams_E-TH-SA	43125.95	01MAY2019 0100	107.00	43.30	47.76		47.80	0.002436	1.61	66.36	21.04	0.16
Williams_E-TH-SA	43125.95	04MAY2019 0000	299.00	43.30	50.70		50.77	0.002503	2.16	138.72	27.90	0.17
Williams_E-TH-SA	43125.95	06MAY2019 0000	440.00	43.30	52.08		52.17	0.002672	2.46	179.01	30.39	0.18
Williams_E-TH-SA	43125.95	08MAY2019 0000	568.99	43.30	52.95		53.06	0.003028	2.76	205.95	31.76	0.19
Williams_E-TH-SA	43125.95	10MAY2019 0000	622.53	43.30	53.21		53.35	0.003237	2.90	214.56	32.18	0.20
Williams_E-TH-SA	43125.95	13MAY2019 0000	626.21	43.30	53.23		53.36	0.003254	2.91	215.08	32.21	0.20
Williams_E-TH-SA	43125.94	01MAY2019 0100	107.00	43.30	47.76		47.80	0.002436	1.61	66.36	21.04	0.16
Williams_E-TH-SA	43125.94	04MAY2019 0000	299.00	43.30	50.70		50.77	0.002503	2.16	138.72	27.90	0.17
Williams_E-TH-SA	43125.94	06MAY2019 0000	440.00	43.30	52.08		52.17	0.002672	2.46	179.01	30.39	0.18
Williams_E-TH-SA	43125.94	08MAY2019 0000	568.99	43.30	52.95		53.06	0.003028	2.76	205.95	31.76	0.19
Williams_E-TH-SA	43125.94	10MAY2019 0000	622.53	43.30	53.21		53.35	0.003237	2.90	214.56	32.18	0.20
Williams_E-TH-SA	43125.94	13MAY2019 0000	626.21	43.30	53.23		53.36	0.003254	2.91	215.07	32.21	0.20
Williams_E-TH-SA	43125.75		Lat Struct									
Williams_E-TH-SA	43125.65		Lat Struct									
Williams_E-TH-SA	42925.09	01MAY2019 0100	107.01	41.82	47.32		47.35	0.002038	1.51	71.01	21.57	0.15
Williams_E-TH-SA	42925.09	04MAY2019 0000	299.00	41.82	50.22		50.29	0.002287	2.05	146.19	30.16	0.16
Williams_E-TH-SA	42925.09	06MAY2019 0000	440.00	41.82	51.57		51.66	0.002475	2.32	189.50	34.13	0.17
Williams_E-TH-SA	42925.09	08MAY2019 0000	568.99	41.82	52.36		52.47	0.002864	2.62	217.47	36.45	0.19
Williams_E-TH-SA	42925.09	10MAY2019 0000	620.91	41.82	52.59		52.71	0.003075	2.75	225.69	37.06	0.20

HEC-RAS Plan: US EC Williams LPIII River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	42925.09	13MAY2019 0000	624.18	41.82	52.60		52.72	0.003088	2.76	226.17	37.07	0.20
Williams_E-TH-SA	42734.93	01MAY2019 0100	107.01	42.61	46.91		46.94	0.002313	1.52	70.37	23.48	0.15
Williams_E-TH-SA	42734.93	04MAY2019 0000	299.00	42.61	49.80		49.86	0.002224	1.99	150.48	31.86	0.16
Williams_E-TH-SA	42734.93	06MAY2019 0000	440.00	42.61	51.12		51.19	0.002387	2.26	194.87	35.65	0.17
Williams_E-TH-SA	42734.93	08MAY2019 0000	557.52	42.61	51.85		51.95	0.002697	2.52	221.66	37.60	0.18
Williams_E-TH-SA	42734.93	10MAY2019 0000	599.16	42.61	52.04		52.15	0.002849	2.62	229.05	38.11	0.19
Williams_E-TH-SA	42734.93	13MAY2019 0000	601.66	42.61	52.05		52.16	0.002858	2.62	229.47	38.14	0.19
Williams_E-TH-SA	42478.93	01MAY2019 0100	107.01	42.59	46.15		46.20	0.003533	1.77	60.38	22.87	0.19
Williams_E-TH-SA	42478.93	04MAY2019 0000	299.00	42.59	49.20		49.26	0.002477	2.07	144.44	32.32	0.17
Williams_E-TH-SA	42478.93	06MAY2019 0000	440.00	42.59	50.47		50.55	0.002616	2.34	188.16	36.27	0.18
Williams_E-TH-SA	42478.93	08MAY2019 0000	557.52	42.59	51.10		51.21	0.003052	2.63	211.74	38.23	0.20
Williams_E-TH-SA	42478.93	10MAY2019 0000	599.08	42.59	51.25		51.37	0.003283	2.76	217.37	38.69	0.20
Williams_E-TH-SA	42478.93	13MAY2019 0000	601.55	42.59	51.26		51.38	0.003297	2.76	217.69	38.71	0.21
Williams_E-TH-SA	42406.63	01MAY2019 0100	107.02	42.02	45.94		45.98	0.002489	1.56	68.63	23.99	0.16
Williams_E-TH-SA	42406.63	04MAY2019 0000	299.00	42.02	49.04		49.10	0.001961	1.91	156.41	32.61	0.15
Williams_E-TH-SA	42406.63	06MAY2019 0000	440.00	42.02	50.31		50.38	0.002177	2.20	199.77	36.12	0.17
Williams_E-TH-SA	42406.63	08MAY2019 0000	557.01	42.02	50.91		51.01	0.002592	2.51	221.86	37.05	0.18
Williams_E-TH-SA	42406.63	10MAY2019 0000	596.86	42.02	51.04		51.15	0.002795	2.63	226.77	37.20	0.19
Williams_E-TH-SA	42406.63	13MAY2019 0000	599.19	42.02	51.05		51.16	0.002808	2.64	227.04	37.21	0.19
Williams_E-TH-SA	42317.02	01MAY2019 0100	107.02	41.19	45.72		45.76	0.002481	1.65	64.81	19.33	0.16
Williams_E-TH-SA	42317.02	04MAY2019 0000	299.00	41.19	48.82		48.90	0.002633	2.23	134.24	25.43	0.17
Williams_E-TH-SA	42317.02	06MAY2019 0000	440.00	41.19	50.03		50.14	0.003185	2.64	166.58	27.82	0.19
Williams_E-TH-SA	42317.02	08MAY2019 0000	554.19	41.19	50.57		50.72	0.003993	3.05	181.80	28.96	0.21
Williams_E-TH-SA	42317.02	10MAY2019 0000	589.17	41.19	50.68		50.84	0.004275	3.19	185.02	30.55	0.22
Williams_E-TH-SA	42317.02	13MAY2019 0000	591.18	41.19	50.69		50.84	0.004290	3.19	185.20	30.78	0.22
Williams_E-TH-SA	42233.9	01MAY2019 0100	107.02	40.72	45.55		45.59	0.001722	1.43	75.10	21.87	0.14
Williams_E-TH-SA	42233.9	04MAY2019 0000	299.00	40.72	48.65		48.71	0.001895	1.94	154.47	29.50	0.15
Williams_E-TH-SA	42233.9	06MAY2019 0000	440.00	40.72	49.83		49.91	0.002323	2.30	191.11	32.54	0.17
Williams_E-TH-SA	42233.9	08MAY2019 0000	553.41	40.72	50.32		50.43	0.002910	2.67	207.78	37.69	0.19
Williams_E-TH-SA	42233.9	10MAY2019 0000	585.45	40.72	50.41		50.53	0.003103	2.78	211.47	39.40	0.19
Williams_E-TH-SA	42233.9	13MAY2019 0000	587.25	40.72	50.42		50.54	0.003114	2.79	211.68	39.49	0.20
Williams_E-TH-SA	42125.52	01MAY2019 0100	107.03	41.14	45.30		45.34	0.002756	1.65	64.69	21.74	0.17
Williams_E-TH-SA	42125.52	04MAY2019 0000	299.00	41.14	48.42		48.48	0.002317	2.05	145.62	30.23	0.16
Williams_E-TH-SA	42125.52	06MAY2019 0000	431.41	41.14	49.56		49.65	0.002608	2.37	181.83	32.81	0.18
Williams_E-TH-SA	42125.52	08MAY2019 0000	520.03	41.14	50.02		50.12	0.003000	2.64	197.70	41.08	0.19
Williams_E-TH-SA	42125.52	10MAY2019 0000	544.09	41.14	50.10		50.21	0.003139	2.72	201.29	44.00	0.20
Williams_E-TH-SA	42125.52	13MAY2019 0000	545.44	41.14	50.10		50.22	0.003147	2.73	201.49	44.16	0.20
Williams_E-TH-SA	42049.79	01MAY2019 0100	107.03	40.46	45.16		45.18	0.001473	1.28	83.30	26.53	0.13
Williams_E-TH-SA	42049.79	04MAY2019 0000	299.00	40.46	48.30		48.34	0.001359	1.69	176.68	32.90	0.13
Williams_E-TH-SA	42049.79	06MAY2019 0000	431.13	40.46	49.43		49.49	0.001638	2.00	215.18	35.18	0.14
Williams_E-TH-SA	42049.79	08MAY2019 0000	510.98	40.46	49.87		49.94	0.001868	2.21	230.74	35.68	0.15
Williams_E-TH-SA	42049.79	10MAY2019 0000	530.46	40.46	49.95		50.03	0.001937	2.27	233.61	35.68	0.16
Williams_E-TH-SA	42049.79	13MAY2019 0000	531.53	40.46	49.95		50.03	0.001941	2.27	233.76	35.68	0.16
Williams_E-TH-SA	41996.44	01MAY2019 0100	107.03	39.13	45.09		45.11	0.001167	1.23	87.26	22.29	0.11
Williams_E-TH-SA	41996.44	04MAY2019 0000	299.00	39.13	48.22		48.26	0.001532	1.77	169.35	30.27	0.13
Williams_E-TH-SA	41996.44	06MAY2019 0000	431.13	39.13	49.33		49.40	0.001854	2.10	211.37	54.12	0.15
Williams_E-TH-SA	41996.44	08MAY2019 0000	506.26	39.13	49.76		49.84	0.001999	2.28	236.06	58.92	0.15
Williams_E-TH-SA	41996.44	10MAY2019 0000	522.10	39.13	49.84		49.92	0.002031	2.31	240.79	59.20	0.16
Williams_E-TH-SA	41996.44	13MAY2019 0000	522.96	39.13	49.85		49.93	0.002033	2.31	241.04	59.22	0.16
Williams_E-TH-SA	41996.43	01MAY2019 0100	107.03	39.13	45.09	41.09	45.11	0.001167	1.23	87.26	22.29	0.11
Williams_E-TH-SA	41996.43	04MAY2019 0000	299.00	39.13	48.22	42.33	48.26	0.001532	1.77	169.35	30.27	0.13
Williams_E-TH-SA	41996.43	06MAY2019 0000	431.13	39.13	49.33	43.01	49.40	0.001854	2.10	211.36	54.12	0.15
Williams_E-TH-SA	41996.43	08MAY2019 0000	506.26	39.13	49.76	43.34	49.84	0.001999	2.28	236.06	58.92	0.15
Williams_E-TH-SA	41996.43	10MAY2019 0000	522.10	39.13	49.84	43.41	49.92	0.002031	2.31	240.79	59.20	0.16
Williams_E-TH-SA	41996.43	13MAY2019 0000	522.96	39.13	49.85	43.42	49.93	0.002033	2.31	241.04	59.22	0.16
Williams_E-TH-SA	41984		Bridge									
Williams_E-TH-SA	41970.62	01MAY2019 0100	107.03	39.49	45.05		45.08	0.001036	1.18	91.08	22.19	0.10
Williams_E-TH-SA	41970.62	04MAY2019 0000	299.00	39.49	47.96		48.01	0.001647	1.85	161.77	26.51	0.13
Williams_E-TH-SA	41970.62	06MAY2019 0000	431.13	39.49	48.90		48.98	0.002295	2.30	187.35	28.06	0.16
Williams_E-TH-SA	41970.62	08MAY2019 0000	506.26	39.49	49.22		49.32	0.002783	2.58	196.89	31.66	0.17
Williams_E-TH-SA	41970.62	10MAY2019 0000	522.10	39.49	49.27		49.38	0.002894	2.63	198.70	32.37	0.18
Williams_E-TH-SA	41970.62	13MAY2019 0000	522.96	39.49	49.28		49.39	0.002900	2.64	198.80	32.41	0.18
Williams_E-TH-SA	41970.61	01MAY2019 0100	107.03	39.49	45.05		45.08	0.001036	1.18	91.08	22.19	0.10
Williams_E-TH-SA	41970.61	04MAY2019 0000	299.00	39.49	47.96		48.01	0.001647	1.85	161.77	26.51	0.13
Williams_E-TH-SA	41970.61	06MAY2019 0000	431.13	39.49	48.90		48.98	0.002295	2.30	187.35	28.06	0.16
Williams_E-TH-SA	41970.61	08MAY2019 0000	506.26	39.49	49.22		49.32	0.002783	2.58	196.89	31.66	0.17
Williams_E-TH-SA	41970.61	10MAY2019 0000	522.10	39.49	49.27		49.38	0.002894	2.63	198.70	32.37	0.18
Williams_E-TH-SA	41970.61	13MAY2019 0000	522.96	39.49	49.28		49.39	0.002900	2.64	198.80	32.41	0.18
Williams_E-TH-SA	41970.42		Lat Struct									

HEC-RAS Plan: US EC Williams LPIII River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	41970.32		Lat Struct									
Williams_E-TH-SA	41904.4	01MAY2019 0100	107.04	40.65	44.97		44.99	0.001484	1.29	82.88	26.21	0.13
Williams_E-TH-SA	41904.4	04MAY2019 0000	299.00	40.65	47.86		47.90	0.001582	1.75	170.74	35.03	0.14
Williams_E-TH-SA	41904.4	06MAY2019 0000	431.13	40.65	48.77		48.84	0.002036	2.11	204.09	37.93	0.16
Williams_E-TH-SA	41904.4	08MAY2019 0000	505.64	40.65	49.06		49.15	0.002397	2.35	215.48	38.36	0.17
Williams_E-TH-SA	41904.4	10MAY2019 0000	521.11	40.65	49.12		49.21	0.002480	2.40	217.47	38.44	0.18
Williams_E-TH-SA	41904.4	13MAY2019 0000	521.94	40.65	49.12		49.21	0.002485	2.40	217.57	38.44	0.18
Williams_E-TH-SA	41777.66	01MAY2019 0100	107.04	40.37	44.61		44.66	0.003757	1.88	56.91	19.71	0.20
Williams_E-TH-SA	41777.66	04MAY2019 0000	299.00	40.37	47.50		47.59	0.003435	2.40	124.53	27.08	0.20
Williams_E-TH-SA	41777.66	06MAY2019 0000	408.39	40.37	48.35		48.47	0.003985	2.75	148.46	29.25	0.22
Williams_E-TH-SA	41777.66	08MAY2019 0000	456.35	40.37	48.61		48.75	0.004300	2.92	156.32	29.82	0.22
Williams_E-TH-SA	41777.66	10MAY2019 0000	465.57	40.37	48.66		48.79	0.004361	2.95	157.66	29.87	0.23
Williams_E-TH-SA	41777.66	13MAY2019 0000	466.06	40.37	48.66		48.80	0.004364	2.95	157.73	29.88	0.23
Williams_E-TH-SA	41694.69	01MAY2019 0100	107.05	40.45	44.32		44.37	0.003380	1.79	59.94	21.12	0.19
Williams_E-TH-SA	41694.69	04MAY2019 0000	299.00	40.45	47.24		47.32	0.002933	2.28	131.40	27.53	0.18
Williams_E-TH-SA	41694.69	06MAY2019 0000	408.38	40.45	48.04		48.15	0.003528	2.65	154.13	29.18	0.20
Williams_E-TH-SA	41694.69	08MAY2019 0000	454.80	40.45	48.28		48.41	0.003876	2.82	161.10	29.67	0.21
Williams_E-TH-SA	41694.69	10MAY2019 0000	463.38	40.45	48.32		48.45	0.003945	2.86	162.26	29.75	0.22
Williams_E-TH-SA	41694.69	13MAY2019 0000	463.83	40.45	48.32		48.45	0.003949	2.86	162.32	29.75	0.22
Williams_E-TH-SA	41555.36	01MAY2019 0100	107.06	39.05	43.99		44.02	0.001667	1.37	78.23	24.34	0.13
Williams_E-TH-SA	41555.36	04MAY2019 0000	299.00	39.05	46.95		47.00	0.001742	1.84	162.55	32.59	0.15
Williams_E-TH-SA	41555.36	06MAY2019 0000	408.36	39.05	47.68		47.75	0.002212	2.18	187.24	34.61	0.17
Williams_E-TH-SA	41555.36	08MAY2019 0000	453.78	39.05	47.88		47.96	0.002477	2.34	194.13	35.15	0.18
Williams_E-TH-SA	41555.36	10MAY2019 0000	462.00	39.05	47.91		48.00	0.002528	2.37	195.24	35.24	0.18
Williams_E-TH-SA	41555.36	13MAY2019 0000	462.44	39.05	47.91		48.00	0.002531	2.37	195.29	35.24	0.18
Williams_E-TH-SA	41465.55	01MAY2019 0100	107.07	38.51	43.79		43.83	0.002553	1.61	66.68	22.05	0.16
Williams_E-TH-SA	41465.55	04MAY2019 0000	299.00	38.51	46.75		46.81	0.002408	2.04	146.84	32.12	0.17
Williams_E-TH-SA	41465.55	06MAY2019 0000	401.66	38.51	47.44		47.53	0.002947	2.36	169.84	34.46	0.19
Williams_E-TH-SA	41465.55	08MAY2019 0000	440.34	38.51	47.62		47.71	0.003220	2.50	176.01	35.07	0.20
Williams_E-TH-SA	41465.55	10MAY2019 0000	447.13	38.51	47.64		47.74	0.003272	2.53	176.97	35.16	0.20
Williams_E-TH-SA	41465.55	13MAY2019 0000	447.48	38.51	47.65		47.74	0.003275	2.53	177.02	35.17	0.20
Williams_E-TH-SA	41368.55	01MAY2019 0100	107.08	37.43	43.60		43.63	0.001510	1.32	81.15	23.11	0.12
Williams_E-TH-SA	41368.55	04MAY2019 0000	299.00	37.43	46.55		46.60	0.001947	1.82	164.72	35.67	0.15
Williams_E-TH-SA	41368.55	06MAY2019 0000	401.10	37.43	47.19		47.26	0.002485	2.13	188.58	38.94	0.17
Williams_E-TH-SA	41368.55	08MAY2019 0000	437.11	37.43	47.34		47.42	0.002708	2.25	194.65	39.49	0.18
Williams_E-TH-SA	41368.55	10MAY2019 0000	443.18	37.43	47.37		47.45	0.002746	2.27	195.57	39.54	0.18
Williams_E-TH-SA	41368.55	13MAY2019 0000	443.50	37.43	47.37		47.45	0.002748	2.27	195.62	39.54	0.18
Williams_E-TH-SA	41095.03	01MAY2019 0100	107.10	37.84	43.10		43.14	0.002100	1.57	68.27	17.85	0.14
Williams_E-TH-SA	41095.03	04MAY2019 0000	294.12	37.84	45.79		45.87	0.003455	2.28	128.80	28.99	0.19
Williams_E-TH-SA	41095.03	06MAY2019 0000	368.04	37.84	46.26		46.36	0.004155	2.57	143.11	31.49	0.21
Williams_E-TH-SA	41095.03	08MAY2019 0000	388.78	37.84	46.35		46.46	0.004387	2.66	146.10	31.85	0.22
Williams_E-TH-SA	41095.03	10MAY2019 0000	391.97	37.84	46.37		46.48	0.004425	2.68	146.53	31.90	0.22
Williams_E-TH-SA	41095.03	13MAY2019 0000	392.13	37.84	46.37		46.48	0.004427	2.68	146.55	31.90	0.22
Williams_E-TH-SA	40939.16	01MAY2019 0100	107.12	38.31	42.80		42.83	0.001910	1.43	74.93	24.45	0.14
Williams_E-TH-SA	40939.16	04MAY2019 0000	294.12	38.31	45.36		45.42	0.002243	1.98	148.74	33.16	0.16
Williams_E-TH-SA	40939.16	06MAY2019 0000	365.95	38.31	45.74		45.82	0.002812	2.26	161.65	34.88	0.19
Williams_E-TH-SA	40939.16	08MAY2019 0000	383.16	38.31	45.81		45.89	0.002971	2.34	164.03	35.19	0.19
Williams_E-TH-SA	40939.16	10MAY2019 0000	385.69	38.31	45.82		45.90	0.002995	2.35	164.36	35.23	0.19
Williams_E-TH-SA	40939.16	13MAY2019 0000	385.82	38.31	45.82		45.91	0.002996	2.35	164.37	35.24	0.19
Williams_E-TH-SA	40822.73	01MAY2019 0100	107.14	36.44	42.67		42.68	0.000591	0.97	110.38	25.03	0.08
Williams_E-TH-SA	40822.73	04MAY2019 0000	290.02	36.44	45.20		45.24	0.000958	1.60	188.75	38.79	0.11
Williams_E-TH-SA	40822.73	06MAY2019 0000	345.99	36.44	45.55		45.60	0.001131	1.80	202.75	41.12	0.12
Williams_E-TH-SA	40822.73	08MAY2019 0000	358.15	36.44	45.61		45.66	0.001175	1.85	205.24	41.51	0.12
Williams_E-TH-SA	40822.73	10MAY2019 0000	359.90	36.44	45.62		45.67	0.001181	1.86	205.58	41.53	0.12
Williams_E-TH-SA	40822.73	13MAY2019 0000	359.99	36.44	45.62		45.67	0.001182	1.86	205.60	41.54	0.12
Williams_E-TH-SA	40787.12		Lat Struct									
Williams_E-TH-SA	40776		Lat Struct									
Williams_E-TH-SA	40723.49	01MAY2019 0100	107.15	36.57	42.54		42.57	0.001578	1.42	75.69	19.74	0.13
Williams_E-TH-SA	40723.49	04MAY2019 0000	263.72	36.57	45.03		45.09	0.002170	2.01	131.52	25.16	0.15
Williams_E-TH-SA	40723.49	06MAY2019 0000	295.88	36.57	45.38		45.45	0.002285	2.11	140.41	25.81	0.16
Williams_E-TH-SA	40723.49	08MAY2019 0000	301.93	36.57	45.44		45.51	0.002300	2.13	141.96	25.81	0.16
Williams_E-TH-SA	40723.49	10MAY2019 0000	302.80	36.57	45.45		45.52	0.002302	2.13	142.18	25.81	0.16
Williams_E-TH-SA	40723.49	13MAY2019 0000	302.84	36.57	45.45		45.52	0.002302	2.13	142.19	25.81	0.16
Williams_E-TH-SA	40666.84	01MAY2019 0100	107.15	35.92	42.47		42.50	0.001167	1.24	86.43	20.80	0.11
Williams_E-TH-SA	40666.84	04MAY2019 0000	263.72	35.92	44.93		44.98	0.001793	1.81	145.44	27.24	0.14
Williams_E-TH-SA	40666.84	06MAY2019 0000	295.78	35.92	45.27		45.33	0.001908	1.91	154.94	28.14	0.14
Williams_E-TH-SA	40666.84	08MAY2019 0000	301.64	35.92	45.33		45.39	0.001928	1.93	156.62	28.29	0.14
Williams_E-TH-SA	40666.84	10MAY2019 0000	302.46	35.92	45.34		45.40	0.001931	1.93	156.85	28.31	0.14
Williams_E-TH-SA	40666.84	13MAY2019 0000	302.50	35.92	45.34		45.40	0.001932	1.93	156.86	28.31	0.14

HEC-RAS Plan: US EC Williams LPIII River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	40637.89	01MAY2019 0100	107.16	37.18	42.40		42.44	0.002753	1.66	64.71	21.41	0.17
Williams_E-TH-SA	40637.89	04MAY2019 0000	263.72	37.18	44.85		44.91	0.002931	2.07	127.36	31.42	0.18
Williams_E-TH-SA	40637.89	06MAY2019 0000	295.78	37.18	45.19		45.26	0.003042	2.14	138.43	33.67	0.19
Williams_E-TH-SA	40637.89	08MAY2019 0000	301.64	37.18	45.25		45.32	0.003077	2.15	140.43	34.23	0.19
Williams_E-TH-SA	40637.89	10MAY2019 0000	302.46	37.18	45.25		45.33	0.003082	2.15	140.71	34.31	0.19
Williams_E-TH-SA	40637.89	13MAY2019 0000	302.50	37.18	45.25		45.33	0.003082	2.15	140.72	34.31	0.19
Williams_E-TH-SA	40593.76	01MAY2019 0100	107.16	34.64	42.34		42.36	0.000960	1.13	95.00	22.51	0.10
Williams_E-TH-SA	40593.76	04MAY2019 0000	263.72	34.64	44.77		44.81	0.001485	1.69	155.87	27.42	0.13
Williams_E-TH-SA	40593.76	06MAY2019 0000	295.78	34.64	45.10		45.15	0.001599	1.79	165.15	28.17	0.13
Williams_E-TH-SA	40593.76	08MAY2019 0000	301.64	34.64	45.16		45.21	0.001622	1.81	166.77	28.34	0.13
Williams_E-TH-SA	40593.76	10MAY2019 0000	302.46	34.64	45.17		45.22	0.001625	1.81	167.00	28.36	0.13
Williams_E-TH-SA	40593.76	13MAY2019 0000	302.50	34.64	45.17		45.22	0.001625	1.81	167.01	28.36	0.13
Williams_E-TH-SA	40529.51	01MAY2019 0100	107.17	36.16	42.24		42.27	0.001714	1.42	75.61	20.87	0.13
Williams_E-TH-SA	40529.51	04MAY2019 0000	263.72	36.16	44.63		44.69	0.002271	2.01	131.36	25.80	0.16
Williams_E-TH-SA	40529.51	06MAY2019 0000	295.78	36.16	44.95		45.02	0.002526	2.11	139.96	27.85	0.17
Williams_E-TH-SA	40529.51	08MAY2019 0000	301.63	36.16	45.01		45.08	0.002573	2.13	141.50	28.24	0.17
Williams_E-TH-SA	40529.51	10MAY2019 0000	302.45	36.16	45.01		45.09	0.002580	2.13	141.71	28.29	0.17
Williams_E-TH-SA	40529.51	13MAY2019 0000	302.49	36.16	45.02		45.09	0.002580	2.13	141.73	28.29	0.17
Williams_E-TH-SA	40522.73	01MAY2019 0100	107.17	35.69	42.22		42.26	0.002569	1.60	66.93	19.69	0.15
Williams_E-TH-SA	40522.73	04MAY2019 0000	263.72	35.69	44.60		44.67	0.003062	2.17	121.50	25.95	0.18
Williams_E-TH-SA	40522.73	06MAY2019 0000	295.78	35.69	44.92		45.00	0.003418	2.27	130.22	28.66	0.19
Williams_E-TH-SA	40522.73	08MAY2019 0000	301.63	35.69	44.98		45.06	0.003476	2.29	131.80	29.08	0.19
Williams_E-TH-SA	40522.73	10MAY2019 0000	302.45	35.69	44.98		45.07	0.003484	2.29	132.01	29.14	0.19
Williams_E-TH-SA	40522.73	13MAY2019 0000	302.49	35.69	44.98		45.07	0.003484	2.29	132.03	29.14	0.19
Williams_E-TH-SA	40504.84	01MAY2019 0100	107.18	34.84	42.20		42.22	0.001110	1.26	84.92	16.99	0.10
Williams_E-TH-SA	40504.84	04MAY2019 0000	263.72	34.84	44.56		44.63	0.002462	1.99	132.46	25.74	0.15
Williams_E-TH-SA	40504.84	06MAY2019 0000	295.78	34.84	44.88		44.95	0.002876	2.10	141.11	29.35	0.17
Williams_E-TH-SA	40504.84	08MAY2019 0000	301.63	34.84	44.93		45.00	0.002945	2.11	142.70	29.97	0.17
Williams_E-TH-SA	40504.84	10MAY2019 0000	302.45	34.84	44.94		45.01	0.002955	2.12	142.92	30.05	0.17
Williams_E-TH-SA	40504.84	13MAY2019 0000	302.49	34.84	44.94		45.01	0.002956	2.12	142.93	30.06	0.17
Williams_E-TH-SA	40479.52	01MAY2019 0100	107.18	34.62	42.14		42.18	0.002602	1.59	67.38	19.49	0.15
Williams_E-TH-SA	40479.52	04MAY2019 0000	263.72	34.62	44.49		44.55	0.003156	2.09	125.98	30.28	0.18
Williams_E-TH-SA	40479.52	06MAY2019 0000	295.78	34.62	44.79		44.87	0.003228	2.19	135.75	33.00	0.18
Williams_E-TH-SA	40479.52	08MAY2019 0000	301.63	34.62	44.85		44.92	0.003244	2.21	137.49	33.47	0.18
Williams_E-TH-SA	40479.52	10MAY2019 0000	302.45	34.62	44.85		44.93	0.003246	2.21	137.73	33.53	0.18
Williams_E-TH-SA	40479.52	13MAY2019 0000	302.49	34.62	44.85		44.93	0.003246	2.21	137.74	33.53	0.18
Williams_E-TH-SA	40436.27	01MAY2019 0100	107.18	36.91	42.04		42.08	0.002177	1.54	69.59	21.33	0.15
Williams_E-TH-SA	40436.27	04MAY2019 0000	263.72	36.91	44.36		44.43	0.002567	2.07	127.26	27.68	0.17
Williams_E-TH-SA	40436.27	06MAY2019 0000	295.78	36.91	44.67		44.74	0.002697	2.18	135.76	28.27	0.18
Williams_E-TH-SA	40436.27	08MAY2019 0000	301.63	36.91	44.72		44.79	0.002724	2.20	137.21	28.37	0.18
Williams_E-TH-SA	40436.27	10MAY2019 0000	302.45	36.91	44.73		44.80	0.002727	2.20	137.41	28.38	0.18
Williams_E-TH-SA	40436.27	13MAY2019 0000	302.49	36.91	44.73		44.80	0.002728	2.20	137.42	28.38	0.18
Williams_E-TH-SA	40386.32	01MAY2019 0100	107.19	36.19	41.93		41.97	0.002078	1.54	69.43	20.05	0.15
Williams_E-TH-SA	40386.32	04MAY2019 0000	263.72	36.19	44.23		44.30	0.002763	2.15	122.74	26.43	0.18
Williams_E-TH-SA	40386.32	06MAY2019 0000	295.78	36.19	44.52		44.60	0.002943	2.26	130.66	27.25	0.18
Williams_E-TH-SA	40386.32	08MAY2019 0000	301.63	36.19	44.57		44.65	0.002977	2.28	132.02	27.39	0.18
Williams_E-TH-SA	40386.32	10MAY2019 0000	302.45	36.19	44.58		44.66	0.002982	2.29	132.21	27.41	0.18
Williams_E-TH-SA	40386.32	13MAY2019 0000	302.49	36.19	44.58		44.66	0.002982	2.29	132.22	27.41	0.18
Williams_E-TH-SA	40323.05	01MAY2019 0100	107.20	35.86	41.81		41.85	0.001851	1.47	72.87	19.68	0.13
Williams_E-TH-SA	40323.05	04MAY2019 0000	263.72	35.86	44.05		44.12	0.002724	2.15	122.65	24.53	0.17
Williams_E-TH-SA	40323.05	06MAY2019 0000	295.78	35.86	44.33		44.41	0.002942	2.28	129.61	25.01	0.18
Williams_E-TH-SA	40323.05	08MAY2019 0000	301.63	35.86	44.38		44.46	0.002982	2.31	130.81	25.10	0.18
Williams_E-TH-SA	40323.05	10MAY2019 0000	302.45	35.86	44.39		44.47	0.002988	2.31	130.98	25.11	0.18
Williams_E-TH-SA	40323.05	13MAY2019 0000	302.49	35.86	44.39		44.47	0.002988	2.31	130.99	25.11	0.18
Williams_E-TH-SA	40237.63	01MAY2019 0100	107.21	36.68	41.65		41.68	0.001948	1.47	72.97	22.12	0.14
Williams_E-TH-SA	40237.63	04MAY2019 0000	263.72	36.68	43.87		43.92	0.002115	1.92	159.23	59.27	0.15
Williams_E-TH-SA	40237.63	06MAY2019 0000	295.78	36.68	44.14		44.20	0.002147	1.97	175.92	61.20	0.16
Williams_E-TH-SA	40237.63	08MAY2019 0000	301.63	36.68	44.19		44.25	0.002155	1.98	178.78	61.53	0.16
Williams_E-TH-SA	40237.63	10MAY2019 0000	302.45	36.68	44.20		44.25	0.002157	1.98	179.17	61.57	0.16
Williams_E-TH-SA	40237.63	13MAY2019 0000	302.49	36.68	44.20		44.25	0.002157	1.98	179.19	61.57	0.16
Williams_E-TH-SA	40181.84	01MAY2019 0100	107.22	36.58	41.56		41.59	0.001552	1.37	78.04	21.97	0.13
Williams_E-TH-SA	40181.84	04MAY2019 0000	263.72	36.58	43.73		43.80	0.002257	2.01	131.16	26.84	0.16
Williams_E-TH-SA	40181.84	06MAY2019 0000	295.78	36.58	44.00		44.07	0.002456	2.14	138.34	27.44	0.17
Williams_E-TH-SA	40181.84	08MAY2019 0000	301.63	36.58	44.04		44.11	0.002494	2.16	139.55	27.53	0.17
Williams_E-TH-SA	40181.84	10MAY2019 0000	302.45	36.58	44.05		44.12	0.002500	2.16	139.72	27.55	0.17
Williams_E-TH-SA	40181.84	13MAY2019 0000	302.49	36.58	44.05		44.12	0.002500	2.16	139.73	27.55	0.17
Williams_E-TH-SA	40129.22	01MAY2019 0100	107.22	35.48	41.43		41.48	0.002575	1.72	62.20	15.45	0.15
Williams_E-TH-SA	40129.22	04MAY2019 0000	263.72	35.48	43.57		43.65	0.003016	2.29	137.74	45.03	0.17
Williams_E-TH-SA	40129.22	06MAY2019 0000	295.59	35.48	43.83		43.90	0.003118	2.38	149.13	45.03	0.17
Williams_E-TH-SA	40129.22	08MAY2019 0000	301.27	35.48	43.87		43.95	0.003138	2.40	151.02	45.03	0.17
Williams_E-TH-SA	40129.22	10MAY2019 0000	302.06	35.48	43.88		43.95	0.003141	2.40	151.28	45.03	0.17
Williams_E-TH-SA	40129.22	13MAY2019 0000	302.10	35.48	43.88		43.95	0.003141	2.40	151.29	45.03	0.17

HEC-RAS Plan: US EC Williams LPIII River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	40079.13	01MAY2019 0100	107.23	35.68	41.31		41.35	0.002476	1.64	65.54	19.33	0.16
Williams_E-TH-SA	40079.13	04MAY2019 0000	263.72	35.68	43.39		43.48	0.003561	2.38	110.83	23.75	0.19
Williams_E-TH-SA	40079.13	06MAY2019 0000	295.59	35.68	43.62		43.72	0.003843	2.54	116.42	24.00	0.20
Williams_E-TH-SA	40079.13	08MAY2019 0000	301.27	35.68	43.66		43.77	0.003897	2.57	117.34	24.04	0.20
Williams_E-TH-SA	40079.13	10MAY2019 0000	302.06	35.68	43.67		43.77	0.003904	2.57	117.47	24.04	0.20
Williams_E-TH-SA	40079.13	13MAY2019 0000	302.10	35.68	43.67		43.77	0.003905	2.57	117.47	24.04	0.20
Williams_E-TH-SA	40036.96	01MAY2019 0100	107.23	35.42	41.22		41.26	0.002079	1.44	74.61	24.90	0.15
Williams_E-TH-SA	40036.96	04MAY2019 0000	263.72	35.42	43.29		43.35	0.002472	2.03	130.09	28.67	0.17
Williams_E-TH-SA	40036.96	06MAY2019 0000	295.59	35.42	43.51		43.59	0.002672	2.17	136.63	29.06	0.17
Williams_E-TH-SA	40036.96	08MAY2019 0000	301.27	35.42	43.55		43.63	0.002710	2.19	137.71	29.12	0.17
Williams_E-TH-SA	40036.96	10MAY2019 0000	302.06	35.42	43.56		43.63	0.002715	2.20	137.86	29.13	0.17
Williams_E-TH-SA	40036.96	13MAY2019 0000	302.10	35.42	43.56		43.63	0.002715	2.20	137.87	29.13	0.17
Williams_E-TH-SA	40029.49	01MAY2019 0100	107.23	34.94	41.23		41.25	0.000679	0.98	109.40	27.92	0.09
Williams_E-TH-SA	40029.49	04MAY2019 0000	263.72	34.94	43.30		43.34	0.001135	1.55	170.56	30.66	0.12
Williams_E-TH-SA	40029.49	06MAY2019 0000	295.59	34.94	43.53		43.57	0.001258	1.66	177.59	30.81	0.12
Williams_E-TH-SA	40029.49	08MAY2019 0000	301.27	34.94	43.57		43.61	0.001281	1.69	178.74	30.83	0.12
Williams_E-TH-SA	40029.49	10MAY2019 0000	302.06	34.94	43.57		43.62	0.001284	1.69	178.90	30.84	0.12
Williams_E-TH-SA	40029.49	13MAY2019 0000	302.10	34.94	43.57		43.62	0.001284	1.69	178.90	30.84	0.12
Williams_E-TH-SA	40027.50	01MAY2019 0100	107.24	34.94	41.23	37.23	41.24	0.000680	0.98	109.36	27.92	0.09
Williams_E-TH-SA	40027.50	04MAY2019 0000	263.72	34.94	43.30	38.12	43.34	0.001137	1.55	170.49	30.66	0.12
Williams_E-TH-SA	40027.50	06MAY2019 0000	295.53	34.94	43.53	38.27	43.57	0.001259	1.67	177.51	30.81	0.12
Williams_E-TH-SA	40027.50	08MAY2019 0000	301.19	34.94	43.56	38.30	43.61	0.001282	1.69	178.66	30.83	0.12
Williams_E-TH-SA	40027.50	10MAY2019 0000	301.98	34.94	43.57	38.30	43.61	0.001285	1.69	178.82	30.83	0.12
Williams_E-TH-SA	40027.50	13MAY2019 0000	302.02	34.94	43.57	38.30	43.61	0.001285	1.69	178.82	30.83	0.12
Williams_E-TH-SA	40022		Bridge									
Williams_E-TH-SA	40014.83	01MAY2019 0100	107.24	34.29	41.20		41.21	0.000276	0.73	146.20	26.39	0.05
Williams_E-TH-SA	40014.83	04MAY2019 0000	263.72	34.29	43.15		43.18	0.000697	1.32	199.73	28.47	0.09
Williams_E-TH-SA	40014.83	06MAY2019 0000	295.53	34.29	43.37		43.40	0.000803	1.44	205.86	29.04	0.09
Williams_E-TH-SA	40014.83	08MAY2019 0000	301.19	34.29	43.40		43.43	0.000821	1.46	206.86	29.06	0.10
Williams_E-TH-SA	40014.83	10MAY2019 0000	301.98	34.29	43.41		43.44	0.000824	1.46	207.00	29.06	0.10
Williams_E-TH-SA	40014.83	13MAY2019 0000	302.02	34.29	43.41		43.44	0.000824	1.46	207.01	29.06	0.10
Williams_E-TH-SA	40014.82	01MAY2019 0100	107.24	34.29	41.20		41.21	0.000276	0.73	146.20	26.39	0.05
Williams_E-TH-SA	40014.82	04MAY2019 0000	263.72	34.29	43.15		43.18	0.000697	1.32	199.72	28.47	0.09
Williams_E-TH-SA	40014.82	06MAY2019 0000	295.53	34.29	43.37		43.40	0.000803	1.44	205.86	29.04	0.09
Williams_E-TH-SA	40014.82	08MAY2019 0000	301.19	34.29	43.40		43.43	0.000821	1.46	206.86	29.06	0.10
Williams_E-TH-SA	40014.82	10MAY2019 0000	301.98	34.29	43.41		43.44	0.000824	1.46	207.00	29.06	0.10
Williams_E-TH-SA	40014.82	13MAY2019 0000	302.02	34.29	43.41		43.44	0.000824	1.46	207.01	29.06	0.10
Williams_E-TH-SA	40014.63		Lat Struct									
Williams_E-TH-SA	40014.53		Lat Struct									
Williams_E-TH-SA	39971.39	01MAY2019 0100	107.24	35.86	41.04		41.12	0.004803	2.17	49.52	15.05	0.21
Williams_E-TH-SA	39971.39	04MAY2019 0000	258.11	35.86	42.87		43.04	0.007283	3.23	80.21	18.20	0.27
Williams_E-TH-SA	39971.39	06MAY2019 0000	284.31	35.86	43.06		43.24	0.007811	3.41	83.69	18.42	0.28
Williams_E-TH-SA	39971.39	08MAY2019 0000	288.77	35.86	43.09		43.28	0.007901	3.44	84.26	18.46	0.28
Williams_E-TH-SA	39971.39	10MAY2019 0000	289.38	35.86	43.10		43.28	0.007913	3.44	84.34	18.46	0.28
Williams_E-TH-SA	39971.39	13MAY2019 0000	289.42	35.86	43.10		43.28	0.007914	3.44	84.34	18.46	0.28
Williams_E-TH-SA	39890.03	01MAY2019 0100	107.25	35.00	40.82		40.85	0.001703	1.45	73.96	19.37	0.13
Williams_E-TH-SA	39890.03	04MAY2019 0000	248.65	35.00	42.53		42.60	0.003648	2.12	117.31	32.30	0.20
Williams_E-TH-SA	39890.03	06MAY2019 0000	271.25	35.00	42.70		42.78	0.003781	2.20	123.14	32.86	0.20
Williams_E-TH-SA	39890.03	08MAY2019 0000	275.06	35.00	42.73		42.81	0.003804	2.22	124.09	32.95	0.20
Williams_E-TH-SA	39890.03	10MAY2019 0000	275.59	35.00	42.74		42.81	0.003807	2.22	124.22	32.97	0.20
Williams_E-TH-SA	39890.03	13MAY2019 0000	275.62	35.00	42.74		42.81	0.003807	2.22	124.23	32.97	0.20
Williams_E-TH-SA	39795.22	01MAY2019 0100	96.77	34.69	40.68		40.71	0.001388	1.32	73.20	18.73	0.12
Williams_E-TH-SA	39795.22	04MAY2019 0000	193.11	34.69	42.30		42.34	0.002288	1.78	108.63	26.63	0.16
Williams_E-TH-SA	39795.22	06MAY2019 0000	209.25	34.69	42.47		42.52	0.002450	1.85	113.24	27.67	0.16
Williams_E-TH-SA	39795.22	08MAY2019 0000	211.98	34.69	42.49		42.55	0.002477	1.86	114.01	27.84	0.16
Williams_E-TH-SA	39795.22	10MAY2019 0000	212.36	34.69	42.50		42.55	0.002480	1.86	114.11	27.86	0.16
Williams_E-TH-SA	39795.22	13MAY2019 0000	212.38	34.69	42.50		42.55	0.002481	1.86	114.12	27.86	0.16
Williams_E-TH-SA	39693.45	01MAY2019 0100	96.79	35.17	40.54		40.57	0.001380	1.31	74.14	19.34	0.12
Williams_E-TH-SA	39693.45	04MAY2019 0000	193.11	35.17	42.07		42.12	0.002118	1.83	105.74	22.53	0.15
Williams_E-TH-SA	39693.45	06MAY2019 0000	209.25	35.17	42.22		42.28	0.002291	1.92	109.19	22.98	0.15
Williams_E-TH-SA	39693.45	08MAY2019 0000	211.98	35.17	42.24		42.30	0.002321	1.93	109.75	23.05	0.16
Williams_E-TH-SA	39693.45	10MAY2019 0000	212.36	35.17	42.25		42.31	0.002325	1.93	109.83	23.06	0.16
Williams_E-TH-SA	39693.45	13MAY2019 0000	212.38	35.17	42.25		42.31	0.002325	1.93	109.84	23.06	0.16
Williams_E-TH-SA	39566.14	01MAY2019 0100	96.80	34.77	40.35		40.38	0.001631	1.36	71.19	20.07	0.13
Williams_E-TH-SA	39566.14	04MAY2019 0000	193.11	34.77	41.77		41.83	0.002505	1.89	102.41	24.18	0.16
Williams_E-TH-SA	39566.14	06MAY2019 0000	209.25	34.77	41.90		41.96	0.002726	1.98	105.49	24.60	0.17
Williams_E-TH-SA	39566.14	08MAY2019 0000	211.98	34.77	41.92		41.98	0.002764	2.00	105.99	24.67	0.17
Williams_E-TH-SA	39566.14	10MAY2019 0000	212.36	34.77	41.92		41.98	0.002769	2.00	106.06	24.68	0.17
Williams_E-TH-SA	39566.14	13MAY2019 0000	212.38	34.77	41.92		41.98	0.002770	2.00	106.06	24.68	0.17

HEC-RAS Plan: US EC Williams LPIII   River: Will-Barbata   Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	39392.4	01MAY2019 0100	96.82	35.08	40.00		40.04	0.002320	1.61	60.09	16.38	0.15
Williams_E-TH-SA	39392.4	04MAY2019 0000	170.58	35.08	41.30		41.36	0.003018	2.07	82.56	18.22	0.17
Williams_E-TH-SA	39392.4	06MAY2019 0000	179.24	35.08	41.40		41.47	0.003129	2.12	84.50	18.37	0.17
Williams_E-TH-SA	39392.4	08MAY2019 0000	180.66	35.08	41.42		41.49	0.003147	2.13	84.80	18.38	0.17
Williams_E-TH-SA	39392.4	10MAY2019 0000	180.86	35.08	41.42		41.49	0.003150	2.13	84.84	18.39	0.17
Williams_E-TH-SA	39392.4	13MAY2019 0000	180.87	35.08	41.42		41.49	0.003150	2.13	84.85	18.39	0.17
Williams_E-TH-SA	39264.35	01MAY2019 0100	96.84	35.21	39.57		39.62	0.004163	1.87	51.80	20.11	0.21
Williams_E-TH-SA	39264.35	04MAY2019 0000	170.44	35.21	40.84		40.91	0.004017	2.11	80.68	25.20	0.21
Williams_E-TH-SA	39264.35	06MAY2019 0000	178.72	35.21	40.94		41.01	0.004085	2.15	83.13	25.55	0.21
Williams_E-TH-SA	39264.35	08MAY2019 0000	180.06	35.21	40.96		41.03	0.004097	2.16	83.52	25.61	0.21
Williams_E-TH-SA	39264.35	10MAY2019 0000	180.24	35.21	40.96		41.03	0.004098	2.16	83.57	25.62	0.21
Williams_E-TH-SA	39264.35	13MAY2019 0000	180.25	35.21	40.96		41.03	0.004098	2.16	83.57	25.62	0.21
Williams_E-TH-SA	39006.66	01MAY2019 0100	96.56	33.44	38.67		38.72	0.002850	1.76	54.98	13.95	0.16
Williams_E-TH-SA	39006.66	04MAY2019 0000	152.06	33.44	39.93		39.99	0.003259	2.07	73.32	15.32	0.17
Williams_E-TH-SA	39006.66	06MAY2019 0000	157.47	33.44	40.01		40.08	0.003341	2.11	74.57	15.41	0.17
Williams_E-TH-SA	39006.66	08MAY2019 0000	158.34	33.44	40.02		40.09	0.003354	2.12	74.76	15.42	0.17
Williams_E-TH-SA	39006.66	10MAY2019 0000	158.45	33.44	40.02		40.09	0.003356	2.12	74.79	15.43	0.17
Williams_E-TH-SA	39006.66	13MAY2019 0000	158.46	33.44	40.02		40.09	0.003356	2.12	74.79	15.43	0.17
Williams_E-TH-SA	38807.86	01MAY2019 0100	96.58	32.35	38.10		38.14	0.002949	1.78	54.13	14.15	0.16
Williams_E-TH-SA	38807.86	04MAY2019 0000	145.73	32.35	39.30		39.37	0.003107	2.02	72.31	15.98	0.17
Williams_E-TH-SA	38807.86	06MAY2019 0000	149.60	32.35	39.38		39.44	0.003138	2.04	73.48	16.09	0.17
Williams_E-TH-SA	38807.86	08MAY2019 0000	150.20	32.35	39.39		39.45	0.003143	2.04	73.66	16.11	0.17
Williams_E-TH-SA	38807.86	10MAY2019 0000	150.28	32.35	39.39		39.45	0.003144	2.04	73.68	16.11	0.17
Williams_E-TH-SA	38807.86	13MAY2019 0000	150.29	32.35	39.39		39.45	0.003144	2.04	73.68	16.11	0.17
Williams_E-TH-SA	38578.48	01MAY2019 0100	96.61	32.45	37.61		37.64	0.001464	1.35	71.80	18.10	0.12
Williams_E-TH-SA	38578.48	04MAY2019 0000	145.73	32.45	38.79		38.83	0.001576	1.55	93.88	19.30	0.12
Williams_E-TH-SA	38578.48	06MAY2019 0000	149.60	32.45	38.86		38.90	0.001599	1.57	95.17	19.37	0.13
Williams_E-TH-SA	38578.48	08MAY2019 0000	150.20	32.45	38.87		38.91	0.001603	1.58	95.36	19.38	0.13
Williams_E-TH-SA	38578.48	10MAY2019 0000	150.28	32.45	38.87		38.91	0.001603	1.58	95.39	19.38	0.13
Williams_E-TH-SA	38578.48	13MAY2019 0000	150.29	32.45	38.87		38.91	0.001603	1.58	95.39	19.38	0.13
Williams_E-TH-SA	38407.9	01MAY2019 0100	96.64	31.52	37.11		37.18	0.003993	2.00	48.31	13.20	0.18
Williams_E-TH-SA	38407.9	04MAY2019 0000	144.40	31.52	38.27		38.34	0.004134	2.24	64.51	14.88	0.19
Williams_E-TH-SA	38407.9	06MAY2019 0000	147.69	31.52	38.33		38.41	0.004164	2.26	65.44	14.97	0.19
Williams_E-TH-SA	38407.9	08MAY2019 0000	148.20	31.52	38.34		38.42	0.004169	2.26	65.57	14.99	0.19
Williams_E-TH-SA	38407.9	10MAY2019 0000	148.27	31.52	38.34		38.42	0.004170	2.26	65.59	14.99	0.19
Williams_E-TH-SA	38407.9	13MAY2019 0000	148.27	31.52	38.34		38.42	0.004170	2.26	65.59	14.99	0.19
Williams_E-TH-SA	38255.83	01MAY2019 0100	96.65	32.18	36.39		36.47	0.005346	2.17	44.59	15.61	0.23
Williams_E-TH-SA	38255.83	04MAY2019 0000	144.40	32.18	37.64		37.71	0.004173	2.20	65.70	18.31	0.20
Williams_E-TH-SA	38255.83	06MAY2019 0000	147.69	32.18	37.70		37.77	0.004172	2.21	66.81	18.44	0.20
Williams_E-TH-SA	38255.83	08MAY2019 0000	148.20	32.18	37.71		37.78	0.004173	2.21	66.98	18.46	0.20
Williams_E-TH-SA	38255.83	10MAY2019 0000	148.27	32.18	37.71		37.79	0.004173	2.21	67.00	18.47	0.20
Williams_E-TH-SA	38255.83	13MAY2019 0000	148.27	32.18	37.71		37.79	0.004173	2.21	67.00	18.47	0.20
Williams_E-TH-SA	38051.7	01MAY2019 0100	96.69	28.30	35.85		35.86	0.000474	0.88	109.35	22.54	0.07
Williams_E-TH-SA	38051.7	04MAY2019 0000	144.40	28.30	37.21		37.23	0.000527	1.02	141.72	25.08	0.08
Williams_E-TH-SA	38051.7	06MAY2019 0000	147.69	28.30	37.27		37.29	0.000535	1.03	143.24	25.19	0.08
Williams_E-TH-SA	38051.7	08MAY2019 0000	148.20	28.30	37.28		37.30	0.000537	1.03	143.46	25.21	0.08
Williams_E-TH-SA	38051.7	10MAY2019 0000	148.27	28.30	37.28		37.30	0.000537	1.03	143.49	25.21	0.08
Williams_E-TH-SA	38051.7	13MAY2019 0000	148.27	28.30	37.28		37.30	0.000537	1.03	143.49	25.21	0.08
Williams_E-TH-SA	37787.34	01MAY2019 0100	96.75	28.77	35.52		35.56	0.001862	1.50	64.52	14.86	0.13
Williams_E-TH-SA	37787.34	04MAY2019 0000	143.79	28.77	36.85		36.89	0.002026	1.67	85.93	18.02	0.14
Williams_E-TH-SA	37787.34	06MAY2019 0000	146.47	28.77	36.90		36.95	0.002045	1.68	86.96	18.20	0.14
Williams_E-TH-SA	37787.34	08MAY2019 0000	146.88	28.77	36.91		36.96	0.002048	1.69	87.11	18.23	0.14
Williams_E-TH-SA	37787.34	10MAY2019 0000	146.93	28.77	36.91		36.96	0.002048	1.69	87.13	18.23	0.14
Williams_E-TH-SA	37787.34	13MAY2019 0000	146.93	28.77	36.91		36.96	0.002048	1.69	87.13	18.23	0.14
Williams_E-TH-SA	37533.79	01MAY2019 0100	96.79	28.62	35.19		35.21	0.000889	1.12	86.78	19.42	0.09
Williams_E-TH-SA	37533.79	04MAY2019 0000	143.79	28.62	36.49		36.52	0.000948	1.27	113.30	21.32	0.10
Williams_E-TH-SA	37533.79	06MAY2019 0000	146.47	28.62	36.54		36.57	0.000958	1.28	114.45	21.47	0.10
Williams_E-TH-SA	37533.79	08MAY2019 0000	146.88	28.62	36.55		36.58	0.000959	1.28	114.62	21.55	0.10
Williams_E-TH-SA	37533.79	10MAY2019 0000	146.93	28.62	36.55		36.58	0.000959	1.28	114.64	21.56	0.10
Williams_E-TH-SA	37533.79	13MAY2019 0000	146.93	28.62	36.55		36.58	0.000959	1.28	114.64	21.57	0.10
Williams_E-TH-SA	37396.18	01MAY2019 0100	96.82	29.28	34.96		35.00	0.002145	1.57	61.65	14.93	0.14
Williams_E-TH-SA	37396.18	04MAY2019 0000	143.79	29.28	36.25		36.30	0.002204	1.75	82.51	19.25	0.14
Williams_E-TH-SA	37396.18	06MAY2019 0000	146.47	29.28	36.30		36.35	0.002223	1.76	83.52	20.02	0.14
Williams_E-TH-SA	37396.18	08MAY2019 0000	146.88	29.28	36.31		36.36	0.002226	1.76	83.67	20.13	0.14
Williams_E-TH-SA	37396.18	10MAY2019 0000	146.93	29.28	36.31		36.36	0.002226	1.76	83.69	20.14	0.14
Williams_E-TH-SA	37396.18	13MAY2019 0000	146.93	29.28	36.31		36.36	0.002226	1.76	83.69	20.14	0.14
Williams_E-TH-SA	37157.42	01MAY2019 0100	96.86	28.51	34.49		34.53	0.001818	1.46	66.13	15.24	0.12
Williams_E-TH-SA	37157.42	04MAY2019 0000	143.79	28.51	35.77		35.81	0.001892	1.65	91.06	29.01	0.13
Williams_E-TH-SA	37157.42	06MAY2019 0000	146.47	28.51	35.82		35.86	0.001909	1.66	92.44	29.56	0.13
Williams_E-TH-SA	37157.42	08MAY2019 0000	146.88	28.51	35.83		35.87	0.001912	1.66	92.64	29.63	0.13
Williams_E-TH-SA	37157.42	10MAY2019 0000	146.93	28.51	35.83		35.87	0.001912	1.66	92.67	29.64	0.13

HEC-RAS Plan: US EC Williams LPIII River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	37157.42	13MAY2019 0000	146.93	28.51	35.83		35.87	0.001912	1.66	92.67	29.64	0.13
Williams_E-TH-SA	36919.78	01MAY2019 0100	96.89	28.48	33.65		33.72	0.005002	2.15	45.02	11.03	0.19
Williams_E-TH-SA	36919.78	04MAY2019 0000	143.50	28.48	34.89		34.98	0.005204	2.39	61.37	20.14	0.19
Williams_E-TH-SA	36919.78	06MAY2019 0000	145.80	28.48	34.93		35.02	0.005242	2.41	62.20	20.77	0.19
Williams_E-TH-SA	36919.78	08MAY2019 0000	146.13	28.48	34.94		35.03	0.005247	2.41	62.32	20.86	0.19
Williams_E-TH-SA	36919.78	10MAY2019 0000	146.18	28.48	34.94		35.03	0.005248	2.41	62.33	20.87	0.19
Williams_E-TH-SA	36919.78	13MAY2019 0000	146.18	28.48	34.94		35.03	0.005248	2.41	62.33	20.87	0.19
Williams_E-TH-SA	36664.16	01MAY2019 0100	96.92	25.87	32.83		32.86	0.001719	1.46	66.38	12.99	0.11
Williams_E-TH-SA	36664.16	04MAY2019 0000	143.50	25.87	33.99		34.04	0.002154	1.75	82.67	26.11	0.13
Williams_E-TH-SA	36664.16	06MAY2019 0000	145.80	25.87	34.02		34.07	0.002193	1.77	83.55	30.32	0.13
Williams_E-TH-SA	36664.16	08MAY2019 0000	146.13	25.87	34.03		34.08	0.002198	1.77	83.68	30.38	0.13
Williams_E-TH-SA	36664.16	10MAY2019 0000	146.18	25.87	34.03		34.08	0.002199	1.77	83.70	30.38	0.13
Williams_E-TH-SA	36664.16	13MAY2019 0000	146.18	25.87	34.03		34.08	0.002199	1.77	83.70	30.38	0.13
Williams_E-TH-SA	36467.93	01MAY2019 0100	96.94	27.36	32.48		32.52	0.001797	1.45	66.92	18.05	0.13
Williams_E-TH-SA	36467.93	04MAY2019 0000	143.50	27.36	33.61		33.65	0.001825	1.62	90.87	41.65	0.14
Williams_E-TH-SA	36467.93	06MAY2019 0000	145.80	27.36	33.64		33.68	0.001855	1.64	91.90	44.89	0.14
Williams_E-TH-SA	36467.93	08MAY2019 0000	146.13	27.36	33.64		33.68	0.001859	1.64	92.05	45.34	0.14
Williams_E-TH-SA	36467.93	10MAY2019 0000	146.18	27.36	33.64		33.68	0.001859	1.64	92.07	45.40	0.14
Williams_E-TH-SA	36467.93	13MAY2019 0000	146.18	27.36	33.64		33.68	0.001859	1.64	92.07	45.41	0.14
Williams_E-TH-SA	36449.34	01MAY2019 0100	96.95	27.32	32.46		32.48	0.001504	1.36	71.58	22.17	0.12
Williams_E-TH-SA	36449.34	04MAY2019 0000	143.50	27.32	33.60		33.62	0.001238	1.36	139.37	103.92	0.11
Williams_E-TH-SA	36449.34	06MAY2019 0000	145.80	27.32	33.62		33.65	0.001265	1.38	141.91	107.03	0.11
Williams_E-TH-SA	36449.34	08MAY2019 0000	146.13	27.32	33.63		33.65	0.001266	1.38	142.27	107.16	0.11
Williams_E-TH-SA	36449.34	10MAY2019 0000	146.18	27.32	33.63		33.65	0.001266	1.38	142.32	107.18	0.11
Williams_E-TH-SA	36449.34	13MAY2019 0000	146.18	27.32	33.63		33.65	0.001266	1.38	142.32	107.18	0.11
Williams_E-TH-SA	36387.27	01MAY2019 0100	96.96	27.86	32.29		32.34	0.003090	1.78	54.42	15.81	0.17
Williams_E-TH-SA	36387.27	04MAY2019 0000	143.50	27.86	33.48		33.52	0.002379	1.72	104.97	71.43	0.15
Williams_E-TH-SA	36387.27	06MAY2019 0000	145.80	27.86	33.50		33.54	0.002392	1.73	106.63	71.84	0.15
Williams_E-TH-SA	36387.27	08MAY2019 0000	146.13	27.86	33.50		33.54	0.002394	1.73	106.86	71.90	0.15
Williams_E-TH-SA	36387.27	10MAY2019 0000	146.18	27.86	33.50		33.54	0.002394	1.73	106.89	71.91	0.15
Williams_E-TH-SA	36387.27	13MAY2019 0000	146.18	27.86	33.50		33.54	0.002394	1.73	106.89	71.91	0.15
Williams_E-TH-SA	36313.92	01MAY2019 0100	96.97	27.84	32.14		32.17	0.001634	1.32	73.45	26.64	0.13
Williams_E-TH-SA	36313.92	04MAY2019 0000	143.50	27.84	33.37		33.39	0.000942	1.15	172.54	129.76	0.10
Williams_E-TH-SA	36313.92	06MAY2019 0000	145.80	27.84	33.40		33.41	0.000943	1.15	175.44	130.46	0.10
Williams_E-TH-SA	36313.92	08MAY2019 0000	146.13	27.84	33.40		33.42	0.000943	1.15	175.84	130.55	0.10
Williams_E-TH-SA	36313.92	10MAY2019 0000	146.18	27.84	33.40		33.42	0.000943	1.15	175.90	130.57	0.10
Williams_E-TH-SA	36313.92	13MAY2019 0000	146.18	27.84	33.40		33.42	0.000943	1.15	175.90	130.57	0.10
Williams_E-TH-SA	36217.71	01MAY2019 0100	97.02	26.07	32.02		32.04	0.001127	1.19	104.48	106.30	0.11
Williams_E-TH-SA	36217.71	04MAY2019 0000	143.50	26.07	33.32		33.32	0.000372	0.76	293.50	166.94	0.06
Williams_E-TH-SA	36217.71	06MAY2019 0000	145.80	26.07	33.34		33.35	0.000373	0.76	297.20	167.47	0.06
Williams_E-TH-SA	36217.71	08MAY2019 0000	146.13	26.07	33.34		33.35	0.000373	0.76	297.71	167.54	0.06
Williams_E-TH-SA	36217.71	10MAY2019 0000	146.18	26.07	33.34		33.35	0.000373	0.76	297.78	167.55	0.06
Williams_E-TH-SA	36217.71	13MAY2019 0000	146.18	26.07	33.34		33.35	0.000373	0.76	297.78	167.55	0.06
Williams_E-TH-SA	36158.16	01MAY2019 0100	97.06	24.61	31.93		31.96	0.001456	1.36	74.49	28.02	0.10
Williams_E-TH-SA	36158.16	04MAY2019 0000	143.50	24.61	33.26		33.28	0.001245	1.35	143.05	88.10	0.09
Williams_E-TH-SA	36158.16	06MAY2019 0000	145.80	24.61	33.28		33.31	0.001273	1.36	144.98	88.57	0.10
Williams_E-TH-SA	36158.16	08MAY2019 0000	146.13	24.61	33.28		33.31	0.001275	1.36	145.25	88.59	0.10
Williams_E-TH-SA	36158.16	10MAY2019 0000	146.18	24.61	33.28		33.31	0.001275	1.36	145.28	88.59	0.10
Williams_E-TH-SA	36158.16	13MAY2019 0000	146.18	24.61	33.28		33.31	0.001275	1.36	145.28	88.59	0.10
Williams_E-TH-SA	36126.37	01MAY2019 0100	97.06	24.83	31.92		31.93	0.000465	0.88	109.98	21.73	0.07
Williams_E-TH-SA	36126.37	04MAY2019 0000	143.50	24.83	33.24		33.25	0.000527	1.02	144.01	46.96	0.07
Williams_E-TH-SA	36126.37	06MAY2019 0000	145.80	24.83	33.26		33.27	0.000538	1.04	145.02	47.70	0.08
Williams_E-TH-SA	36126.37	08MAY2019 0000	146.13	24.83	33.26		33.28	0.000540	1.04	145.16	47.84	0.08
Williams_E-TH-SA	36126.37	10MAY2019 0000	146.18	24.83	33.26		33.28	0.000540	1.04	145.18	47.85	0.08
Williams_E-TH-SA	36126.37	13MAY2019 0000	146.18	24.83	33.26		33.28	0.000540	1.04	145.18	47.85	0.08
Williams_E-TH-SA	35961.96	01MAY2019 0100	97.09	25.63	31.81		31.82	0.000839	1.10	88.17	16.96	0.09
Williams_E-TH-SA	35961.96	04MAY2019 0000	143.06	25.63	33.11		33.13	0.000898	1.25	128.16	48.90	0.09
Williams_E-TH-SA	35961.96	06MAY2019 0000	144.94	25.63	33.13		33.15	0.000909	1.26	129.10	48.90	0.09
Williams_E-TH-SA	35961.96	08MAY2019 0000	145.20	25.63	33.13		33.16	0.000911	1.26	129.23	48.90	0.09
Williams_E-TH-SA	35961.96	10MAY2019 0000	145.24	25.63	33.13		33.16	0.000911	1.26	129.25	48.90	0.09
Williams_E-TH-SA	35961.96	13MAY2019 0000	145.24	25.63	33.13		33.16	0.000911	1.26	129.25	48.90	0.09
Williams_E-TH-SA	35779.59	01MAY2019 0100	97.12	25.26	31.49	27.26	31.53	0.002401	1.63	59.72	12.47	0.13
Williams_E-TH-SA	35779.59	04MAY2019 0000	135.17	25.26	32.79	27.69	32.84	0.002368	1.77	76.56	13.51	0.13
Williams_E-TH-SA	35779.59	06MAY2019 0000	135.75	25.26	32.81	27.69	32.86	0.002365	1.77	76.81	13.51	0.13
Williams_E-TH-SA	35779.59	08MAY2019 0000	135.83	25.26	32.81	27.70	32.86	0.002365	1.77	76.85	13.51	0.13
Williams_E-TH-SA	35779.59	10MAY2019 0000	135.84	25.26	32.81	27.70	32.86	0.002365	1.77	76.85	13.51	0.13
Williams_E-TH-SA	35779.59	13MAY2019 0000	135.84	25.26	32.81	27.70	32.86	0.002365	1.77	76.85	13.51	0.13

HEC-RAS Plan: US Will Calibration River: Will-Barbata Reach: Williams_E-TH-SA

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)	
Williams_E-TH-SA	45856.67	01MAY2019 0000	113.00	54.44	58.59		58.62	0.001819	1.38	81.68	27.04	0.14
Williams_E-TH-SA	45856.67	08MAY2019 0000	433.00	54.44	62.12		62.20	0.002349	2.26	192.01	35.31	0.17
Williams_E-TH-SA	45856.67	10MAY2019 0000	722.00	54.44	63.94		64.06	0.002790	2.80	257.86	36.69	0.19
Williams_E-TH-SA	45758.48	01MAY2019 0000	113.00	54.28	58.33		58.38	0.002933	1.73	65.49	21.71	0.18
Williams_E-TH-SA	45758.48	08MAY2019 0000	433.00	54.28	61.76		61.88	0.004027	2.81	153.98	29.57	0.22
Williams_E-TH-SA	45758.48	10MAY2019 0000	722.00	54.28	63.46		63.65	0.005081	3.49	206.86	32.46	0.24
Williams_E-TH-SA	45751.51		Lat Struct									
Williams_E-TH-SA	45748.78		Lat Struct									
Williams_E-TH-SA	45569.15	01MAY2019 0000	113.00	54.06	57.74		57.78	0.003341	1.75	64.60	23.73	0.19
Williams_E-TH-SA	45569.15	08MAY2019 0000	433.00	54.06	60.98		61.10	0.004207	2.81	153.97	31.51	0.22
Williams_E-TH-SA	45569.15	10MAY2019 0000	668.79	54.06	62.53		62.70	0.004469	3.30	202.91	31.61	0.23
Williams_E-TH-SA	45327.73	01MAY2019 0000	113.00	53.79	56.94		56.99	0.003237	1.65	68.43	27.47	0.18
Williams_E-TH-SA	45327.73	08MAY2019 0000	433.00	53.79	60.05		60.15	0.003671	2.57	168.70	37.22	0.21
Williams_E-TH-SA	45327.73	10MAY2019 0000	661.70	53.79	61.50		61.63	0.003760	2.94	225.35	40.15	0.22
Williams_E-TH-SA	45254.33	01MAY2019 0000	113.00	53.20	56.59		56.66	0.005530	2.04	55.28	24.18	0.24
Williams_E-TH-SA	45254.33	08MAY2019 0000	433.00	53.20	59.70		59.83	0.005202	2.85	152.20	38.18	0.25
Williams_E-TH-SA	45254.33	10MAY2019 0000	661.70	53.20	61.13		61.29	0.004805	3.15	210.29	41.35	0.25
Williams_E-TH-SA	45009.08	01MAY2019 0000	113.00	51.79	55.79		55.81	0.001185	1.10	102.82	36.10	0.11
Williams_E-TH-SA	45009.08	08MAY2019 0000	433.00	51.79	58.93		58.99	0.001643	1.81	238.62	49.29	0.15
Williams_E-TH-SA	45009.08	10MAY2019 0000	661.14	51.79	60.34		60.41	0.001783	2.13	311.00	52.95	0.15
Williams_E-TH-SA	44890.09	01MAY2019 0000	113.00	51.97	55.62		55.64	0.001598	1.29	87.64	30.19	0.13
Williams_E-TH-SA	44890.09	08MAY2019 0000	433.00	51.97	58.66		58.74	0.002478	2.23	194.39	39.91	0.18
Williams_E-TH-SA	44890.09	10MAY2019 0000	660.22	51.97	60.03		60.13	0.002828	2.62	251.67	44.29	0.19
Williams_E-TH-SA	44762.89	01MAY2019 0000	113.00	51.67	55.22		55.27	0.004133	1.78	63.63	27.97	0.21
Williams_E-TH-SA	44762.89	08MAY2019 0000	433.00	51.67	58.23		58.32	0.004104	2.50	173.05	44.93	0.22
Williams_E-TH-SA	44762.89	10MAY2019 0000	660.22	51.67	59.58		59.70	0.004024	2.76	238.89	52.56	0.23
Williams_E-TH-SA	44597.17	01MAY2019 0000	113.00	51.11	54.55		54.60	0.003898	1.85	61.03	23.14	0.20
Williams_E-TH-SA	44597.17	08MAY2019 0000	433.00	51.11	57.31		57.48	0.006169	3.25	133.05	29.06	0.27
Williams_E-TH-SA	44597.17	10MAY2019 0000	660.22	51.11	58.52		58.76	0.007345	3.89	169.91	32.01	0.30
Williams_E-TH-SA	44515.71	01MAY2019 0000	113.00	50.78	53.97		54.06	0.009277	2.41	46.79	23.40	0.30
Williams_E-TH-SA	44515.71	08MAY2019 0000	433.00	50.78	56.73		56.91	0.007857	3.35	129.89	36.97	0.30
Williams_E-TH-SA	44515.71	10MAY2019 0000	660.22	50.78	57.94		58.16	0.007397	3.81	178.85	44.28	0.31
Williams_E-TH-SA	44269.18		Lat Struct									
Williams_E-TH-SA	44261.25	01MAY2019 0000	113.00	48.15	52.68		52.70	0.001055	1.08	104.83	34.94	0.11
Williams_E-TH-SA	44261.25	08MAY2019 0000	433.00	48.15	55.61		55.67	0.001843	1.99	217.22	41.93	0.15
Williams_E-TH-SA	44261.25	10MAY2019 0000	622.24	48.15	56.89		56.97	0.001988	2.28	273.11	46.69	0.16
Williams_E-TH-SA	44260.8		Lat Struct									
Williams_E-TH-SA	44050.21	01MAY2019 0000	113.00	48.35	52.33		52.36	0.002119	1.47	76.70	26.27	0.15
Williams_E-TH-SA	44050.21	08MAY2019 0000	433.00	48.35	54.88		55.01	0.004470	2.82	153.31	33.72	0.23
Williams_E-TH-SA	44050.21	10MAY2019 0000	622.25	48.35	56.12		56.28	0.004554	3.13	205.17	61.63	0.24
Williams_E-TH-SA	43968.46	01MAY2019 0000	113.00	48.44	51.24		51.40	0.020501	3.19	35.40	21.66	0.44
Williams_E-TH-SA	43968.46	08MAY2019 0000	433.00	48.44	54.29		54.45	0.009054	3.29	131.58	41.52	0.33
Williams_E-TH-SA	43968.46	10MAY2019 0000	622.25	48.44	55.66		55.82	0.006570	3.19	195.29	61.12	0.29
Williams_E-TH-SA	43833.6	01MAY2019 0000	113.00	46.16	49.72		49.76	0.003066	1.61	70.22	27.87	0.18
Williams_E-TH-SA	43833.6	08MAY2019 0000	433.00	46.16	53.62		53.69	0.002262	2.17	199.80	38.70	0.17
Williams_E-TH-SA	43833.6	10MAY2019 0000	622.25	46.16	55.05		55.14	0.003224	2.39	260.29	58.05	0.20
Williams_E-TH-SA	43668.62	01MAY2019 0000	113.00	45.08	49.29		49.32	0.002212	1.48	76.54	27.26	0.16
Williams_E-TH-SA	43668.62	08MAY2019 0000	433.00	45.08	53.27		53.34	0.001962	2.08	207.69	38.70	0.16
Williams_E-TH-SA	43668.62	10MAY2019 0000	622.25	45.08	54.59		54.68	0.002155	2.38	266.40	60.15	0.17
Williams_E-TH-SA	43481.48	01MAY2019 0000	113.00	44.17	48.96		48.98	0.001391	1.30	86.93	24.92	0.12
Williams_E-TH-SA	43481.48	08MAY2019 0000	433.00	44.17	52.91		52.98	0.001898	2.10	206.65	35.52	0.15
Williams_E-TH-SA	43481.48	10MAY2019 0000	622.12	44.17	54.17		54.27	0.002229	2.45	255.59	64.75	0.17
Williams_E-TH-SA	43344.64	01MAY2019 0000	113.00	45.01	48.52		48.58	0.004370	1.89	59.95	24.60	0.21
Williams_E-TH-SA	43344.64	08MAY2019 0000	433.00	45.01	52.59		52.67	0.002669	2.27	190.71	39.74	0.18
Williams_E-TH-SA	43344.64	10MAY2019 0000	617.23	45.01	53.82		53.92	0.002830	2.54	242.55	44.28	0.19
Williams_E-TH-SA	43191.84	01MAY2019 0000	113.00	43.26	48.07		48.10	0.001732	1.43	78.99	22.88	0.14
Williams_E-TH-SA	43191.84	08MAY2019 0000	433.00	43.26	52.22		52.30	0.002168	2.24	193.13	32.19	0.16
Williams_E-TH-SA	43191.84	10MAY2019 0000	616.55	43.26	53.40		53.51	0.002639	2.65	233.97	50.99	0.18
Williams_E-TH-SA	43139.97	01MAY2019 0000	113.00	43.44	47.94	45.12	47.98	0.002678	1.73	65.40	19.19	0.17
Williams_E-TH-SA	43139.97	08MAY2019 0000	433.00	43.44	52.04	46.93	52.15	0.003486	2.75	157.43	25.70	0.20
Williams_E-TH-SA	43139.97	10MAY2019 0000	611.47	43.44	53.17	47.66	53.33	0.004269	3.26	187.62	28.19	0.22

HEC-RAS Plan: US Will Calibration River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	43130		Bridge									
Williams_E-TH-SA	43125.95	01MAY2019 0000	113.00	43.30	47.90		47.94	0.002411	1.63	69.29	21.39	0.16
Williams_E-TH-SA	43125.95	08MAY2019 0000	433.00	43.30	52.02		52.11	0.002659	2.44	177.27	30.30	0.18
Williams_E-TH-SA	43125.95	10MAY2019 0000	611.47	43.30	53.16		53.29	0.003190	2.87	212.90	32.10	0.20
Williams_E-TH-SA	43125.94	01MAY2019 0000	113.00	43.30	47.90		47.94	0.002411	1.63	69.29	21.39	0.16
Williams_E-TH-SA	43125.94	08MAY2019 0000	433.00	43.30	52.02		52.11	0.002659	2.44	177.27	30.30	0.18
Williams_E-TH-SA	43125.94	10MAY2019 0000	611.47	43.30	53.16		53.29	0.003191	2.87	212.90	32.10	0.20
Williams_E-TH-SA	43125.75		Lat Struct									
Williams_E-TH-SA	43125.65		Lat Struct									
Williams_E-TH-SA	42925.09	01MAY2019 0000	113.00	41.82	47.45		47.49	0.002039	1.53	73.92	21.97	0.15
Williams_E-TH-SA	42925.09	08MAY2019 0000	433.00	41.82	51.52		51.60	0.002460	2.31	187.65	33.97	0.17
Williams_E-TH-SA	42925.09	10MAY2019 0000	610.59	41.82	52.55		52.66	0.003037	2.72	224.14	37.01	0.19
Williams_E-TH-SA	42734.93	01MAY2019 0000	113.00	42.61	47.04		47.08	0.002279	1.54	73.56	23.87	0.15
Williams_E-TH-SA	42734.93	08MAY2019 0000	433.00	42.61	51.06		51.14	0.002372	2.24	193.04	35.51	0.17
Williams_E-TH-SA	42734.93	10MAY2019 0000	591.12	42.61	52.01		52.11	0.002819	2.60	227.67	38.02	0.19
Williams_E-TH-SA	42478.93	01MAY2019 0000	113.00	42.59	46.30		46.35	0.003353	1.77	63.95	23.35	0.19
Williams_E-TH-SA	42478.93	08MAY2019 0000	433.00	42.59	50.42		50.51	0.002596	2.32	186.47	36.13	0.18
Williams_E-TH-SA	42478.93	10MAY2019 0000	591.11	42.59	51.22		51.34	0.003237	2.73	216.35	38.61	0.20
Williams_E-TH-SA	42406.63	01MAY2019 0000	113.00	42.02	46.10		46.14	0.002380	1.56	72.46	24.43	0.16
Williams_E-TH-SA	42406.63	08MAY2019 0000	433.00	42.02	50.26		50.34	0.002156	2.19	198.13	36.00	0.16
Williams_E-TH-SA	42406.63	10MAY2019 0000	589.31	42.02	51.02		51.12	0.002756	2.61	225.89	37.18	0.19
Williams_E-TH-SA	42317.02	01MAY2019 0000	113.00	41.19	45.88		45.92	0.002423	1.66	67.97	19.65	0.16
Williams_E-TH-SA	42317.02	08MAY2019 0000	433.00	41.19	49.99		50.10	0.003143	2.62	165.42	27.74	0.19
Williams_E-TH-SA	42317.02	10MAY2019 0000	582.66	41.19	50.66		50.82	0.004223	3.16	184.43	29.82	0.22
Williams_E-TH-SA	42233.9	01MAY2019 0000	113.00	40.72	45.71		45.75	0.001692	1.44	78.63	22.26	0.13
Williams_E-TH-SA	42233.9	08MAY2019 0000	433.00	40.72	49.79		49.87	0.002290	2.28	189.83	32.44	0.17
Williams_E-TH-SA	42233.9	10MAY2019 0000	579.59	40.72	50.40		50.52	0.003067	2.76	210.81	39.10	0.19
Williams_E-TH-SA	42125.52	01MAY2019 0000	113.00	41.14	45.46		45.51	0.002641	1.65	68.30	22.19	0.17
Williams_E-TH-SA	42125.52	08MAY2019 0000	425.51	41.14	49.53		49.61	0.002584	2.36	180.61	32.73	0.18
Williams_E-TH-SA	42125.52	10MAY2019 0000	539.70	41.14	50.08		50.20	0.003113	2.71	200.64	43.49	0.20
Williams_E-TH-SA	42049.79	01MAY2019 0000	113.00	40.46	45.32		45.35	0.001420	1.29	87.62	26.92	0.13
Williams_E-TH-SA	42049.79	08MAY2019 0000	425.36	40.46	49.39		49.45	0.001621	1.99	213.91	35.10	0.14
Williams_E-TH-SA	42049.79	10MAY2019 0000	526.94	40.46	49.93		50.01	0.001924	2.26	233.11	35.68	0.16
Williams_E-TH-SA	41996.44	01MAY2019 0000	113.00	39.13	45.25		45.28	0.001165	1.24	90.89	22.70	0.11
Williams_E-TH-SA	41996.44	08MAY2019 0000	425.36	39.13	49.29		49.36	0.001839	2.08	209.47	53.05	0.15
Williams_E-TH-SA	41996.44	10MAY2019 0000	519.28	39.13	49.83		49.91	0.002025	2.31	239.96	59.15	0.16
Williams_E-TH-SA	41996.43	01MAY2019 0000	113.00	39.13	45.25	41.14	45.28	0.001165	1.24	90.89	22.70	0.11
Williams_E-TH-SA	41996.43	08MAY2019 0000	425.36	39.13	49.29	42.98	49.36	0.001839	2.08	209.47	53.05	0.15
Williams_E-TH-SA	41996.43	10MAY2019 0000	519.28	39.13	49.83	43.40	49.91	0.002025	2.31	239.96	59.15	0.16
Williams_E-TH-SA	41984		Bridge									
Williams_E-TH-SA	41970.62	01MAY2019 0000	113.00	39.49	45.21		45.23	0.001039	1.19	94.59	22.43	0.10
Williams_E-TH-SA	41970.62	08MAY2019 0000	425.36	39.49	48.87		48.95	0.002261	2.28	186.54	28.01	0.16
Williams_E-TH-SA	41970.62	10MAY2019 0000	519.28	39.49	49.26		49.37	0.002874	2.62	198.38	32.25	0.18
Williams_E-TH-SA	41970.61	01MAY2019 0000	113.00	39.49	45.21		45.23	0.001039	1.19	94.59	22.43	0.10
Williams_E-TH-SA	41970.61	08MAY2019 0000	425.36	39.49	48.87		48.95	0.002261	2.28	186.54	28.01	0.16
Williams_E-TH-SA	41970.61	10MAY2019 0000	519.28	39.49	49.26		49.37	0.002874	2.62	198.38	32.24	0.18
Williams_E-TH-SA	41970.42		Lat Struct									
Williams_E-TH-SA	41970.32		Lat Struct									
Williams_E-TH-SA	41904.4	01MAY2019 0000	113.00	40.65	45.12		45.15	0.001440	1.30	87.05	26.67	0.13
Williams_E-TH-SA	41904.4	08MAY2019 0000	425.36	40.65	48.74		48.81	0.002011	2.09	203.06	37.89	0.16
Williams_E-TH-SA	41904.4	10MAY2019 0000	518.36	40.65	49.11		49.20	0.002465	2.39	217.12	38.43	0.18
Williams_E-TH-SA	41777.66	01MAY2019 0000	113.00	40.37	44.77		44.82	0.003602	1.88	60.09	20.12	0.19
Williams_E-TH-SA	41777.66	08MAY2019 0000	404.41	40.37	48.32		48.44	0.003959	2.74	147.74	29.19	0.21
Williams_E-TH-SA	41777.66	10MAY2019 0000	463.95	40.37	48.65		48.79	0.004350	2.95	157.43	29.86	0.23
Williams_E-TH-SA	41694.69	01MAY2019 0000	113.00	40.45	44.49		44.54	0.003188	1.78	63.57	21.53	0.18
Williams_E-TH-SA	41694.69	08MAY2019 0000	404.41	40.45	48.02		48.13	0.003500	2.63	153.48	29.13	0.20
Williams_E-TH-SA	41694.69	10MAY2019 0000	461.88	40.45	48.31		48.44	0.003933	2.85	162.06	29.73	0.22
Williams_E-TH-SA	41555.36	01MAY2019 0000	113.00	39.05	44.17		44.19	0.001597	1.37	82.61	24.86	0.13
Williams_E-TH-SA	41555.36	08MAY2019 0000	404.40	39.05	47.66		47.73	0.002191	2.17	186.57	34.56	0.16

HEC-RAS Plan: US Will Calibration River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	41555.36	10MAY2019 0000	460.57	39.05	47.90		47.99	0.002519	2.36	195.05	35.22	0.18
Williams_E-TH-SA	41465.55	01MAY2019 0000	113.00	38.51	43.97		44.01	0.002423	1.60	70.78	22.68	0.16
Williams_E-TH-SA	41465.55	08MAY2019 0000	398.19	38.51	47.42		47.51	0.002924	2.35	169.23	34.40	0.19
Williams_E-TH-SA	41465.55	10MAY2019 0000	445.95	38.51	47.64		47.74	0.003263	2.52	176.81	35.14	0.20
Williams_E-TH-SA	41368.55	01MAY2019 0000	113.00	37.43	43.79		43.82	0.001464	1.32	85.46	23.68	0.12
Williams_E-TH-SA	41368.55	08MAY2019 0000	397.76	37.43	47.17		47.24	0.002464	2.12	187.98	38.87	0.17
Williams_E-TH-SA	41368.55	10MAY2019 0000	442.13	37.43	47.36		47.44	0.002739	2.26	195.42	39.53	0.18
Williams_E-TH-SA	41095.03	01MAY2019 0000	113.00	37.84	43.30		43.33	0.002040	1.57	71.78	18.22	0.14
Williams_E-TH-SA	41095.03	08MAY2019 0000	365.99	37.84	46.25		46.35	0.004133	2.56	142.80	31.45	0.21
Williams_E-TH-SA	41095.03	10MAY2019 0000	391.42	37.84	46.37		46.48	0.004418	2.67	146.46	31.89	0.22
Williams_E-TH-SA	40939.16	01MAY2019 0000	113.00	38.31	43.00		43.03	0.001774	1.41	80.05	25.14	0.14
Williams_E-TH-SA	40939.16	08MAY2019 0000	364.17	38.31	45.73		45.81	0.002796	2.26	161.40	34.85	0.18
Williams_E-TH-SA	40939.16	10MAY2019 0000	385.26	38.31	45.82		45.90	0.002991	2.34	164.30	35.23	0.19
Williams_E-TH-SA	40822.73	01MAY2019 0000	113.00	36.44	42.87		42.89	0.000583	0.98	115.60	25.65	0.08
Williams_E-TH-SA	40822.73	08MAY2019 0000	344.70	36.44	45.54		45.59	0.001127	1.80	202.47	41.05	0.12
Williams_E-TH-SA	40822.73	10MAY2019 0000	359.60	36.44	45.62		45.67	0.001180	1.85	205.53	41.53	0.12
Williams_E-TH-SA	40787.12		Lat Struct									
Williams_E-TH-SA	40776		Lat Struct									
Williams_E-TH-SA	40723.49	01MAY2019 0000	113.00	36.57	42.75		42.78	0.001524	1.42	79.77	20.18	0.13
Williams_E-TH-SA	40723.49	08MAY2019 0000	295.24	36.57	45.37		45.44	0.002284	2.11	140.24	25.81	0.16
Williams_E-TH-SA	40723.49	10MAY2019 0000	302.65	36.57	45.45		45.52	0.002302	2.13	142.14	25.81	0.16
Williams_E-TH-SA	40666.84	01MAY2019 0000	113.00	35.92	42.68		42.70	0.001143	1.25	90.70	21.33	0.11
Williams_E-TH-SA	40666.84	08MAY2019 0000	295.15	35.92	45.27		45.32	0.001905	1.91	154.76	28.12	0.14
Williams_E-TH-SA	40666.84	10MAY2019 0000	302.32	35.92	45.34		45.40	0.001931	1.93	156.81	28.31	0.14
Williams_E-TH-SA	40637.89	01MAY2019 0000	113.00	37.18	42.60		42.64	0.002577	1.64	69.08	22.15	0.16
Williams_E-TH-SA	40637.89	08MAY2019 0000	295.15	37.18	45.18		45.25	0.003040	2.14	138.22	33.62	0.19
Williams_E-TH-SA	40637.89	10MAY2019 0000	302.32	37.18	45.25		45.32	0.003081	2.15	140.66	34.29	0.19
Williams_E-TH-SA	40593.76	01MAY2019 0000	113.00	34.64	42.53		42.55	0.000941	1.14	99.39	22.88	0.10
Williams_E-TH-SA	40593.76	08MAY2019 0000	295.15	34.64	45.10		45.15	0.001597	1.79	164.97	28.16	0.13
Williams_E-TH-SA	40593.76	10MAY2019 0000	302.32	34.64	45.17		45.22	0.001624	1.81	166.96	28.36	0.13
Williams_E-TH-SA	40529.51	01MAY2019 0000	113.00	36.16	42.43		42.47	0.001648	1.42	79.67	21.26	0.13
Williams_E-TH-SA	40529.51	08MAY2019 0000	295.15	36.16	44.95		45.02	0.002521	2.11	139.79	27.81	0.17
Williams_E-TH-SA	40529.51	10MAY2019 0000	302.31	36.16	45.01		45.08	0.002578	2.13	141.68	28.28	0.17
Williams_E-TH-SA	40522.73	01MAY2019 0000	113.00	35.69	42.41		42.45	0.002456	1.60	70.74	20.22	0.15
Williams_E-TH-SA	40522.73	08MAY2019 0000	295.15	35.69	44.92		45.00	0.003412	2.27	130.05	28.61	0.19
Williams_E-TH-SA	40522.73	10MAY2019 0000	302.31	35.69	44.98		45.06	0.003483	2.29	131.98	29.13	0.19
Williams_E-TH-SA	40504.84	01MAY2019 0000	113.00	34.84	42.38		42.41	0.001119	1.28	88.07	17.23	0.10
Williams_E-TH-SA	40504.84	08MAY2019 0000	295.15	34.84	44.87		44.94	0.002868	2.09	140.94	29.29	0.17
Williams_E-TH-SA	40504.84	10MAY2019 0000	302.31	34.84	44.94		45.01	0.002953	2.12	142.88	30.04	0.17
Williams_E-TH-SA	40479.52	01MAY2019 0000	113.00	34.62	42.32		42.36	0.002571	1.59	70.99	20.54	0.15
Williams_E-TH-SA	40479.52	08MAY2019 0000	295.15	34.62	44.79		44.86	0.003226	2.19	135.56	32.95	0.18
Williams_E-TH-SA	40479.52	10MAY2019 0000	302.31	34.62	44.85		44.93	0.003246	2.21	137.69	33.52	0.18
Williams_E-TH-SA	40436.27	01MAY2019 0000	113.00	36.91	42.22		42.26	0.002089	1.54	73.50	21.87	0.15
Williams_E-TH-SA	40436.27	08MAY2019 0000	295.15	36.91	44.66		44.74	0.002694	2.18	135.60	28.26	0.18
Williams_E-TH-SA	40436.27	10MAY2019 0000	302.31	36.91	44.72		44.80	0.002727	2.20	137.37	28.38	0.18
Williams_E-TH-SA	40386.32	01MAY2019 0000	113.00	36.19	42.12		42.15	0.002007	1.54	73.18	20.55	0.14
Williams_E-TH-SA	40386.32	08MAY2019 0000	295.15	36.19	44.52		44.59	0.002939	2.26	130.51	27.24	0.18
Williams_E-TH-SA	40386.32	10MAY2019 0000	302.31	36.19	44.58		44.66	0.002981	2.29	132.18	27.40	0.18
Williams_E-TH-SA	40323.05	01MAY2019 0000	113.00	35.86	42.00		42.03	0.001815	1.48	76.58	20.31	0.13
Williams_E-TH-SA	40323.05	08MAY2019 0000	295.15	35.86	44.33		44.41	0.002937	2.28	129.48	25.01	0.18
Williams_E-TH-SA	40323.05	10MAY2019 0000	302.31	35.86	44.39		44.47	0.002987	2.31	130.95	25.11	0.18
Williams_E-TH-SA	40237.63	01MAY2019 0000	113.00	36.68	41.84		41.88	0.001839	1.46	77.25	22.64	0.14
Williams_E-TH-SA	40237.63	08MAY2019 0000	295.15	36.68	44.14		44.19	0.002147	1.97	175.60	61.16	0.16
Williams_E-TH-SA	40237.63	10MAY2019 0000	302.31	36.68	44.20		44.25	0.002156	1.98	179.11	61.56	0.16
Williams_E-TH-SA	40181.84	01MAY2019 0000	113.00	36.58	41.75		41.78	0.001484	1.37	82.37	22.41	0.13
Williams_E-TH-SA	40181.84	08MAY2019 0000	295.15	36.58	43.99		44.06	0.002452	2.14	138.20	27.42	0.17
Williams_E-TH-SA	40181.84	10MAY2019 0000	302.31	36.58	44.05		44.12	0.002499	2.16	139.69	27.55	0.17
Williams_E-TH-SA	40129.22	01MAY2019 0000	113.00	35.48	41.62		41.67	0.002515	1.73	65.21	17.03	0.15
Williams_E-TH-SA	40129.22	08MAY2019 0000	294.96	35.48	43.82		43.90	0.003115	2.38	148.92	45.03	0.17
Williams_E-TH-SA	40129.22	10MAY2019 0000	301.93	35.48	43.87		43.95	0.003140	2.40	151.24	45.03	0.17
Williams_E-TH-SA	40079.13	01MAY2019 0000	113.00	35.68	41.50		41.55	0.002360	1.63	69.34	19.80	0.15

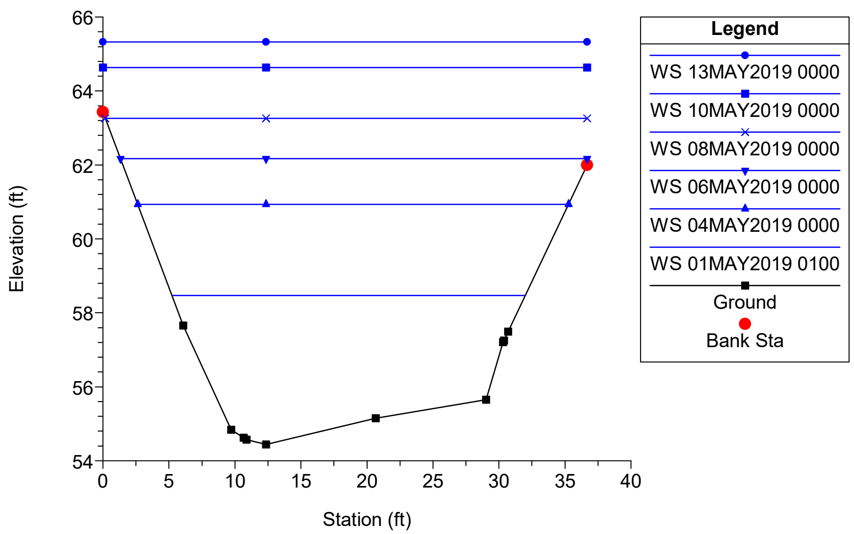
HEC-RAS Plan: US Will Calibration River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	40079.13	08MAY2019 0000	294.96	35.68	43.62		43.72	0.003837	2.54	116.31	23.99	0.20
Williams_E-TH-SA	40079.13	10MAY2019 0000	301.93	35.68	43.67		43.77	0.003903	2.57	117.44	24.04	0.20
Williams_E-TH-SA	40036.96	01MAY2019 0000	113.00	35.42	41.42		41.45	0.001919	1.42	79.50	25.31	0.14
Williams_E-TH-SA	40036.96	08MAY2019 0000	294.96	35.42	43.51		43.58	0.002667	2.16	136.52	29.05	0.17
Williams_E-TH-SA	40036.96	10MAY2019 0000	301.93	35.42	43.56		43.63	0.002714	2.20	137.83	29.13	0.17
Williams_E-TH-SA	40029.49	01MAY2019 0000	113.00	34.94	41.42		41.43	0.000659	0.99	114.66	28.25	0.09
Williams_E-TH-SA	40029.49	08MAY2019 0000	294.96	34.94	43.52		43.57	0.001255	1.66	177.46	30.81	0.12
Williams_E-TH-SA	40029.49	10MAY2019 0000	301.93	34.94	43.57		43.61	0.001283	1.69	178.87	30.84	0.12
Williams_E-TH-SA	40027.50	01MAY2019 0000	113.00	34.94	41.42	37.27	41.43	0.000659	0.99	114.62	28.24	0.09
Williams_E-TH-SA	40027.50	08MAY2019 0000	294.91	34.94	43.52	38.28	43.57	0.001257	1.66	177.38	30.80	0.12
Williams_E-TH-SA	40027.50	10MAY2019 0000	301.84	34.94	43.57	38.30	43.61	0.001284	1.69	178.79	30.83	0.12
Williams_E-TH-SA	40022		Bridge									
Williams_E-TH-SA	40014.83	01MAY2019 0000	113.00	34.29	41.38		41.38	0.000281	0.75	150.79	26.58	0.06
Williams_E-TH-SA	40014.83	08MAY2019 0000	294.91	34.29	43.36		43.40	0.000800	1.43	205.75	29.03	0.09
Williams_E-TH-SA	40014.83	10MAY2019 0000	301.84	34.29	43.41		43.44	0.000824	1.46	206.98	29.06	0.10
Williams_E-TH-SA	40014.82	01MAY2019 0000	113.00	34.29	41.38		41.38	0.000281	0.75	150.79	26.58	0.06
Williams_E-TH-SA	40014.82	08MAY2019 0000	294.91	34.29	43.36		43.40	0.000800	1.43	205.75	29.03	0.09
Williams_E-TH-SA	40014.82	10MAY2019 0000	301.84	34.29	43.41		43.44	0.000824	1.46	206.98	29.06	0.10
Williams_E-TH-SA	40014.63		Lat Struct									
Williams_E-TH-SA	40014.53		Lat Struct									
Williams_E-TH-SA	39971.39	01MAY2019 0000	113.00	35.86	41.18		41.26	0.004775	2.19	51.60	15.31	0.21
Williams_E-TH-SA	39971.39	08MAY2019 0000	283.82	35.86	43.06		43.24	0.007801	3.40	83.63	18.42	0.28
Williams_E-TH-SA	39971.39	10MAY2019 0000	289.28	35.86	43.10		43.28	0.007911	3.44	84.33	18.46	0.28
Williams_E-TH-SA	39890.03	01MAY2019 0000	113.00	35.00	40.94		40.97	0.001744	1.48	76.23	19.64	0.13
Williams_E-TH-SA	39890.03	08MAY2019 0000	270.83	35.00	42.70		42.78	0.003779	2.20	123.03	32.85	0.20
Williams_E-TH-SA	39890.03	10MAY2019 0000	275.50	35.00	42.74		42.81	0.003806	2.22	124.20	32.97	0.20
Williams_E-TH-SA	39795.22	01MAY2019 0000	100.64	34.69	40.79		40.82	0.001397	1.34	75.19	18.95	0.12
Williams_E-TH-SA	39795.22	08MAY2019 0000	208.95	34.69	42.46		42.51	0.002447	1.85	113.16	27.65	0.16
Williams_E-TH-SA	39795.22	10MAY2019 0000	212.29	34.69	42.50		42.55	0.002480	1.86	114.09	27.86	0.16
Williams_E-TH-SA	39693.45	01MAY2019 0000	100.64	35.17	40.65		40.68	0.001385	1.32	76.17	19.51	0.12
Williams_E-TH-SA	39693.45	08MAY2019 0000	208.95	35.17	42.22		42.27	0.002288	1.91	109.13	22.97	0.15
Williams_E-TH-SA	39693.45	10MAY2019 0000	212.29	35.17	42.25		42.31	0.002324	1.93	109.82	23.06	0.16
Williams_E-TH-SA	39566.14	01MAY2019 0000	100.64	34.77	40.45		40.48	0.001631	1.37	73.27	20.32	0.13
Williams_E-TH-SA	39566.14	08MAY2019 0000	208.95	34.77	41.90		41.96	0.002722	1.98	105.44	24.59	0.17
Williams_E-TH-SA	39566.14	10MAY2019 0000	212.29	34.77	41.92		41.98	0.002768	2.00	106.05	24.68	0.17
Williams_E-TH-SA	39392.4	01MAY2019 0000	100.64	35.08	40.09		40.14	0.002332	1.63	61.68	16.51	0.15
Williams_E-TH-SA	39392.4	08MAY2019 0000	179.08	35.08	41.40		41.47	0.003127	2.12	84.46	18.36	0.17
Williams_E-TH-SA	39392.4	10MAY2019 0000	180.82	35.08	41.42		41.49	0.003150	2.13	84.84	18.39	0.17
Williams_E-TH-SA	39264.35	01MAY2019 0000	100.64	35.21	39.67		39.72	0.004065	1.87	53.81	20.51	0.20
Williams_E-TH-SA	39264.35	08MAY2019 0000	178.58	35.21	40.94		41.01	0.004084	2.15	83.09	25.55	0.21
Williams_E-TH-SA	39264.35	10MAY2019 0000	180.21	35.21	40.96		41.03	0.004098	2.16	83.56	25.62	0.21
Williams_E-TH-SA	39006.66	01MAY2019 0000	99.84	33.44	38.78		38.83	0.002827	1.77	56.52	14.07	0.16
Williams_E-TH-SA	39006.66	08MAY2019 0000	157.38	33.44	40.01		40.07	0.003339	2.11	74.55	15.41	0.17
Williams_E-TH-SA	39006.66	10MAY2019 0000	158.43	33.44	40.02		40.09	0.003356	2.12	74.78	15.43	0.17
Williams_E-TH-SA	38807.86	01MAY2019 0000	99.84	32.35	38.21		38.26	0.002910	1.79	55.77	14.32	0.16
Williams_E-TH-SA	38807.86	08MAY2019 0000	149.53	32.35	39.37		39.44	0.003137	2.04	73.46	16.09	0.17
Williams_E-TH-SA	38807.86	10MAY2019 0000	150.27	32.35	39.39		39.45	0.003144	2.04	73.68	16.11	0.17
Williams_E-TH-SA	38578.48	01MAY2019 0000	99.84	32.45	37.72		37.75	0.001447	1.35	73.81	18.21	0.12
Williams_E-TH-SA	38578.48	08MAY2019 0000	149.53	32.45	38.86		38.90	0.001599	1.57	95.15	19.37	0.12
Williams_E-TH-SA	38578.48	10MAY2019 0000	150.27	32.45	38.87		38.91	0.001603	1.58	95.39	19.38	0.13
Williams_E-TH-SA	38407.9	01MAY2019 0000	99.84	31.52	37.22		37.28	0.003960	2.01	49.67	13.35	0.18
Williams_E-TH-SA	38407.9	08MAY2019 0000	147.63	31.52	38.33		38.41	0.004163	2.26	65.42	14.97	0.19
Williams_E-TH-SA	38407.9	10MAY2019 0000	148.25	31.52	38.34		38.42	0.004170	2.26	65.59	14.99	0.19
Williams_E-TH-SA	38255.83	01MAY2019 0000	99.84	32.18	36.52		36.59	0.005084	2.15	46.52	15.87	0.22
Williams_E-TH-SA	38255.83	08MAY2019 0000	147.63	32.18	37.70		37.77	0.004172	2.21	66.79	18.44	0.20
Williams_E-TH-SA	38255.83	10MAY2019 0000	148.25	32.18	37.71		37.79	0.004173	2.21	67.00	18.46	0.20
Williams_E-TH-SA	38051.7	01MAY2019 0000	99.84	28.30	35.98		35.99	0.000470	0.89	112.33	22.78	0.07
Williams_E-TH-SA	38051.7	08MAY2019 0000	147.63	28.30	37.27		37.29	0.000535	1.03	143.21	25.19	0.08
Williams_E-TH-SA	38051.7	10MAY2019 0000	148.25	28.30	37.28		37.30	0.000537	1.03	143.49	25.21	0.08
Williams_E-TH-SA	37787.34	01MAY2019 0000	99.84	28.77	35.65		35.68	0.001837	1.50	66.41	15.05	0.13
Williams_E-TH-SA	37787.34	08MAY2019 0000	146.43	28.77	36.90		36.95	0.002045	1.68	86.94	18.20	0.14

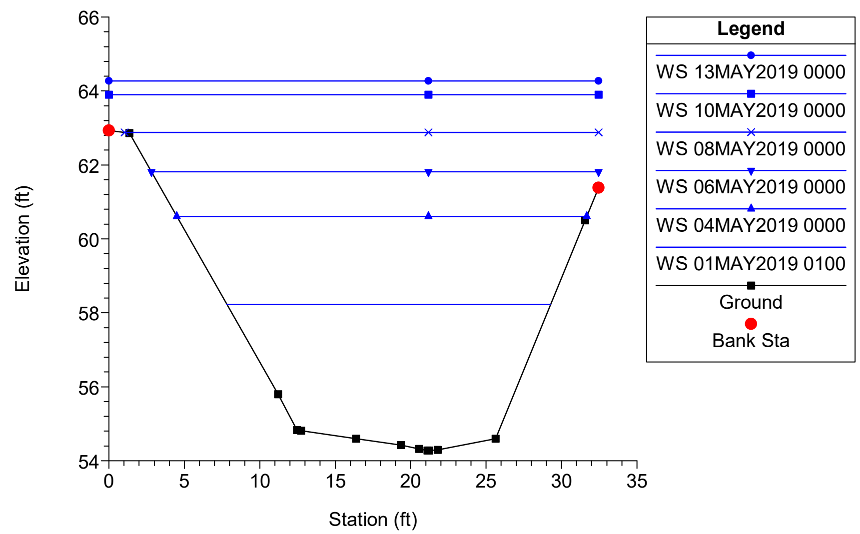
HEC-RAS Plan: US Will Calibration River: Will-Barbata Reach: Williams_E-TH-SA (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Williams_E-TH-SA	37787.34	10MAY2019 0000	146.92	28.77	36.91		36.96	0.002048	1.69	87.12	18.23	0.14
Williams_E-TH-SA	37533.79	01MAY2019 0000	99.84	28.62	35.31		35.33	0.000878	1.12	89.17	19.60	0.09
Williams_E-TH-SA	37533.79	08MAY2019 0000	146.43	28.62	36.54		36.57	0.000958	1.28	114.43	21.46	0.10
Williams_E-TH-SA	37533.79	10MAY2019 0000	146.92	28.62	36.55		36.58	0.000959	1.28	114.63	21.56	0.10
Williams_E-TH-SA	37396.18	01MAY2019 0000	99.84	29.28	35.08		35.12	0.002116	1.57	63.43	15.13	0.14
Williams_E-TH-SA	37396.18	08MAY2019 0000	146.43	29.28	36.30		36.35	0.002223	1.76	83.50	20.00	0.14
Williams_E-TH-SA	37396.18	10MAY2019 0000	146.92	29.28	36.31		36.36	0.002226	1.76	83.69	20.14	0.14
Williams_E-TH-SA	37157.42	01MAY2019 0000	99.84	28.51	34.62		34.65	0.001790	1.47	68.00	15.36	0.12
Williams_E-TH-SA	37157.42	08MAY2019 0000	146.43	28.51	35.82		35.86	0.001909	1.66	92.42	29.55	0.13
Williams_E-TH-SA	37157.42	10MAY2019 0000	146.92	28.51	35.83		35.87	0.001912	1.66	92.66	29.64	0.13
Williams_E-TH-SA	36919.78	01MAY2019 0000	99.84	28.48	33.77		33.84	0.004912	2.15	46.38	11.18	0.19
Williams_E-TH-SA	36919.78	08MAY2019 0000	145.76	28.48	34.93		35.02	0.005241	2.41	62.18	20.76	0.19
Williams_E-TH-SA	36919.78	10MAY2019 0000	146.17	28.48	34.94		35.03	0.005248	2.41	62.33	20.87	0.19
Williams_E-TH-SA	36664.16	01MAY2019 0000	99.84	25.87	32.95		32.98	0.001717	1.47	67.92	13.08	0.11
Williams_E-TH-SA	36664.16	08MAY2019 0000	145.76	25.87	34.02		34.07	0.002192	1.77	83.54	30.32	0.13
Williams_E-TH-SA	36664.16	10MAY2019 0000	146.17	25.87	34.03		34.08	0.002199	1.77	83.69	30.38	0.13
Williams_E-TH-SA	36467.93	01MAY2019 0000	99.84	27.36	32.61		32.64	0.001740	1.44	69.15	18.23	0.13
Williams_E-TH-SA	36467.93	08MAY2019 0000	145.76	27.36	33.64		33.68	0.001854	1.64	91.88	44.84	0.14
Williams_E-TH-SA	36467.93	10MAY2019 0000	146.17	27.36	33.64		33.68	0.001859	1.64	92.07	45.39	0.14
Williams_E-TH-SA	36449.34	01MAY2019 0000	99.84	27.32	32.58		32.61	0.001464	1.36	74.54	26.40	0.12
Williams_E-TH-SA	36449.34	08MAY2019 0000	145.76	27.32	33.62		33.65	0.001265	1.38	141.87	107.02	0.11
Williams_E-TH-SA	36449.34	10MAY2019 0000	146.17	27.32	33.63		33.65	0.001266	1.38	142.31	107.18	0.11
Williams_E-TH-SA	36387.27	01MAY2019 0000	99.84	27.86	32.41		32.46	0.002979	1.77	56.33	15.98	0.17
Williams_E-TH-SA	36387.27	08MAY2019 0000	145.76	27.86	33.50		33.54	0.002392	1.73	106.60	71.84	0.15
Williams_E-TH-SA	36387.27	10MAY2019 0000	146.17	27.86	33.50		33.54	0.002394	1.73	106.88	71.91	0.15
Williams_E-TH-SA	36313.92	01MAY2019 0000	99.84	27.84	32.26		32.29	0.001562	1.31	76.79	30.55	0.13
Williams_E-TH-SA	36313.92	08MAY2019 0000	145.76	27.84	33.40		33.41	0.000943	1.15	175.40	130.45	0.10
Williams_E-TH-SA	36313.92	10MAY2019 0000	146.17	27.84	33.40		33.42	0.000943	1.15	175.89	130.57	0.10
Williams_E-TH-SA	36217.71	01MAY2019 0000	99.84	26.07	32.14		32.16	0.001026	1.15	118.25	123.89	0.10
Williams_E-TH-SA	36217.71	08MAY2019 0000	145.76	26.07	33.34		33.35	0.000373	0.76	297.15	167.46	0.06
Williams_E-TH-SA	36217.71	10MAY2019 0000	146.17	26.07	33.34		33.35	0.000373	0.76	297.77	167.55	0.06
Williams_E-TH-SA	36158.16	01MAY2019 0000	99.84	24.61	32.05		32.08	0.001438	1.36	77.92	30.29	0.10
Williams_E-TH-SA	36158.16	08MAY2019 0000	145.76	24.61	33.28		33.30	0.001273	1.36	144.95	88.56	0.10
Williams_E-TH-SA	36158.16	10MAY2019 0000	146.17	24.61	33.28		33.31	0.001275	1.36	145.28	88.59	0.10
Williams_E-TH-SA	36126.37	01MAY2019 0000	99.84	24.83	32.03		32.04	0.000463	0.89	112.39	21.85	0.07
Williams_E-TH-SA	36126.37	08MAY2019 0000	145.76	24.83	33.26		33.27	0.000538	1.04	145.00	47.69	0.08
Williams_E-TH-SA	36126.37	10MAY2019 0000	146.17	24.83	33.26		33.28	0.000540	1.04	145.17	47.85	0.08
Williams_E-TH-SA	35961.96	01MAY2019 0000	99.84	25.63	31.91		31.93	0.000838	1.11	90.01	17.01	0.09
Williams_E-TH-SA	35961.96	08MAY2019 0000	144.91	25.63	33.13		33.15	0.000909	1.26	129.09	48.90	0.09
Williams_E-TH-SA	35961.96	10MAY2019 0000	145.23	25.63	33.13		33.16	0.000911	1.26	129.25	48.90	0.09
Williams_E-TH-SA	35779.59	01MAY2019 0000	99.84	25.26	31.59	27.30	31.63	0.002400	1.64	60.98	12.53	0.13
Williams_E-TH-SA	35779.59	08MAY2019 0000	135.74	25.26	32.81	27.69	32.86	0.002365	1.77	76.81	13.51	0.13
Williams_E-TH-SA	35779.59	10MAY2019 0000	135.84	25.26	32.81	27.70	32.86	0.002365	1.77	76.85	13.51	0.13

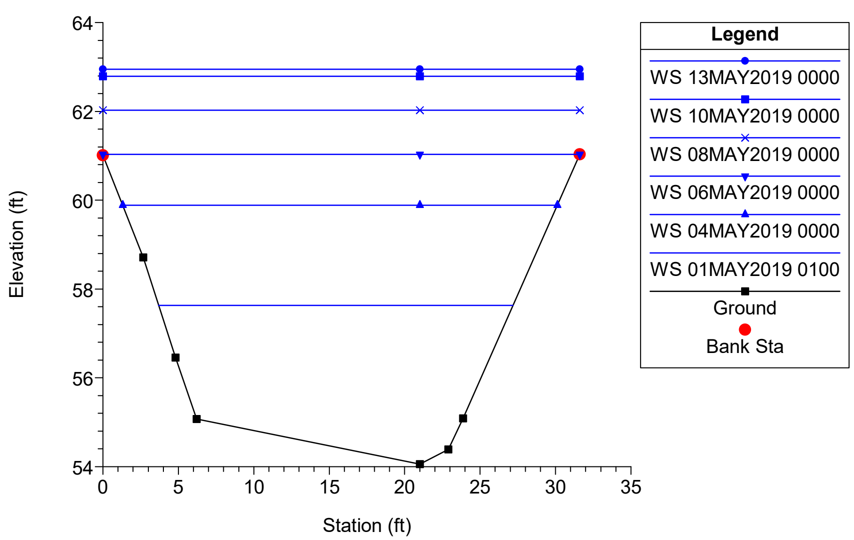
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



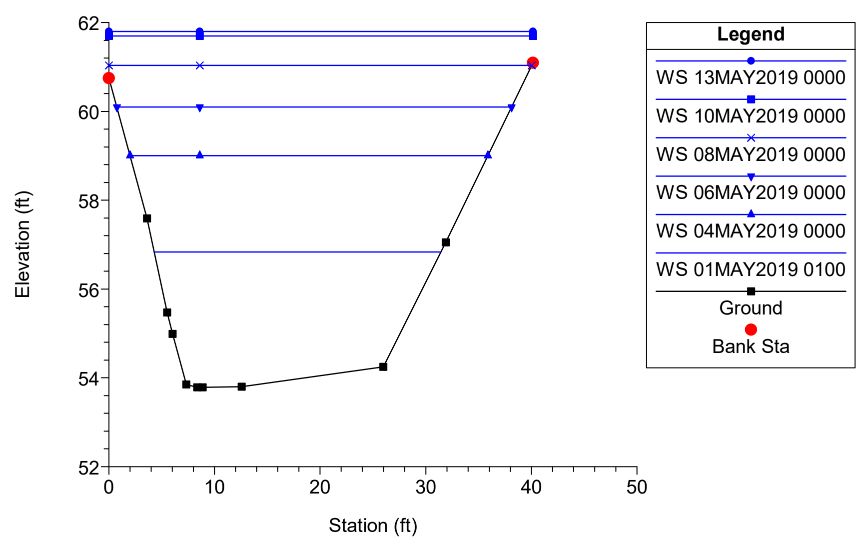
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



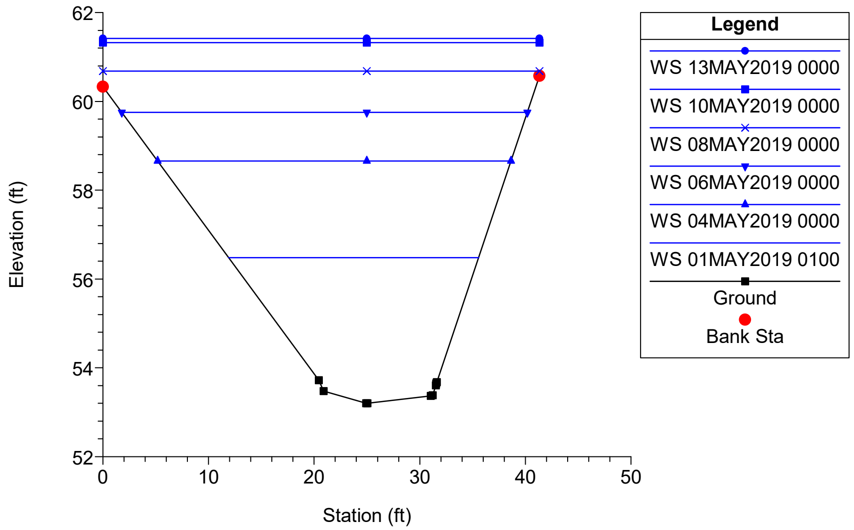
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



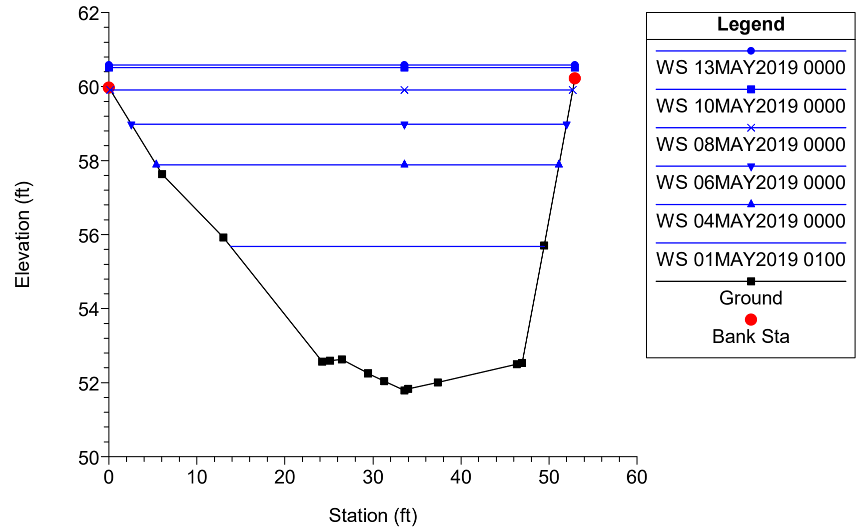
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



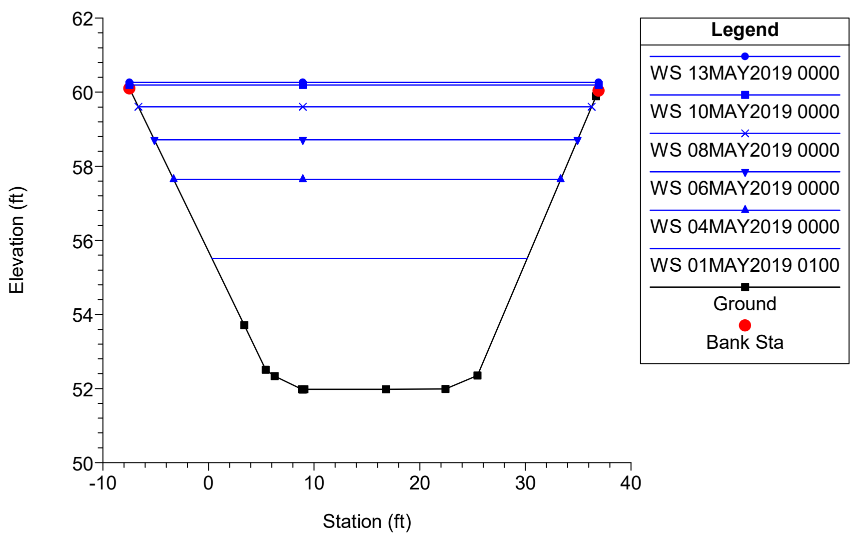
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



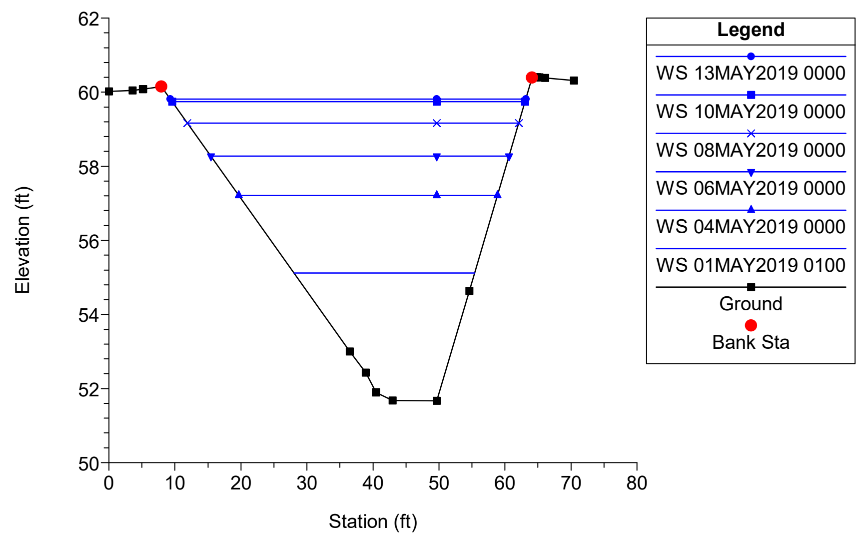
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020

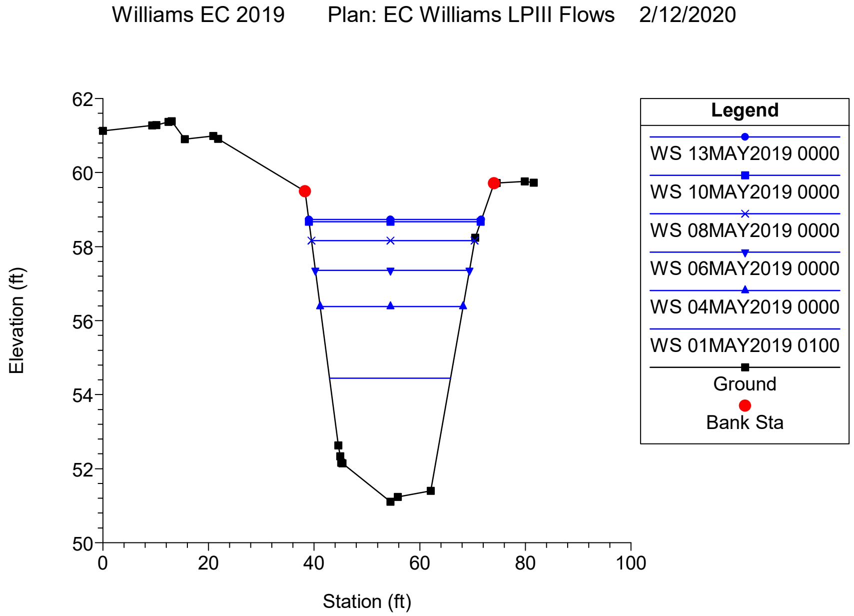


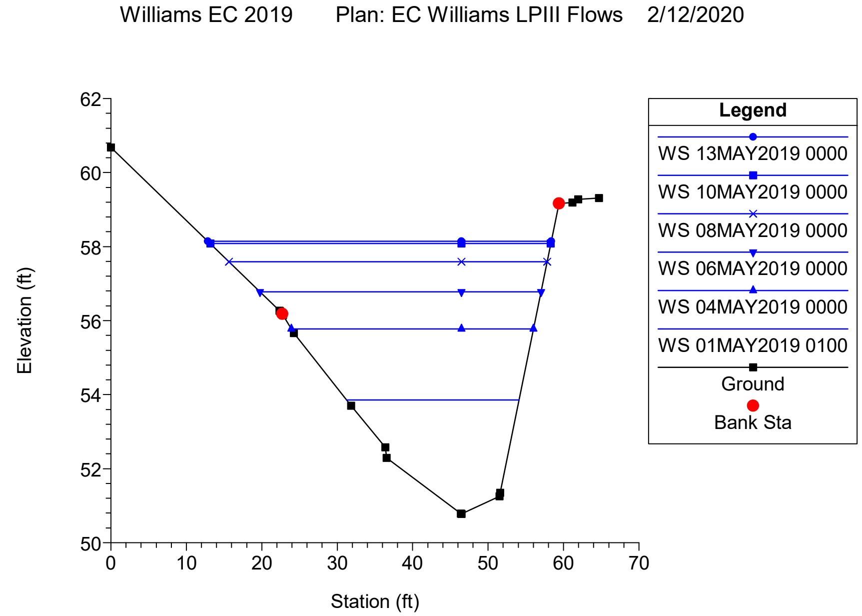
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020

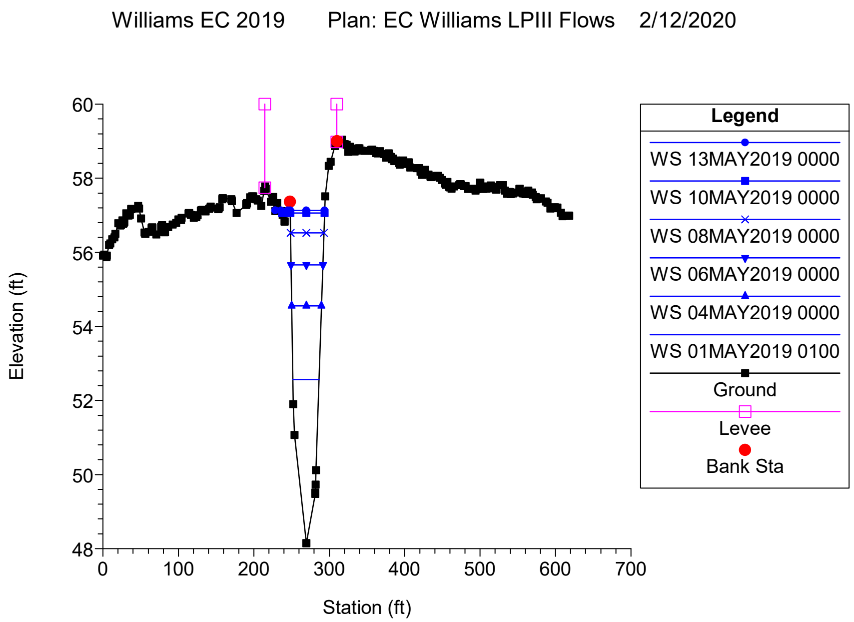


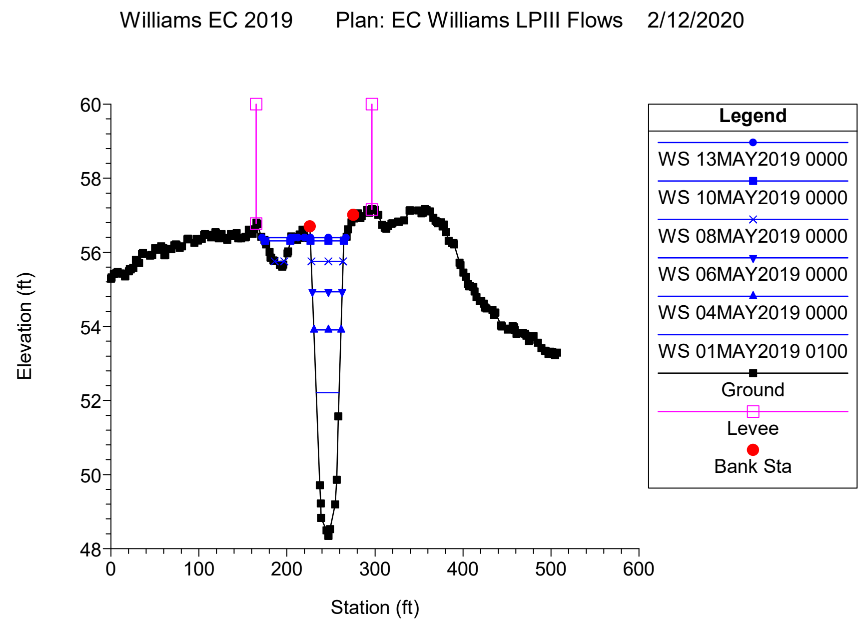
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020

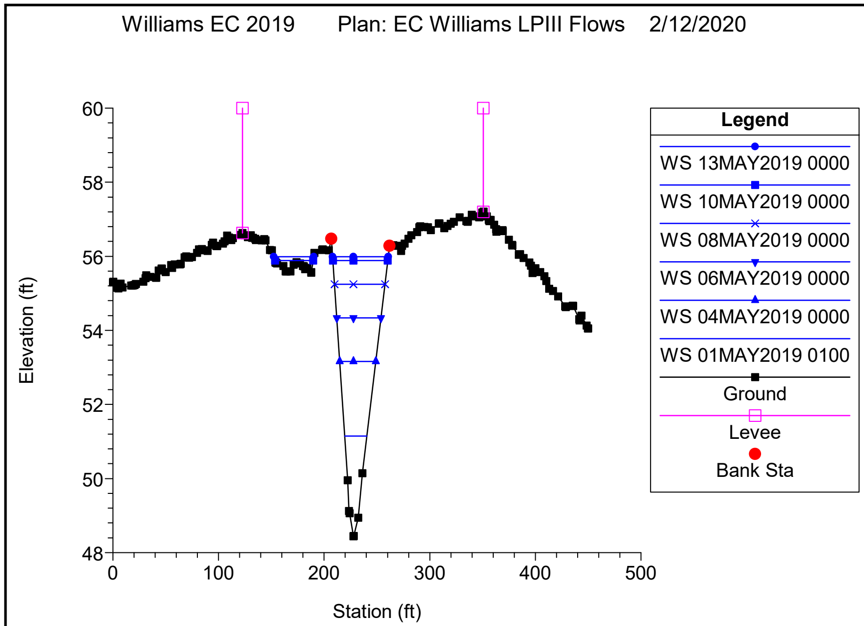


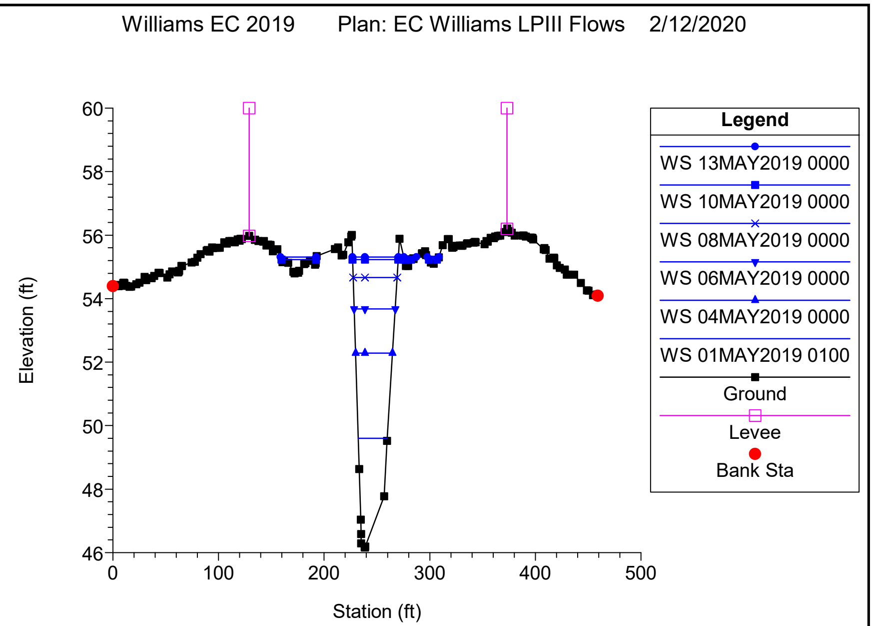

Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
62
60
58
56
54
52
50
0
20
40
60
80
100
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Bank Sta

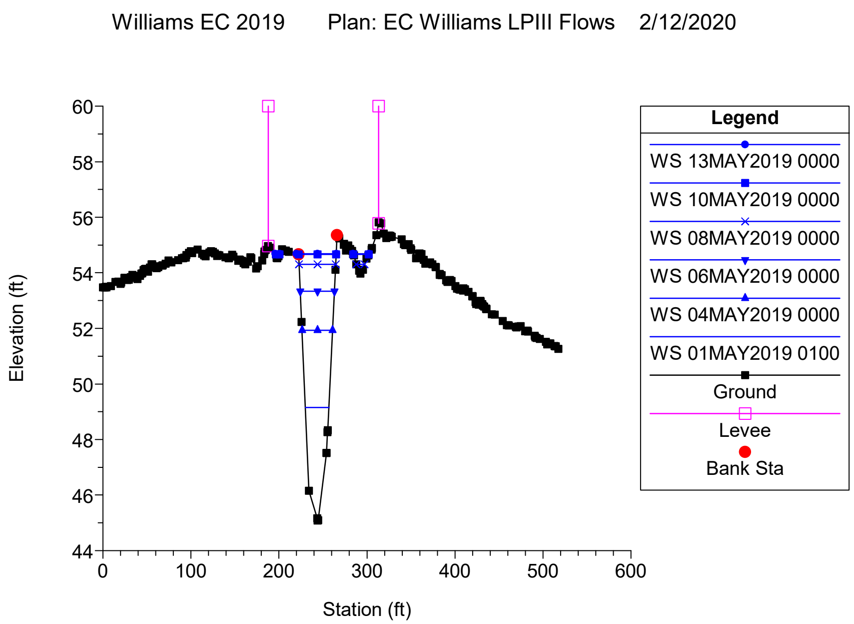

Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
62
60
58
56
54
52
50
0
10
20
30
40
50
60
70
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Bank Sta

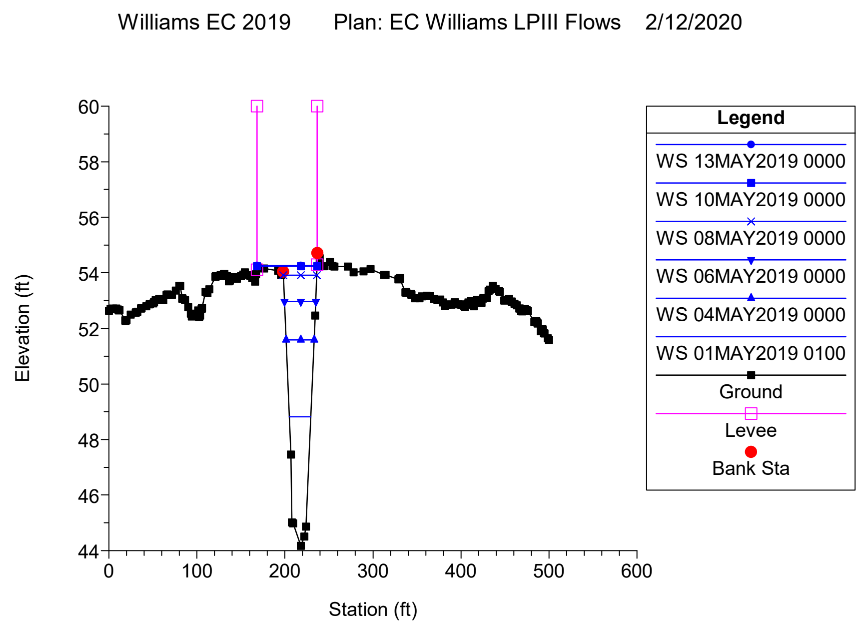

Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
60
58
56
54
52
50
48
0
100
200
300
400
500
600
700
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
60
58
56
54
52
50
48
0
100
200
300
400
500
600
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
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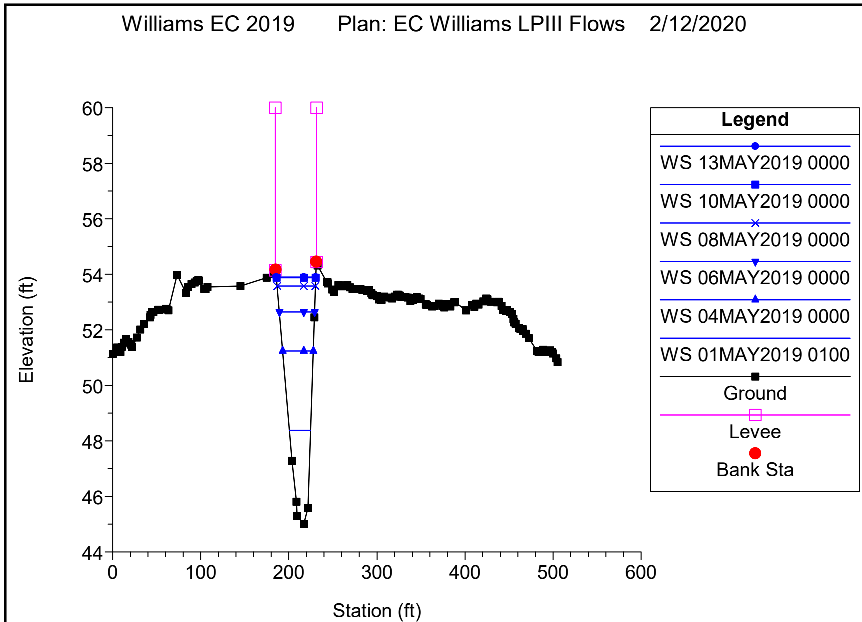
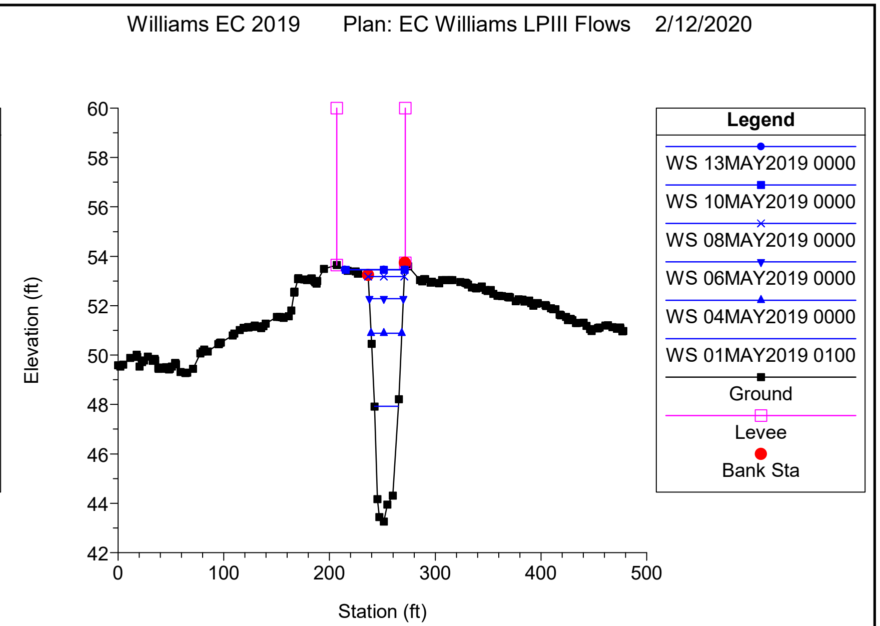
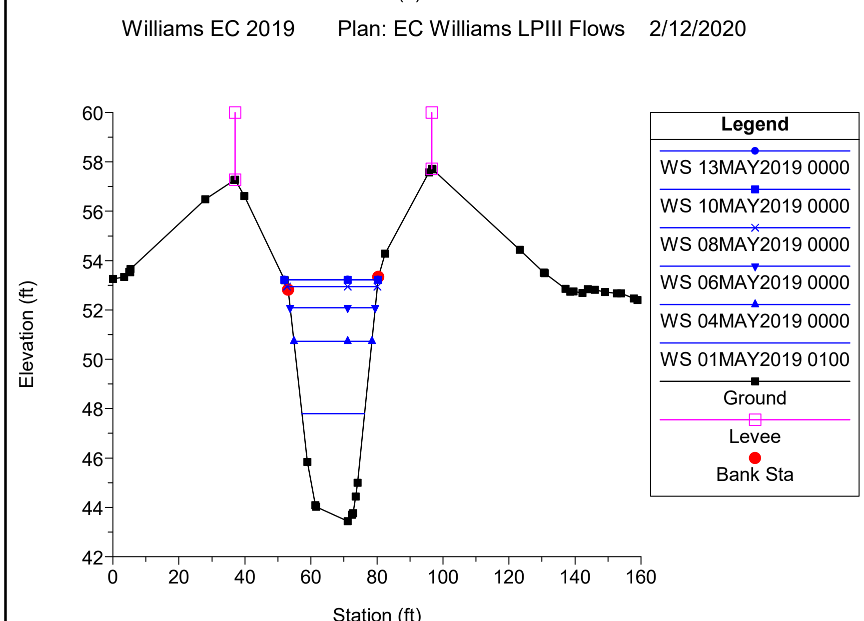
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
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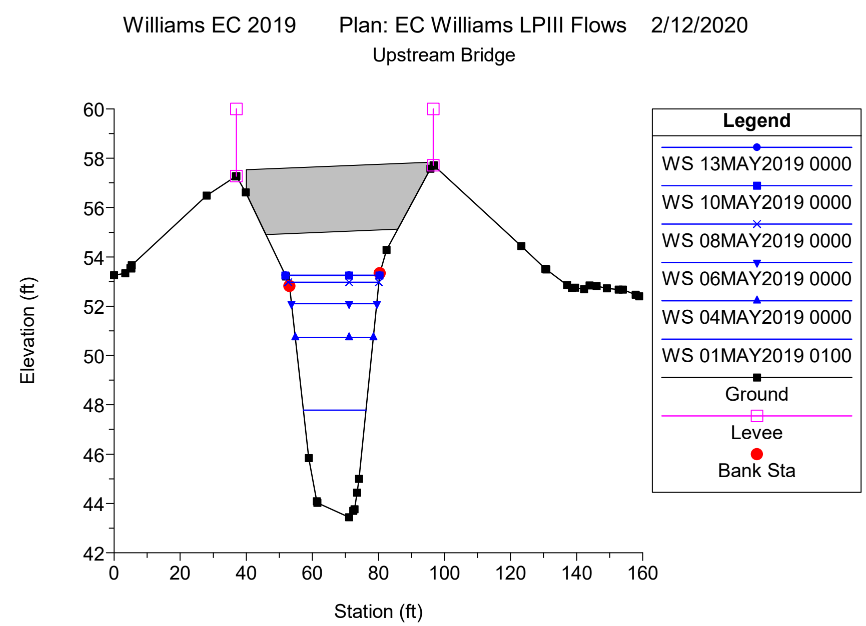
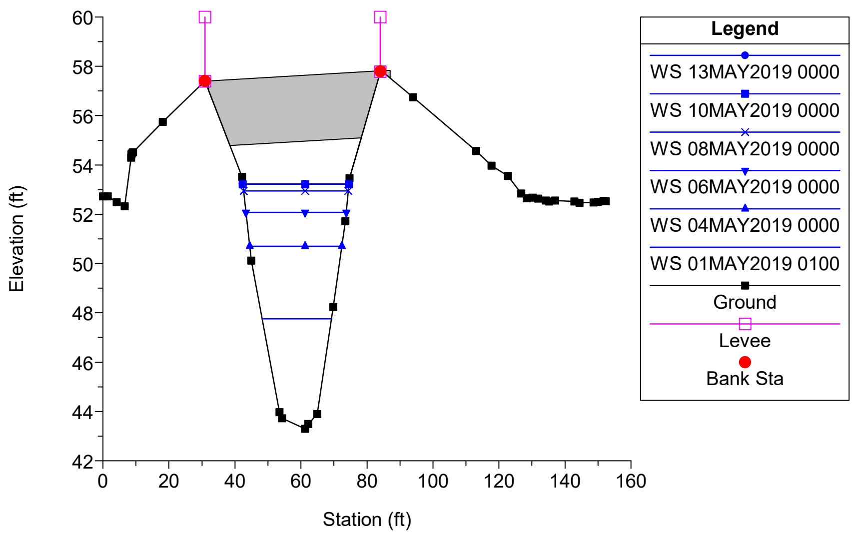
WS 01MAY2019 0100
Ground
Levee
Bank Sta

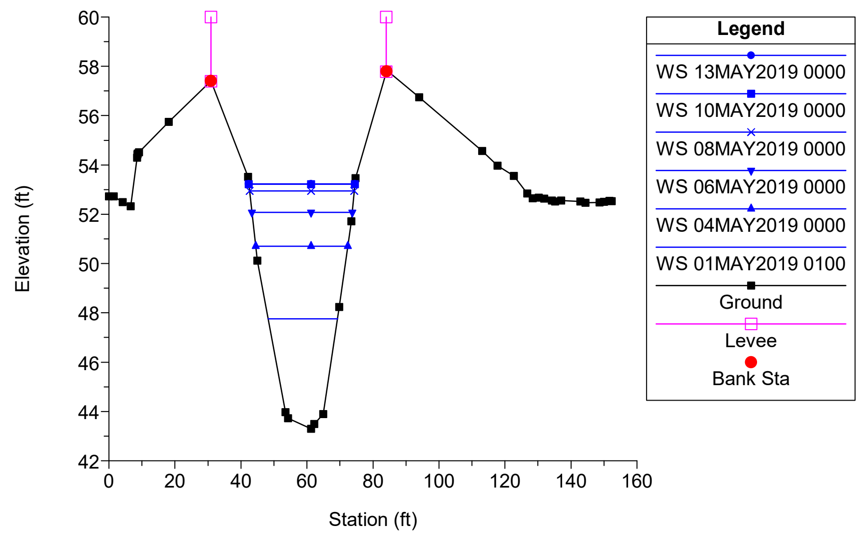

Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Upstream Bridge
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta

Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020

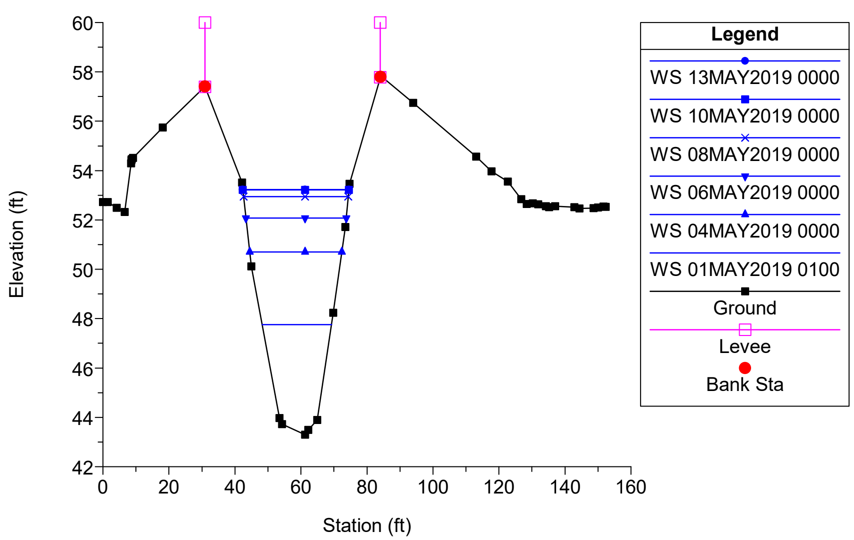
Upstream Bridge



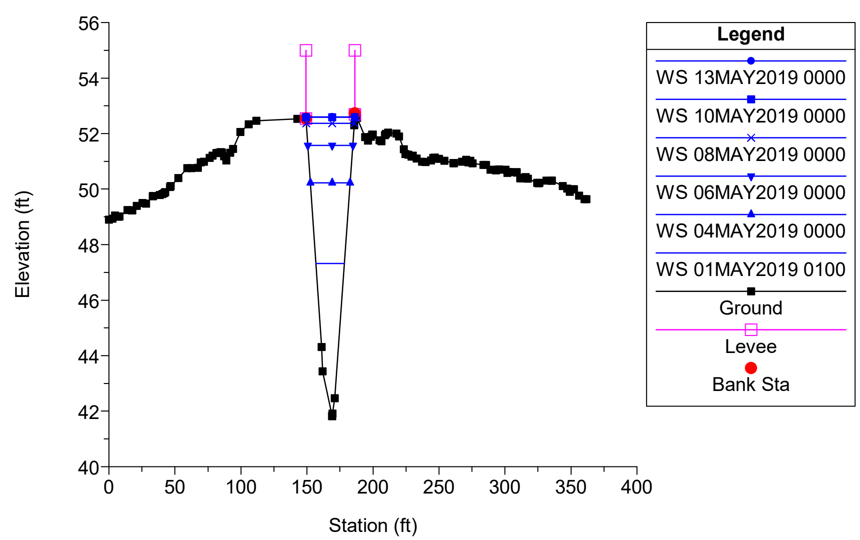
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



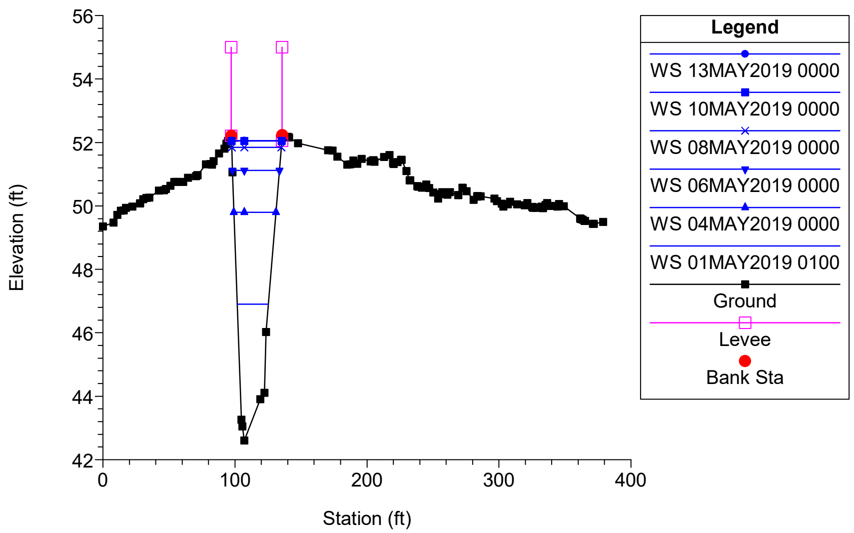
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



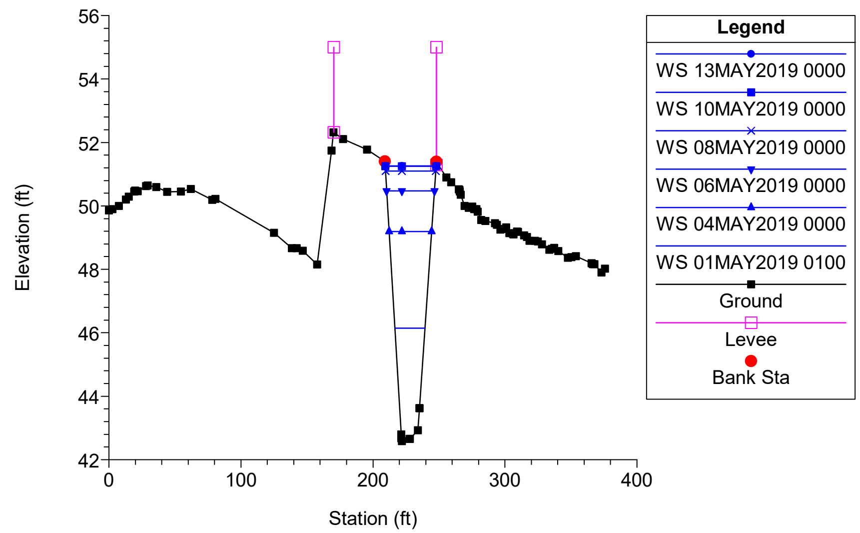
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



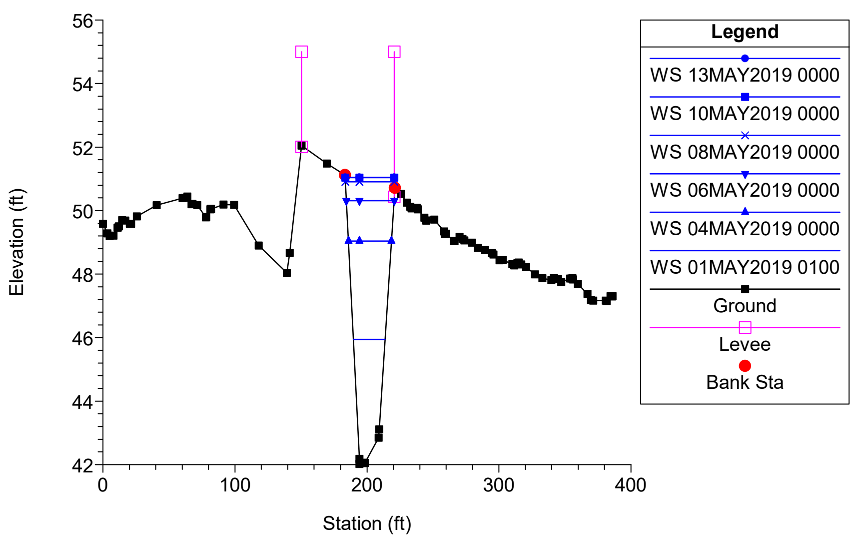
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



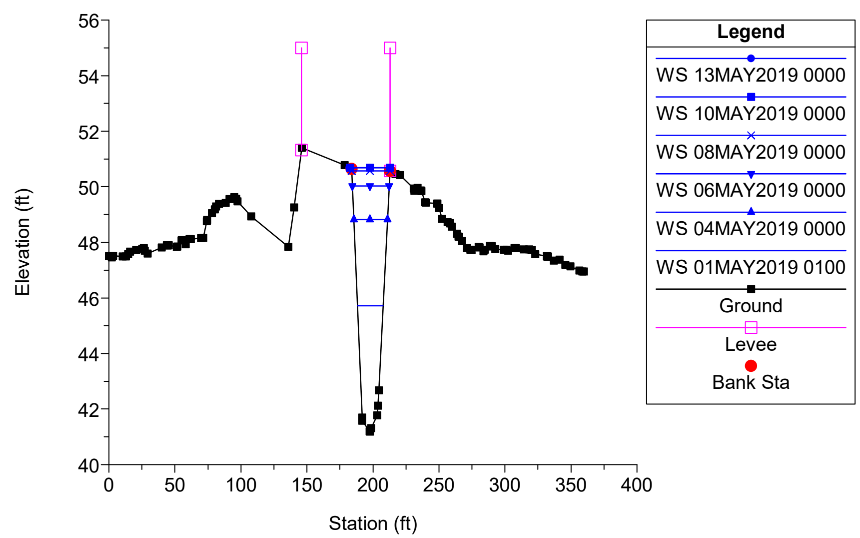
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020

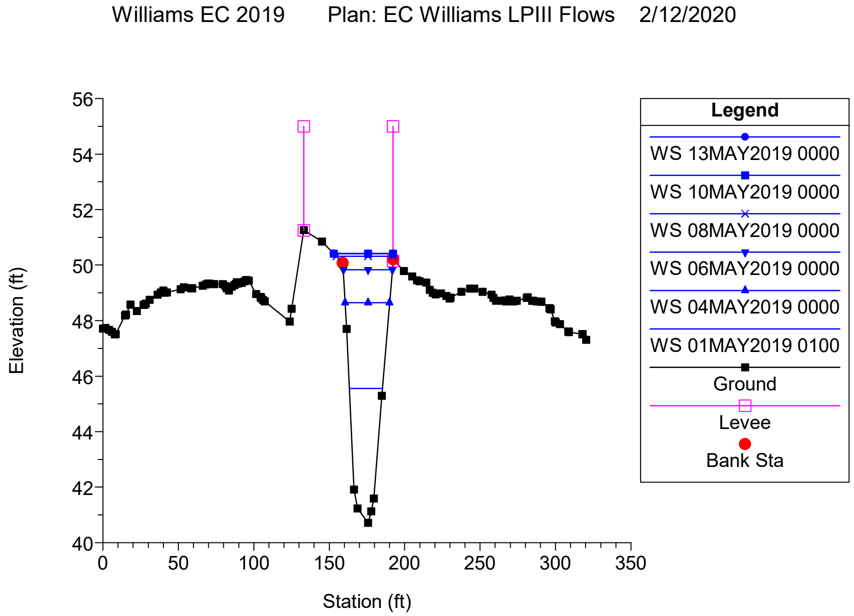


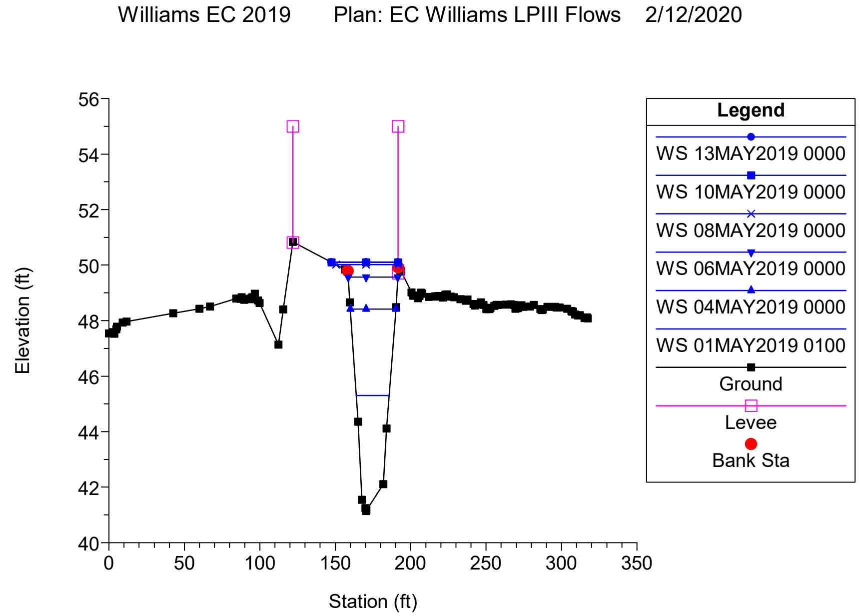
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020



Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020




Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
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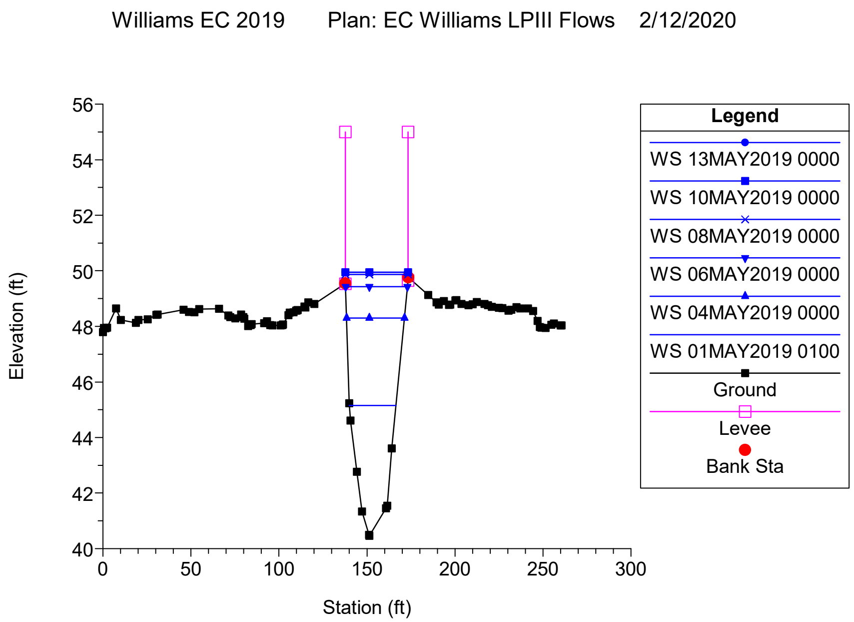
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
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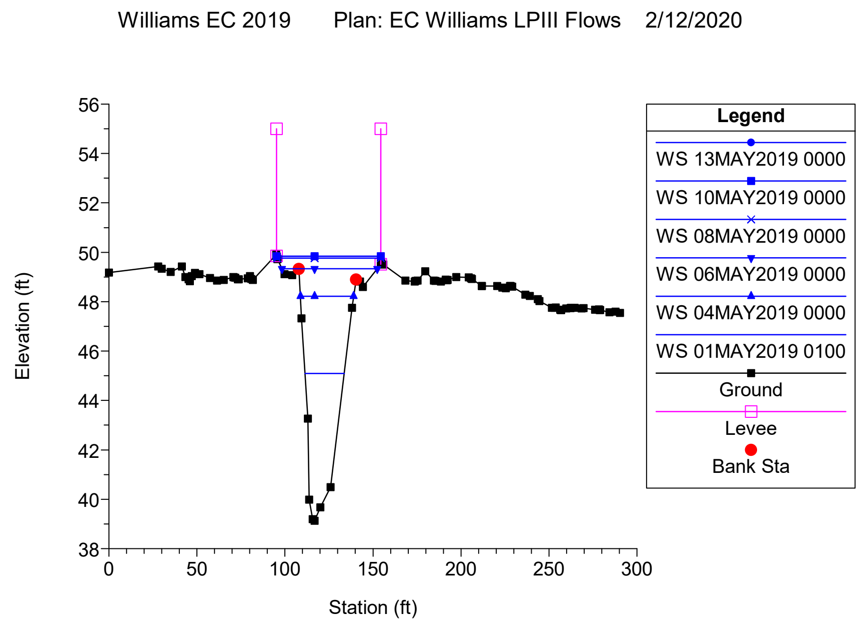
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
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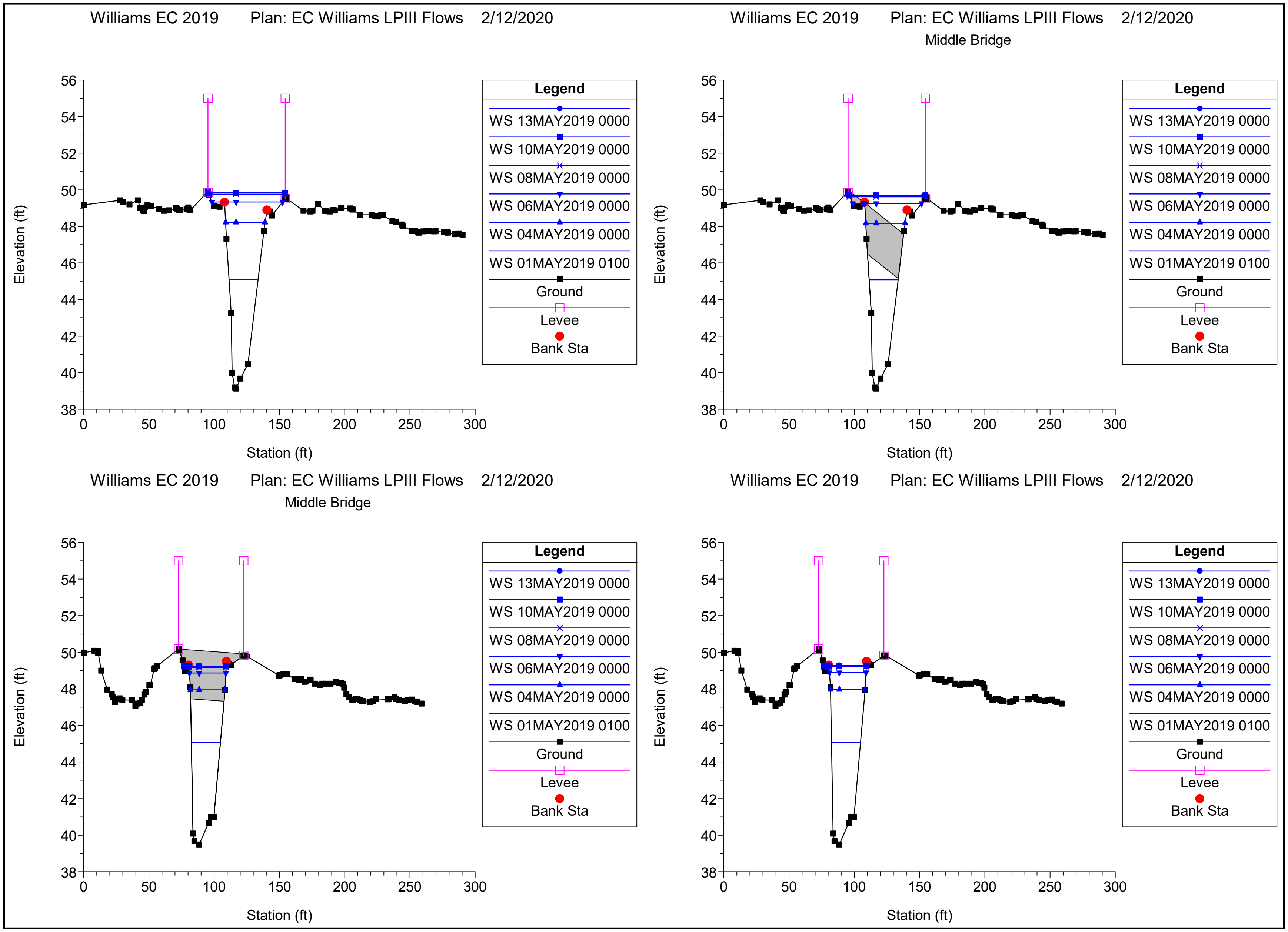
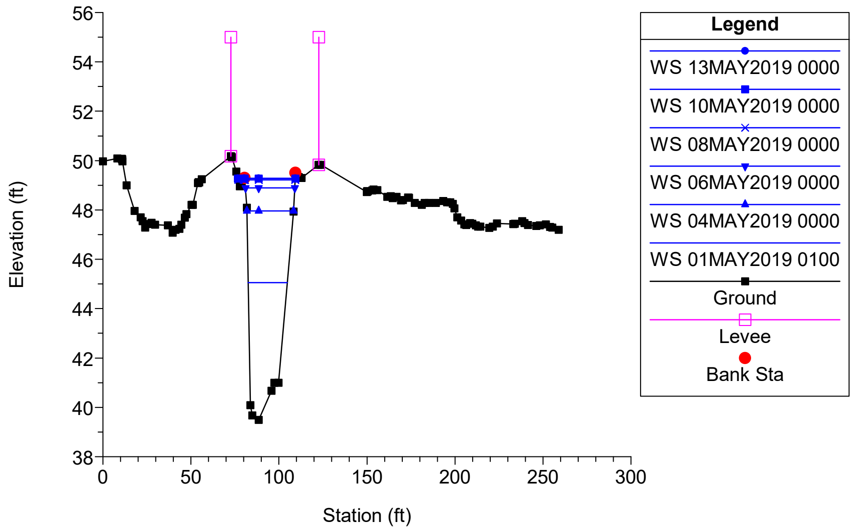
Ground
Levee
Bank Sta

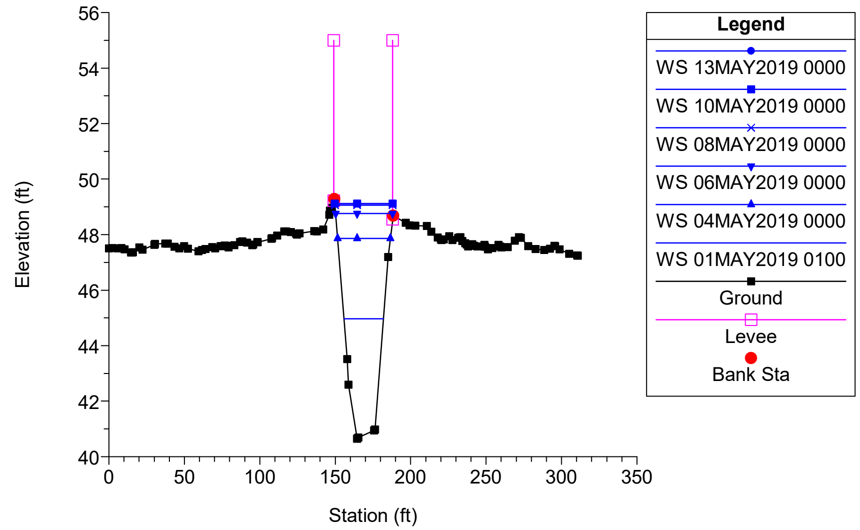


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Middle Bridge
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Middle Bridge
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta

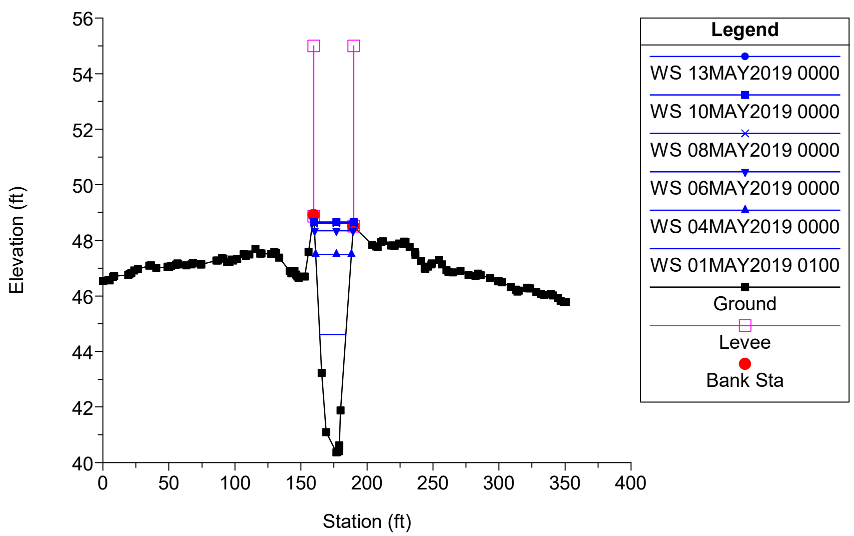
Williams EC 2019   Plan: EC Williams LPIII Flows   2/12/2020



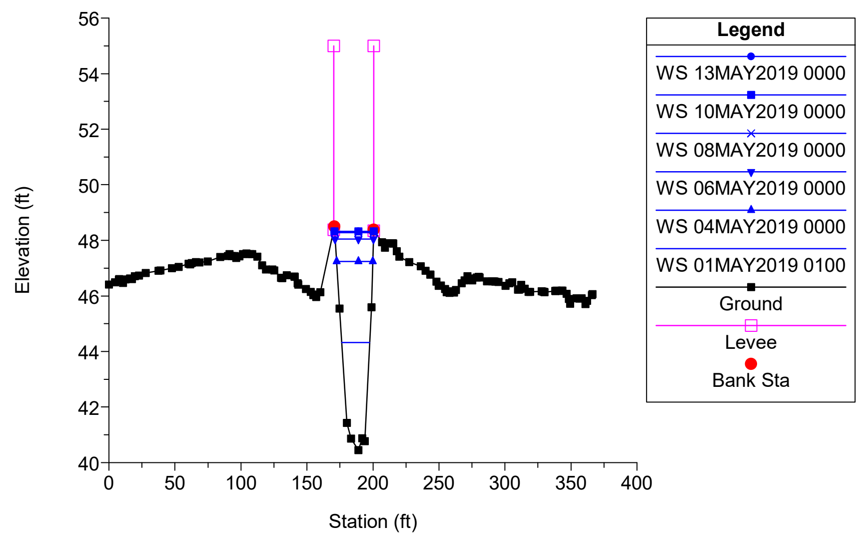
Williams EC 2019   Plan: EC Williams LPIII Flows   2/12/2020

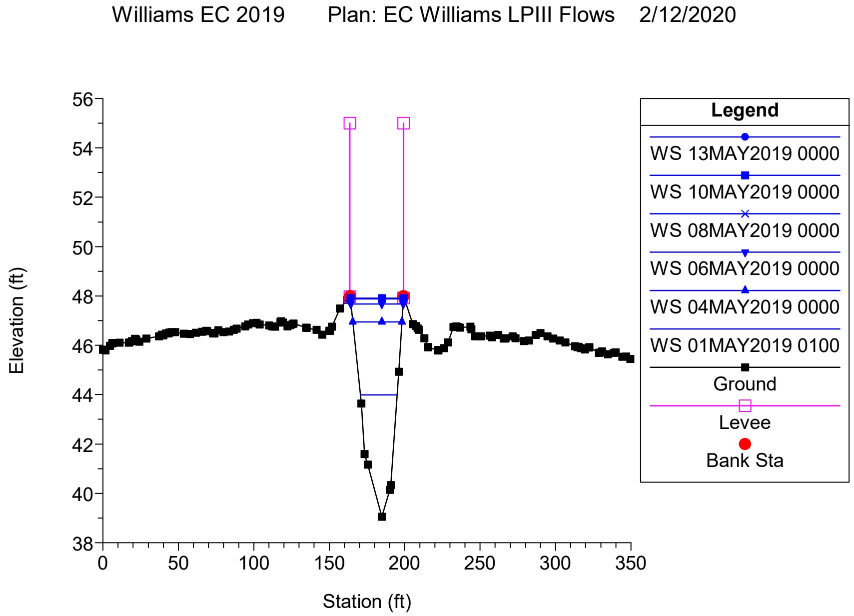


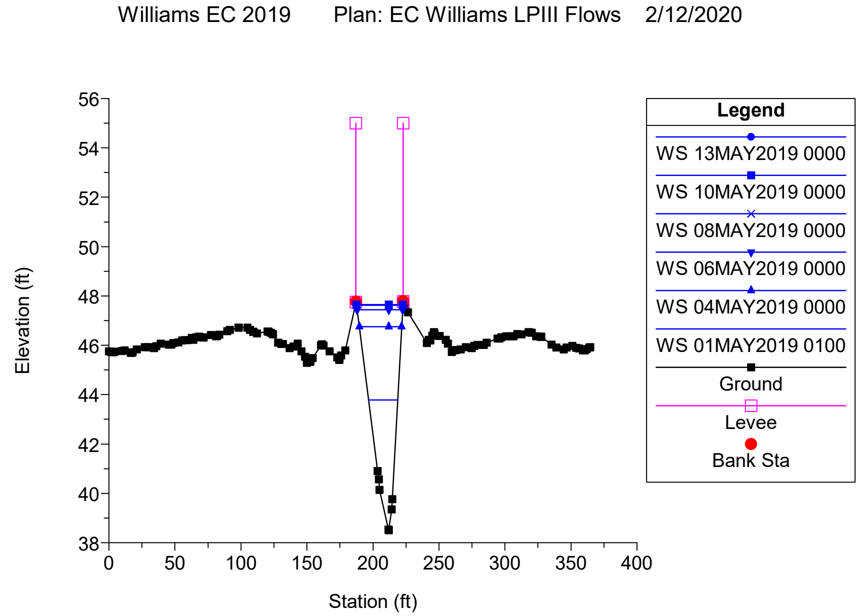
Williams EC 2019   Plan: EC Williams LPIII Flows   2/12/2020

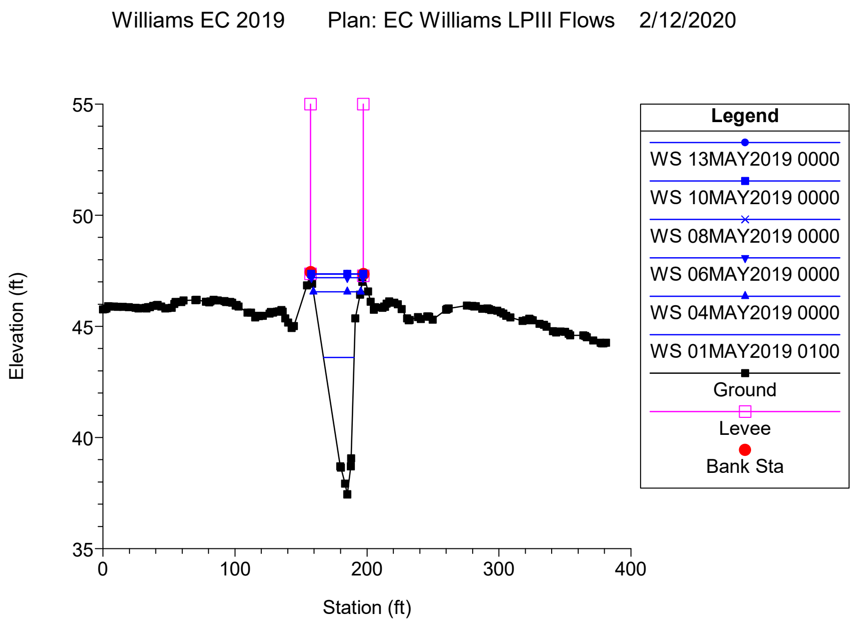


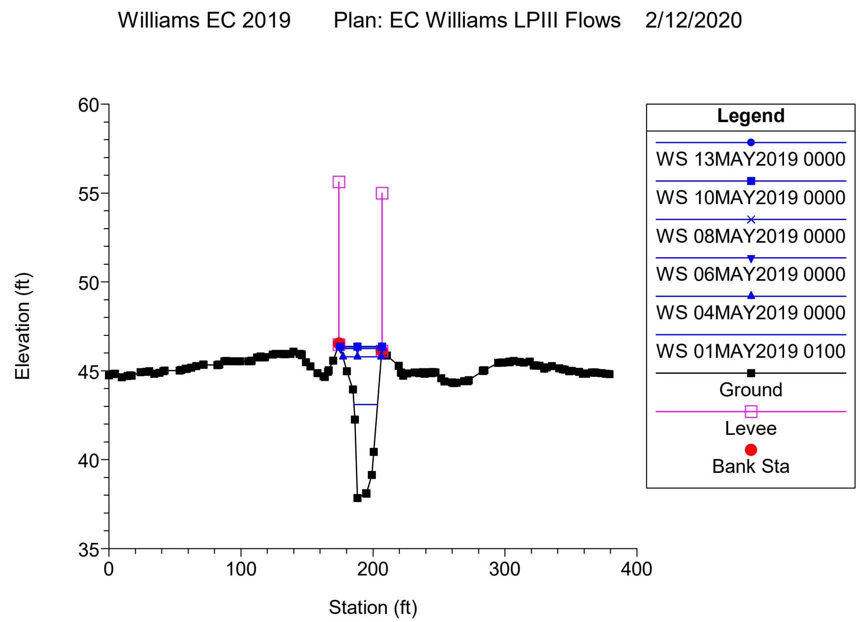
Williams EC 2019   Plan: EC Williams LPIII Flows   2/12/2020




Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
38
40
42
44
46
48
50
52
54
56
0
50
100
150
200
250
300
350
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
38
40
42
44
46
48
50
52
54
56
0
50
100
150
200
250
300
350
400
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta


Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
35
40
45
50
55
0
100
200
300
400
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta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Elevation (ft)
Station (ft)
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400
Legend
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WS 08MAY2019 0000
WS 06MAY2019 0000
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Ground
Levee
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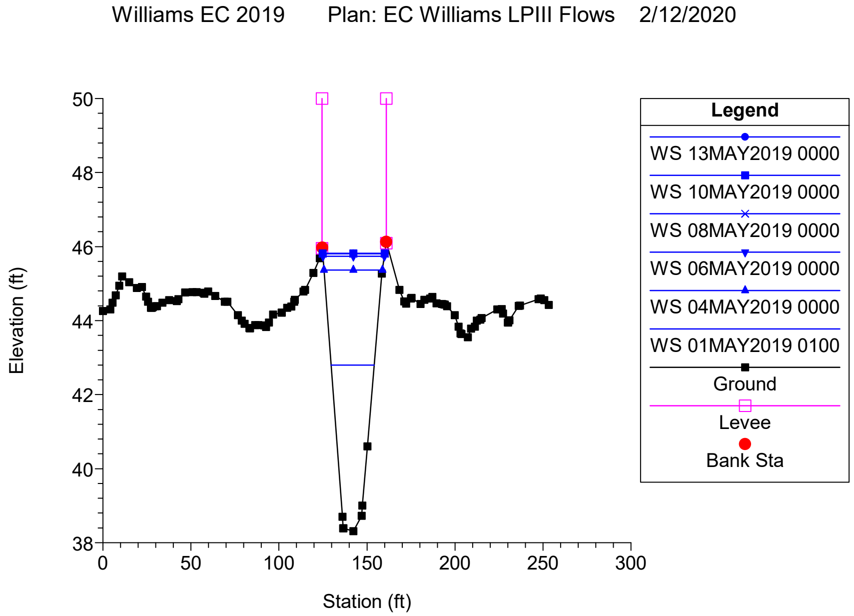
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Station (ft)
Legend
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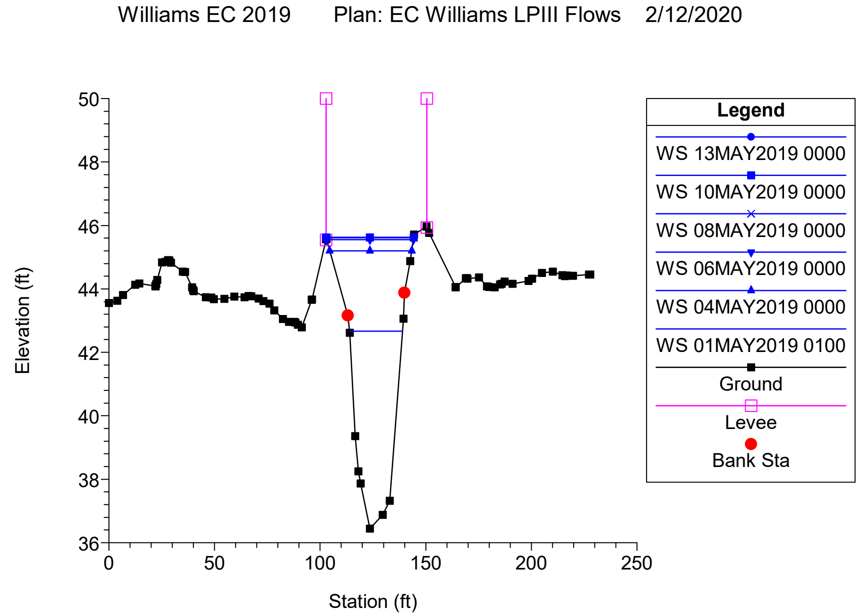
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Station (ft)
Legend
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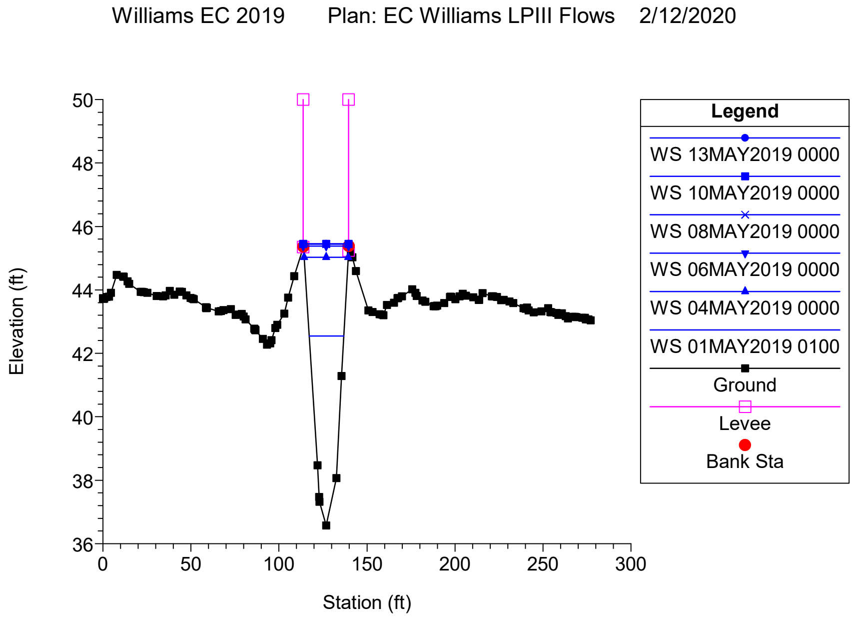
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Station (ft)
Legend
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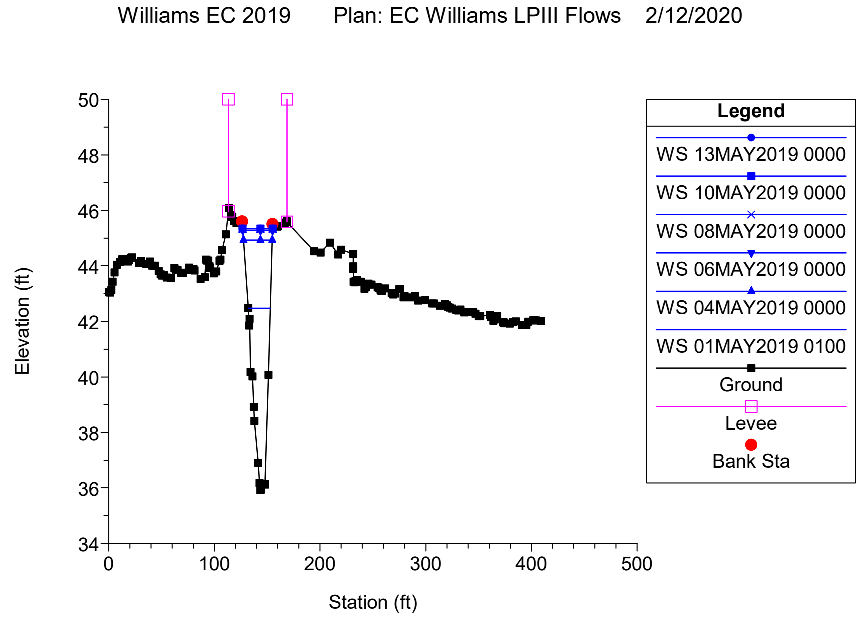
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Elevation (ft)
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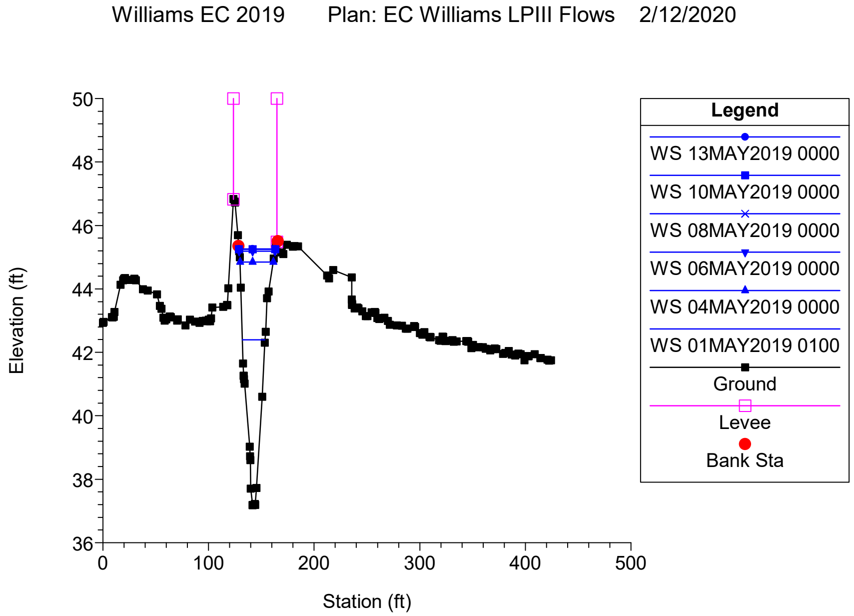
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Elevation (ft)
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200
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400
500
Station (ft)
Legend
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WS 08MAY2019 0000
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Levee
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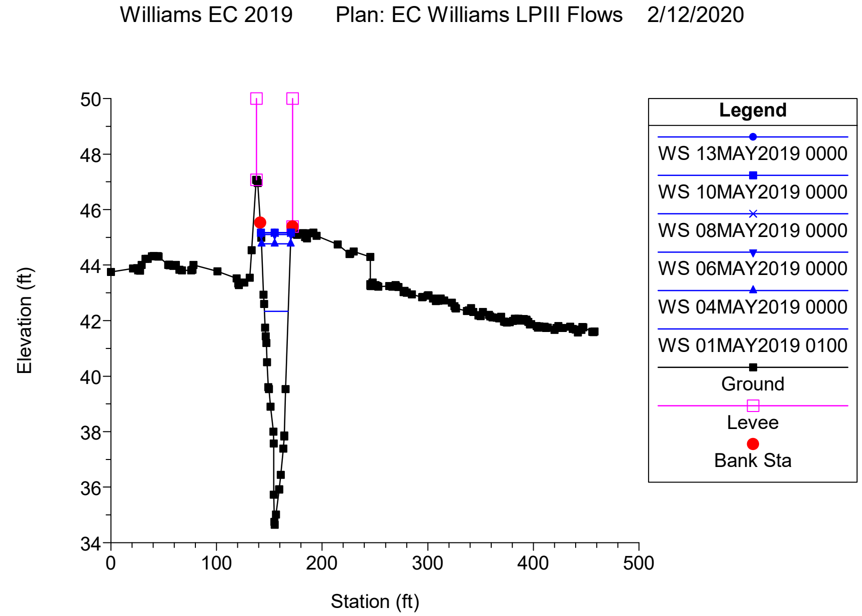
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Elevation (ft)
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Station (ft)
Legend
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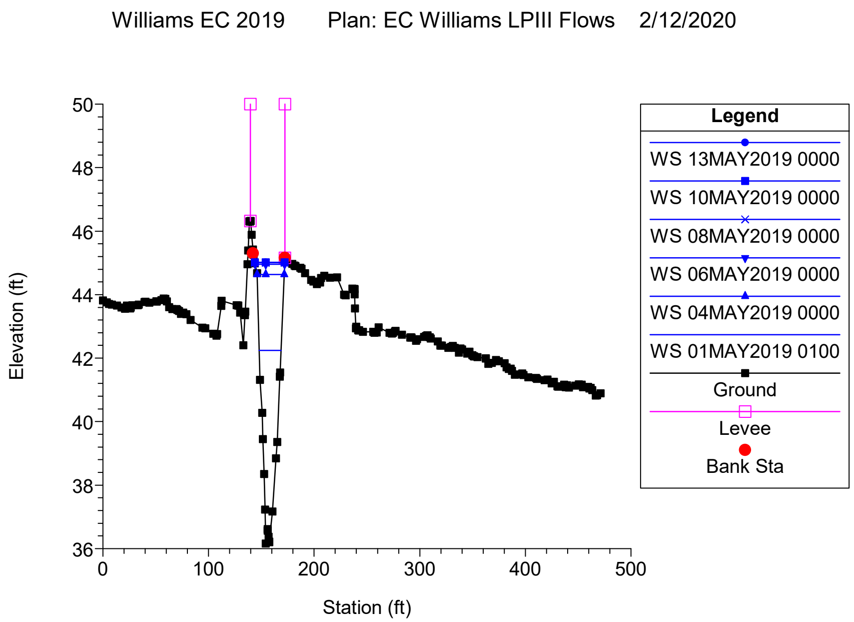
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Elevation (ft)
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Station (ft)
Legend
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Levee
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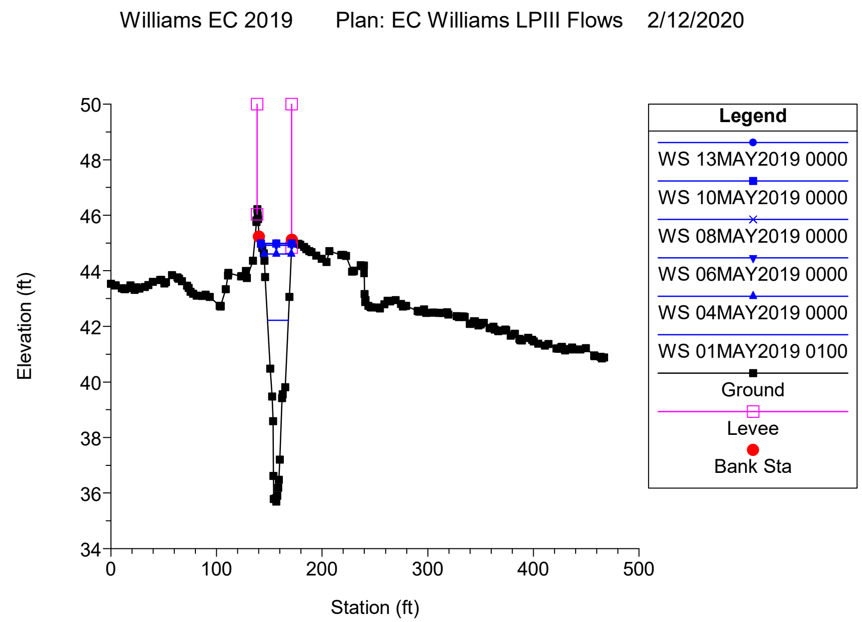
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Station (ft)
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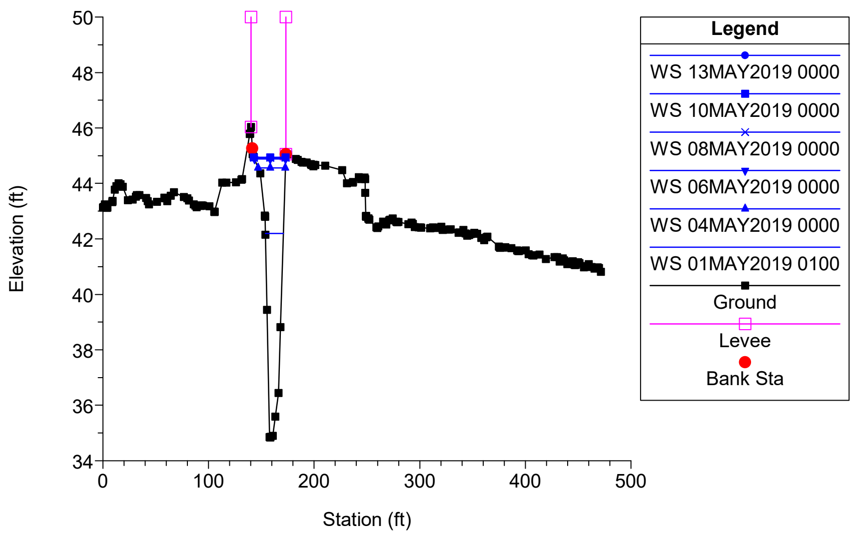

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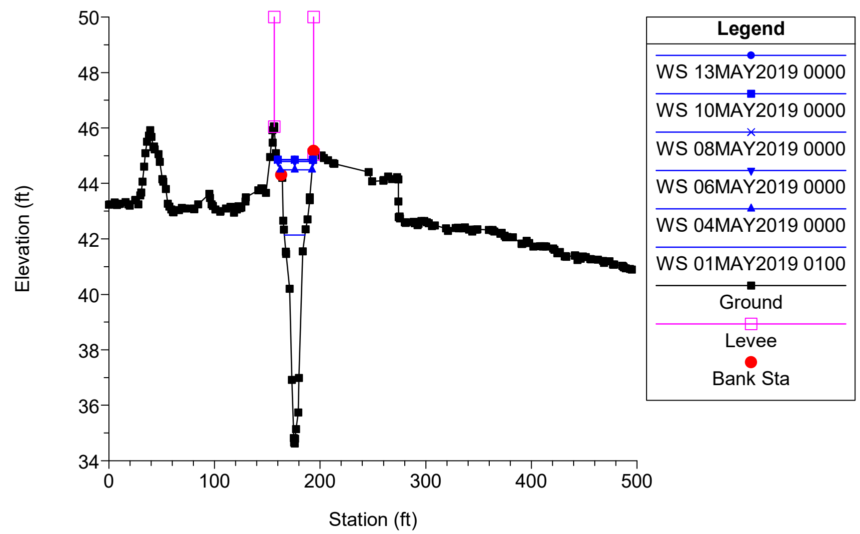

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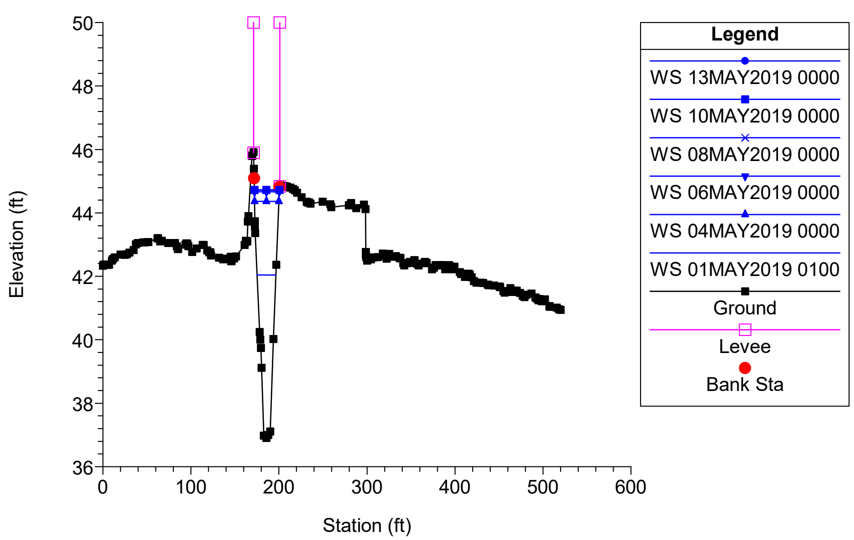

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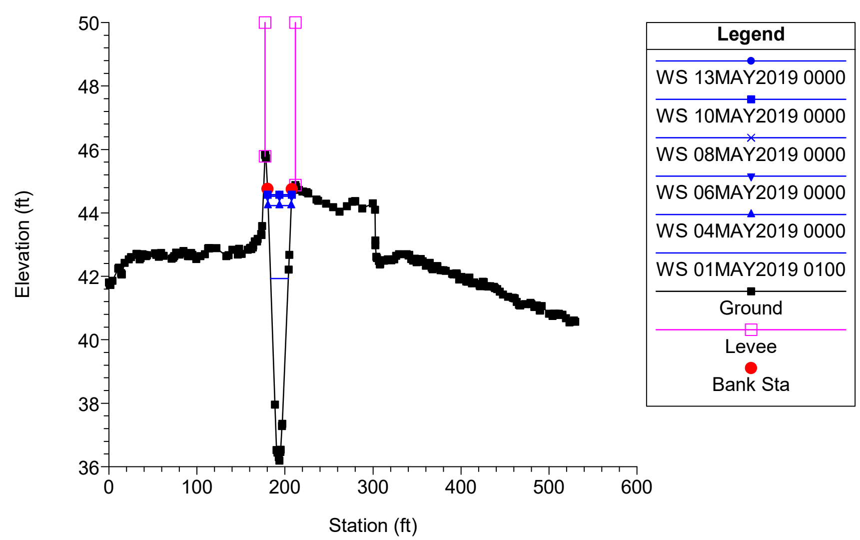

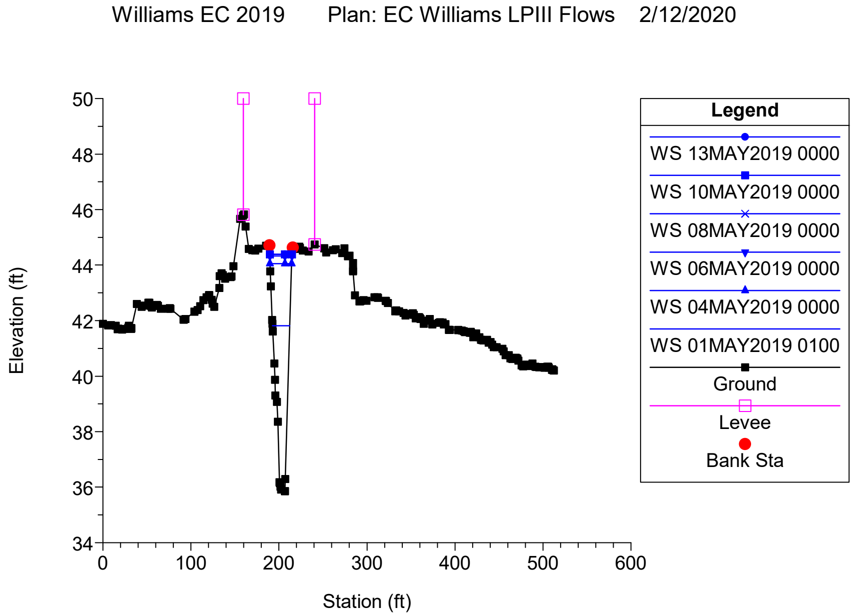
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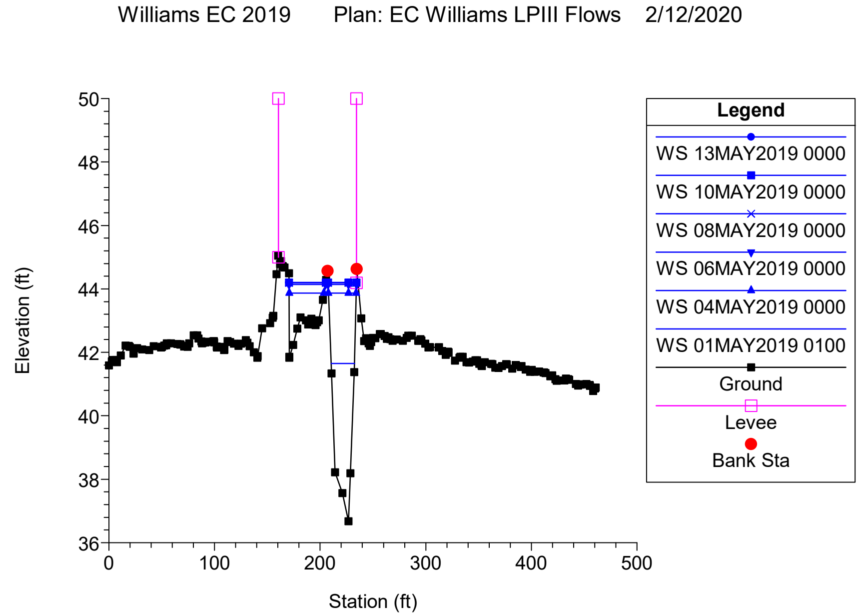
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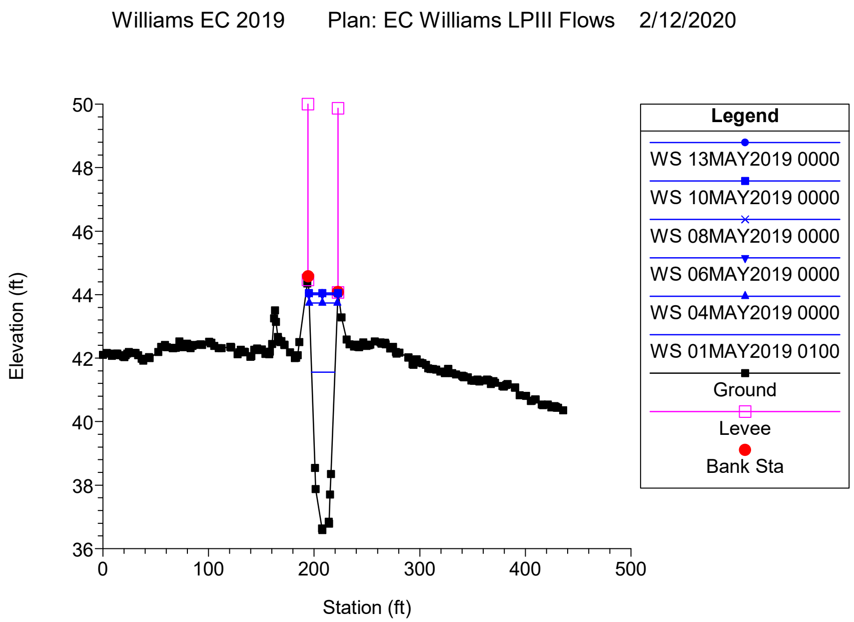
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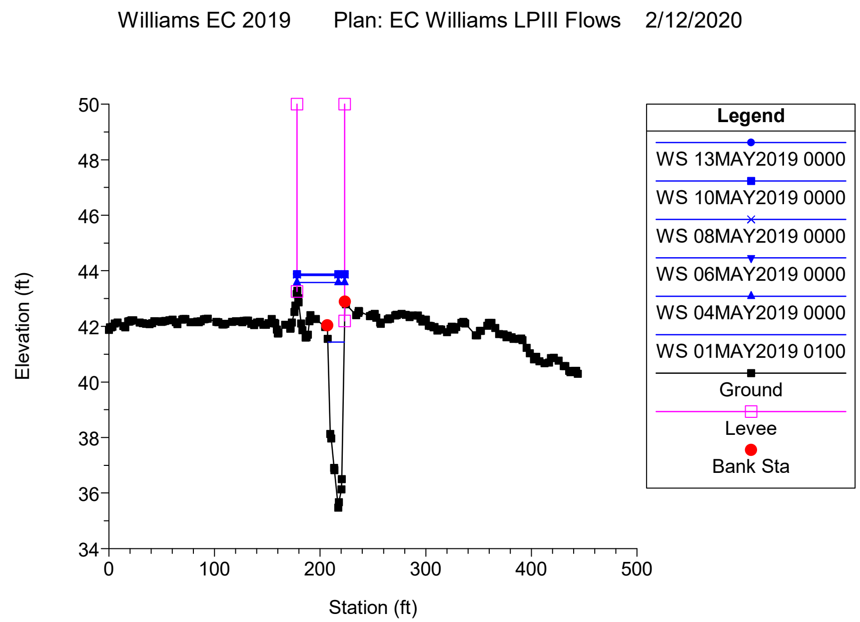
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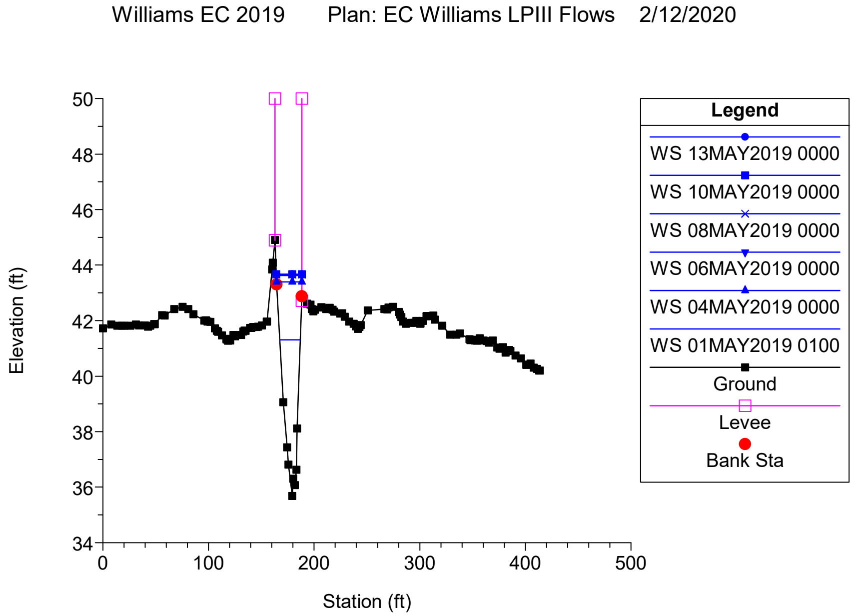
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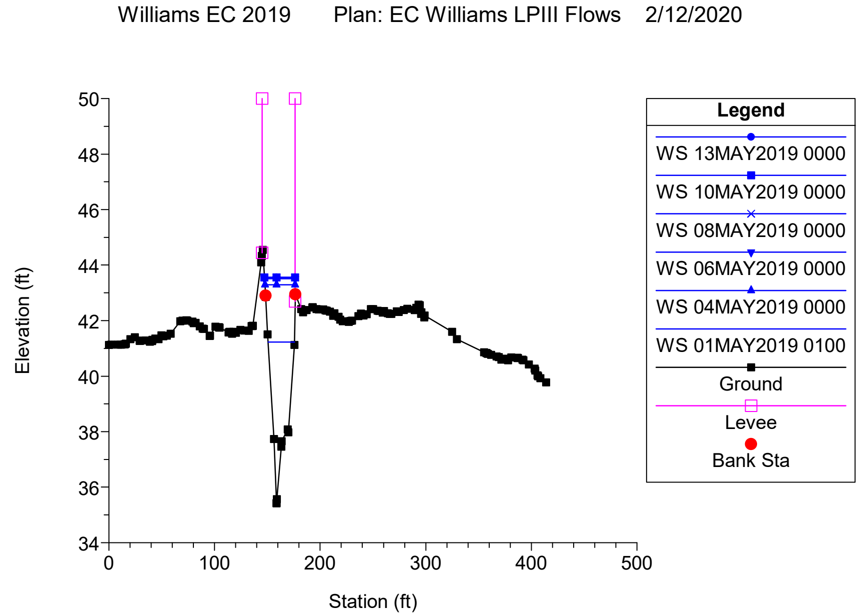
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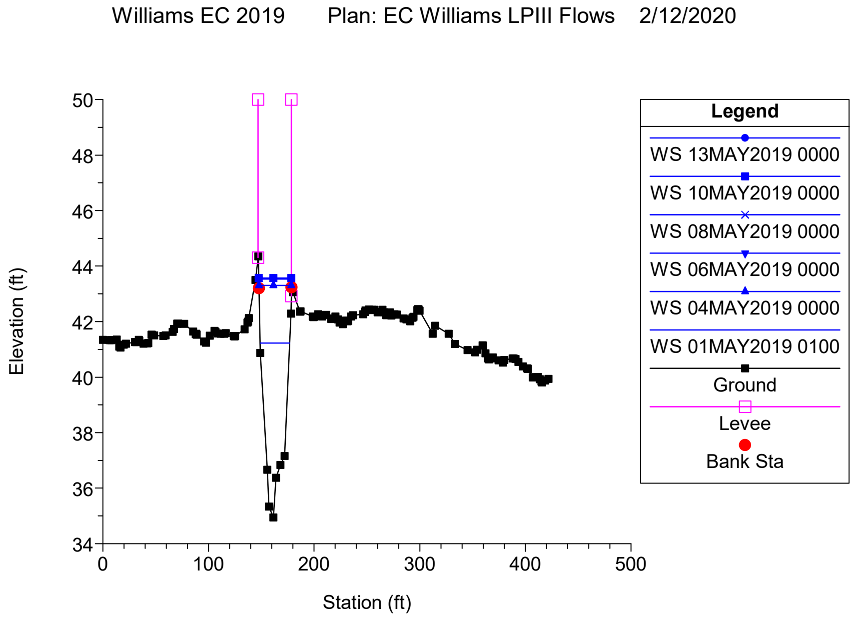
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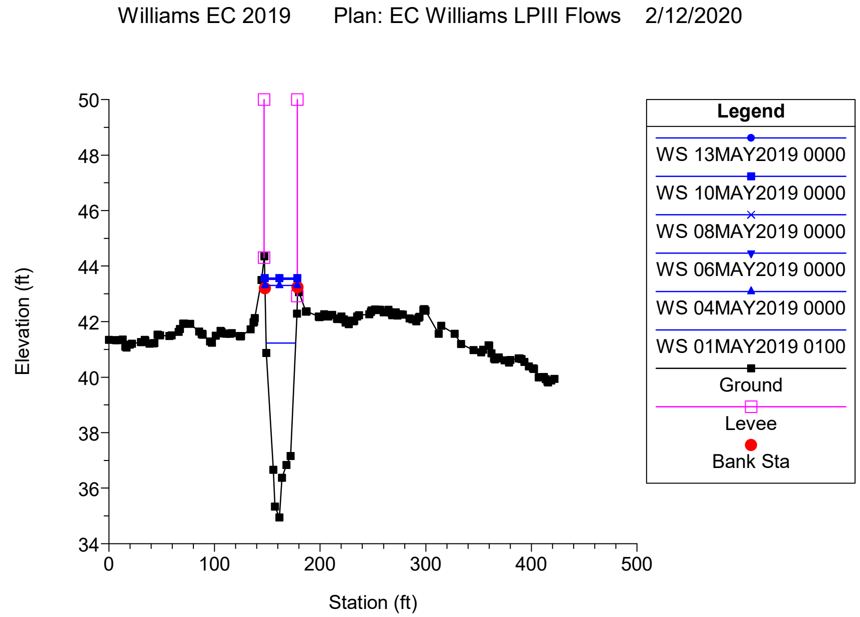
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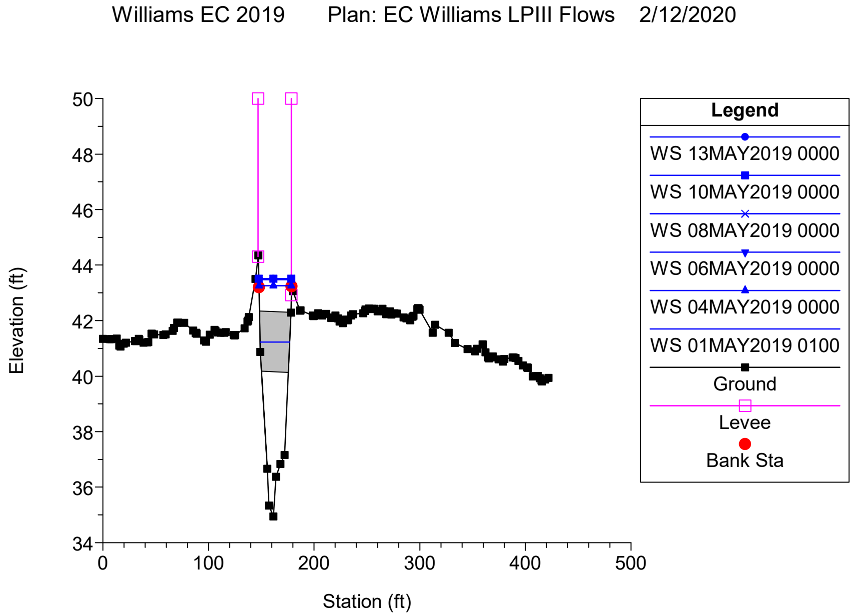
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Ground
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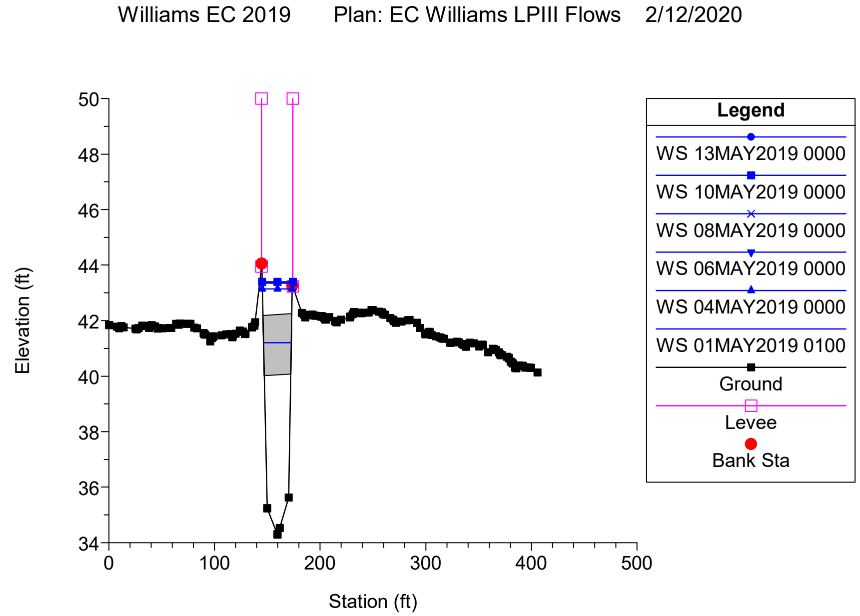
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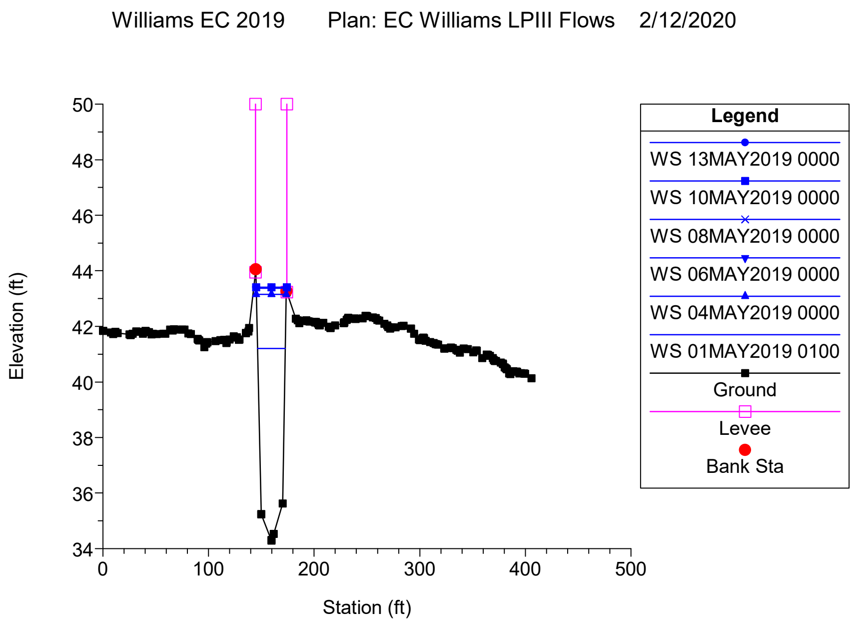
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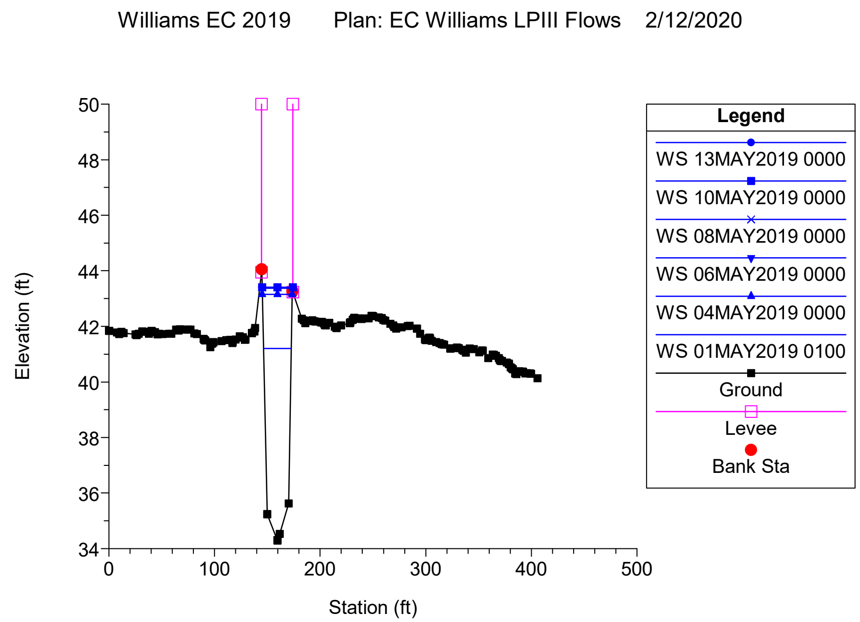
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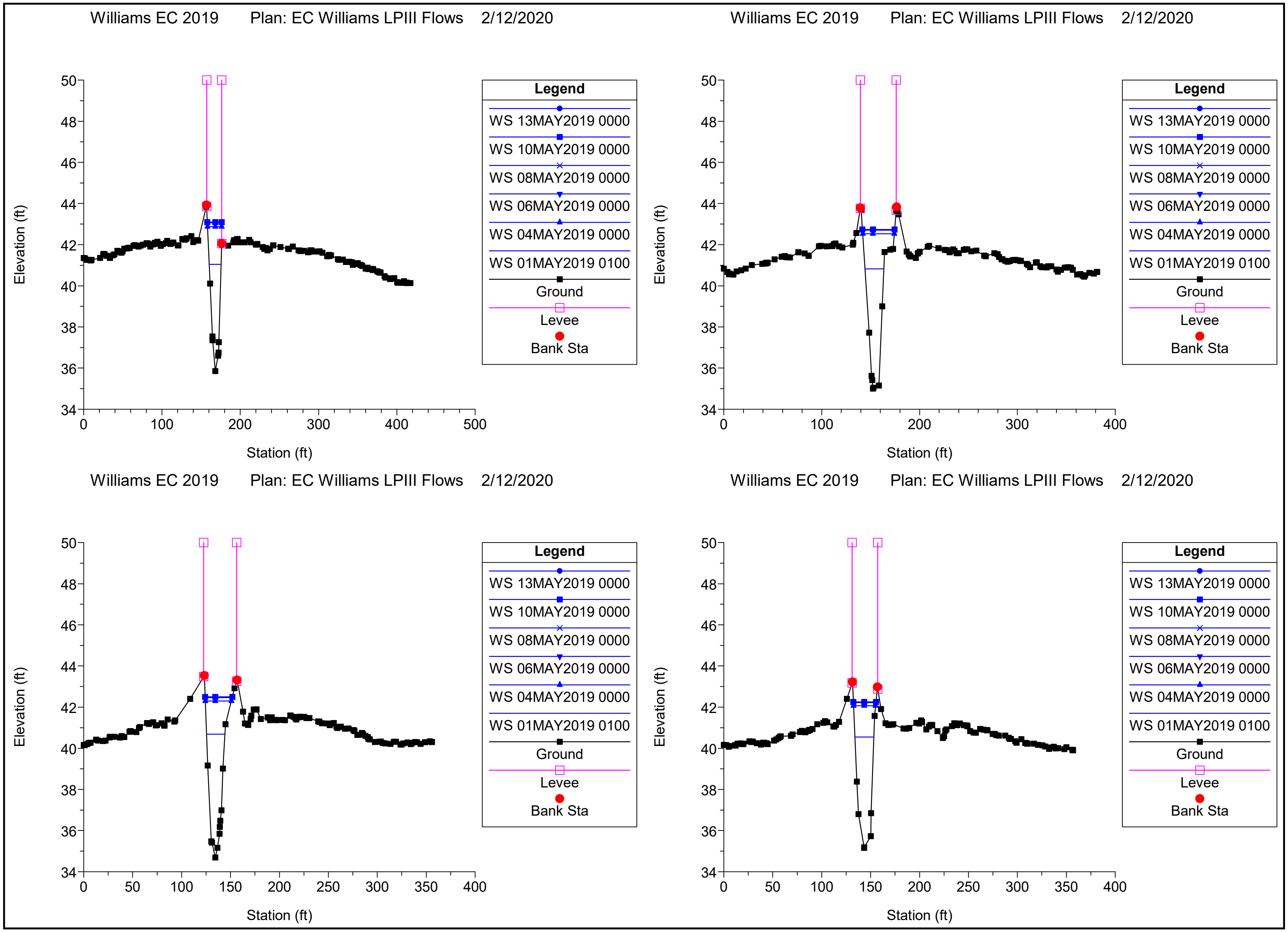

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Station (ft)
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Station (ft)
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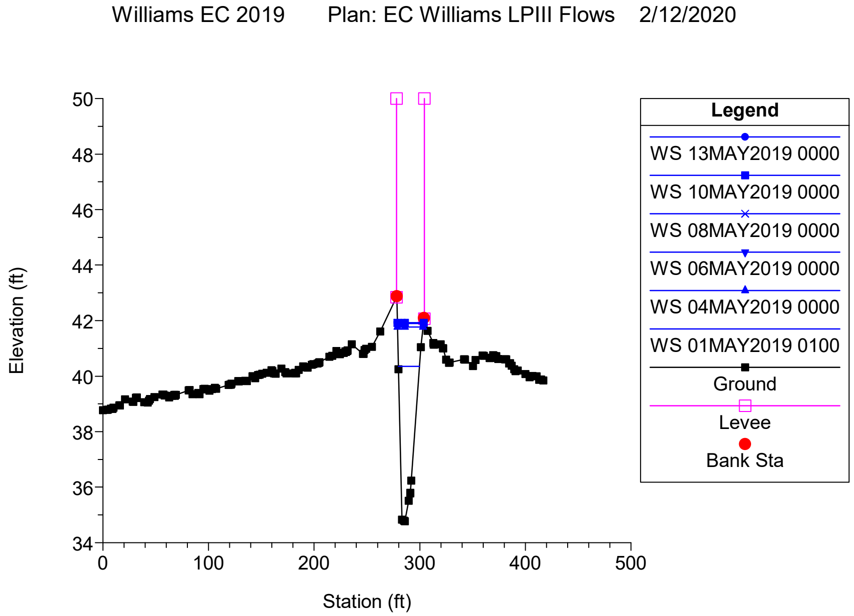
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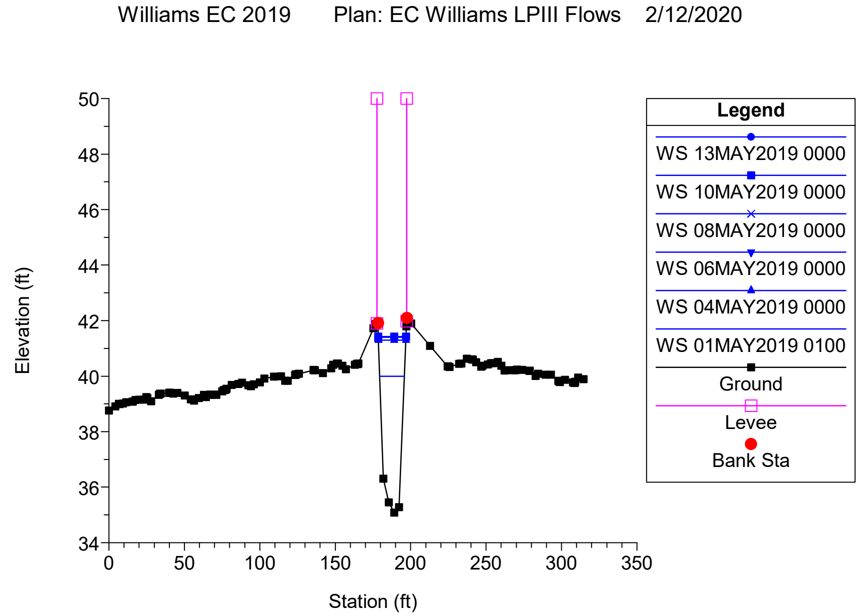
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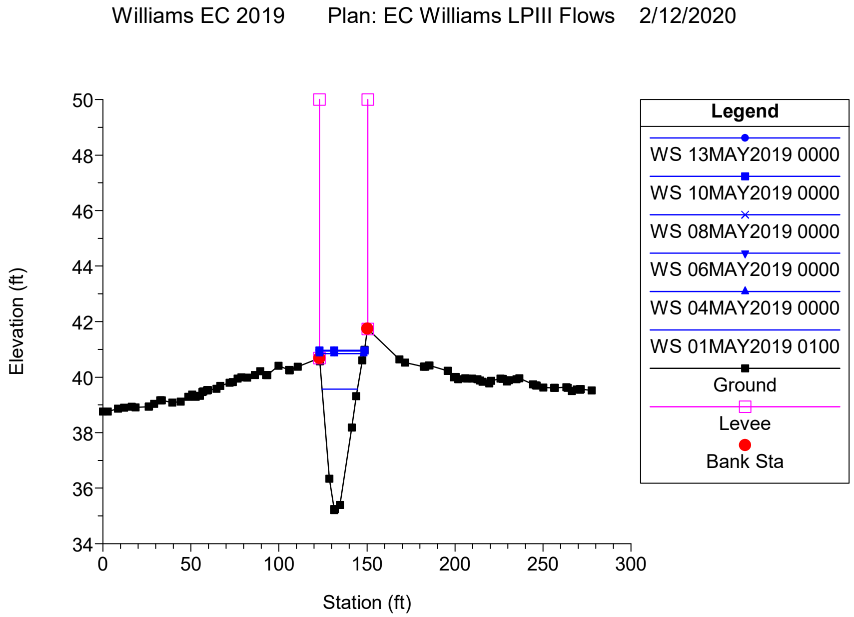
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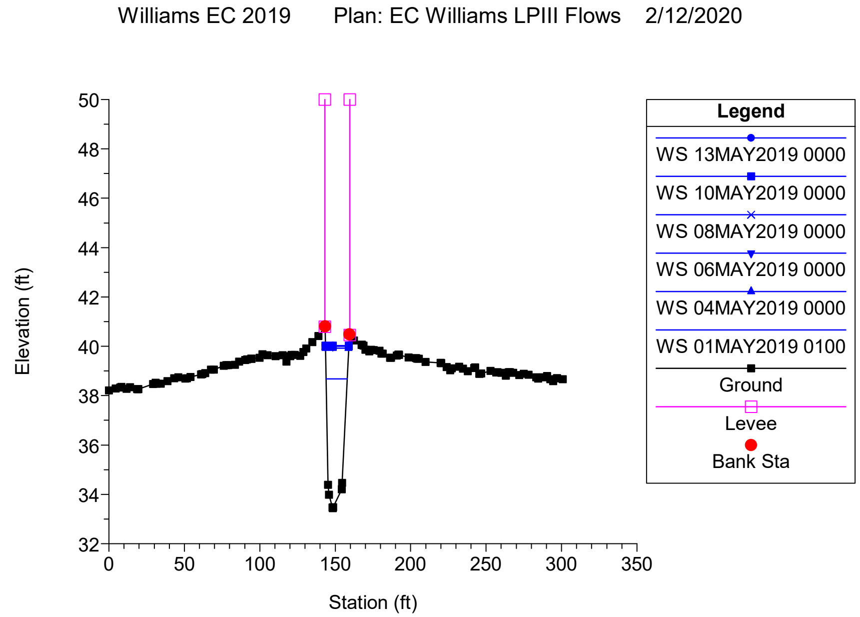
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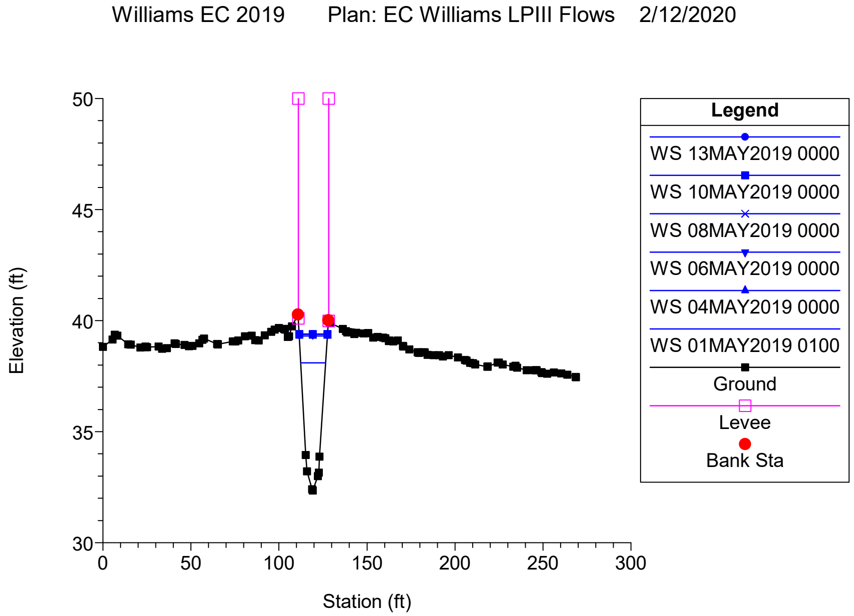

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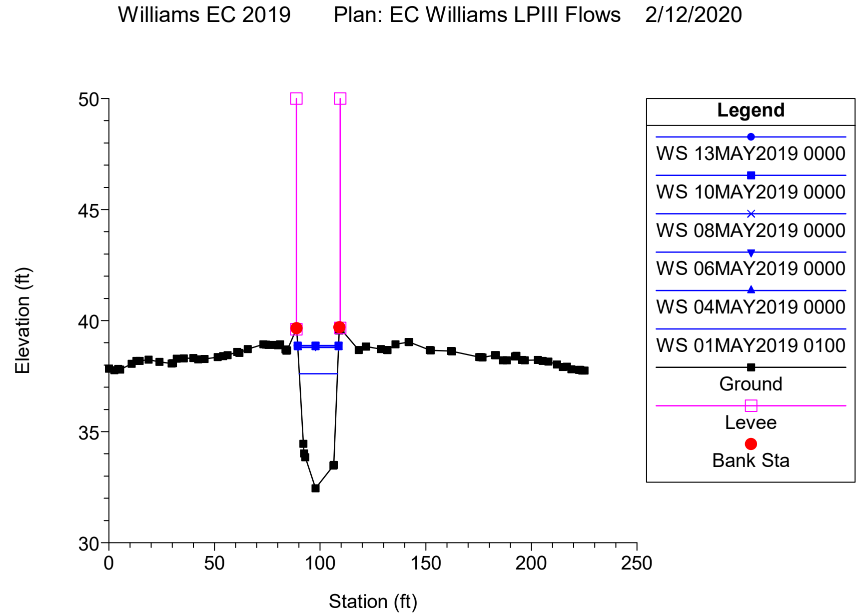

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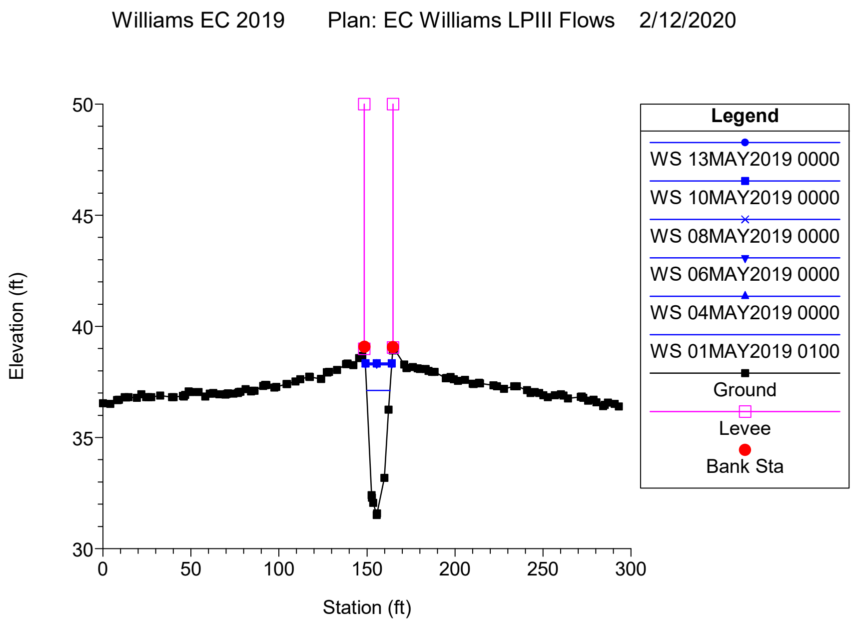

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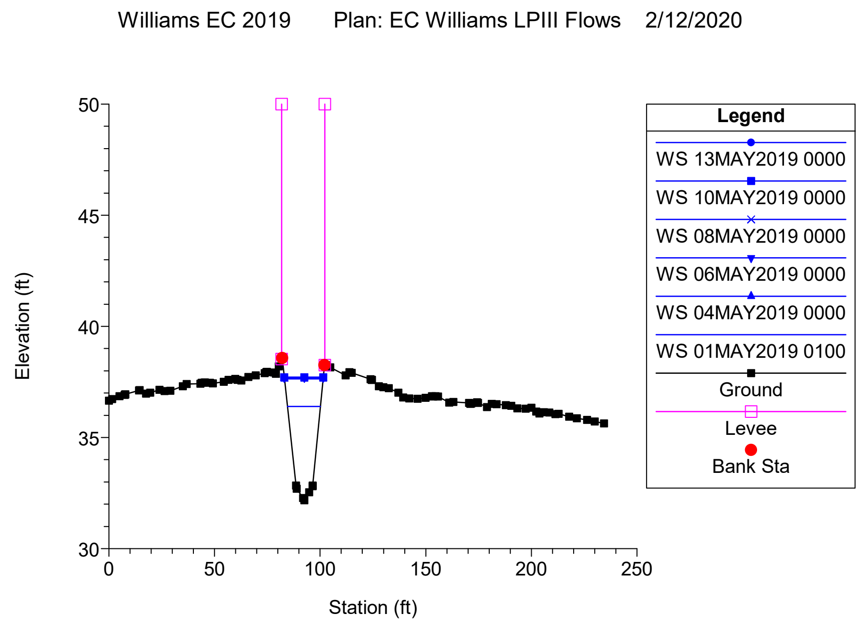

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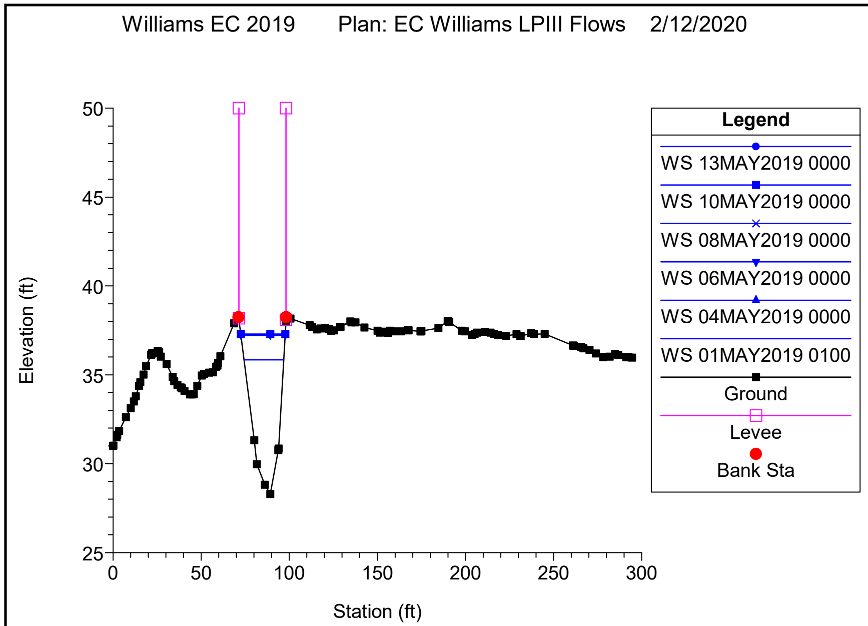
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Levee
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Elevation (ft)
Station (ft)
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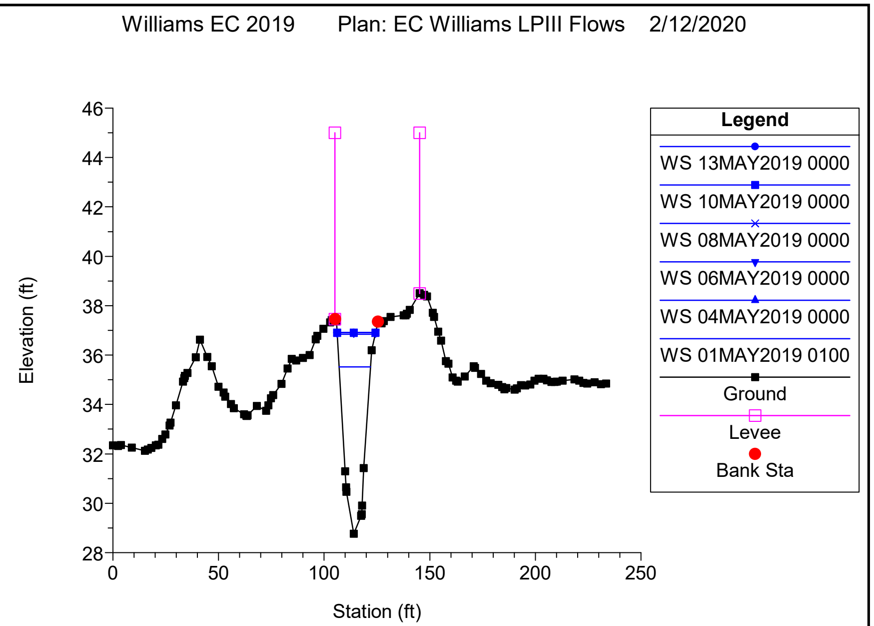
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Station (ft)
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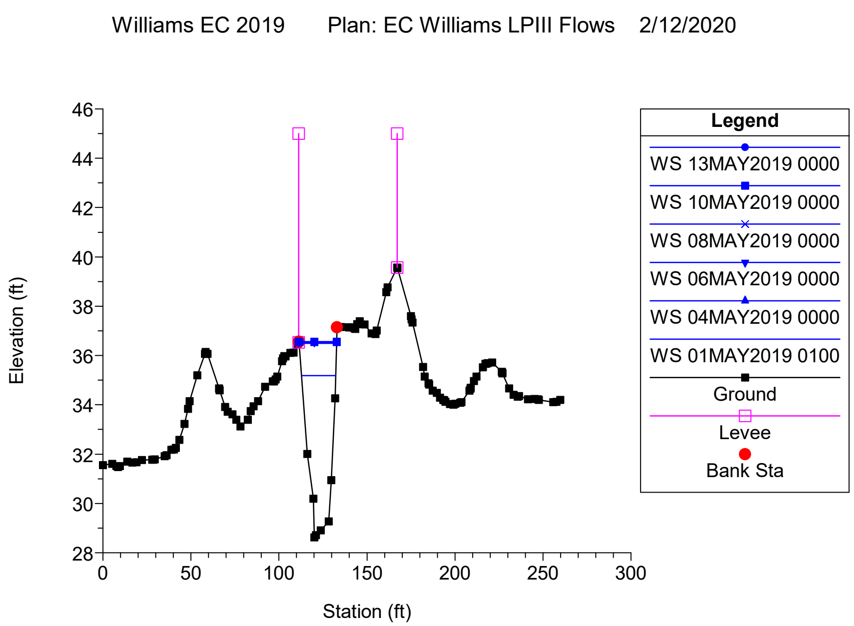
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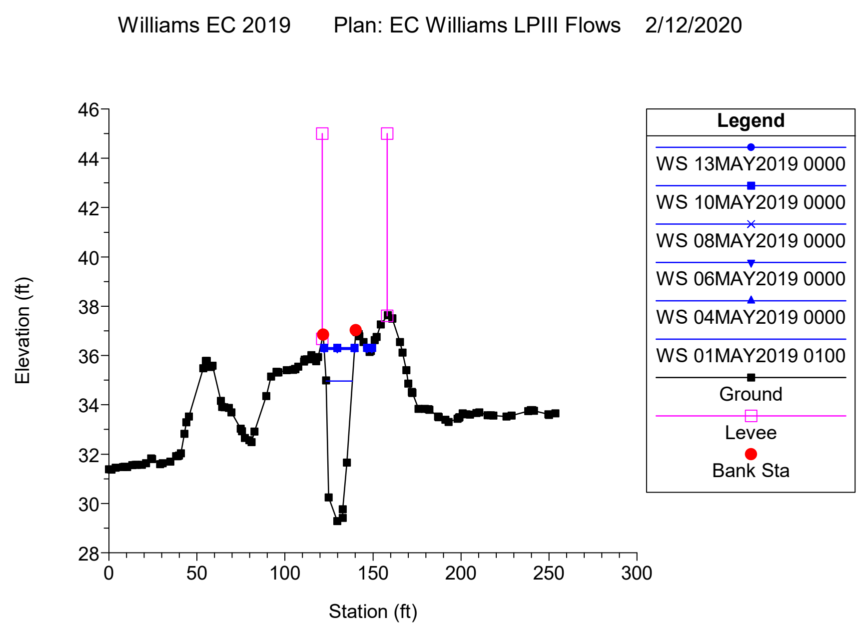
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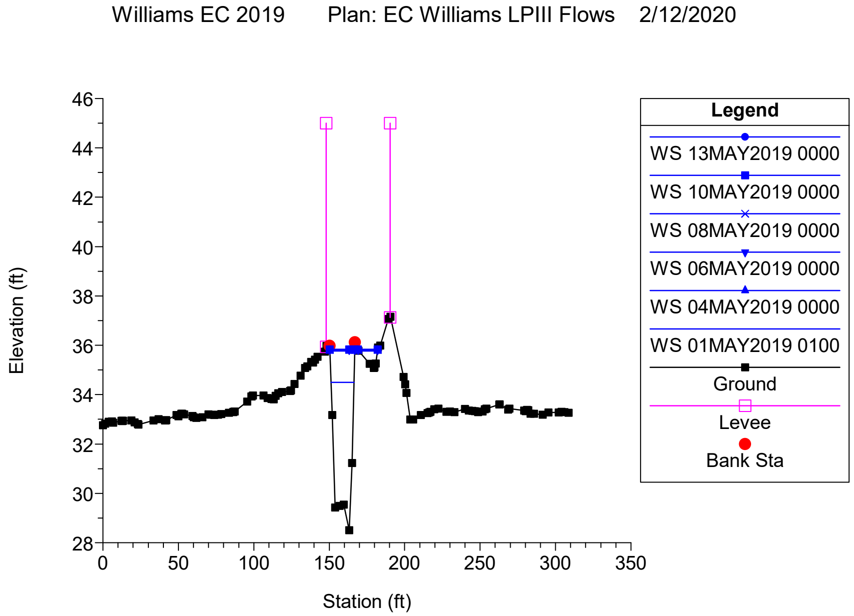
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
28 30 32 34 36 38 40 42 44 46
0 50 100 150 200 250 300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Elevation (ft)
Station (ft)
Legend
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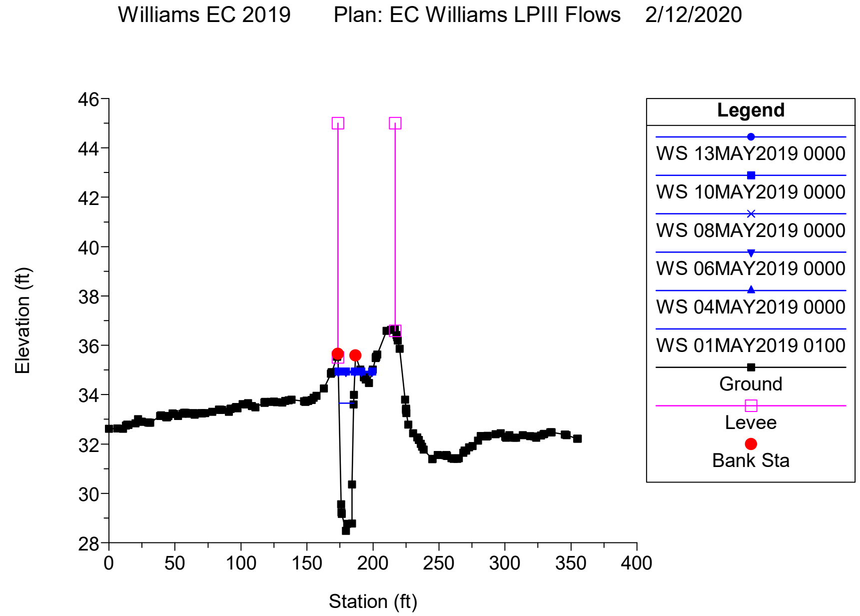
Ground
Levee
Bank Sta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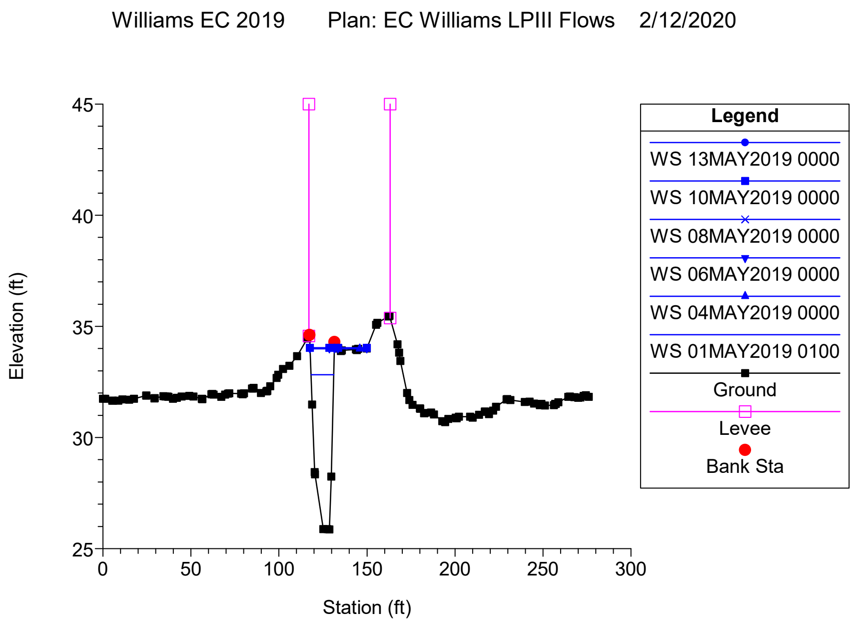
Ground
Levee
Bank Sta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Elevation (ft)
Station (ft)
Legend
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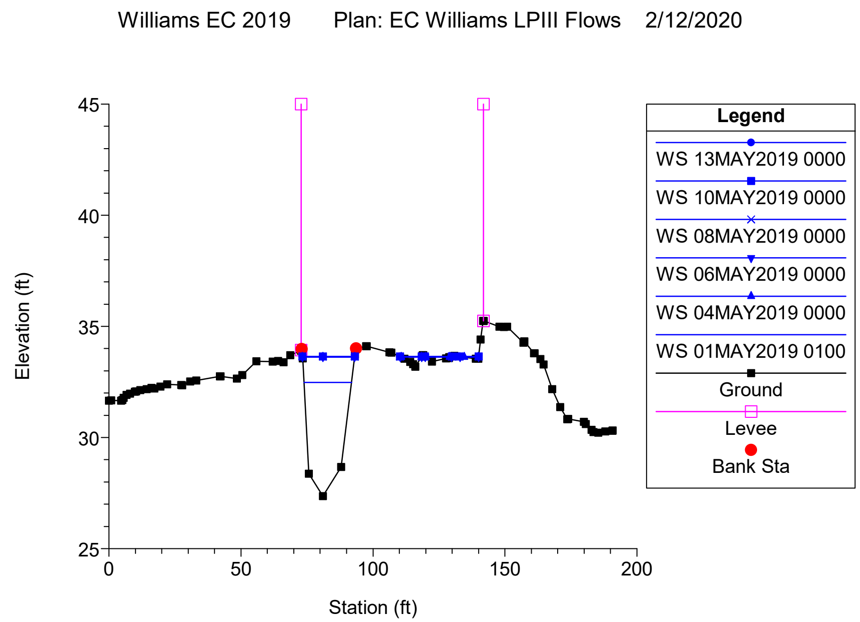
Ground
Levee
Bank Sta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Elevation (ft)
Station (ft)
Legend
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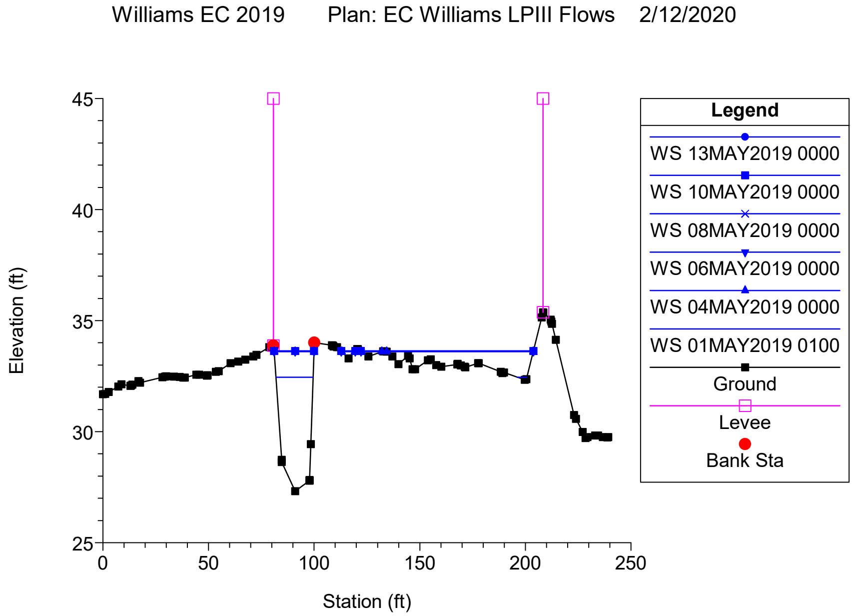
Ground
Levee
Bank Sta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Legend
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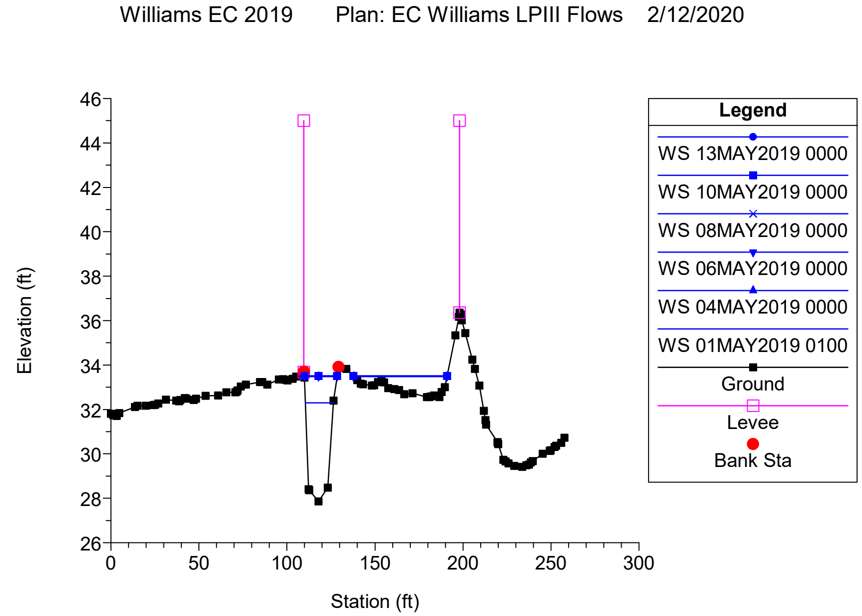
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
25
30
35
40
45
0
50
100
150
200
250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WS 01MAY2019 0100
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
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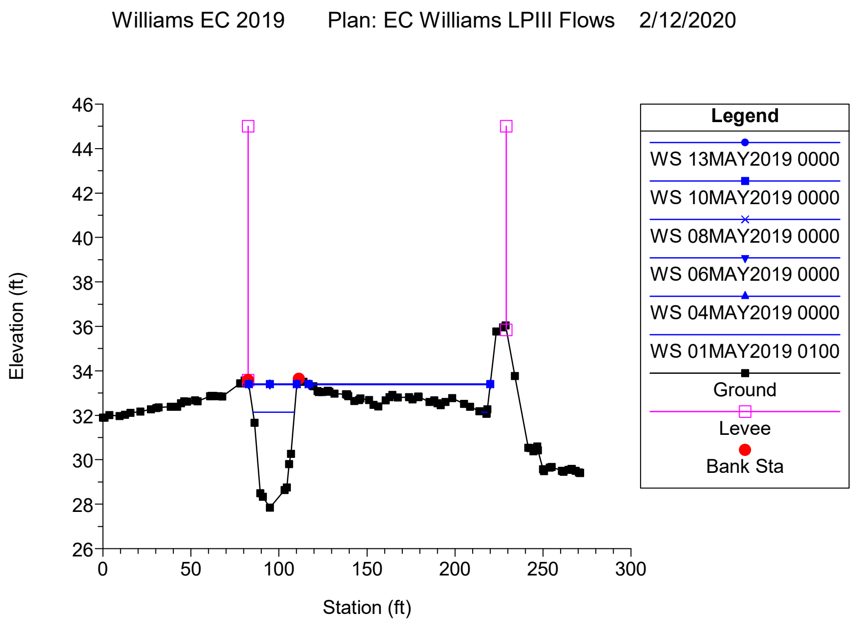
30
32
34
36
38
40
42
44
46
0
50
100
150
200
250
300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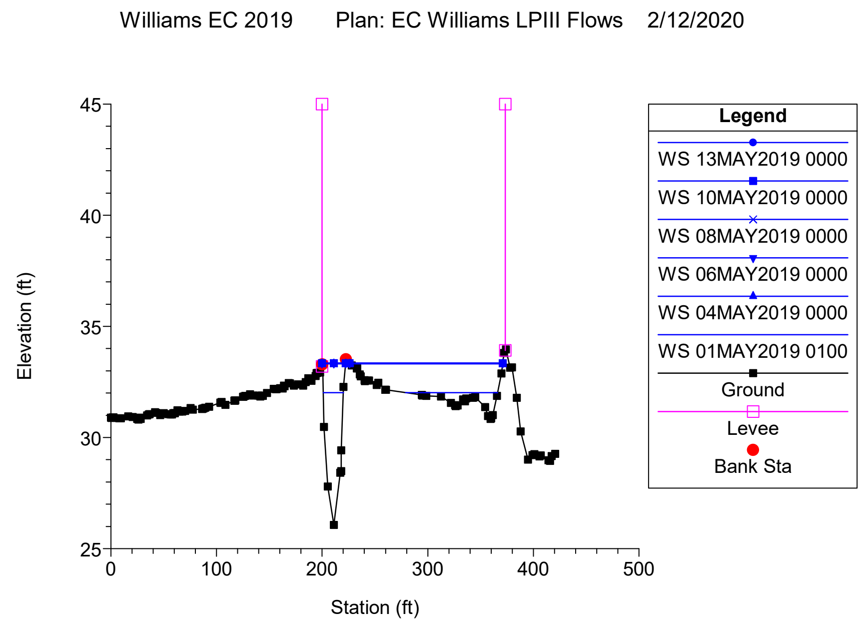
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
26
28
30
32
34
36
38
40
42
44
46
0
50
100
150
200
250
300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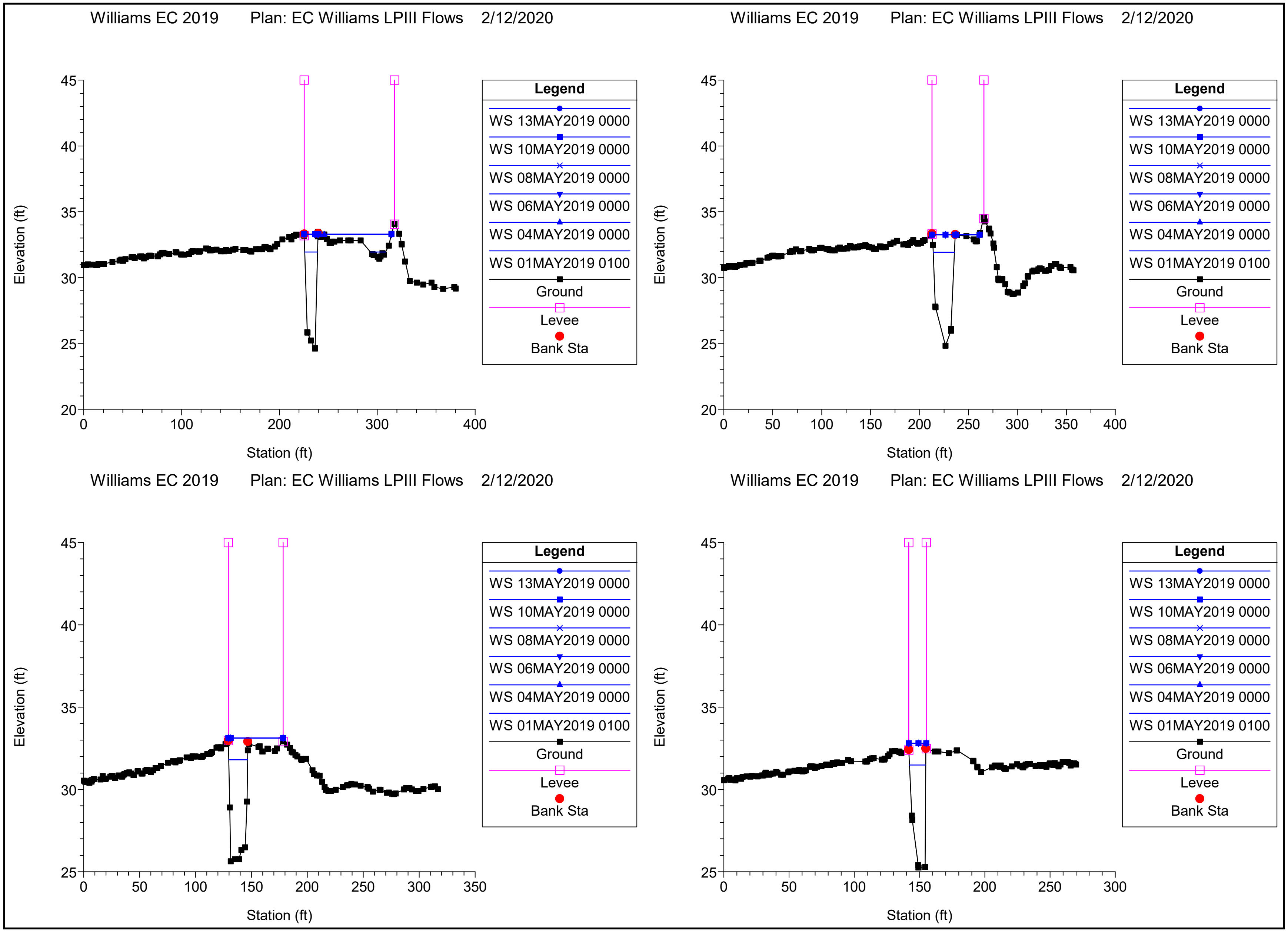
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
25
30
35
40
45
0
100
200
300
400
500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Elevation (ft)
Station (ft)
Legend
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WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta
Williams EC 2019 Plan: EC Williams LPIII Flows 2/12/2020
Elevation (ft)
Station (ft)
Legend
WS 13MAY2019 0000
WS 10MAY2019 0000
WS 08MAY2019 0000
WS 06MAY2019 0000
WS 04MAY2019 0000
WS 01MAY2019 0100
Ground
Levee
Bank Sta

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Hydrologic Solutions
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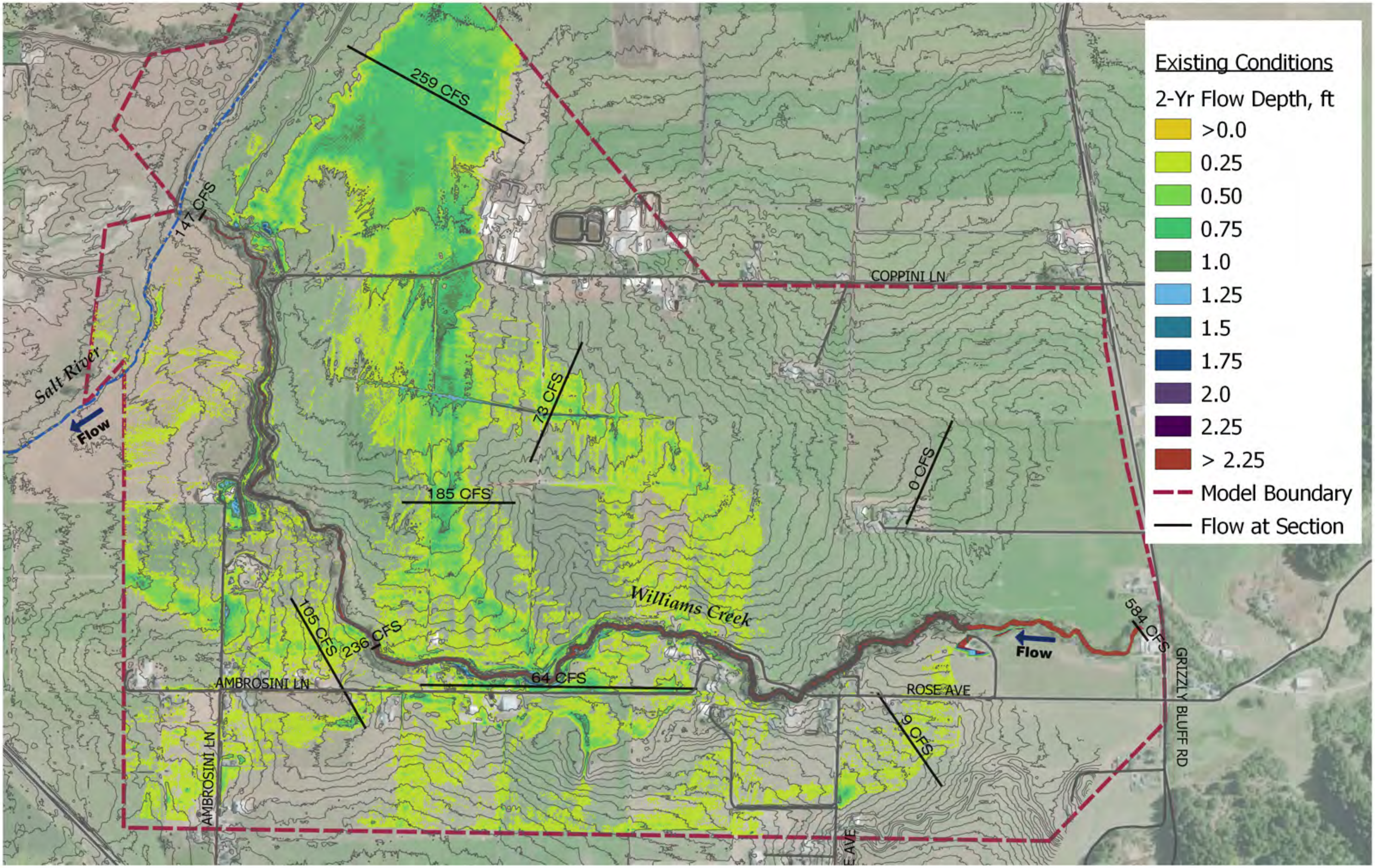
Attachment 5

Existing Condition 2-Dimensional HEC-RAS Hydraulic Modeling Results



0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

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WILLIAMS CREEK
Existing Conditions
2-Year Flow Depth

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\E_COND_Depth.qgz

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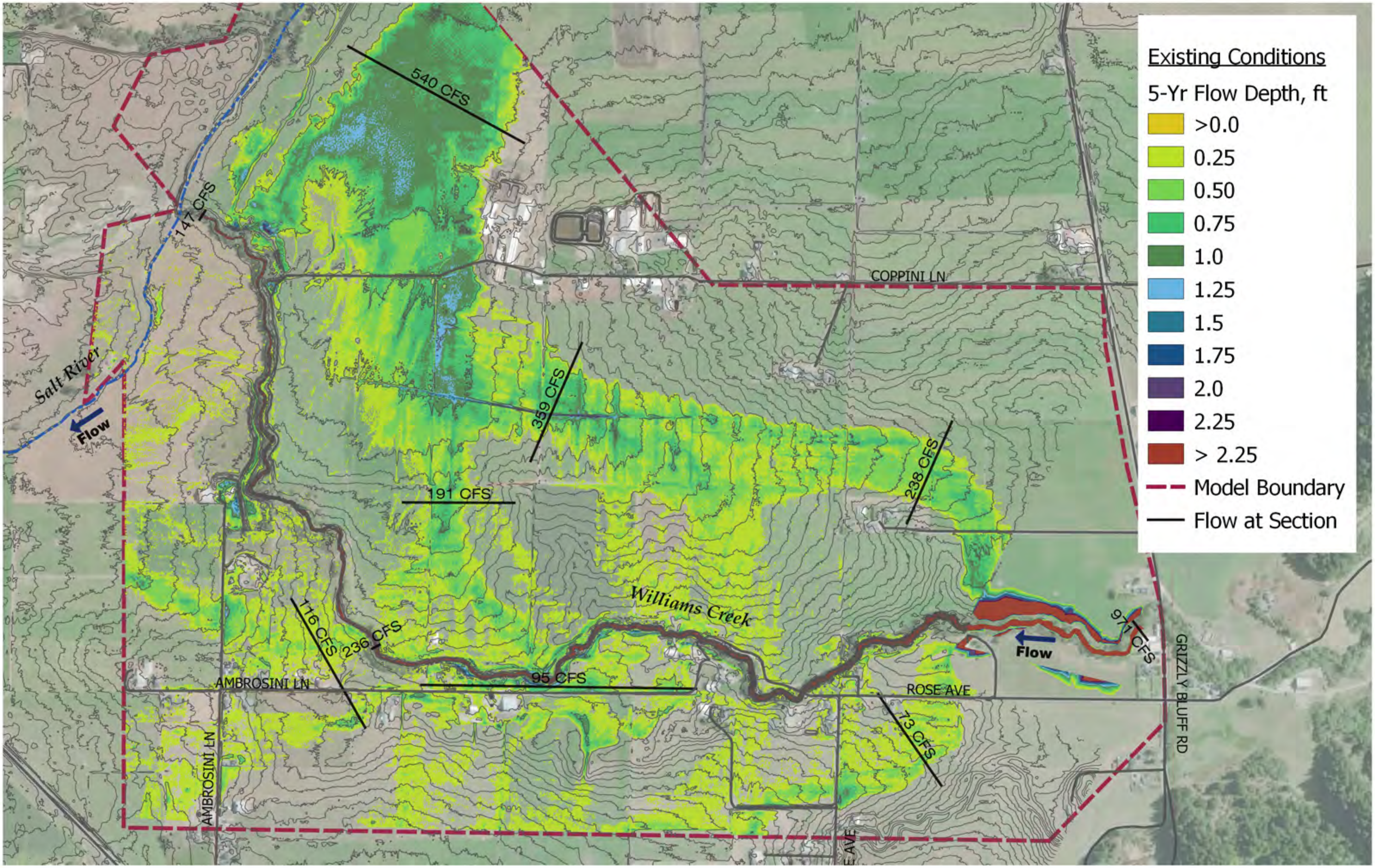


0 750 1500 ft

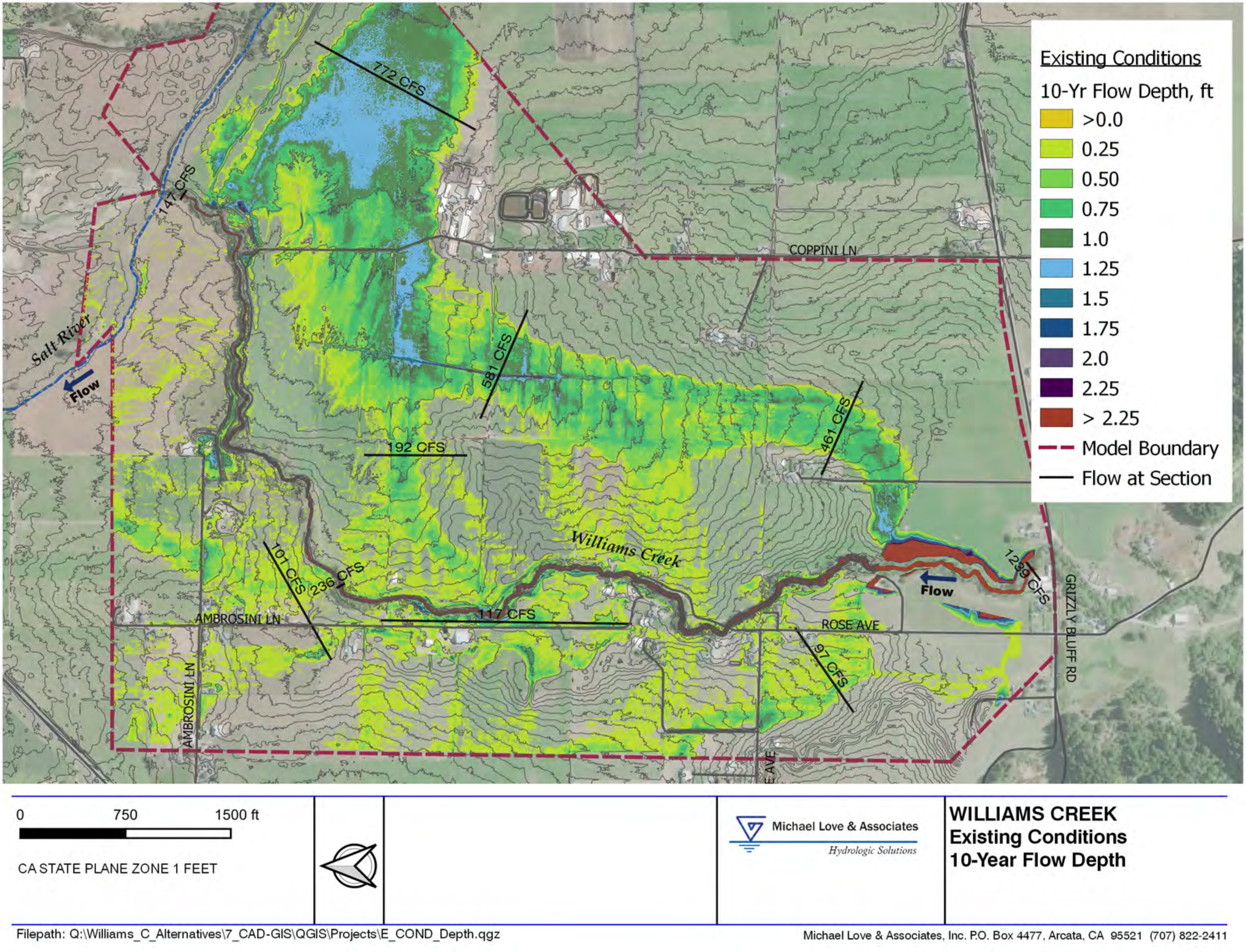
CA STATE PLANE ZONE 1 FEET

Michael Love & Associates
Hydrologic Solutions

WILLIAMS CREEK
Existing Conditions
5-Year Flow Depth

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\E_COND_Depth.qgz

Michael Love & Associates, Inc. P.O. Box 4477, Arcata, CA 95521 (707) 822-2411



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WILLIAMS CREEK
Existing Conditions
10-Year Flow Depth

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\E_COND_Depth.qgz

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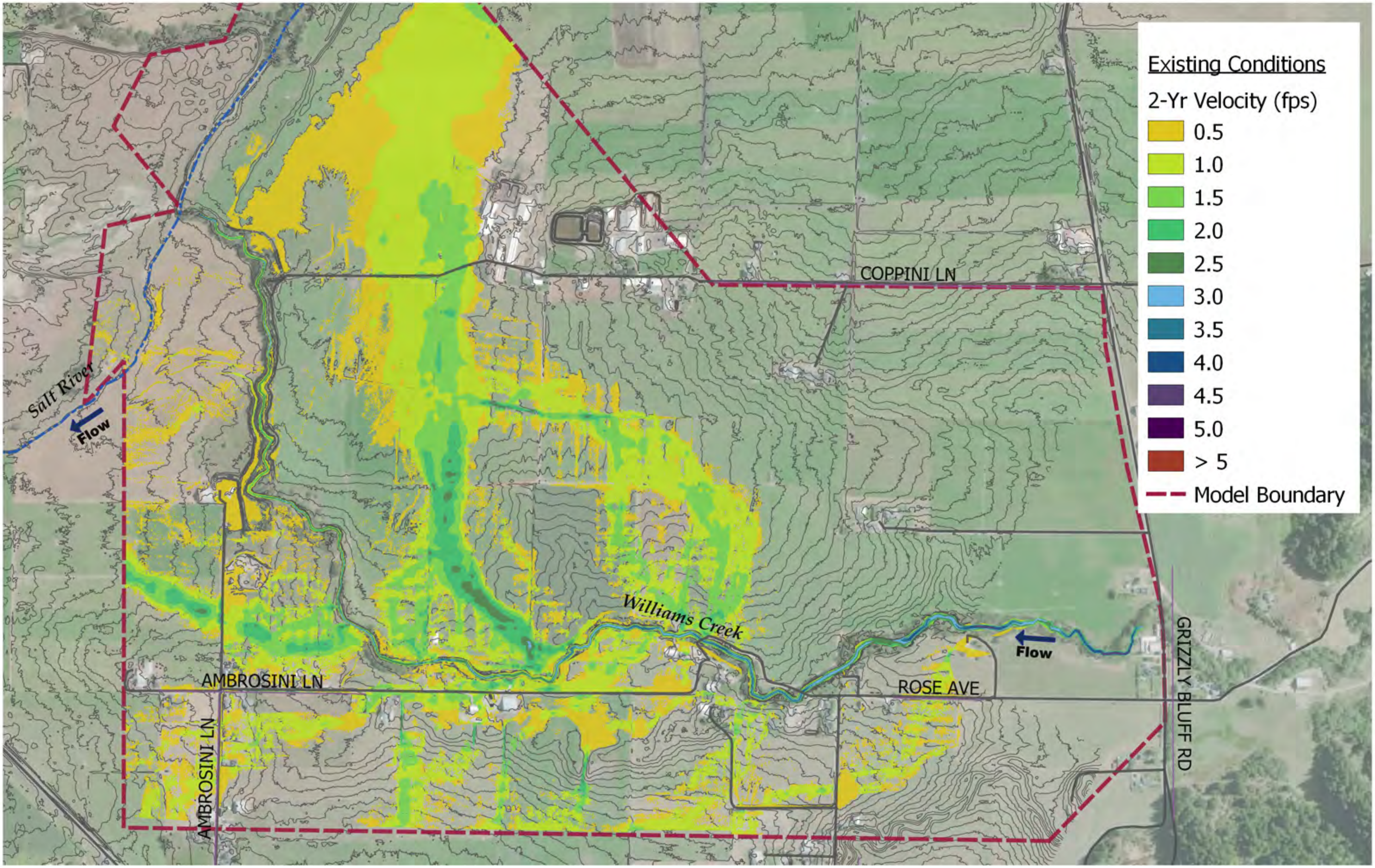


0 750 1500 ft

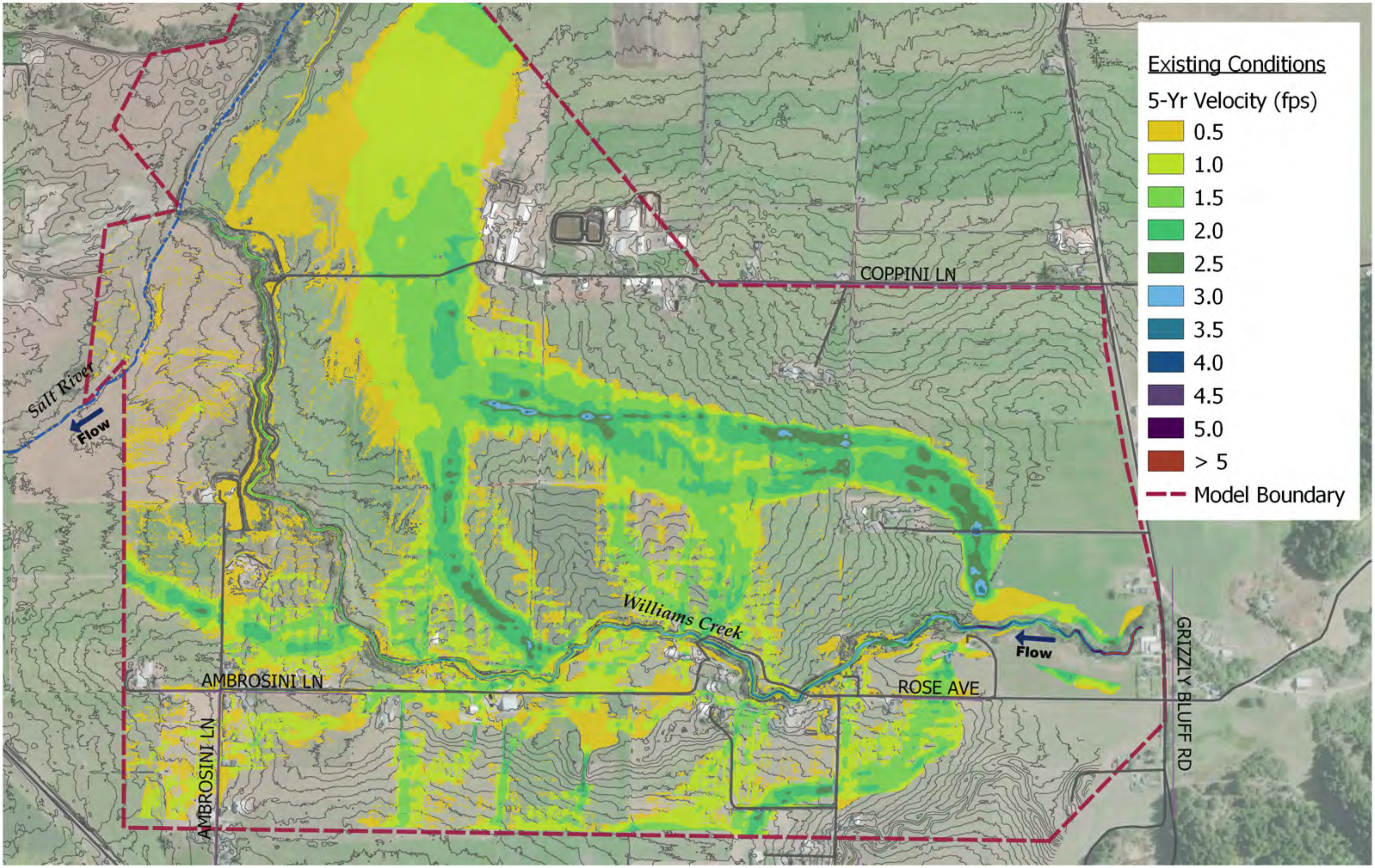
CA STATE PLANE ZONE 1 FEET

Michael Love & Associates
Hydrologic Solutions

WILLIAMS CREEK
Existing Conditions
2-Year Velocity

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\E_COND_Velocity.qgz

Michael Love & Associates, Inc. P.O. Box 4477, Arcata, CA 95521 (707) 822-2411



0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

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WILLIAMS CREEK
Existing Conditions
5-Year Velocity

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\E_COND_Velocity.qgz

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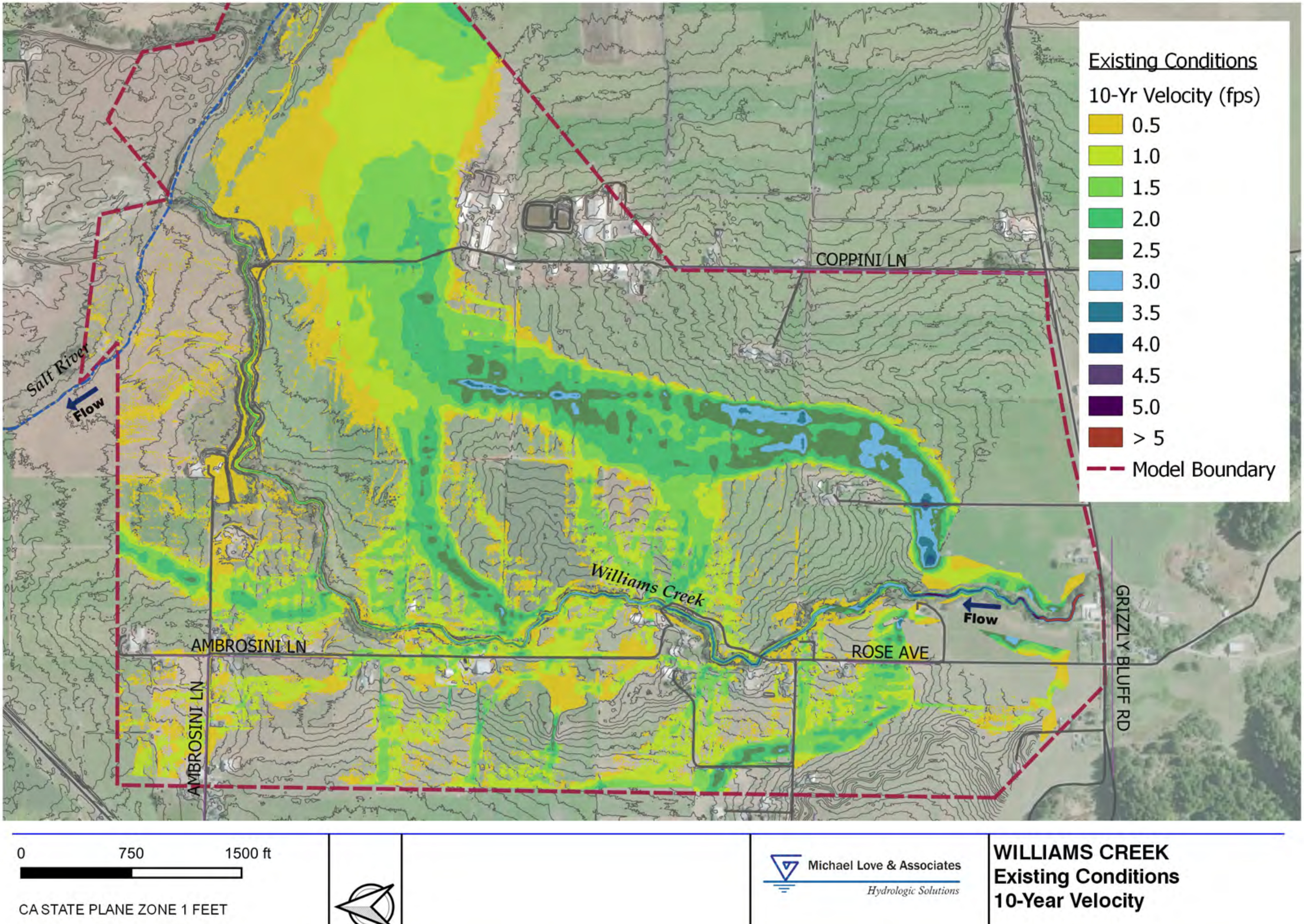

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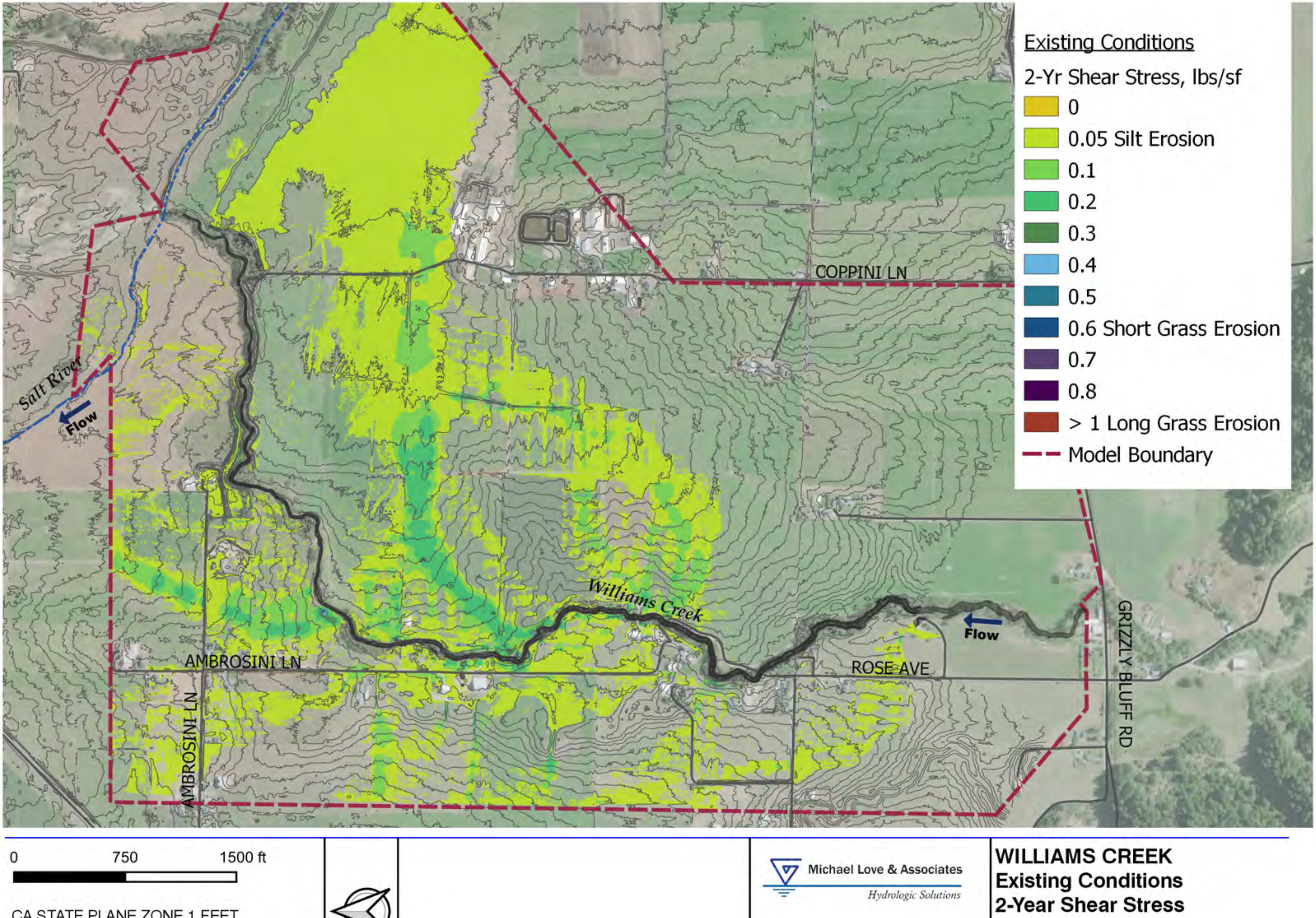
WILLIAMS CREEK
Existing Conditions
10-Year Velocity

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\E_COND_Velocity.qgz

Michael Love & Associates, Inc. P.O. Box 4477, Arcata, CA 95521 (707) 822-2411



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WILLIAMS CREEK
Existing Conditions
2-Year Shear Stress

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\E_COND_Shear.qgz

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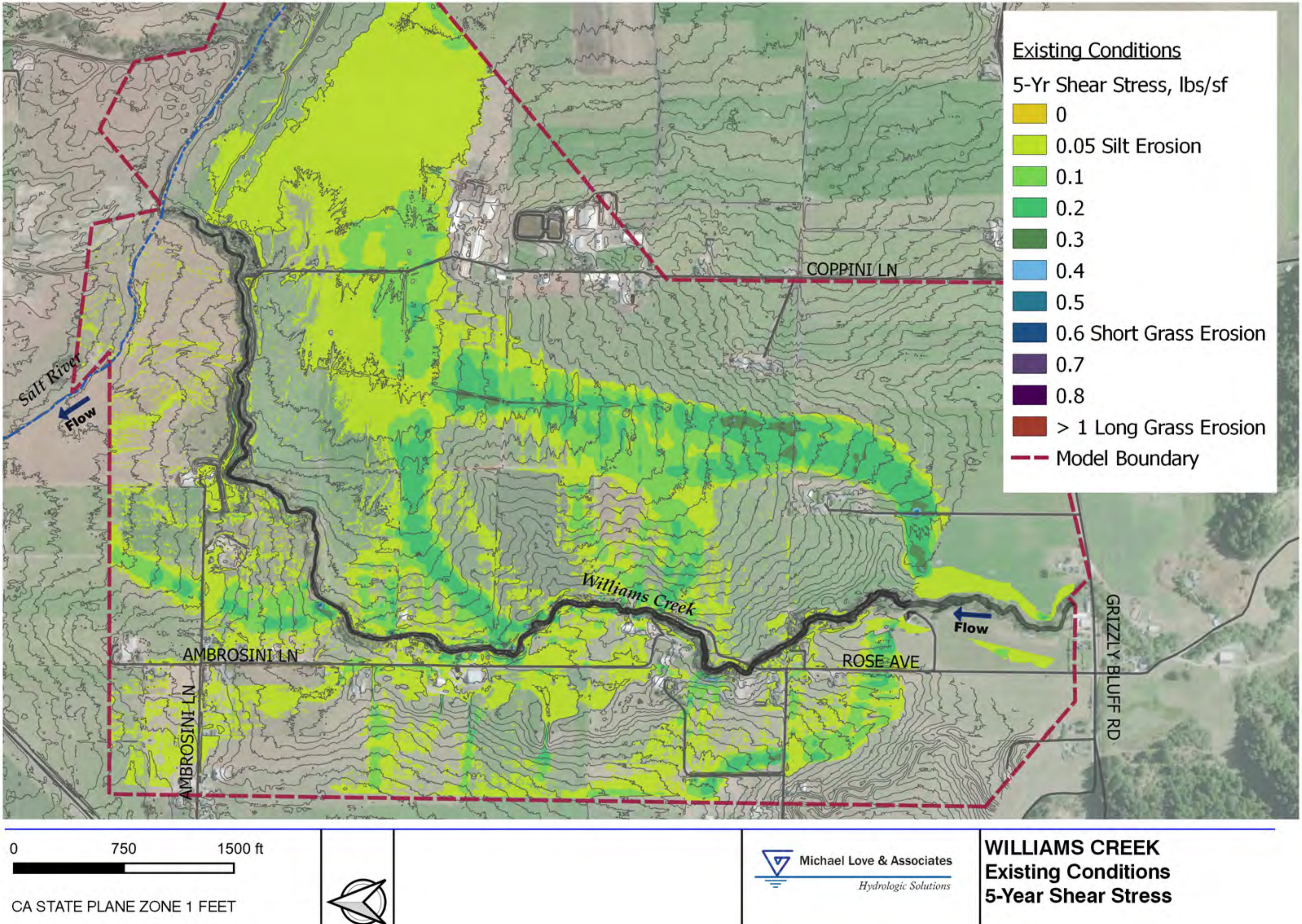

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WILLIAMS CREEK
Existing Conditions
5-Year Shear Stress

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\E_COND_Shear.qgz

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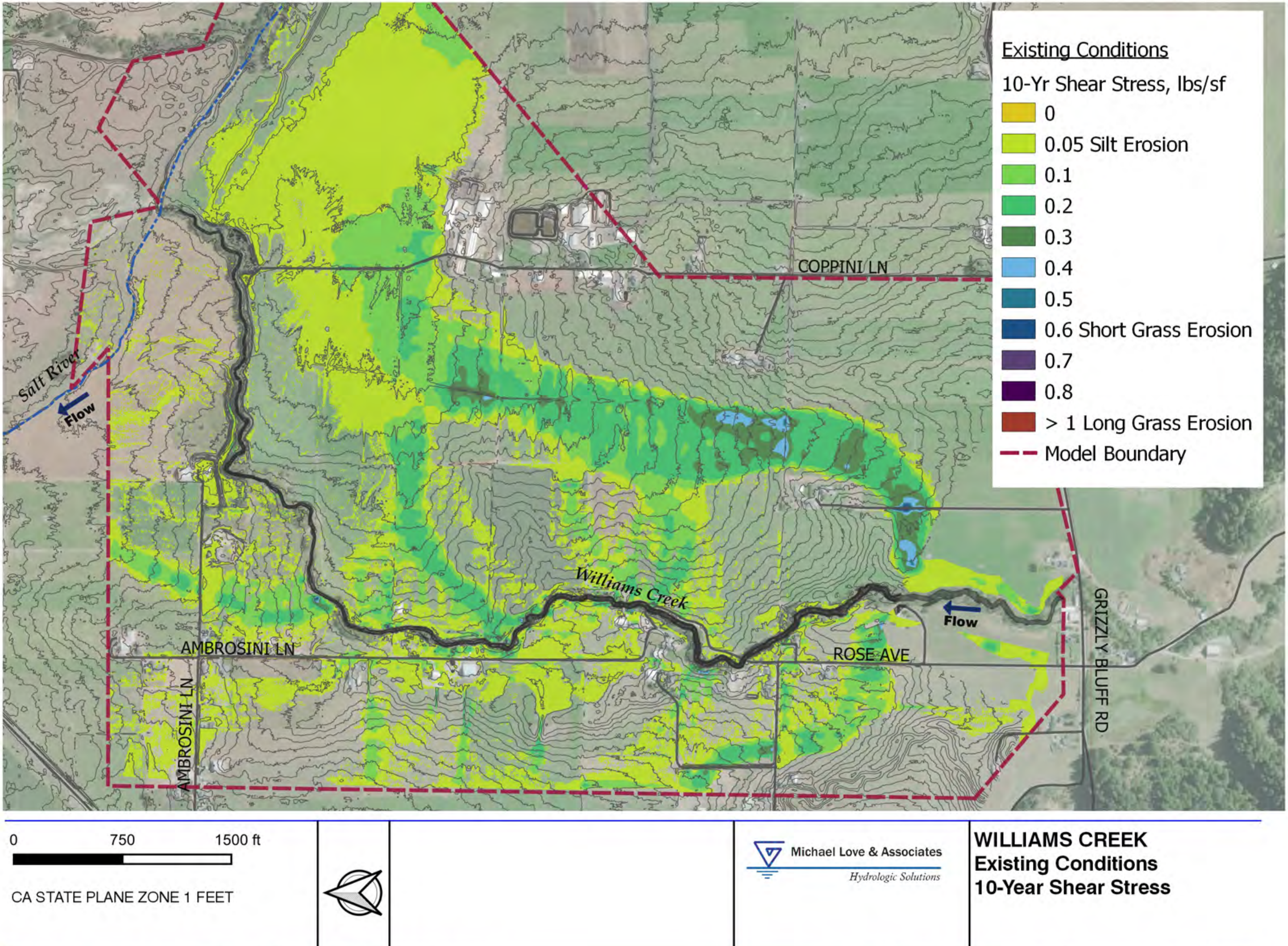

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WILLIAMS CREEK
Existing Conditions
10-Year Shear Stress

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\E_COND_Shear.qgz

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Attachment 6

Ackers-White Sediment Transport Computations for the Salt River

Ackers-White Cross Section Analysis-Salt River Grading Section at Sta. 255+50 D50 =0.09 mm

Cross Section Controls:

S	HEC-RAS Energy Slope	**0.00094**	
τ^*	Shields Parameter	0.035	
WSEL	Water Surface Elevation	16.0	feet

Cross Section Survey

Feature	X_i Station (feet)	Z_i Elevation (feet)	n_i Manning's "n"
Left Overbank	-66.35	16.50	
Left Edge Active Channel	-7.99	15.00	0.050
Left Toe Active Channel	-3.43	11.96	0.035
Thalweg	0.00	11.96	0.035
Right Toe Active Channel	3.50	11.96	0.035
Right Edge Active Channel	8.06	15.00	0.035
Left Berm Top	13.20	17.08	0.090
Right Berm Top	24.50	17.09	0.090
Left Edge Active Bench	32.59	15.08	0.090
TB Secondary Channel	77.14	14.37	0.045
Side Channel Thalweg	80.52	13.52	0.045
Right Edge Secondary Channel	85.22	14.37	0.045
Right Edge Active Bench	215.00	15.16	0.050
Right Overbank	220.90	16.57	0.090

Analysis for Channel

			Units
Q_c	Discharge (computed by subsection)	156.7	ft^3/sec
A_c	Area	71.7	ft^2
d_c	Mean Depth	1.25	ft
Wc	Width	57.4	ft
$Wc_/dc$	Width/Depth ratio	46.0	
d_{max}	Maximum Depth	4.04	ft
R	Mean Hydraulic Radius	1.20	ft
V_c	Mean Velocity	2.19	ft/sec
τ_{oc}	Section Shear Stress	0.07	lbs/ft^2
Fr	Froude	0.34	
D_{crit}	Critical Sediment Size	6	mm
P_c	Wetted Perimeter	59.5	ft
Qsc	Sediment Channel	304.8	lbs/sec
Qsc*	Sediment Discharge Channel	209.3	lbs/sec

Analysis for Total Section:

			Units
Z_0	Thalweg Elevation	11.96	
Q	Discharge (computed by subsection)	420.6	ft^3/sec
A	Area	308.5	ft^2
d	Mean Depth	1.25	ft
W	Width	247.1	ft
$W_/d$	Width/Depth ratio	197.8	
d_{max}	Maximum Depth	4.04	ft
R	Mean Hydraulic Radius	1.24	ft
V	Mean Velocity	1.36	ft/sec
τ_o	Section Shear Stress	0.07	lbs/ft^2
Fr	Froude	0.21	
D_{crit}	Critical Sediment Size	6	mm
P	Wetted Perimeter	249.5	ft
Qs	Sediment Discharge by Subsection	336.2	lbs/sec
Qsc	Sediment Channel	304.8	lbs/sec
Qso	Sediment Active Bench	31.4	lbs/sec
Qs*	Sediment Discharge by Subdivision	234.1	lbs/sec
Qsc*	Sediment Discharge Channel	209.3	lbs/sec
Qso*	Sediment Discharge Overbank	24.7	lbs/sec

Hydraulic Calculations by Channel and Overbanks

Q_{lb}	Discharge Left Bank	14.6	ft^3/sec
Q_c	Discharge Channel	141.5	ft^3/sec
Q_{rb}	Discharge Right Bank	264.5	ft^3/sec
A_{lb}	Area Left Bank	19.5	ft^2
A_c	Area Channel	51.0	ft^2
A_{rb}	Area Right Bank	238.1	ft^2
V_{lb}	Mean Velocity Left Bank	0.8	ft/sec
V_c	Mean Velocity Channel	2.8	ft/sec
V_{rb}	Mean Velocity Right Bank	1.1	ft/sec
P_{lb}	Wetted Perimeter Left Bank	38.9	ft
P_c	Wetted Perimeter Channel	17.9	ft
P_{rb}	Wetted Perimeter Right Bank	192.7	ft
R_{lb}	Hydraulic Radius Left Bank	0.5	ft
R_c	Hydraulic Radius Channel	2.8	ft
R_{rb}	Hydraulic Radius Right Bank	1.2	ft
u^*_{lb}	Shear Velocity Left Bank	0.12	ft/sec
u^*_c	Shear Velocity Channel	0.29	ft/sec
u^*_{rb}	Shear Velocity Right Bank	0.19	ft/sec
$F_{gr(lb)}$	Sediment Mobility Left Bank	0.8	
$F_{gr(c)}$	Sediment Mobility Channel	2.0	
$F_{gr(rb)}$	Sediment Mobility Right Bank	1.2	
$G_{gr(lb)}$	Sediment Transport Left Bank	0.0	
$G_{gr(c)}$	Sediment Transport Channel	13.0	
$G_{gr(rb)}$	Sediment Transport Right Bank	0.5	
X_{lb}	Sediment Concentration Left Bank	0.00	
X_c	Sediment Concentration Channel	0.02	
X_{rb}	Sediment Concentration Right Bank	0.00	
qs_{lb}	Sediment Discharge Left Bank	0.1	lbs/sec
qs_c	Sediment Discharge Channel	209.3	lbs/sec
qs_{rb}	Sediment Discharge Right Bank	24.6	lbs/sec

Bank Stations

X_{lb}	Left Bank	-7.9	ft
X_{rb}	Right Bank	8.1	ft

Ackers White Parameter Values

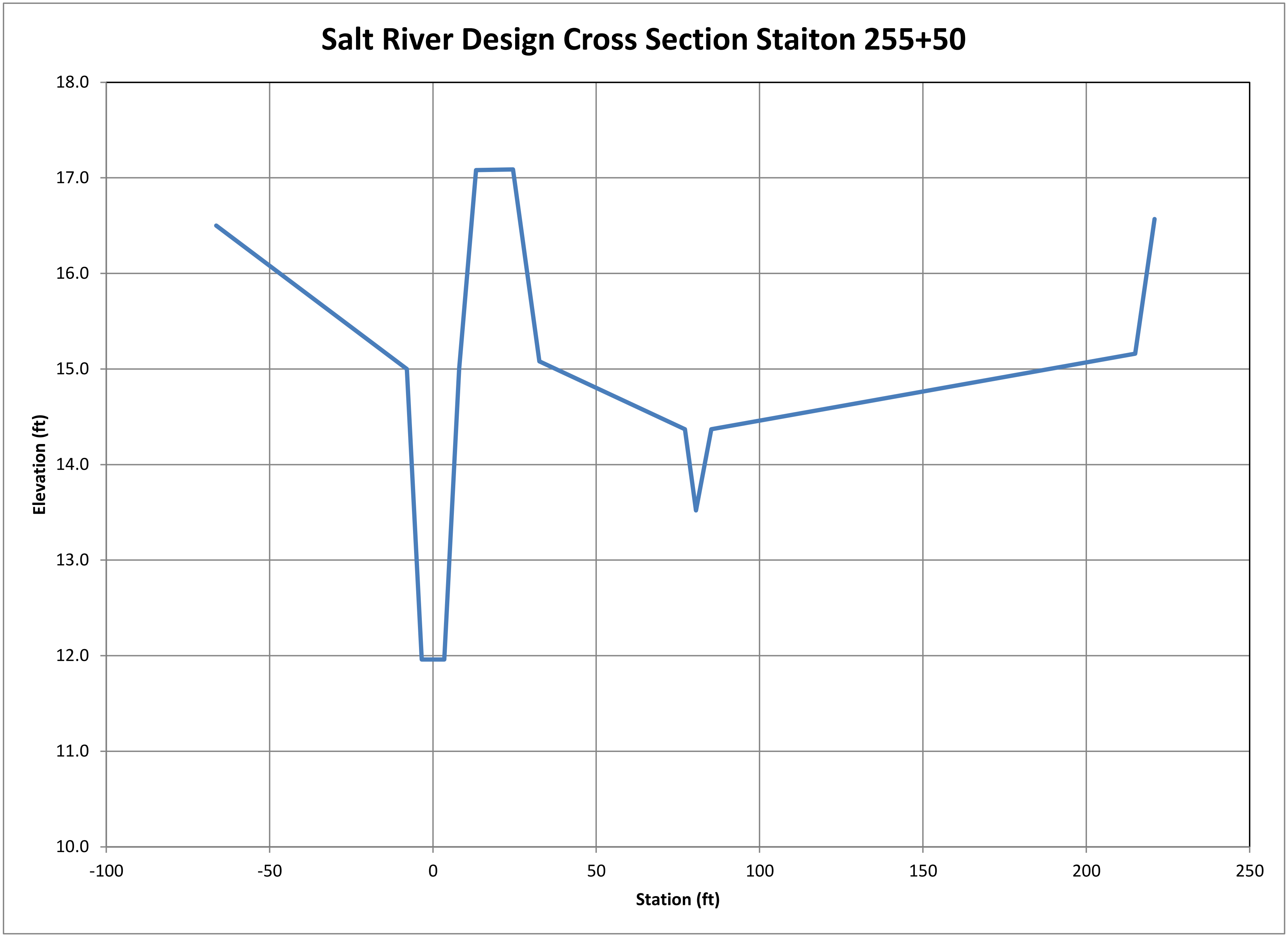
d	Mean Particle Diameter	0.00	feet
g	Gravitational Attraction	32.20	ft/sec^2
d_{gr}	Dimensionless Grain Size	1.90	
m	Ackers White Exponent	5.26	
A	Initial Motion Parameter	0.31	
n	Transitional Parameter	0.84	
C	Coefficient	0.00	

Ackers White Variables

d_{50}	Median particle diameter	**0.090**	mm
S_s	Specific Gravity Sediment	2.65	
ν	Kinematic Viscosity	1.410E-05	ft^2/sec
α	Coefficient for Turbulent Flow	10.0	

Rating Curve Controls:

Z_t	Terminating Elevation	16.5	ft
Z_i	Rating Curve Increment	0.1	ft



Salt River Design Cross Section Staiton 255+50
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
Elevation (ft)
-100
-50
0
50
100
150
200
250
Station (ft)

Ackers-White Cross Section Analysis-Salt River Grading Section at Sta. 255+50 D50 =0.09 mm

Z_i Elevation ft	Q_i Discharge ft^3/sec	A_i Area ft^2	d_i Mean Depth ft	W_i Width ft	W_i/d_i Width/Depth ratio	$d_{max(i)}$ Maximum Depth ft	R_i Mean Hydraulic Radius ft	V_i Mean Velocity ft/sec	t_o Section Shear Stress lbs/ft^2	Fr_i Froude	$D_{crit(i)}$ Critical Sediment Size mm	P_i Wetted Perimeter feet	Qs Sediment Discharge by Subsection lbs/sec	Qs Sediment Discharge Channel lbs/sec	Qsc Sediment Discharge Overbanks lbs/sec	Qso Sediment Discharge by Subdivision lbs/sec	Qsc Sediment Discharge Channel lbs/sec	Qso Sediment Discharge Overbanks lbs/sec	MLA Qso Total Sediment Discharge by Tons/day	MLA Qsc Sediment Discharge Channel Tons/day	MLA Qso Sediment Discharge Overbanks Tons/day
11.960	0.0	0.0	0.00	0.0	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.060	0.2	0.7	0.10	7.2	73.83	0.10	0.097	0.31	0.01	0.17	0.48	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.160	0.7	1.4	0.19	7.5	39.21	0.20	0.189	0.49	0.01	0.20	0.94	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.260	1.4	2.2	0.28	7.8	27.69	0.30	0.276	0.64	0.02	0.21	1.37	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
12.360	2.3	3.0	0.37	8.1	21.94	0.40	0.360	0.77	0.02	0.22	1.78	8.4	0.1	0.1	0.0	0.0	0.0	0.0	0.5	0.5	0.0
12.460	3.4	3.8	0.46	8.4	18.51	0.50	0.440	0.89	0.03	0.23	2.18	8.7	0.1	0.1	0.0	0.0	0.0	0.0	1.5	1.5	0.0
12.560	4.7	4.7	0.54	8.7	16.22	0.60	0.517	0.99	0.03	0.24	2.56	9.1	0.2	0.2	0.0	0.1	0.1	0.0	3.5	3.5	0.0
12.660	6.1	5.6	0.62	9.0	14.60	0.70	0.591	1.09	0.03	0.24	2.93	9.5	0.4	0.4	0.0	0.2	0.2	0.0	7.2	7.2	0.0
12.760	7.7	6.5	0.70	9.3	13.38	0.80	0.663	1.18	0.04	0.25	3.29	9.8	0.6	0.6	0.0	0.3	0.3	0.0	13.1	13.1	0.0
12.860	9.4	7.5	0.77	9.6	12.44	0.90	0.732	1.26	0.04	0.25	3.63	10.2	0.8	0.8	0.0	0.5	0.5	0.0	21.8	21.8	0.0
12.960	11.3	8.4	0.85	9.9	11.70	1.00	0.800	1.34	0.05	0.26	3.97	10.5	1.2	1.2	0.0	0.8	0.8	0.0	34.0	34.0	0.0
13.060	13.3	9.4	0.92	10.2	11.09	1.10	0.866	1.41	0.05	0.26	4.30	10.9	1.8	1.8	0.0	1.2	1.2	0.0	50.5	50.5	0.0
13.160	15.5	10.5	0.99	10.5	10.58	1.20	0.931	1.48	0.05	0.26	4.62	11.3	2.5	2.5	0.0	1.7	1.7	0.0	71.9	71.9	0.0
13.260	17.8	11.5	1.07	10.8	10.16	1.30	0.994	1.54	0.06	0.26	4.93	11.6	3.3	3.3	0.0	2.3	2.3	0.0	99.0	99.0	0.0
13.360	20.3	12.6	1.14	11.1	9.80	1.40	1.055	1.60	0.06	0.27	5.24	12.0	4.4	4.4	0.0	3.1	3.1	0.0	132.5	132.5	0.0
13.460	22.9	13.8	1.20	11.4	9.49	1.50	1.116	1.66	0.07	0.27	5.54	12.3	5.8	5.8	0.0	4.0	4.0	0.0	173.1	173.1	0.0
13.560	25.6	14.9	1.23	12.1	9.82	1.60	1.141	1.71	0.07	0.27	5.66	13.1	7.5	7.5	0.0	5.1	5.1	0.0	221.5	221.5	0.0
13.660	28.5	16.2	1.21	13.4	11.01	1.70	1.124	1.76	0.07	0.28	5.58	14.4	9.5	9.5	0.0	6.4	6.4	0.0	278.5	278.5	0.0
13.760	31.6	17.6	1.21	14.6	12.12	1.80	1.118	1.79	0.07	0.29	5.55	15.8	11.9	11.8	0.0	8.0	8.0	0.0	344.8	344.8	0.0
13.860	34.8	19.1	1.21	15.9	13.15	1.90	1.120	1.82	0.07	0.29	5.56	17.1	14.7	14.7	0.0	9.7	9.7	0.0	421.0	421.0	0.0
13.960	38.3	20.8	1.21	17.1	14.09	2.00	1.128	1.84	0.07	0.29	5.60	18.4	17.9	17.9	0.0	11.8	11.8	0.0	508.0	508.0	0.0
14.060	41.9	22.6	1.23	18.4	14.95	2.10	1.142	1.86	0.07	0.30	5.67	19.8	21.7	21.7	0.0	14.0	14.0	0.0	606.3	606.2	0.0
14.160	45.7	24.5	1.25	19.6	15.73	2.20	1.160	1.87	0.07	0.30	5.75	21.1	26.1	26.1	0.0	16.6	16.6	0.0	716.6	716.5	0.1
14.260	49.7	26.5	1.27	20.9	16.44	2.30	1.181	1.88	0.07	0.29	5.86	22.4	31.1	31.1	0.0	19.4	19.4	0.0	839.6	839.5	0.1
14.360	53.9	28.6	1.29	22.1	17.09	2.40	1.205	1.88	0.07	0.29	5.98	23.7	36.7	36.7	0.0	22.6	22.6	0.0	976.0	975.8	0.2
14.460	58.9	31.8	0.74	42.9	58.02	2.50	0.712	1.85	0.04	0.38	3.53	44.6	43.1	43.1	0.0	26.1	26.1	0.0	1126.1	1126.1	0.0
14.560	65.4	37.2	0.56	65.9	116.82	2.60	0.550	1.76	0.03	0.41	2.73	67.7	50.3	50.3	0.0	29.9	29.9	0.0	1291.0	1290.9	0.1
14.660	73.2	45.0	0.51	88.9	175.93	2.70	0.495	1.63	0.03	0.40	2.46	90.8	58.4	58.3	0.1	34.1	34.1	0.0	1471.2	1471.0	0.2
14.760	82.4	55.0	0.49	111.9	227.81	2.80	0.483	1.50	0.03	0.38	2.40	113.8	67.4	67.2	0.2	38.6	38.6	0.0	1667.4	1666.8	0.5
14.860	92.9	67.4	0.50	135.0	270.37	2.90	0.492	1.38	0.03	0.34	2.44	136.9	77.4	77.1	0.3	43.5	43.5	0.0	1880.3	1879.1	1.2
14.960	104.7	82.0	0.52	158.0	304.25	3.00	0.513	1.28	0.03	0.31	2.54	160.0	88.5	88.0	0.5	48.9	48.8	0.1	2110.6	2108.3	2.4
15.060	118.4	99.0	0.54	183.3	339.17	3.10	0.534	1.20	0.03	0.29	2.65	185.3	101.3	100.6	0.7	56.5	56.4	0.1	2441.7	2437.4	4.2
15.160	135.6	118.5	0.58	205.4	356.04	3.20	0.571	1.14	0.03	0.27	2.83	207.5	116.0	114.9	1.1	66.5	66.3	0.2	2873.7	2865.7	8.1
15.260	159.8	139.3	0.66	210.4	317.70	3.30	0.656	1.15	0.04	0.25	3.25	212.5	132.4	130.6	1.8	78.0	77.5	0.5	3370.1	3348.2	21.9
15.360	186.8	160.6	0.75	215.3	288.73	3.40	0.738	1.16	0.04	0.24	3.66	217.5	150.8	148.0	2.8	91.2	90.0	1.1	3938.1	3889.2	48.9
15.460	216.6	182.4	0.83	220.3	266.09	3.50	0.820	1.19	0.05	0.23	4.07	222.5	171.4	167.1	4.3	106.2	104.0	2.2	4588.9	4493.3	95.6
15.560	249.0	204.6	0.91	225.2	247.92	3.60	0.900	1.22	0.05	0.22	4.46	227.5	194.6	188.0	6.6	123.5	119.6	3.9	5334.7	5164.9	169.8
15.660	283.9	227.4	0.99	230.2	233.03	3.70	0.978	1.25	0.06	0.22	4.85	232.5	220.7	210.9	9.8	143.3	136.8	6.5	6189.1	5908.7	280.4
15.760	321.3	250.7	1.07	235.2	220.60	3.80	1.055	1.28	0.06	0.22	5.24	237.5	250.0	235.8	14.2	165.9	155.8	10.1	7166.6	6729.5	437.1
15.860	361.1	274.4	1.14	240.1	210.09	3.90	1.132	1.32	0.07	0.22	5.61	242.5	283.0	262.9	20.1	191.7	176.7	15.1	8283.1	7632.3	650.8
15.960	403.2	298.7	1.22	245.1	201.08	4.00	1.207	1.35	0.07	0.22	5.99	247.5	320.1	292.3	27.8	221.2	199.6	21.6	9555.0	8622.1	932.9
16.060	447.5	323.4	1.29	250.0	193.28	4.10	1.281	1.38	0.08	0.21	6.36	252.5	361.8	324.2	37.6	254.6	224.6	30.0	11000.1	9704.1	1296.0
16.160	494.1	348.7	1.37	255.0	186.47	4.20	1.354	1.42	0.08	0.21	6.72	257.5	408.5	358.6	49.9	292.5	251.9	40.6	12636.7	10883.7	1753.0
16.260	542.8	374.4	1.44	259.9	180.46	4.30	1.426	1.45	0.08	0.21	7.08	262.5	460.8	395.7	65.2	335.3	281.6	53.7	14484.0	12166.1	2317.8
16.360	593.7	400.7	1.51	264.9	175.14	4.40	1.498	1.48	0.09	0.21	7.43	267.5	519.2	435.6	83.7	383.4	313.8	69.6	16561.8	13557.1	3004.7
16.460	646.7	427.4	1.58	269.9	170.39	4.50	1.568	1.51	0.09	0.21	7.78	272.5	584.4	478.4	105.9	437.3	348.7	88.6	18890.8	15062.2	3828.6

Ackers_White Seciton Analysis - Salt River Grading Section at Sta. 255+50 D50 = 0.18 mm (Williams Full Load)

Cross Section Controls:

S	HEC-RAS Energy Slope	**0.00094**	
τ*	Shields Parameter	0.035	
WSEL	Water Surface Elevation	16.0	feet

Cross Section Survey

Feature	X_i Station (feet)	Z_i Elevation (feet)	n_i Manning's "n"
Left Overbank	-66.35	16.50	
Left Edge Active Channel	-7.99	15.00	0.050
Left Toe Active Channel	-3.43	11.96	0.035
Thalweg	0.00	11.96	0.035
Right Toe Active Channel	3.50	11.96	0.035
Right Edge Active Channel	8.06	15.00	0.035
Left Berm Top	13.20	17.08	0.090
Right Berm Top	24.50	17.09	0.090
Left Edge Active Bench	32.59	15.08	0.090
TB Secondary Channel	77.14	14.37	0.045
Side Channel Thalweg	80.52	13.52	0.045
Right Edge Secondary Channel	85.22	14.37	0.045
Right Edge Active Bench	215.00	15.16	0.050
Right Overbank	220.90	16.57	0.090

Analysis for Channel

			Units
Q_c	Discharge (computed by subsection)	156.7	ft^3/sec
A_c	Area	71.7	ft^2
d_c	Mean Depth	1.25	ft
Wc	Width	57.4	ft
$Wc_/dc$	Width/Depth ratio	46.0	
d_{max}	Maximum Depth	4.04	ft
R	Mean Hydraulic Radius	1.20	ft
V_c	Mean Velocity	2.19	ft/sec
τ_{oc}	Section Shear Stress	0.07	lbs/ft^2
Fr	Froude	0.34	
D_{crit}	Critical Sediment Size	6	mm
P_c	Wetted Perimeter	59.5	ft
Qsc	Sediment Channel	14.2	lbs/sec
Qsc*	Sediment Discharge Channel	12.6	lbs/sec

Analysis for Total Section:

			Units
Z_0	Thalweg Elevation	11.96	
Q	Discharge (computed by subsection)	420.6	ft^3/sec
A	Area	308.5	ft^2
d	Mean Depth	1.25	ft
W	Width	247.1	ft
$W_/d$	Width/Depth ratio	197.8	
d_{max}	Maximum Depth	4.04	ft
R	Mean Hydraulic Radius	1.24	ft
V	Mean Velocity	1.36	ft/sec
τ_o	Section Shear Stress	0.07	lbs/ft^2
Fr	Froude	0.21	
D_{crit}	Critical Sediment Size	6	mm
P	Wetted Perimeter	249.5	ft
Qs	Sediment Discharge by Subsection	17.2	lbs/sec
Qsc	Sediment Channel	14.2	lbs/sec
Qso	Sediment Active Bench	3.0	lbs/sec
Qs*	Sediment Discharge by Subdivision	15.2	lbs/sec
Qsc*	Sediment Discharge Channel	12.6	lbs/sec
Qso*	Sediment Discharge Overbank	2.6	lbs/sec

Hydraulic Calculations by Channel and Overbanks

Q_{lb}	Discharge Left Bank	14.6	ft^3/sec
Q_c	Discharge Channel	141.5	ft^3/sec
Q_{rb}	Discharge Right Bank	264.5	ft^3/sec
A_{lb}	Area Left Bank	19.5	ft^2
A_c	Area Channel	51.0	ft^2
A_{rb}	Area Right Bank	238.1	ft^2
V_{lb}	Mean Velocity Left Bank	0.8	ft/sec
V_c	Mean Velocity Channel	2.8	ft/sec
V_{rb}	Mean Velocity Right Bank	1.1	ft/sec
P_{lb}	Wetted Perimeter Left Bank	38.9	ft
P_c	Wetted Perimeter Channel	17.9	ft
P_{rb}	Wetted Perimeter Right Bank	192.7	ft
R_{lb}	Hydraulic Radius Left Bank	0.5	ft
R_c	Hydraulic Radius Channel	2.8	ft
R_{rb}	Hydraulic Radius Right Bank	1.2	ft
u^*_{lb}	Shear Velocity Left Bank	0.12	ft/sec
u^*_c	Shear Velocity Channel	0.29	ft/sec
u^*_{rb}	Shear Velocity Right Bank	0.19	ft/sec
$F_{gr(lb)}$	Sediment Mobility Left Bank	0.5	
$F_{gr(c)}$	Sediment Mobility Channel	1.2	
$F_{gr(rb)}$	Sediment Mobility Right Bank	0.7	
$G_{gr(lb)}$	Sediment Transport Left Bank	0.0	
$G_{gr(c)}$	Sediment Transport Channel	0.6	
$G_{gr(rb)}$	Sediment Transport Right Bank	0.0	
X_{lb}	Sediment Concentration Left Bank	0.00	
X_c	Sediment Concentration Channel	0.00	
X_{rb}	Sediment Concentration Right Bank	0.00	
qs_{lb}	Sediment Discharge Left Bank	0.0	lbs/sec
qs_c	Sediment Discharge Channel	12.6	lbs/sec
qs_{rb}	Sediment Discharge Right Bank	2.6	lbs/sec

Bank Stations

X_{lb}	Left Bank	-7.9	ft
X_{rb}	Right Bank	8.1	ft

Ackers White Parameter Values (Wallingford, 1990)

d	Mean Particle Diameter	0.00059	feet
g	Gravitational Attraction	32.20	ft/sec^2
d_{gr}	Dimensionless Grain Size	3.80	
m	Ackers White Exponent	3.47	
A	Initial Motion Parameter	0.26	
n	Transitional Parameter	0.68	
C	Coefficient	0.01	

Ackers White Variables

d_{50}	Median particle diameter	**0.180**	mm
S_s	Specific Gravity Sediment	2.65	
ν	Kinematic Viscosity	1.410E-05	ft^2/sec
α	Coefficient for Turbulent Flow	10.0	

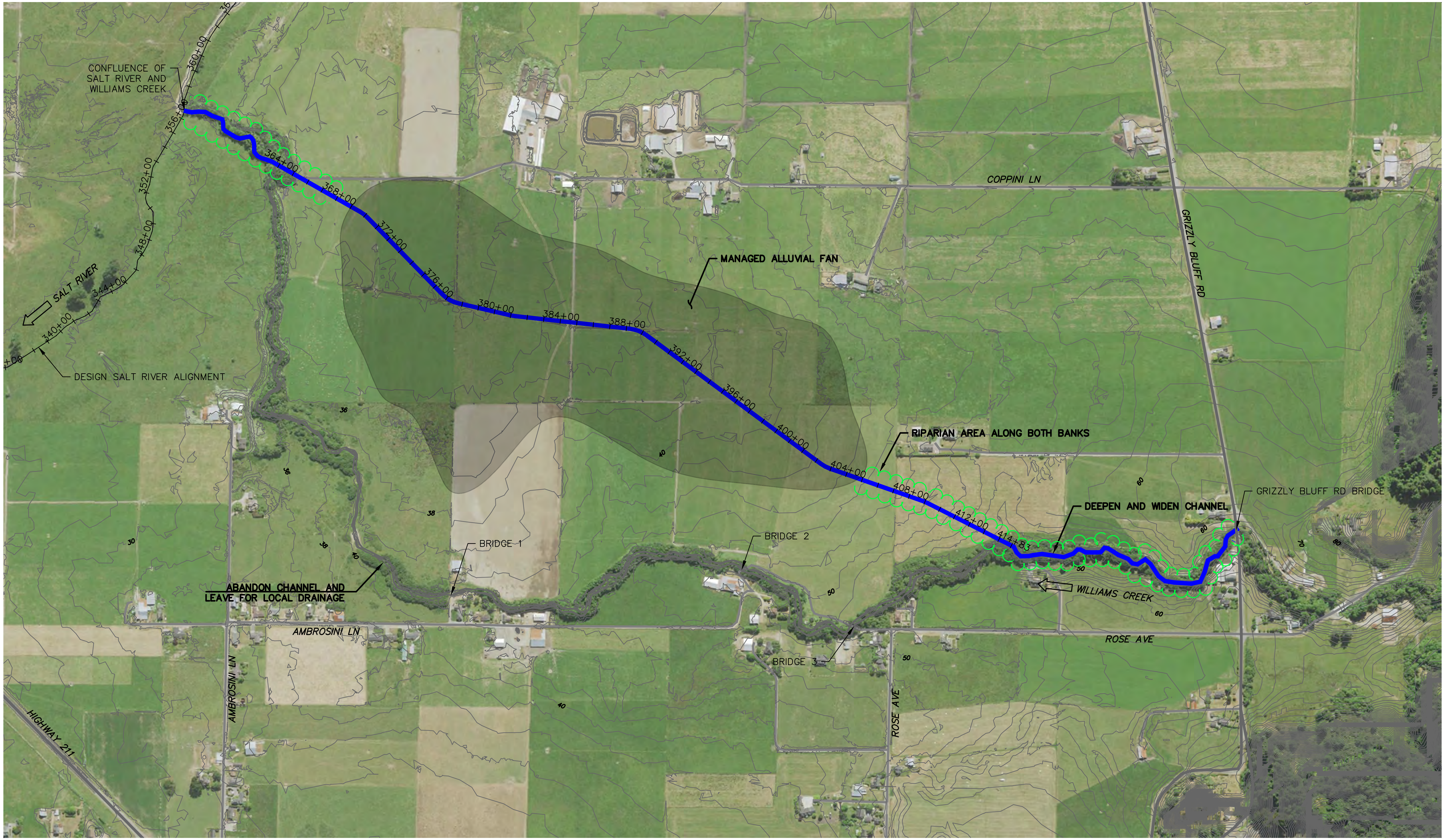
Rating Curve Controls:

Z_t	Terminating Elevation	16.5	ft
Z_i	Rating Curve Increment	0.1	ft

Ackers_White Seciton Analysis - Salt River Grading Section at Sta. 255+50 D50 = 0.18 mm (Williams Full Load)

Z_i Elevation ft	Q_i Discharge ft^3/sec	A_i Area ft^2	d_i Mean Depth ft	W_i Width ft	W_i/d_i Width/Depth ratio	$d_{max(i)}$ Maximum Depth ft	R_i Mean Hydraulic Radius ft	V_i Mean Velocity ft/sec	t_o Section Shear Stress lbs/ft^2	Fr_i Froude	$D_{crit(i)}$ Critical Sediment Size mm	P_i Wetted Perimeter feet	Qs Sediment Discharge by Subsection lbs/sec	Qs Sediment Discharge Channel lbs/sec	Qsc Sediment Discharge Overbanks lbs/sec	Qso Sediment Discharge by Subdivision lbs/sec	Qsc Sediment Discharge Channel lbs/sec	Qso Sediment Discharge Overbanks lbs/sec	MLA Qso Total Sediment Discharge by Tons/day	MLA Qsc Sediment Discharge Channel Tons/day	MLA Qso Sediment Discharge Overbanks Tons/day
11.960	0.0	0.0	0.00	0.0	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.060	0.2	0.7	0.10	7.2	73.83	0.10	0.097	0.31	0.01	0.17	0.48	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.160	0.7	1.4	0.19	7.5	39.21	0.20	0.189	0.49	0.01	0.20	0.94	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.260	1.4	2.2	0.28	7.8	27.69	0.30	0.276	0.64	0.02	0.21	1.37	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.360	2.3	3.0	0.37	8.1	21.94	0.40	0.360	0.77	0.02	0.22	1.78	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
12.460	3.4	3.8	0.46	8.4	18.51	0.50	0.440	0.89	0.03	0.23	2.18	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.0
12.560	4.7	4.7	0.54	8.7	16.22	0.60	0.517	0.99	0.03	0.24	2.56	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0
12.660	6.1	5.6	0.62	9.0	14.60	0.70	0.591	1.09	0.03	0.24	2.93	9.5	0.1	0.1	0.0	0.0	0.0	0.0	1.7	1.7	0.0
12.760	7.7	6.5	0.70	9.3	13.38	0.80	0.663	1.18	0.04	0.25	3.29	9.8	0.1	0.1	0.0	0.1	0.1	0.0	2.8	2.8	0.0
12.860	9.4	7.5	0.77	9.6	12.44	0.90	0.732	1.26	0.04	0.25	3.63	10.2	0.1	0.1	0.0	0.1	0.1	0.0	4.4	4.4	0.0
12.960	11.3	8.4	0.85	9.9	11.70	1.00	0.800	1.34	0.05	0.26	3.97	10.5	0.2	0.2	0.0	0.1	0.1	0.0	6.4	6.4	0.0
13.060	13.3	9.4	0.92	10.2	11.09	1.10	0.866	1.41	0.05	0.26	4.30	10.9	0.2	0.2	0.0	0.2	0.2	0.0	9.0	9.0	0.0
13.160	15.5	10.5	0.99	10.5	10.58	1.20	0.931	1.48	0.05	0.26	4.62	11.3	0.3	0.3	0.0	0.3	0.3	0.0	12.0	12.0	0.0
13.260	17.8	11.5	1.07	10.8	10.16	1.30	0.994	1.54	0.06	0.26	4.93	11.6	0.4	0.4	0.0	0.4	0.4	0.0	15.7	15.7	0.0
13.360	20.3	12.6	1.14	11.1	9.80	1.40	1.055	1.60	0.06	0.27	5.24	12.0	0.5	0.5	0.0	0.5	0.5	0.0	19.9	19.9	0.0
13.460	22.9	13.8	1.20	11.4	9.49	1.50	1.116	1.66	0.07	0.27	5.54	12.3	0.6	0.6	0.0	0.6	0.6	0.0	24.8	24.8	0.0
13.560	25.6	14.9	1.23	12.1	9.82	1.60	1.141	1.71	0.07	0.27	5.66	13.1	0.8	0.8	0.0	0.7	0.7	0.0	30.3	30.3	0.0
13.660	28.5	16.2	1.21	13.4	11.01	1.70	1.124	1.76	0.07	0.28	5.58	14.4	0.9	0.9	0.0	0.8	0.8	0.0	36.5	36.5	0.0
13.760	31.6	17.6	1.21	14.6	12.12	1.80	1.118	1.79	0.07	0.29	5.55	15.8	1.1	1.1	0.0	1.0	1.0	0.0	43.3	43.3	0.0
13.860	34.8	19.1	1.21	15.9	13.15	1.90	1.120	1.82	0.07	0.29	5.56	17.1	1.3	1.3	0.0	1.2	1.2	0.0	50.9	50.9	0.0
13.960	38.3	20.8	1.21	17.1	14.09	2.00	1.128	1.84	0.07	0.29	5.60	18.4	1.5	1.5	0.0	1.4	1.4	0.0	59.2	59.2	0.0
14.060	41.9	22.6	1.23	18.4	14.95	2.10	1.142	1.86	0.07	0.30	5.67	19.8	1.8	1.8	0.0	1.6	1.6	0.0	68.1	68.1	0.0
14.160	45.7	24.5	1.25	19.6	15.73	2.20	1.160	1.87	0.07	0.30	5.75	21.1	2.0	2.0	0.0	1.8	1.8	0.0	77.9	77.9	0.0
14.260	49.7	26.5	1.27	20.9	16.44	2.30	1.181	1.88	0.07	0.29	5.86	22.4	2.3	2.3	0.0	2.0	2.0	0.0	88.3	88.3	0.0
14.360	53.9	28.6	1.29	22.1	17.09	2.40	1.205	1.88	0.07	0.29	5.98	23.7	2.6	2.6	0.0	2.3	2.3	0.0	99.5	99.5	0.0
14.460	58.9	31.8	0.74	42.9	58.02	2.50	0.712	1.85	0.04	0.38	3.53	44.6	3.0	3.0	0.0	2.6	2.6	0.0	111.4	111.4	0.0
14.560	65.4	37.2	0.56	65.9	116.82	2.60	0.550	1.76	0.03	0.41	2.73	67.7	3.4	3.4	0.0	2.9	2.9	0.0	124.0	124.0	0.0
14.660	73.2	45.0	0.51	88.9	175.93	2.70	0.495	1.63	0.03	0.40	2.46	90.8	3.8	3.8	0.0	3.2	3.2	0.0	137.5	137.4	0.1
14.760	82.4	55.0	0.49	111.9	227.81	2.80	0.483	1.50	0.03	0.38	2.40	113.8	4.2	4.2	0.0	3.5	3.5	0.0	151.7	151.5	0.1
14.860	92.9	67.4	0.50	135.0	270.37	2.90	0.492	1.38	0.03	0.34	2.44	136.9	4.7	4.7	0.0	3.9	3.9	0.0	166.7	166.4	0.3
14.960	104.7	82.0	0.52	158.0	304.25	3.00	0.513	1.28	0.03	0.31	2.54	160.0	5.3	5.2	0.1	4.2	4.2	0.0	182.5	182.0	0.5
15.060	118.4	99.0	0.54	183.3	339.17	3.10	0.534	1.20	0.03	0.29	2.65	185.3	5.9	5.8	0.1	4.7	4.7	0.0	203.9	203.1	0.8
15.160	135.6	118.5	0.58	205.4	356.04	3.20	0.571	1.14	0.03	0.27	2.83	207.5	6.6	6.4	0.1	5.3	5.3	0.0	230.6	229.2	1.4
15.260	159.8	139.3	0.66	210.4	317.70	3.30	0.656	1.15	0.04	0.25	3.25	212.5	7.4	7.2	0.2	6.0	6.0	0.1	261.1	257.5	3.6
15.360	186.8	160.6	0.75	215.3	288.73	3.40	0.738	1.16	0.04	0.24	3.66	217.5	8.2	7.9	0.3	6.8	6.7	0.2	295.7	288.1	7.6
15.460	216.6	182.4	0.83	220.3	266.09	3.50	0.820	1.19	0.05	0.23	4.07	222.5	9.2	8.7	0.5	7.8	7.4	0.3	335.1	321.1	14.0
15.560	249.0	204.6	0.91	225.2	247.92	3.60	0.900	1.22	0.05	0.22	4.46	227.5	10.4	9.6	0.7	8.8	8.3	0.5	379.9	356.5	23.3
15.660	283.9	227.4	0.99	230.2	233.03	3.70	0.978	1.25	0.06	0.22	4.85	232.5	11.6	10.6	1.0	10.0	9.1	0.8	430.6	394.5	36.1
15.760	321.3	250.7	1.07	235.2	220.60	3.80	1.055	1.28	0.06	0.22	5.24	237.5	13.0	11.6	1.5	11.3	10.1	1.2	488.0	435.1	52.8
15.860	361.1	274.4	1.14	240.1	210.09	3.90	1.132	1.32	0.07	0.22	5.61	242.5	14.6	12.6	2.0	12.8	11.1	1.7	552.5	478.5	74.1
15.960	403.2	298.7	1.22	245.1	201.08	4.00	1.207	1.35	0.07	0.22	5.99	247.5	16.4	13.8	2.7	14.5	12.1	2.3	624.8	524.6	100.3
16.060	447.5	323.4	1.29	250.0	193.28	4.10	1.281	1.38	0.08	0.21	6.36	252.5	18.4	15.0	3.4	16.3	13.3	3.1	705.5	573.5	131.9
16.160	494.1	348.7	1.37	255.0	186.47	4.20	1.354	1.42	0.08	0.21	6.72	257.5	20.6	16.2	4.4	18.4	14.5	3.9	794.9	625.4	169.5
16.260	542.8	374.4	1.44	259.9	180.46	4.30	1.426	1.45	0.08	0.21	7.08	262.5	23.0	17.6	5.5	20.7	15.7	4.9	893.7	680.4	213.3
16.360	593.7	400.7	1.51	264.9	175.14	4.40	1.498	1.48	0.09	0.21	7.43	267.5	25.7	19.0	6.7	23.2	17.1	6.1	1002.3	738.4	264.0
16.460	646.7	427.4	1.58	269.9	170.39	4.50	1.568	1.51	0.09	0.21	7.78	272.5	28.7	20.5	8.2	26.0	18.5	7.4	1121.3	799.6	321.7

Appendix D
Plan and Profile View of Project Approaches



WILLIAMS CREEK - PLAN VIEW

0 300 600
GRAPHIC SCALE

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HUMBOLDT COUNTY RESOURCE CONSERVATION DISTRICT
100 Berding Street Ferndale, CA 95536

GHD

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

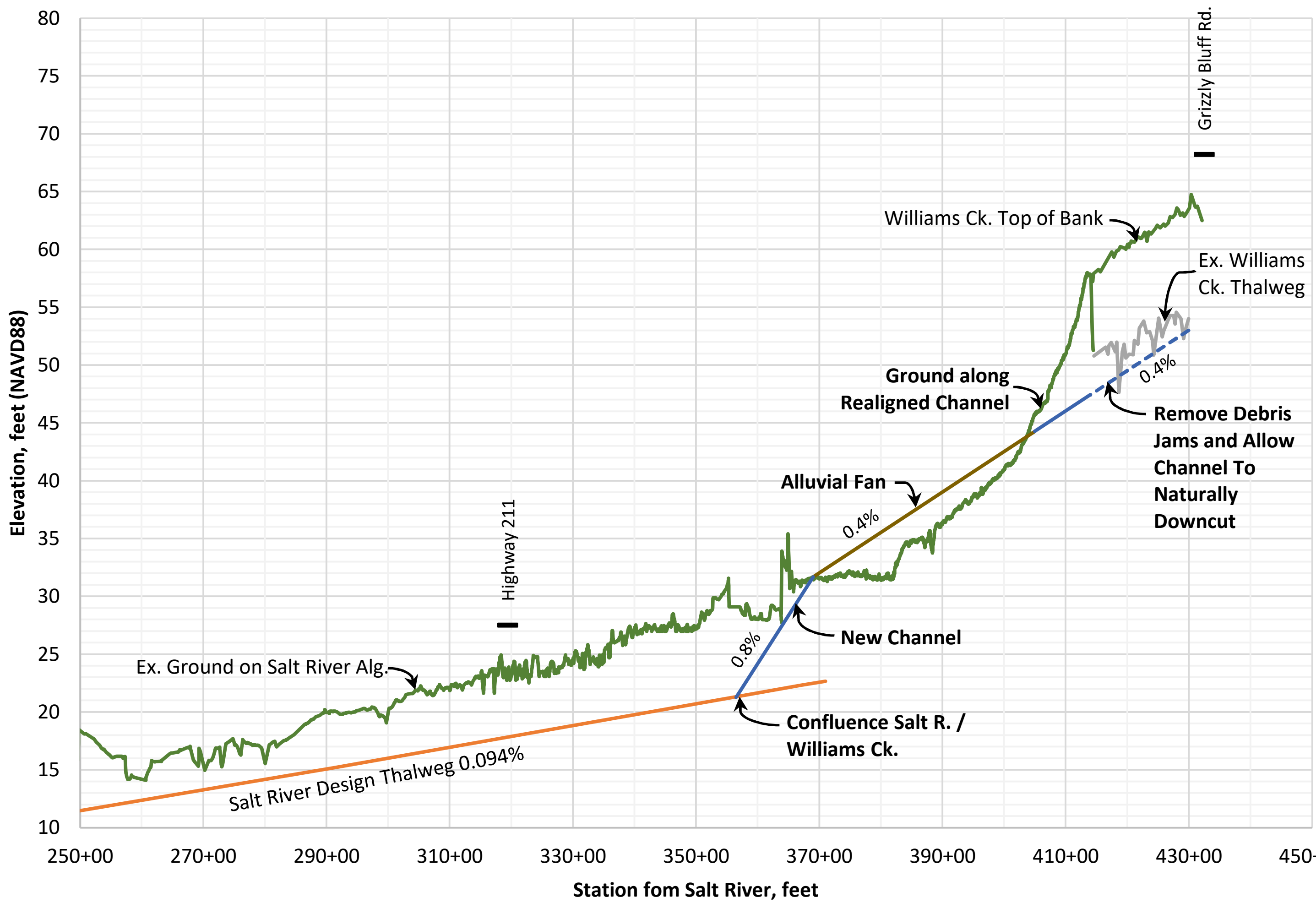
HUMBOLDT COUNTY RESOURCE CONSERVATION DISTRICT
WILLIAMS CREEK RESTORATION PLANNING
FERNDALE, CA

PROJECT APPROACH 1
MANAGED ALLUVIAL FAN

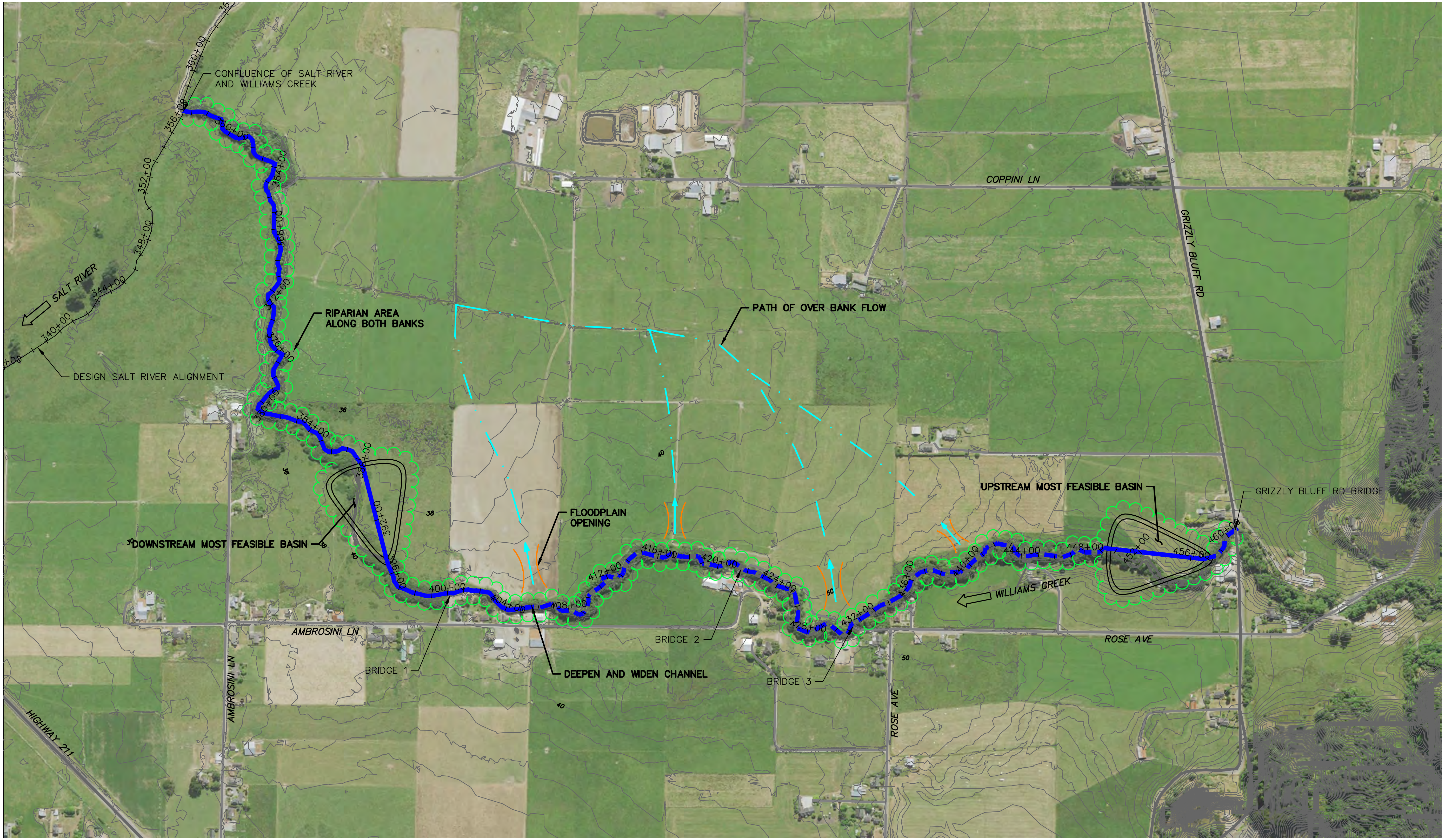
DATE
MARCH 2020

FIGURE
3-1

2/10/2020 Q:\Williams_C_Alternatives\7_CAD-GIS\Civil3D\Sheets\1_WilliamsCr_Aluvial Fan.dwg



Approach 1 Managed Fan



WILLIAMS CREEK - PLAN VIEW

0 300 600
GRAPHIC SCALE

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PROJECT APPROACH 2
ALIGNMENT 1

DATE
MARCH 2020

FIGURE
1

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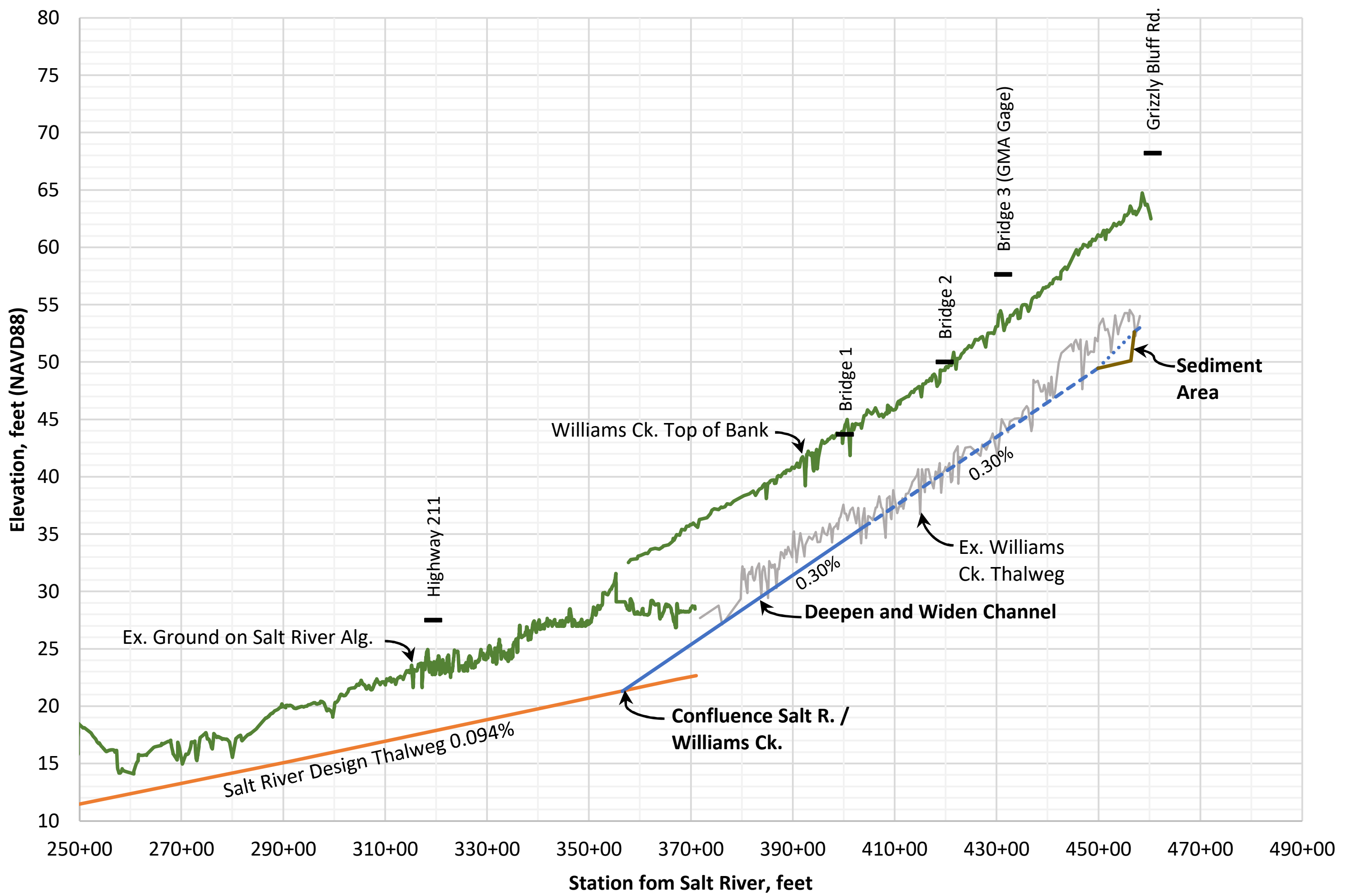
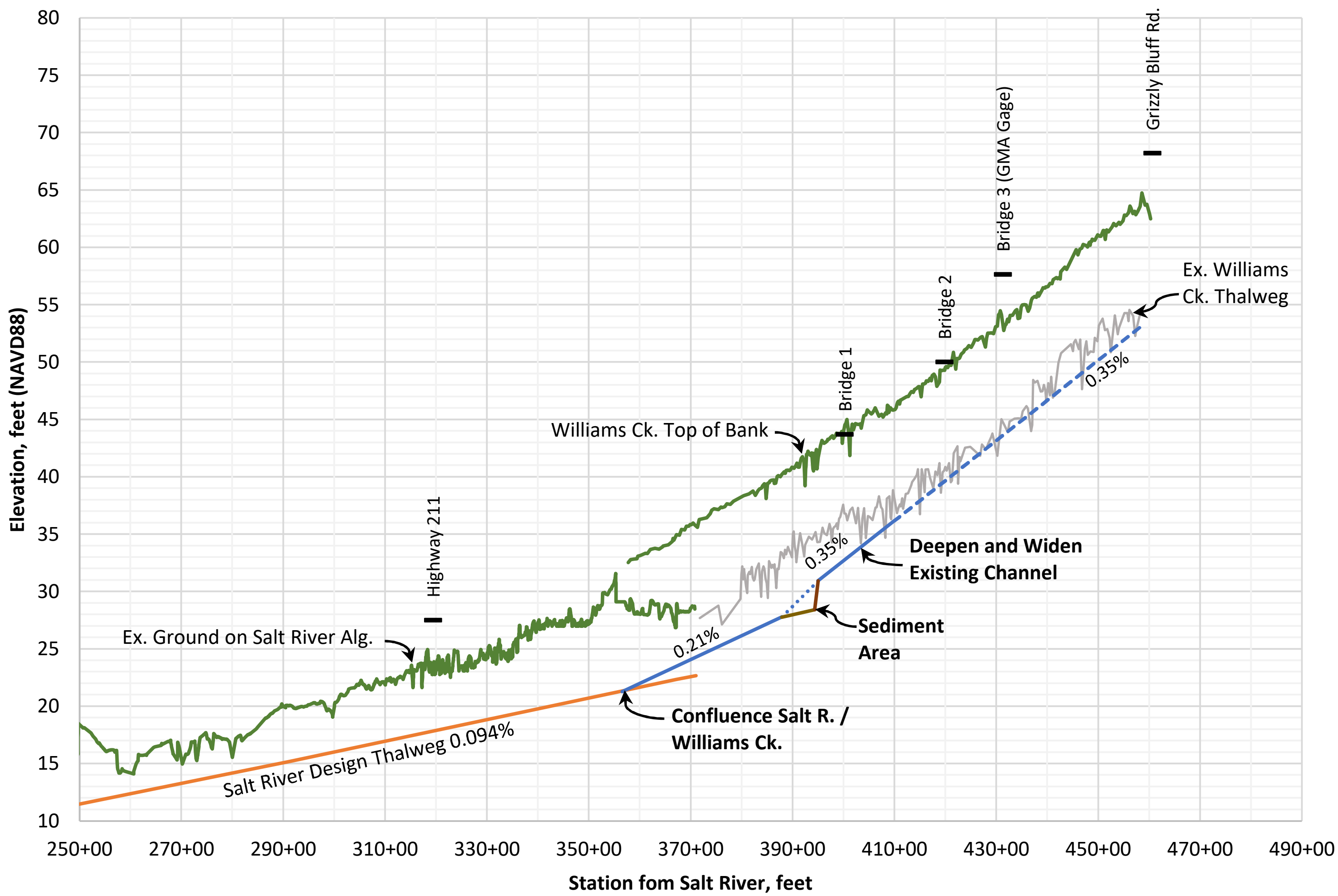
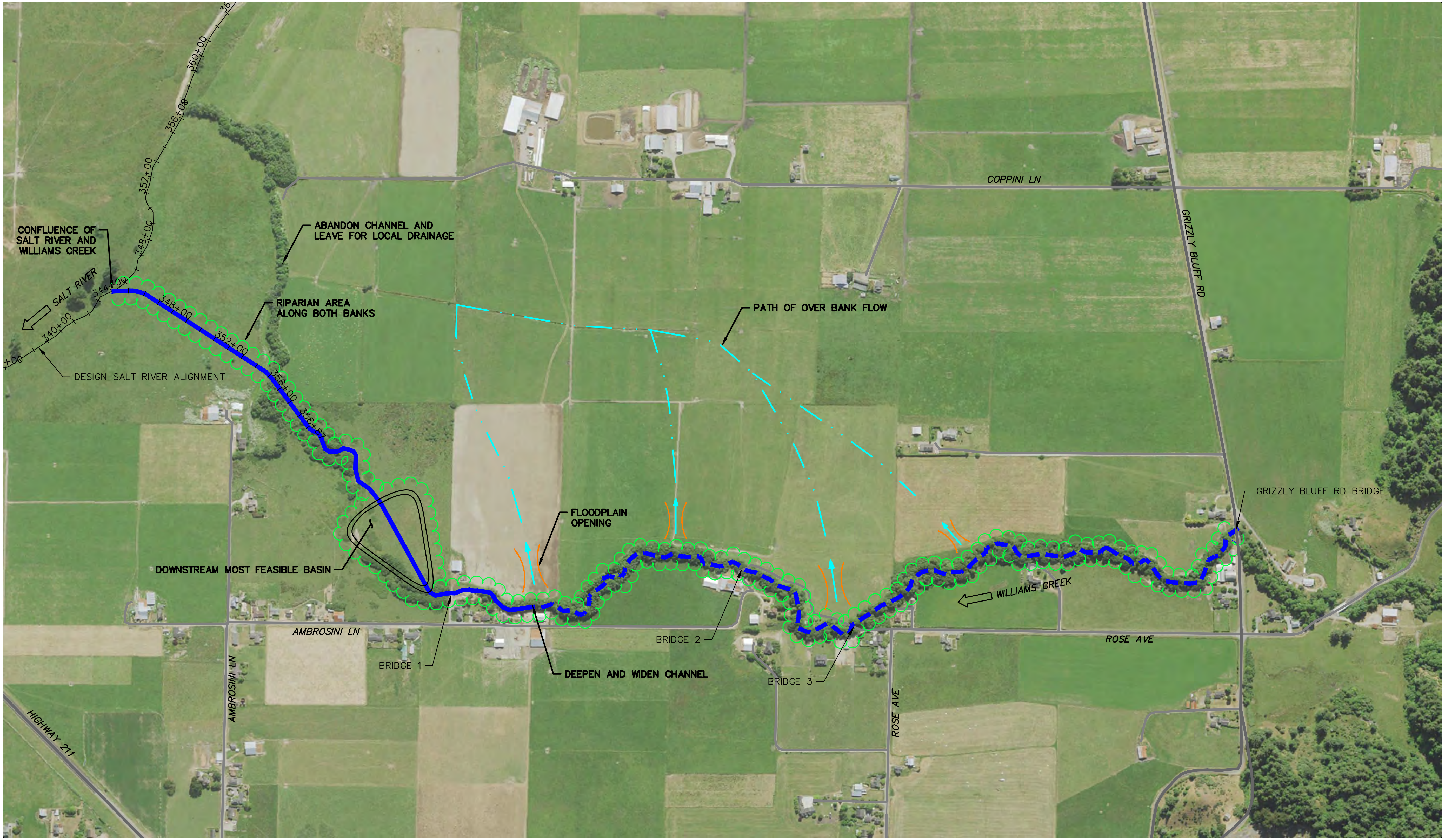


Alignment 1 Upstream Basin



Alignment 1 Downstream Basin



WILLIAMS CREEK - PLAN VIEW

0 300 600
GRAPHIC SCALE

N

2/10/2020 Q:\Williams_C_Alternatives\7_CAD-GIS\Civil3D\Sheets\1_WilliamsCr_Alg2.dwg

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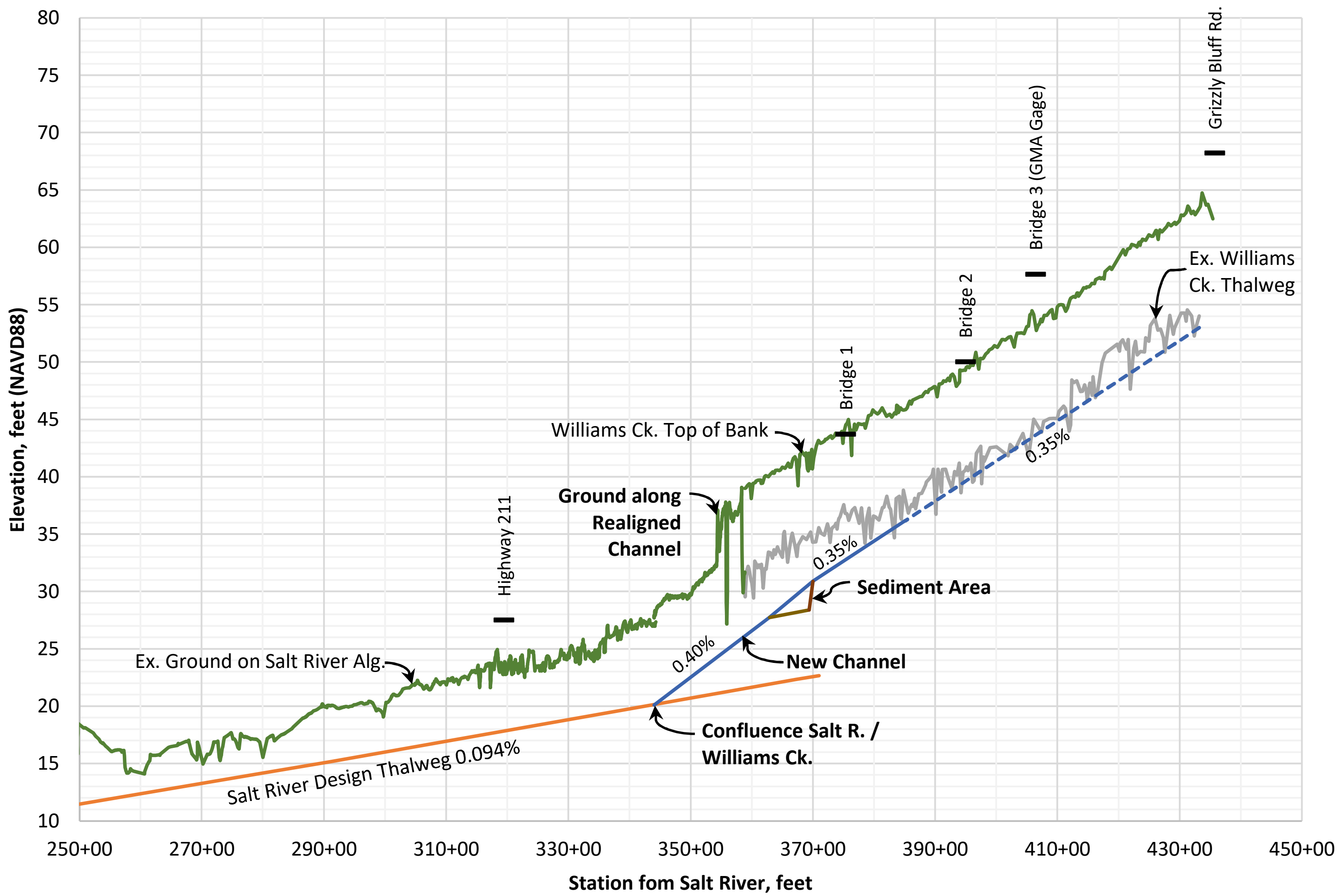
PROJECT APPROACH 2
ALIGNMENT 2

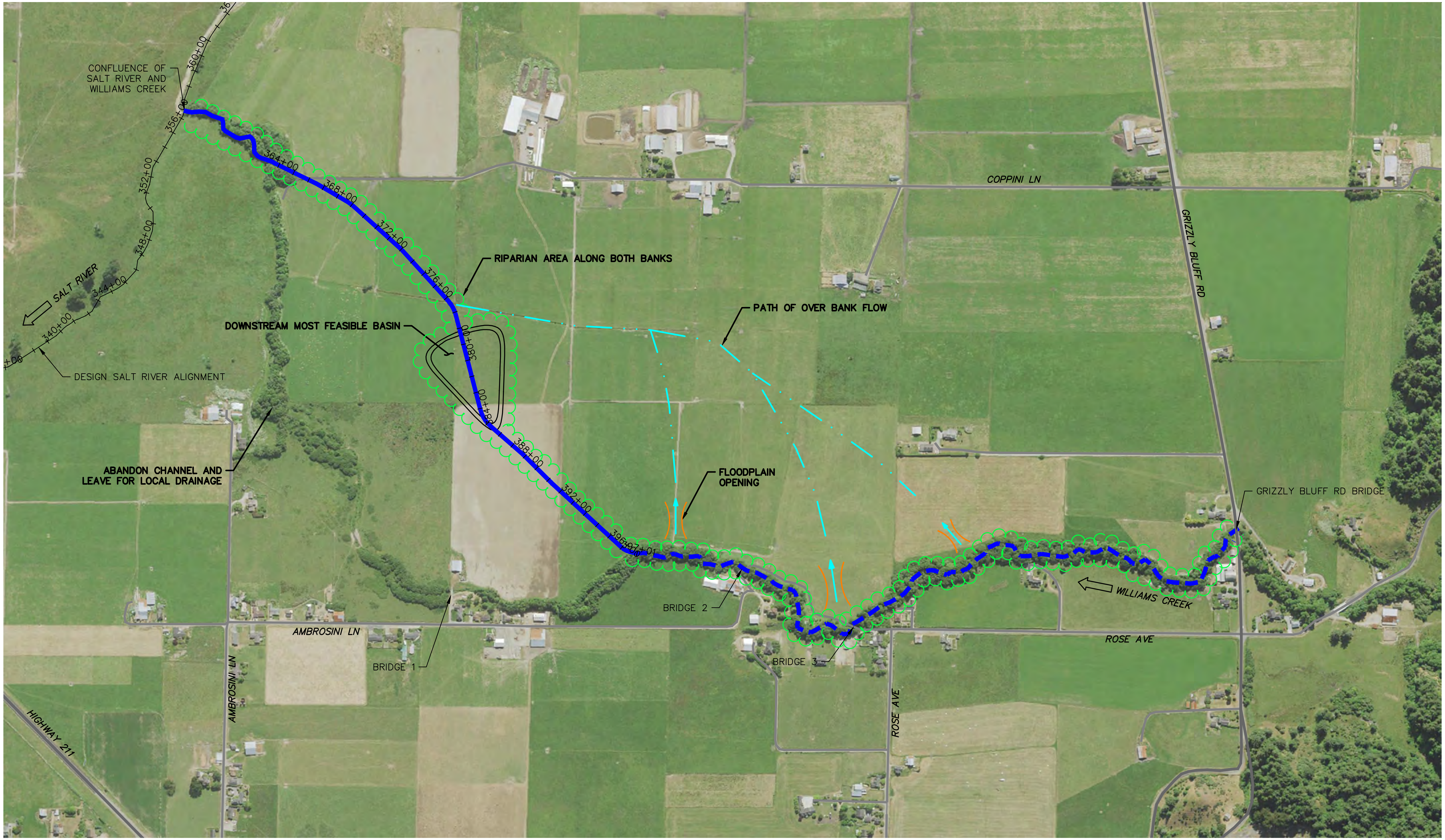
DATE
MARCH 2020

FIGURE
2



Elevation, feet (NAVD88)
Station fom Salt River, feet
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
250+00
270+00
290+00
310+00
330+00
350+00
370+00
390+00
410+00
430+00
450+00
Grizzly Bluff Rd.
Bridge 3 (GMA Gage)
Bridge 2
Bridge 1
Highway 211
Ex. Williams Ck. Thalweg
Williams Ck. Top of Bank
Ground along Realigned Channel
0.35%
0.35%
Sediment Area
0.40%
New Channel
Ex. Ground on Salt River Alg.
Confluence Salt R. / Williams Ck.
Salt River Design Thalweg 0.094%

Alignment 2



WILLIAMS CREEK - PLAN VIEW

0 300 600
GRAPHIC SCALE

2/10/2020 Q:\Williams_C_Alternatives\7_CAD-GIS\Civil3D\Sheets\1_WilliamsCr_Alg4.dwg

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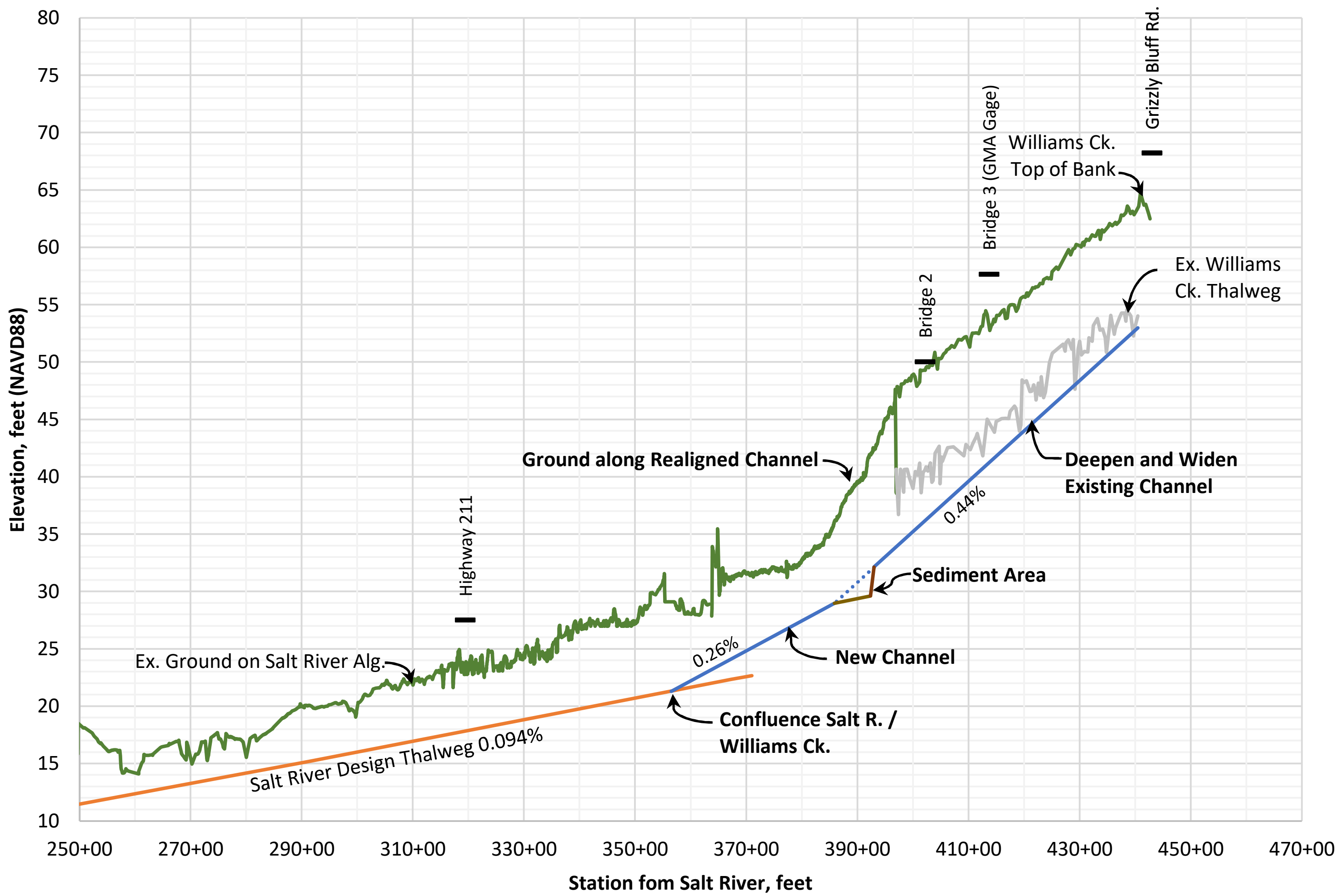
WILLIAMS CREEK RESTORATION PLANNING
FERNDALE, CA

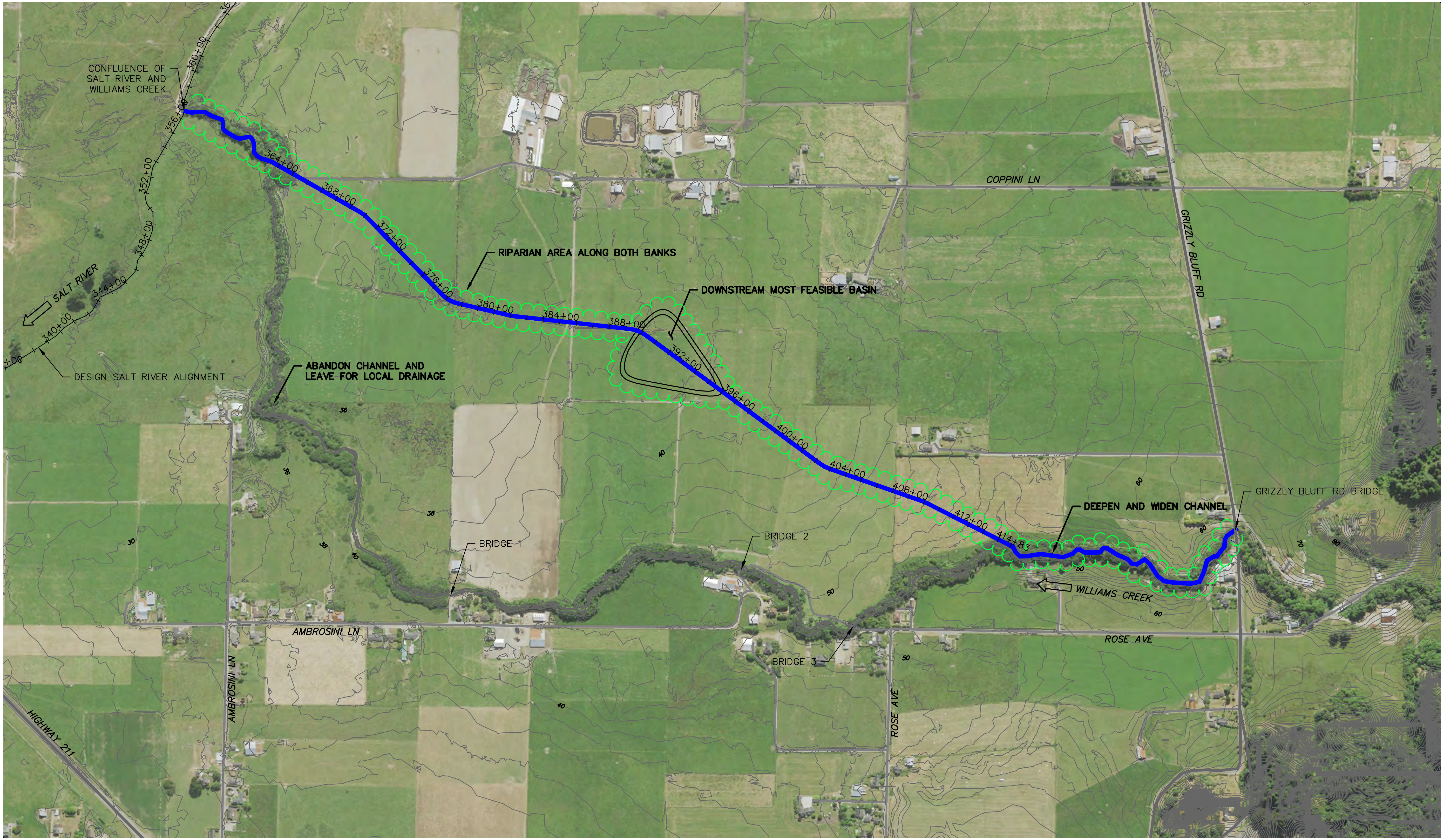
PROJECT APPROACH 2
ALIGNMENT 3

DATE
MARCH 2020

FIGURE
3


Elevation, feet (NAVD88)
Station fom Salt River, feet
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
250+00
270+00
290+00
310+00
330+00
350+00
370+00
390+00
410+00
430+00
450+00
470+00
Highway 211
Bridge 2
Bridge 3 (GMA Gage)
Grizzly Bluff Rd.
Williams Ck.
Top of Bank
Ex. Williams
Ck. Thalweg
Ground along Realigned Channel
Deepen and Widen
Existing Channel
0.44%
Sediment Area
Ex. Ground on Salt River Alg.
0.26%
New Channel
Confluence Salt R. /
Williams Ck.
Salt River Design Thalweg 0.094%

Alignment 3



WILLIAMS CREEK - PLAN VIEW

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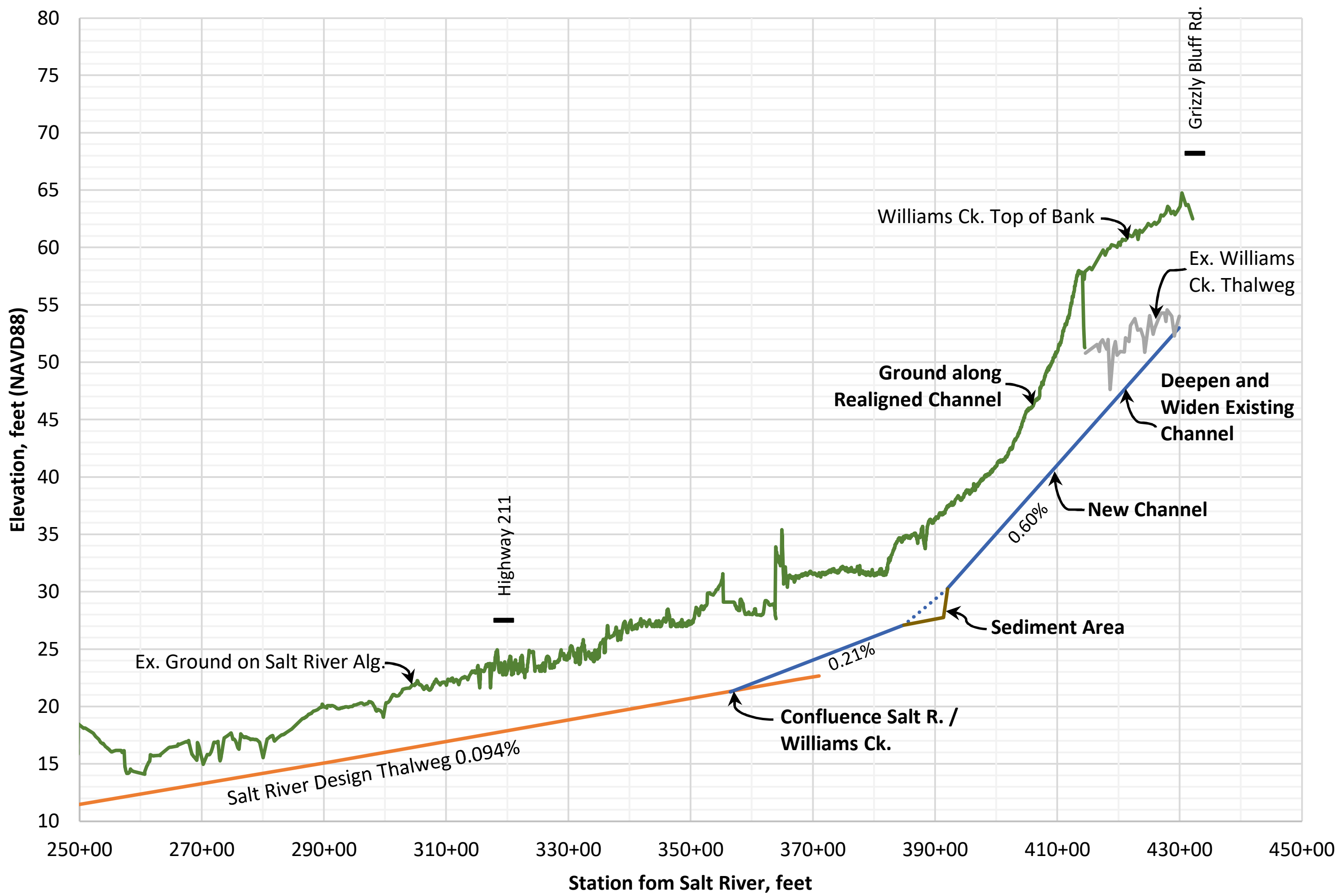
HUMBOLDT COUNTY RESOURCE CONSERVATION DISTRICT
WILLIAMS CREEK RESTORATION PLANNING
FERNDALE, CA

PROJECT APPROACH 2
ALIGNMENT 4

DATE
MARCH 2020

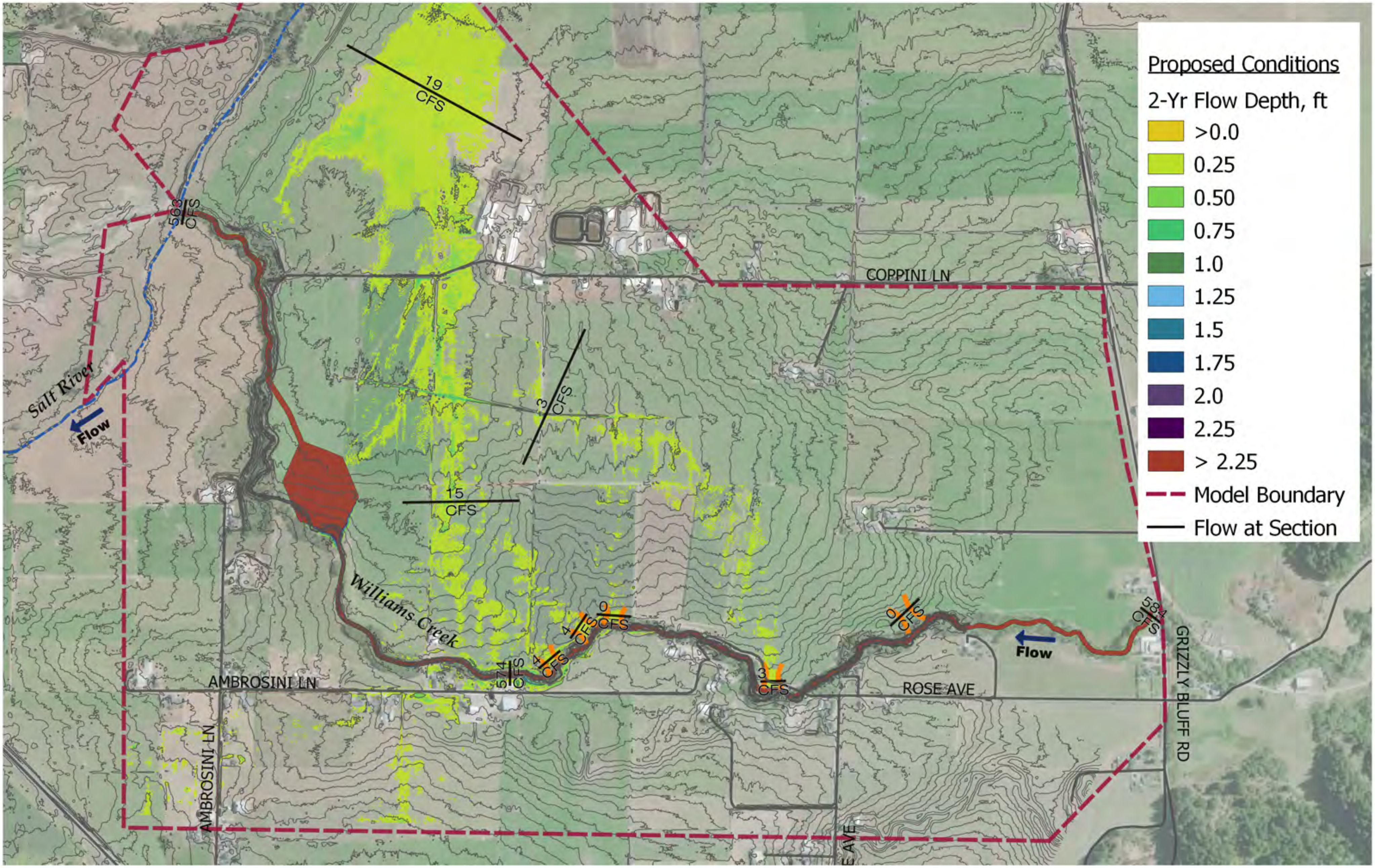
FIGURE
4



Grizzly Bluff Rd.
Williams Ck. Top of Bank
Ex. Williams Ck. Thalweg
Ground along Realigned Channel
Deepen and Widen Existing Channel
New Channel
0.60%
Highway 211
Sediment Area
Ex. Ground on Salt River Alg.
0.21%
Confluence Salt R. / Williams Ck.
Salt River Design Thalweg 0.094%
Elevation, feet (NAVD88)
Station fom Salt River, feet
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
250+00
270+00
290+00
310+00
330+00
350+00
370+00
390+00
410+00
430+00
450+00

Alignment 4

Appendix E
Proposed Condition 2-Dimensional Modeling Results for Alternative 1



0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

Michael Love & Associates
Hydrologic Solutions

WILLIAMS CREEK
Alternative 1
2-Year Flow Depth

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_Depth.qgz

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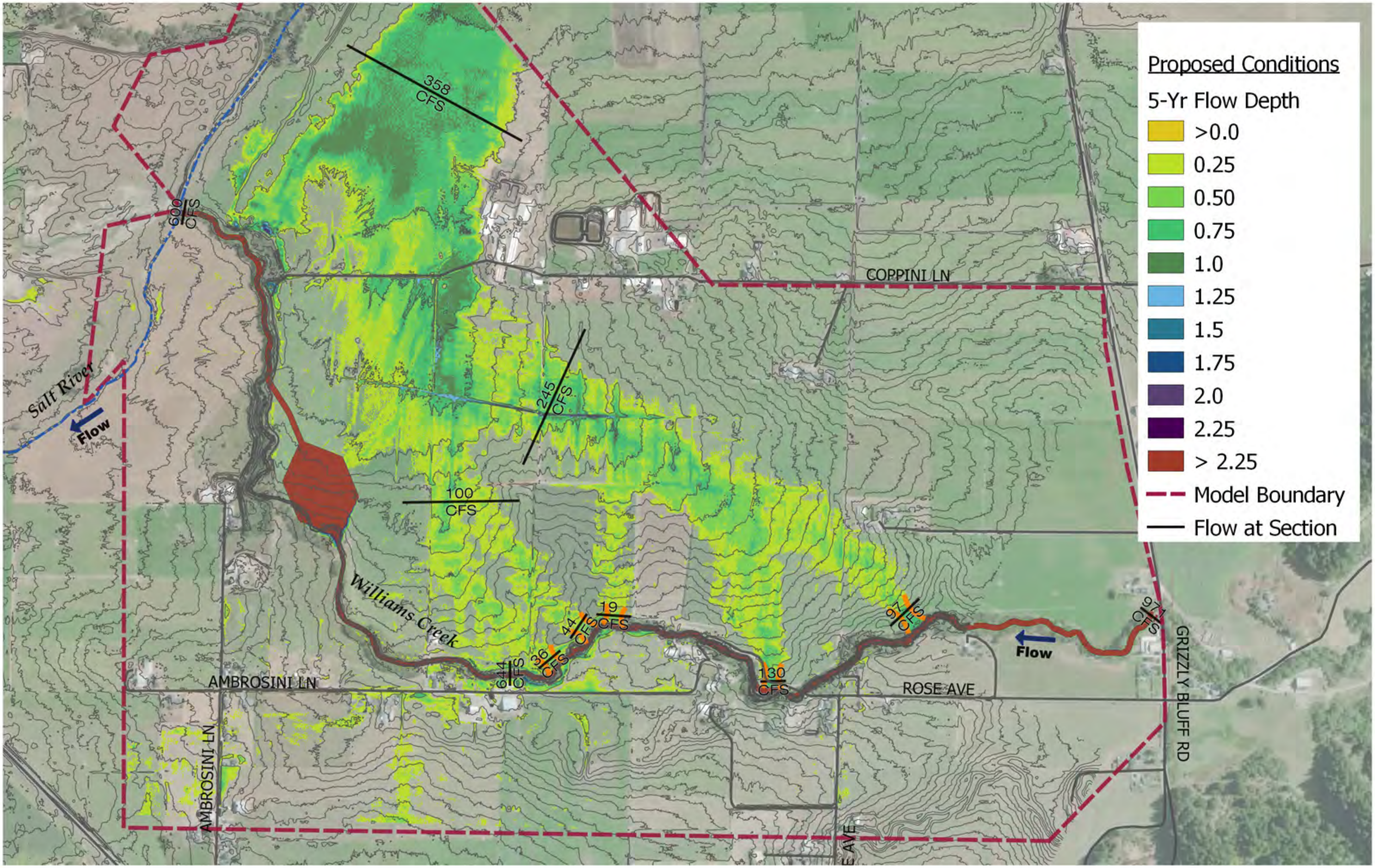

0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

Michael Love & Associates
Hydrologic Solutions

WILLIAMS CREEK
Alternative 1
5-Year Flow Depth

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_Depth.qgz

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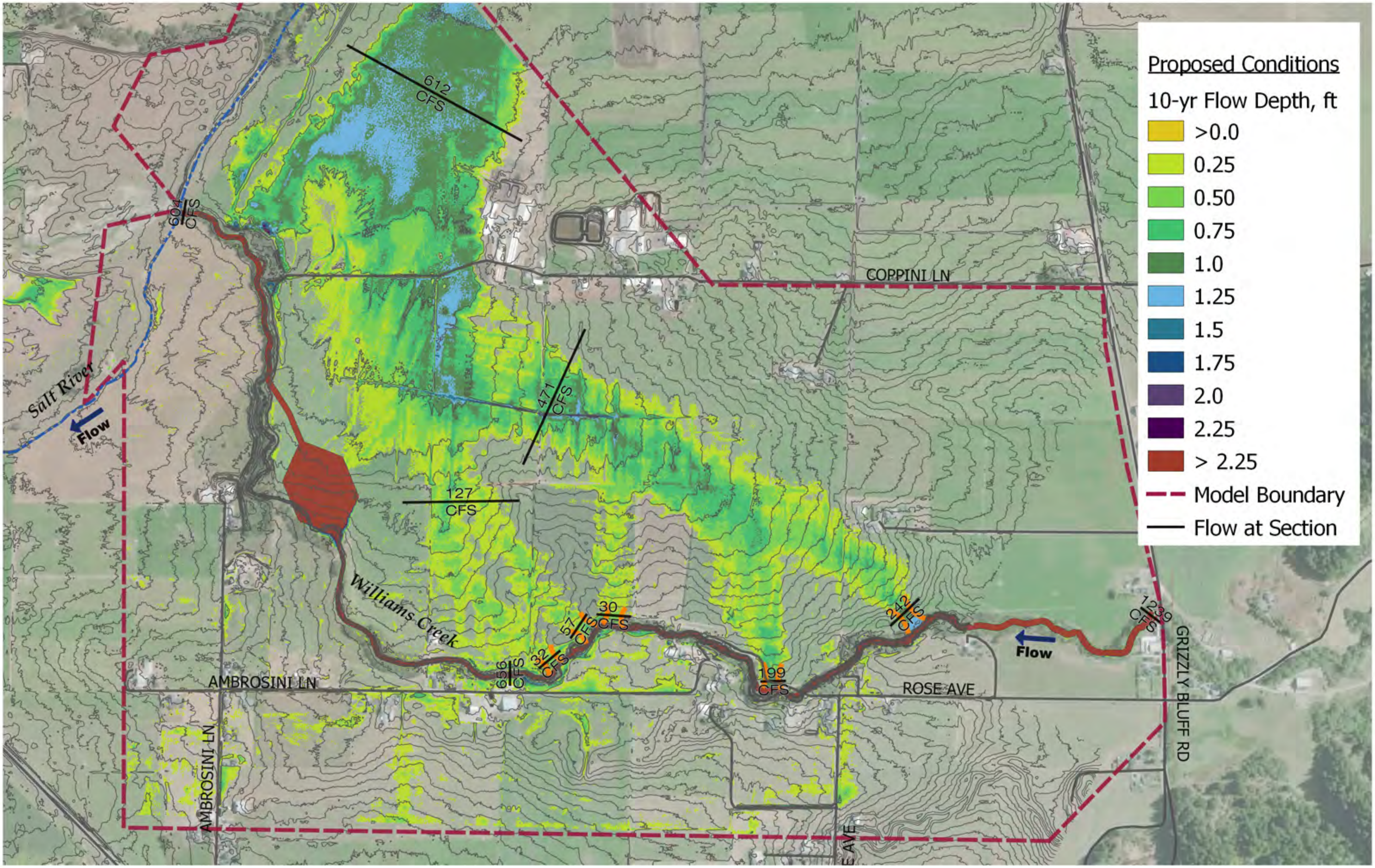

0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

Michael Love & Associates
Hydrologic Solutions

WILLIAMS CREEK
Alternative 1
10-Year Flow Depth

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_Depth.qgz

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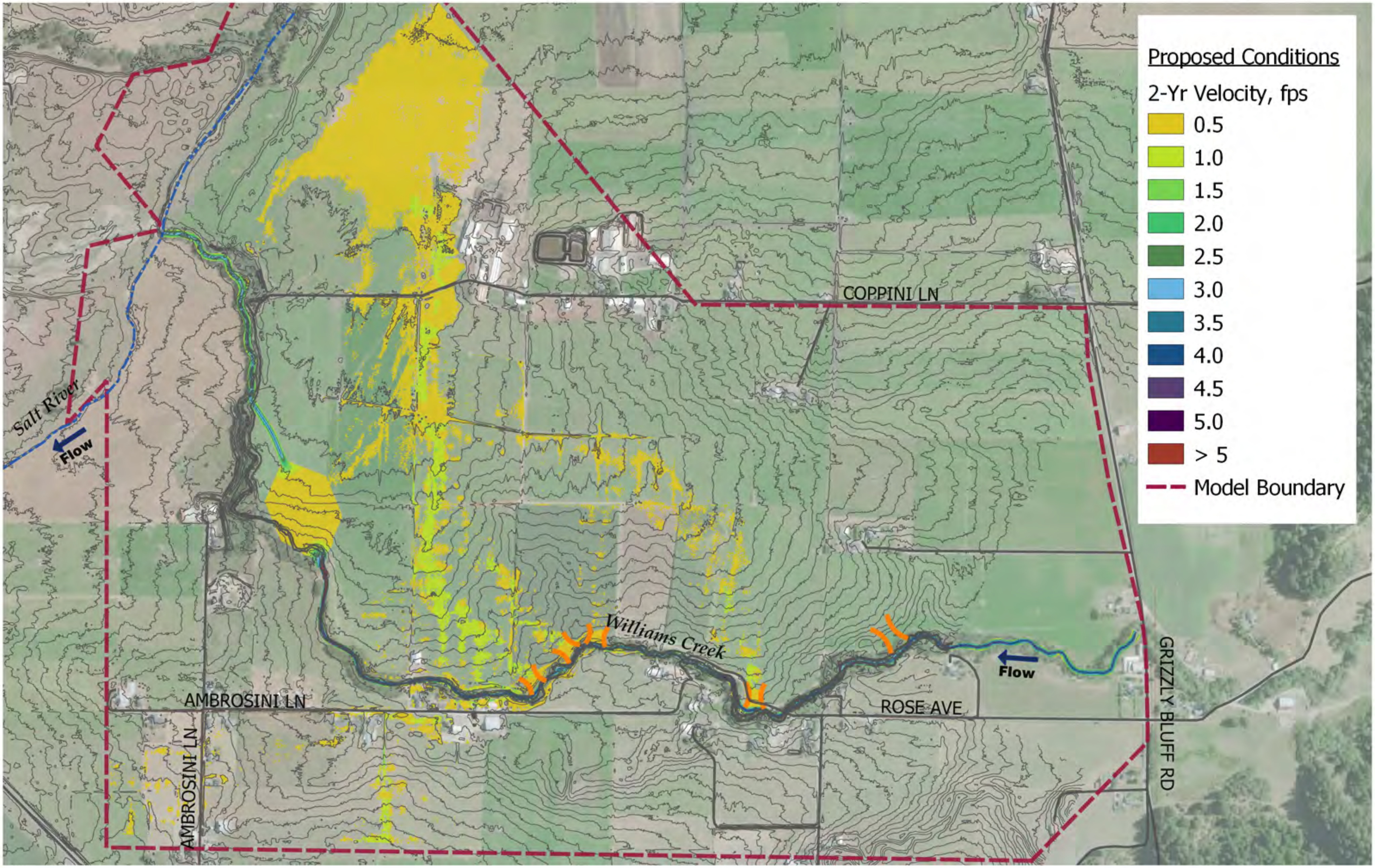

0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

Michael Love & Associates
Hydrologic Solutions

WILLIAMS CREEK
Alternative 1
2-Year Velocity

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_VELOCITY.qgz

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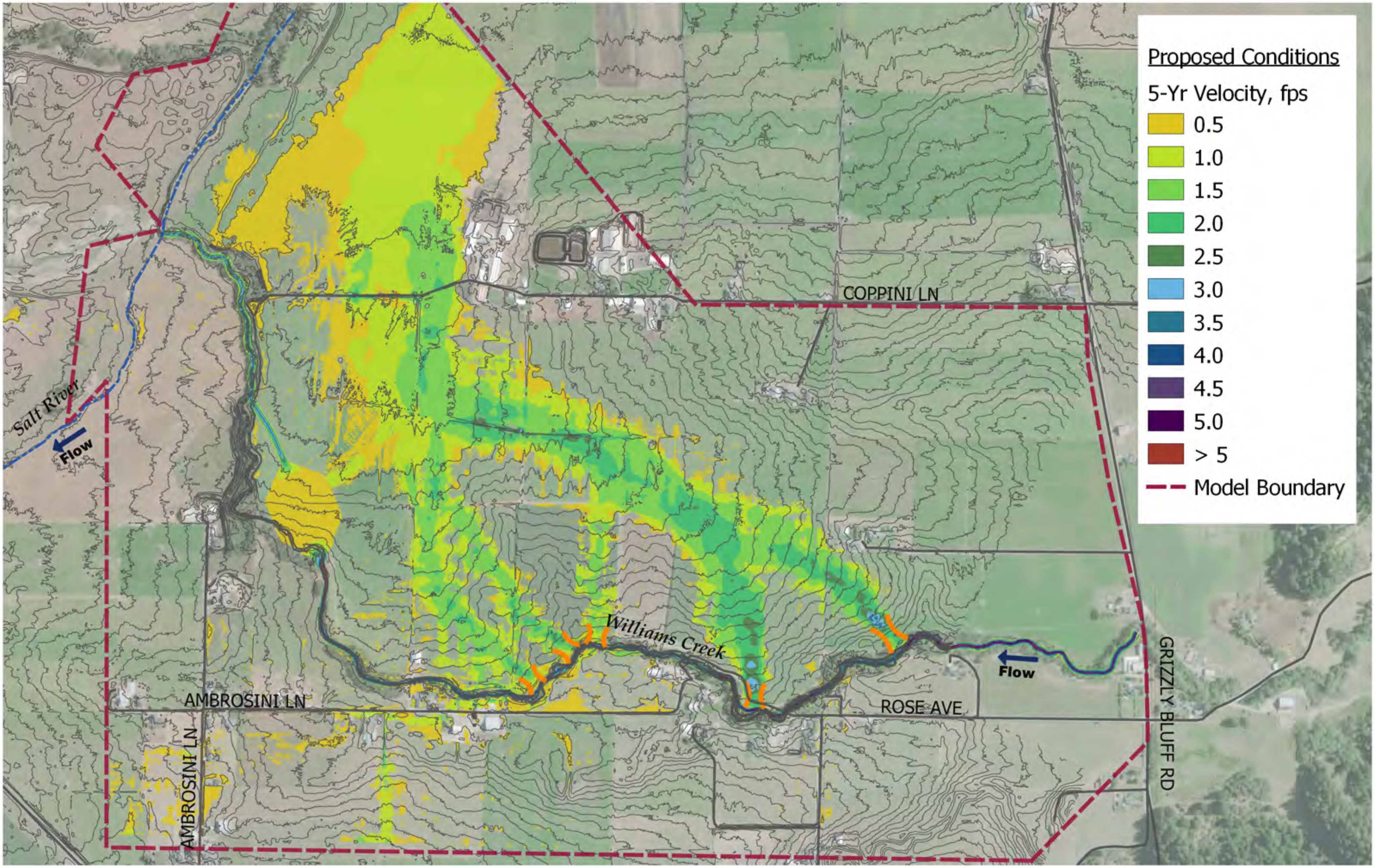

Michael Love & Associates
Hydrologic Solutions

WILLIAMS CREEK
Alternative 1
5-Year Velocity

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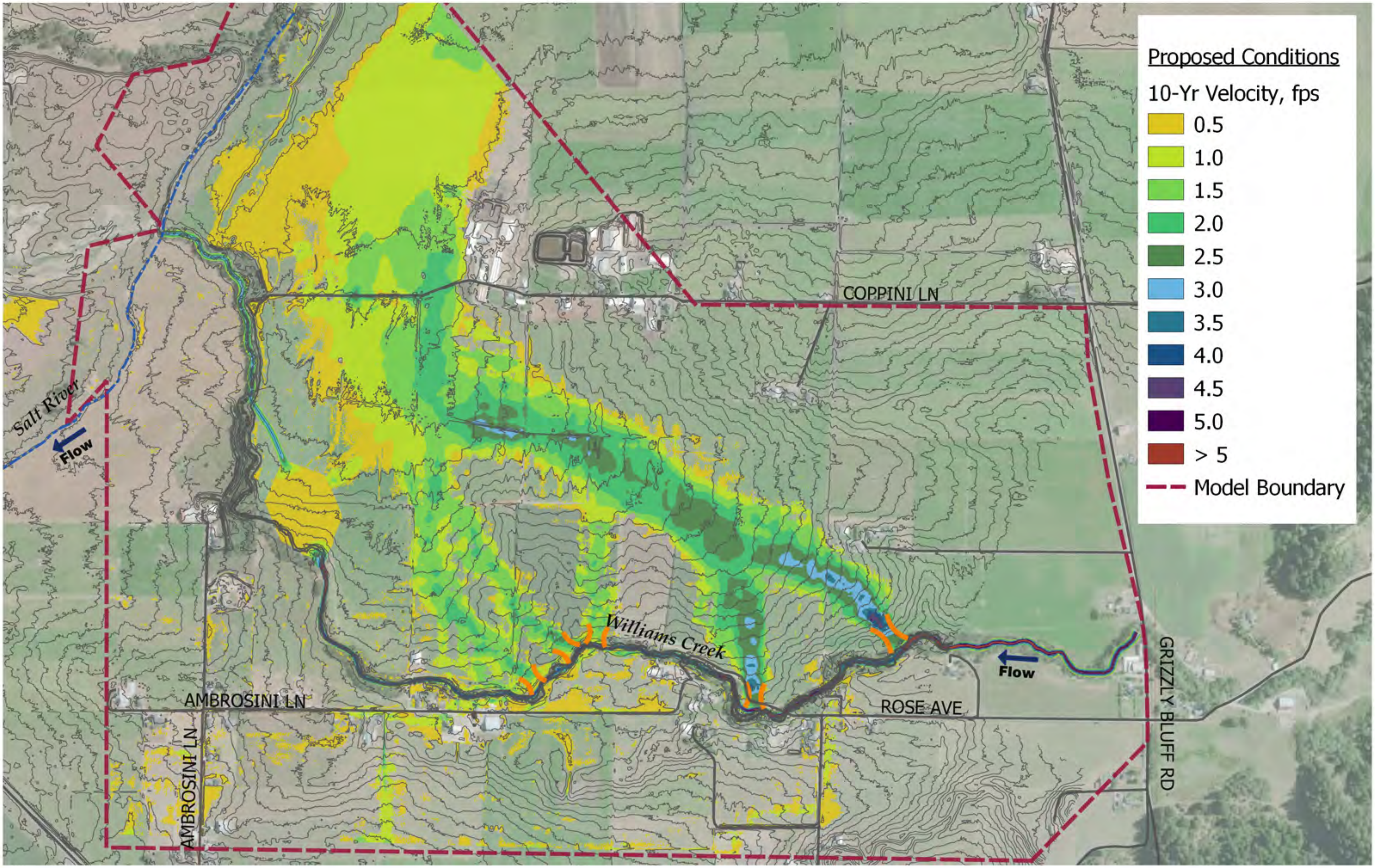

0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

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Hydrologic Solutions

WILLIAMS CREEK
Alternative 1
10-Year Velocity

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_VELOCITY.qgz

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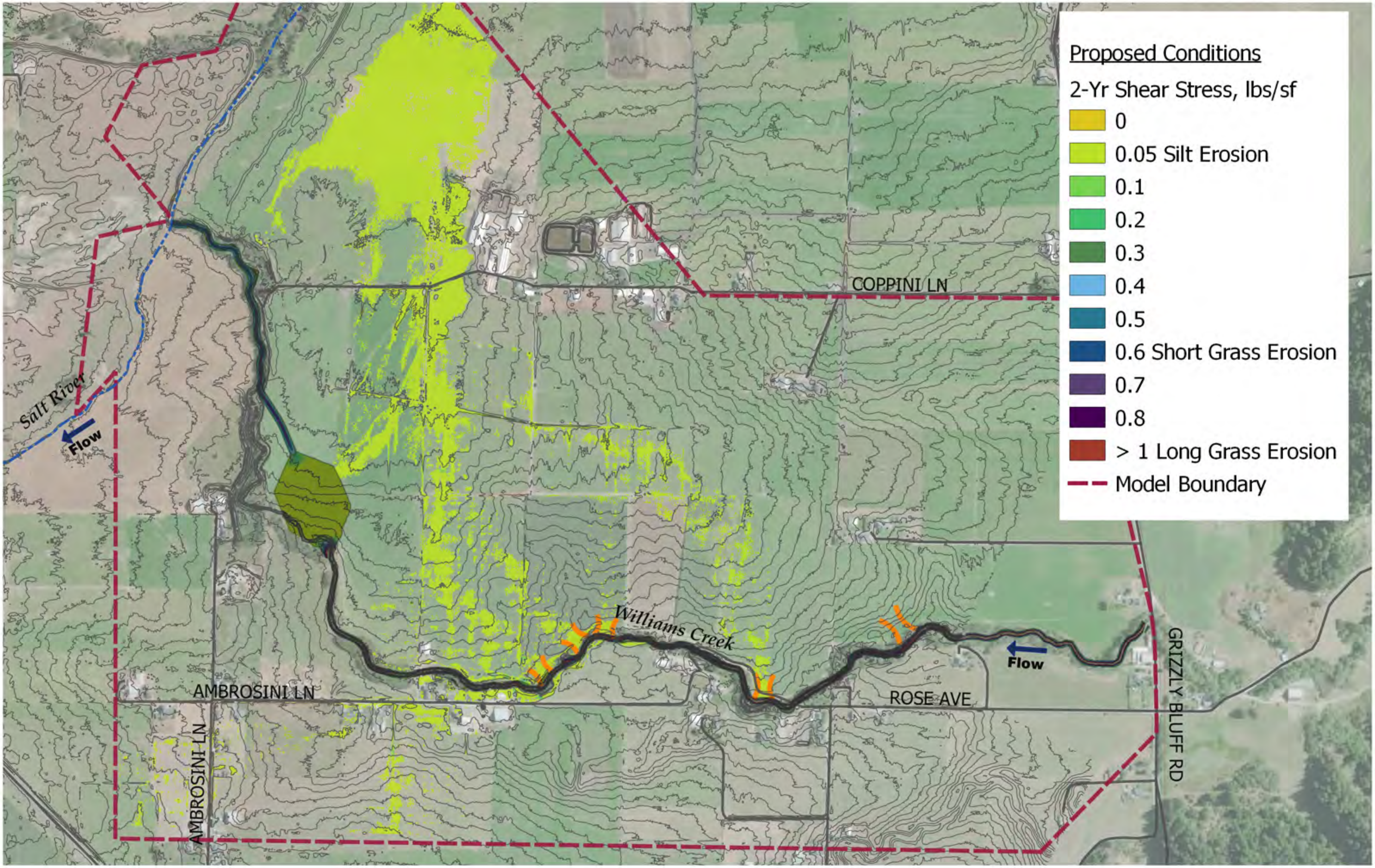

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CA STATE PLANE ZONE 1 FEET

Michael Love & Associates
Hydrologic Solutions

WILLIAMS CREEK
Alternative 1
2-Year Shear Stress

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_SHEAR.qgz

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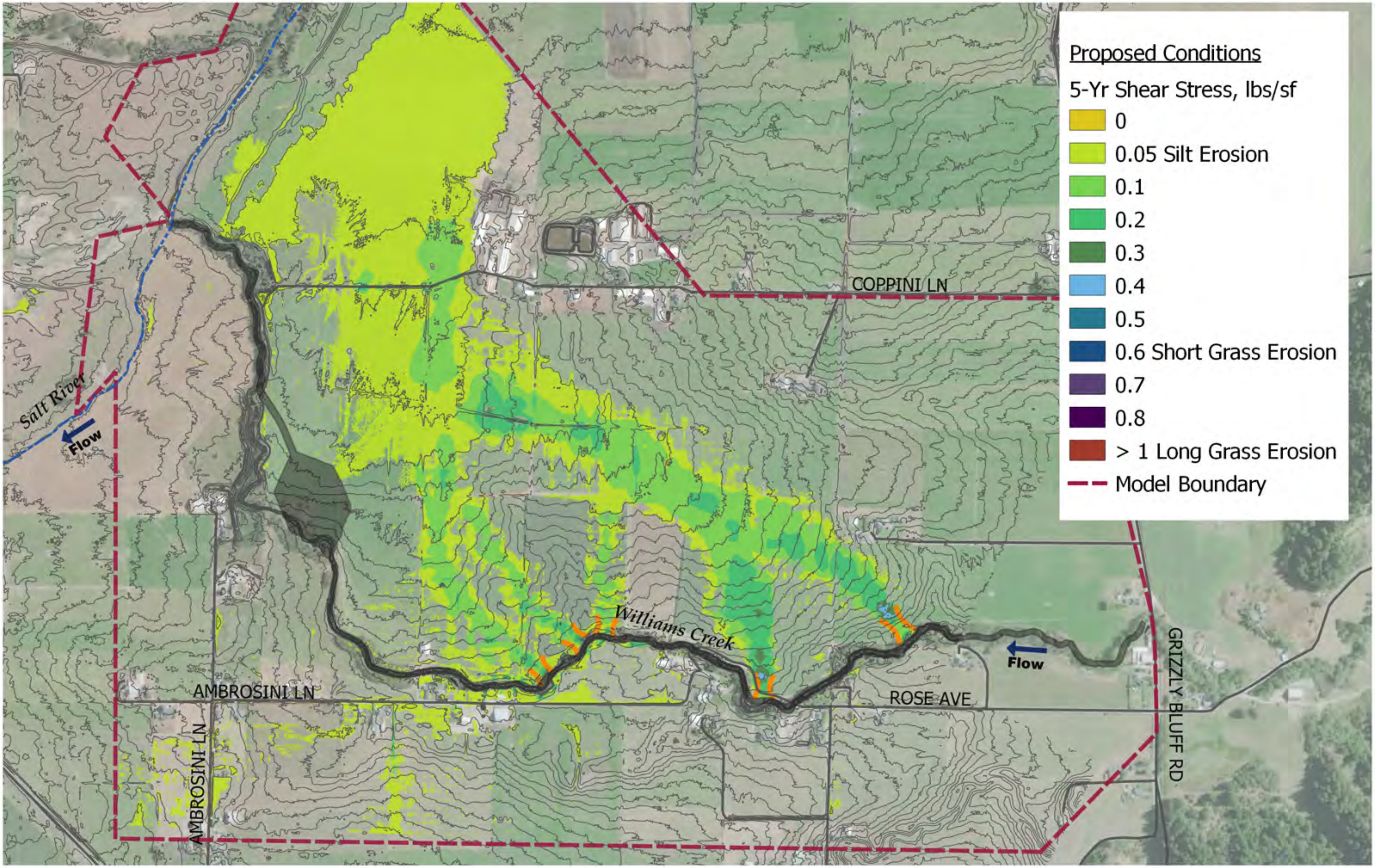

0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

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WILLIAMS CREEK
Alternative 1
5-Year Shear Stress

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_SHEAR.qgz

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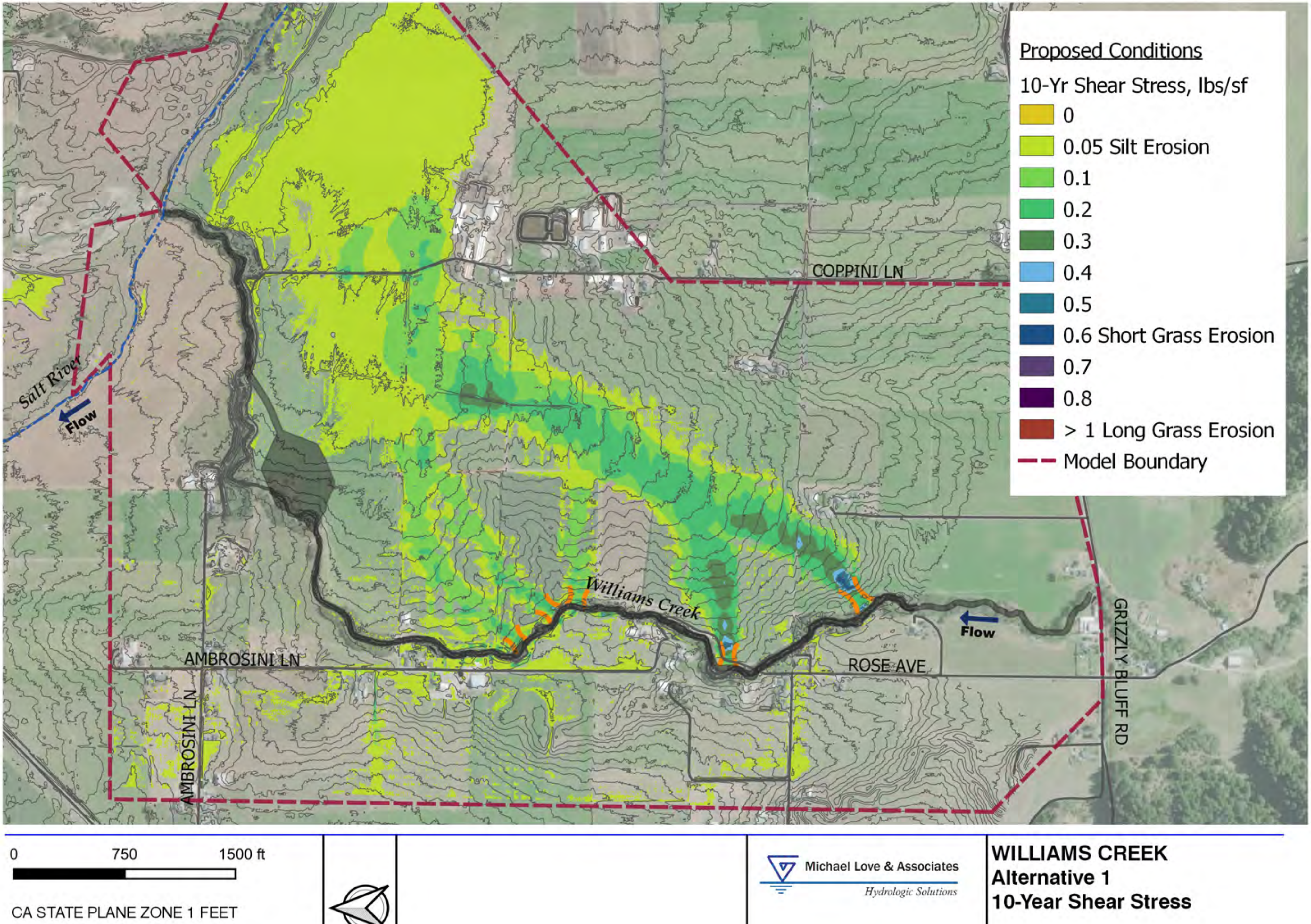

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WILLIAMS CREEK
Alternative 1
10-Year Shear Stress

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 1_SHEAR.qgz

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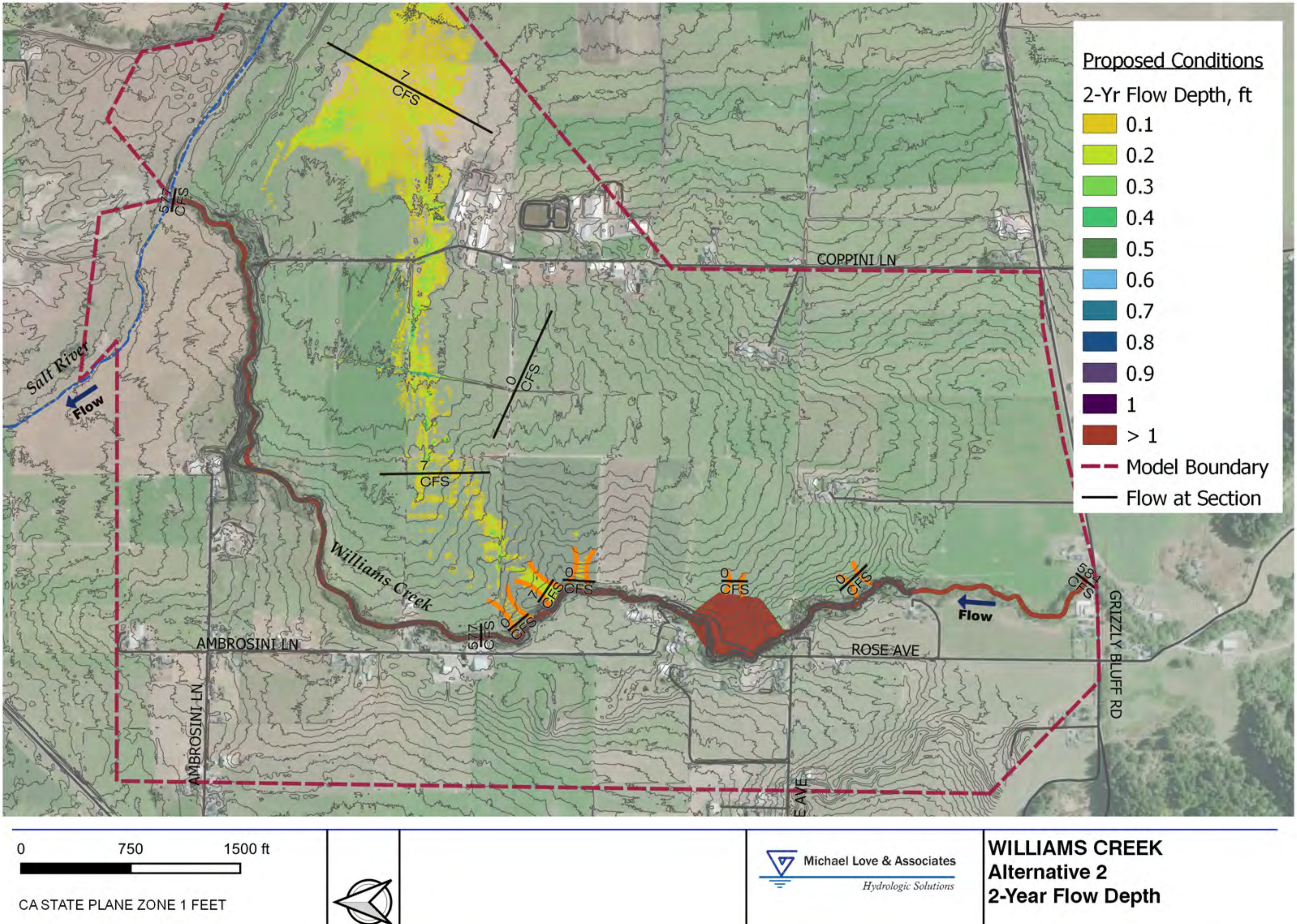
Appendix F
Proposed Condition 2-Dimensional Modeling Results for Alternative 2



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WILLIAMS CREEK
Alternative 2
2-Year Flow Depth

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_Depth.qgz

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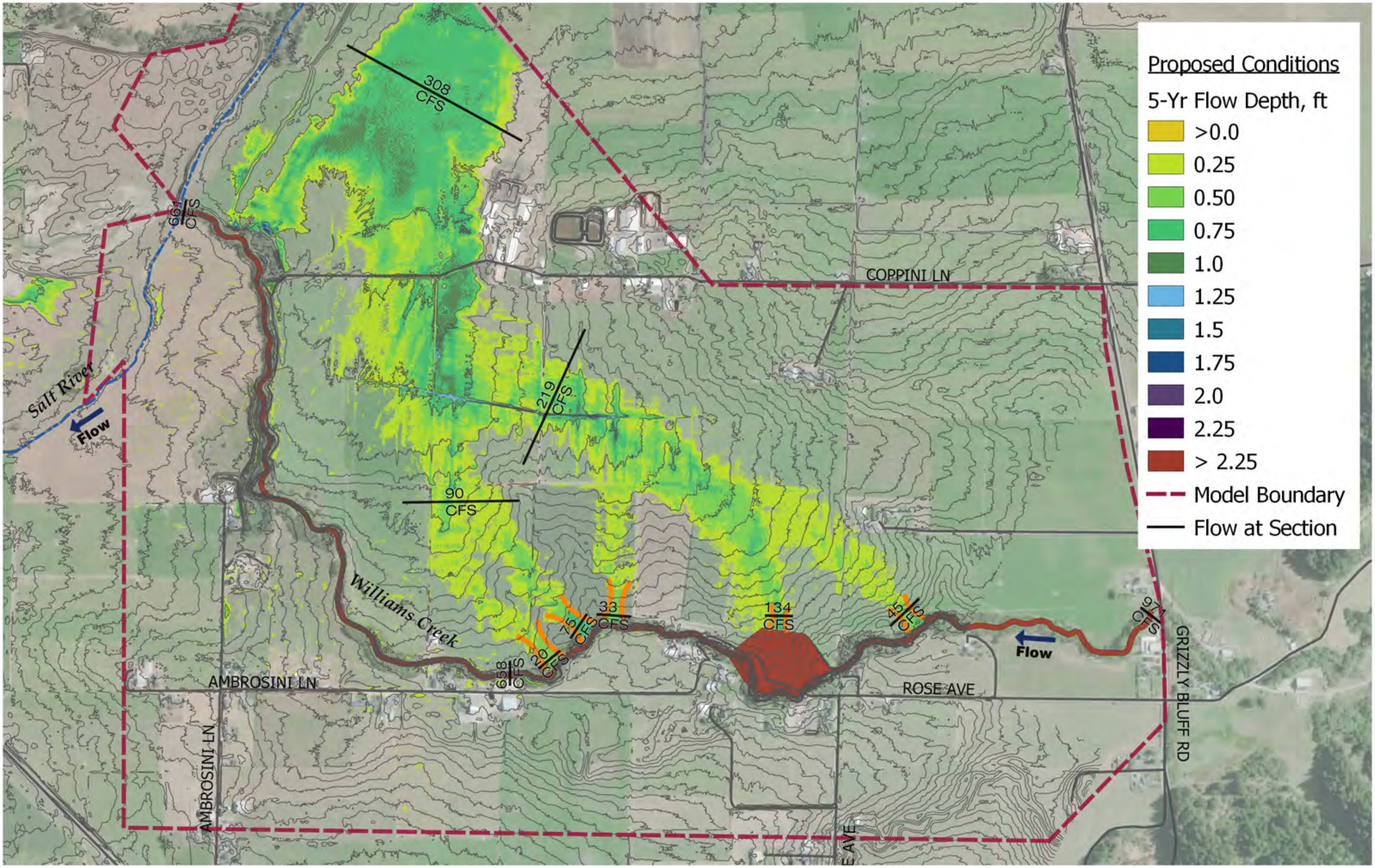

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CA STATE PLANE ZONE 1 FEET

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WILLIAMS CREEK
Alternative 2
5-Year Flow Depth

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_Depth.qgz

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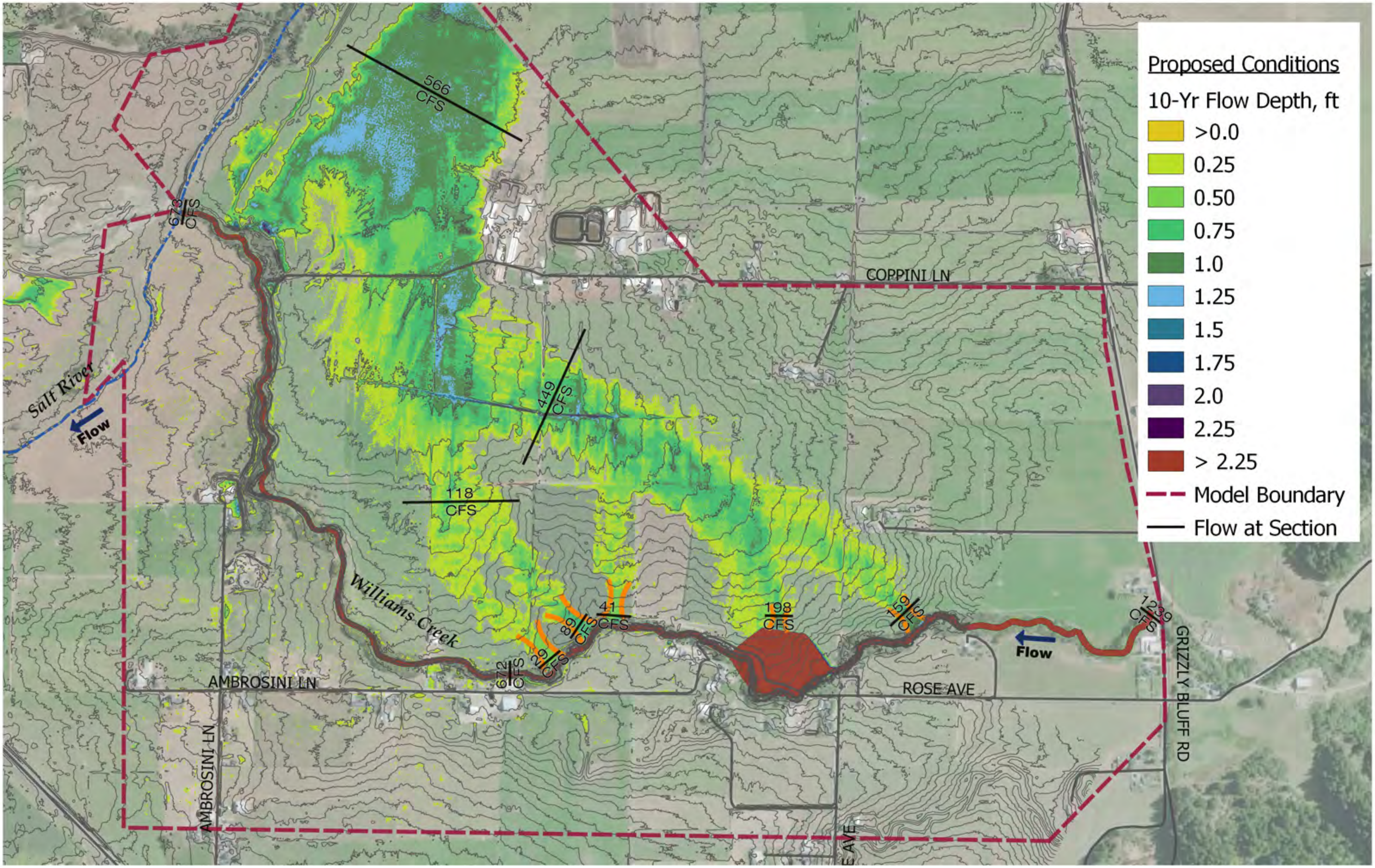

0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

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WILLIAMS CREEK
Alternative 2
10-Year Flow Depth

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_Depth.qgz

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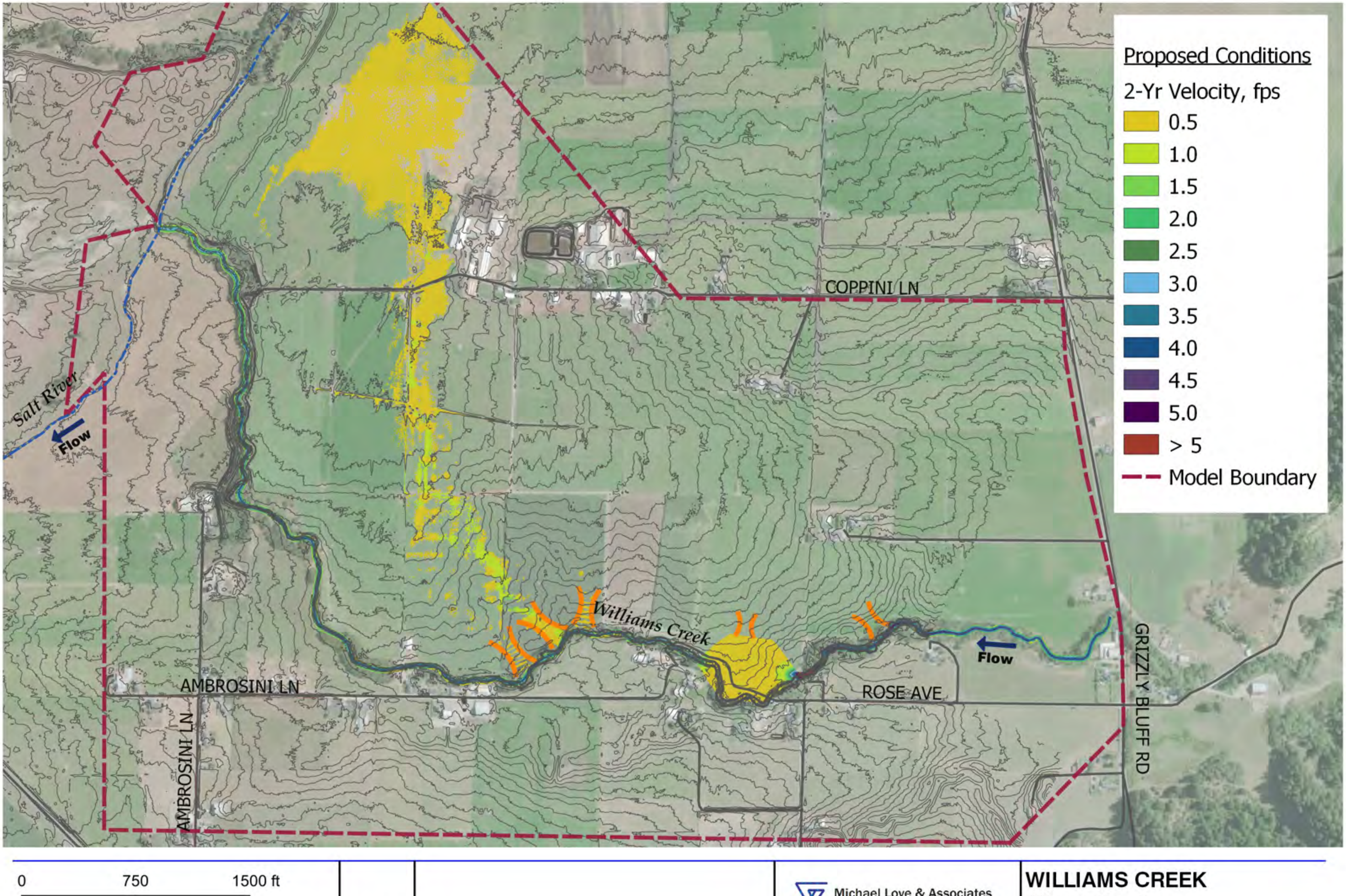

CA STATE PLANE ZONE 1 FEET

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WILLIAMS CREEK
Alternative 2
2-Year Velocity

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_VELOCITY.qgz

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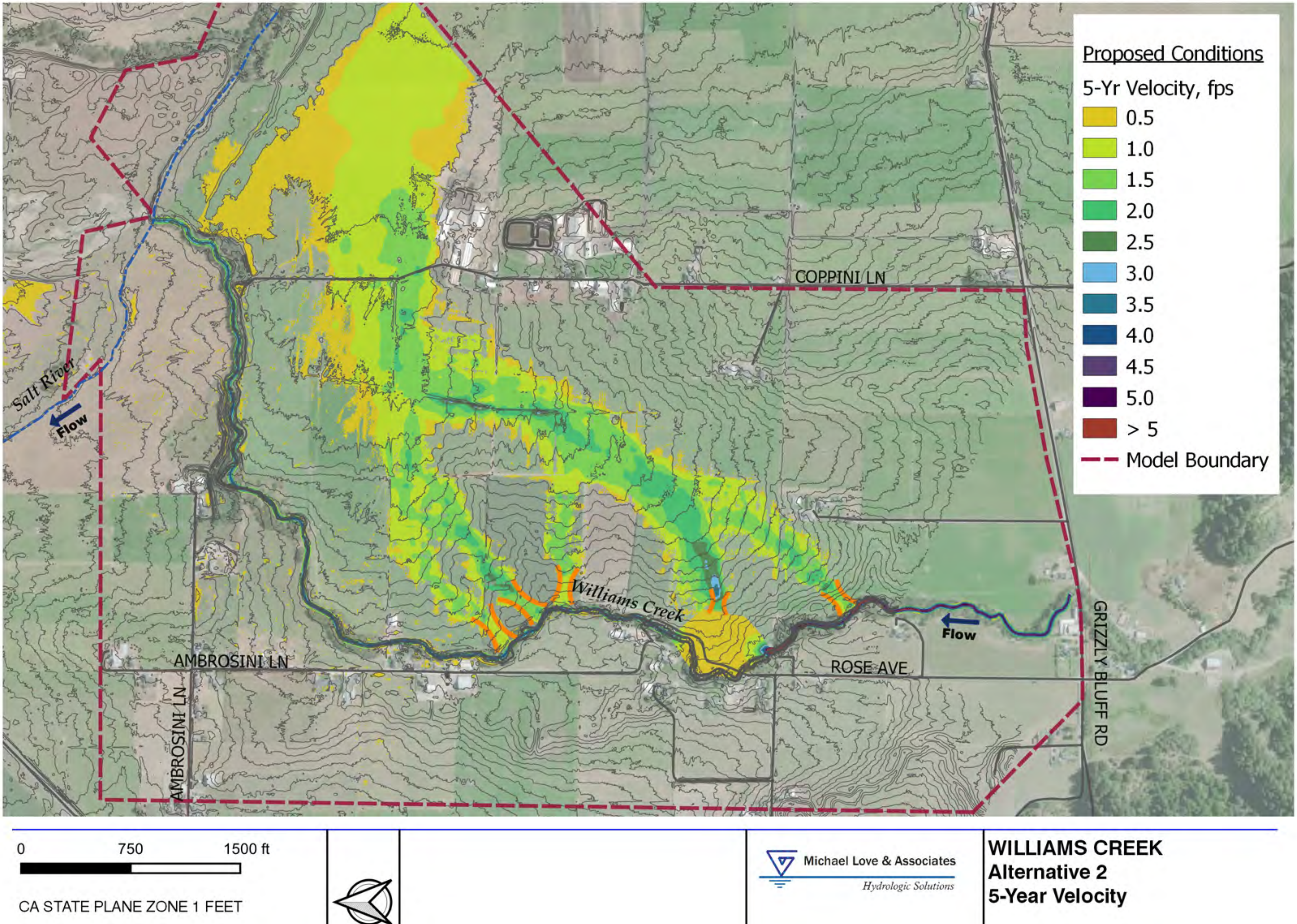

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WILLIAMS CREEK
Alternative 2
5-Year Velocity

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_VELOCITY.qgz

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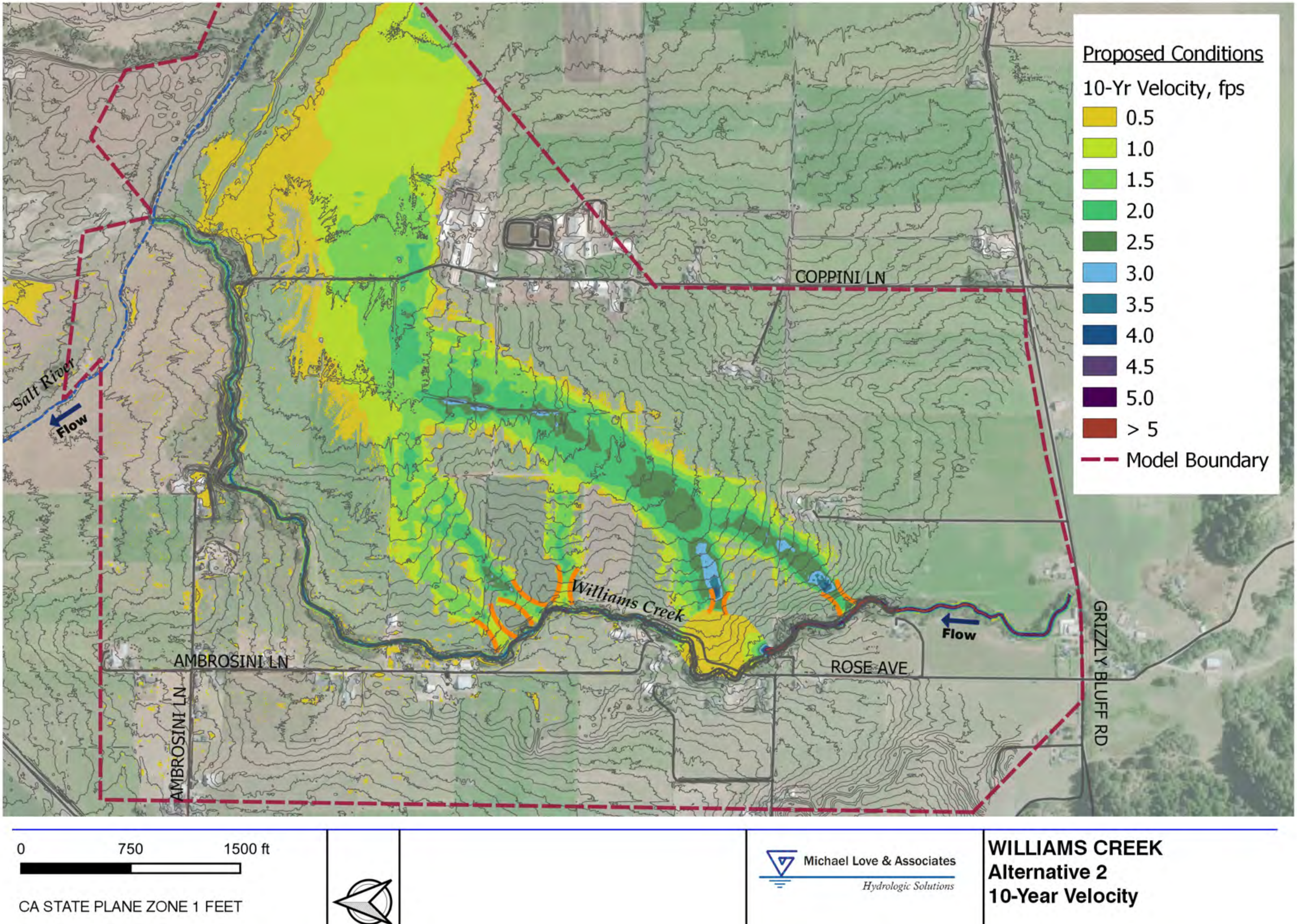

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Hydrologic Solutions

WILLIAMS CREEK
Alternative 2
10-Year Velocity

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_VELOCITY.qgz

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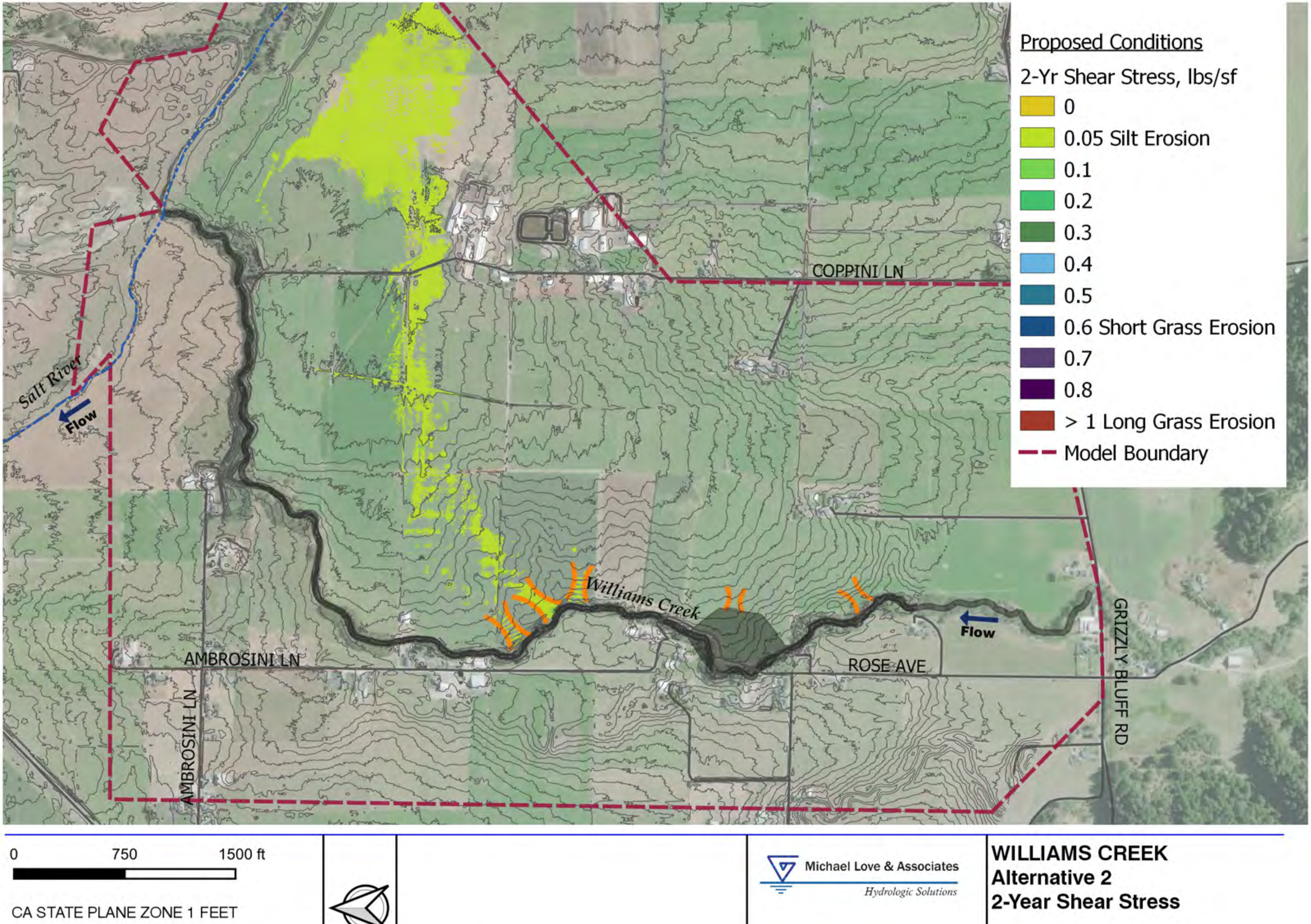

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WILLIAMS CREEK
Alternative 2
2-Year Shear Stress

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_SHEAR.qgz

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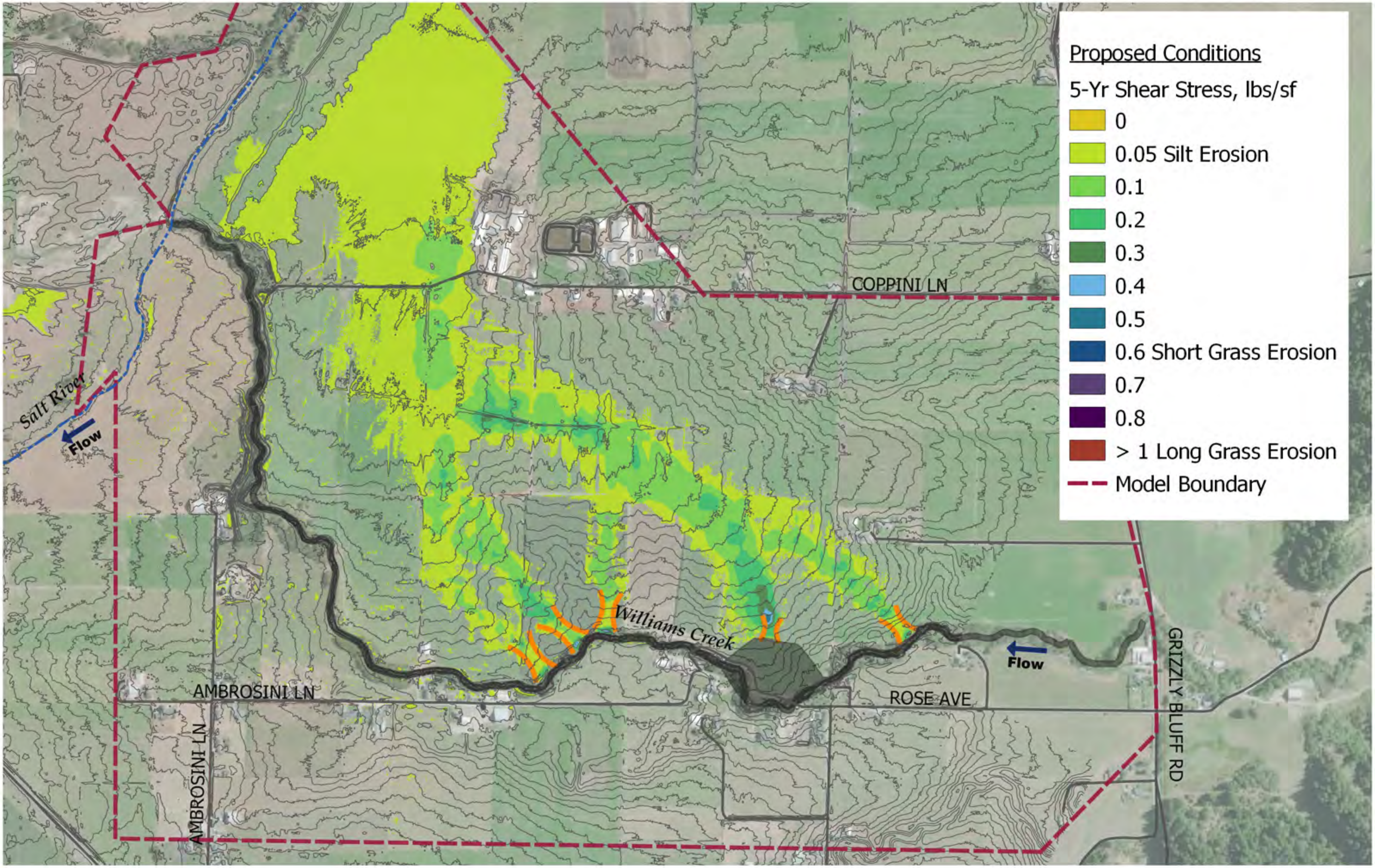

0 750 1500 ft

CA STATE PLANE ZONE 1 FEET

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WILLIAMS CREEK
Alternative 2
5-Year Shear Stress

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_SHEAR.qgz

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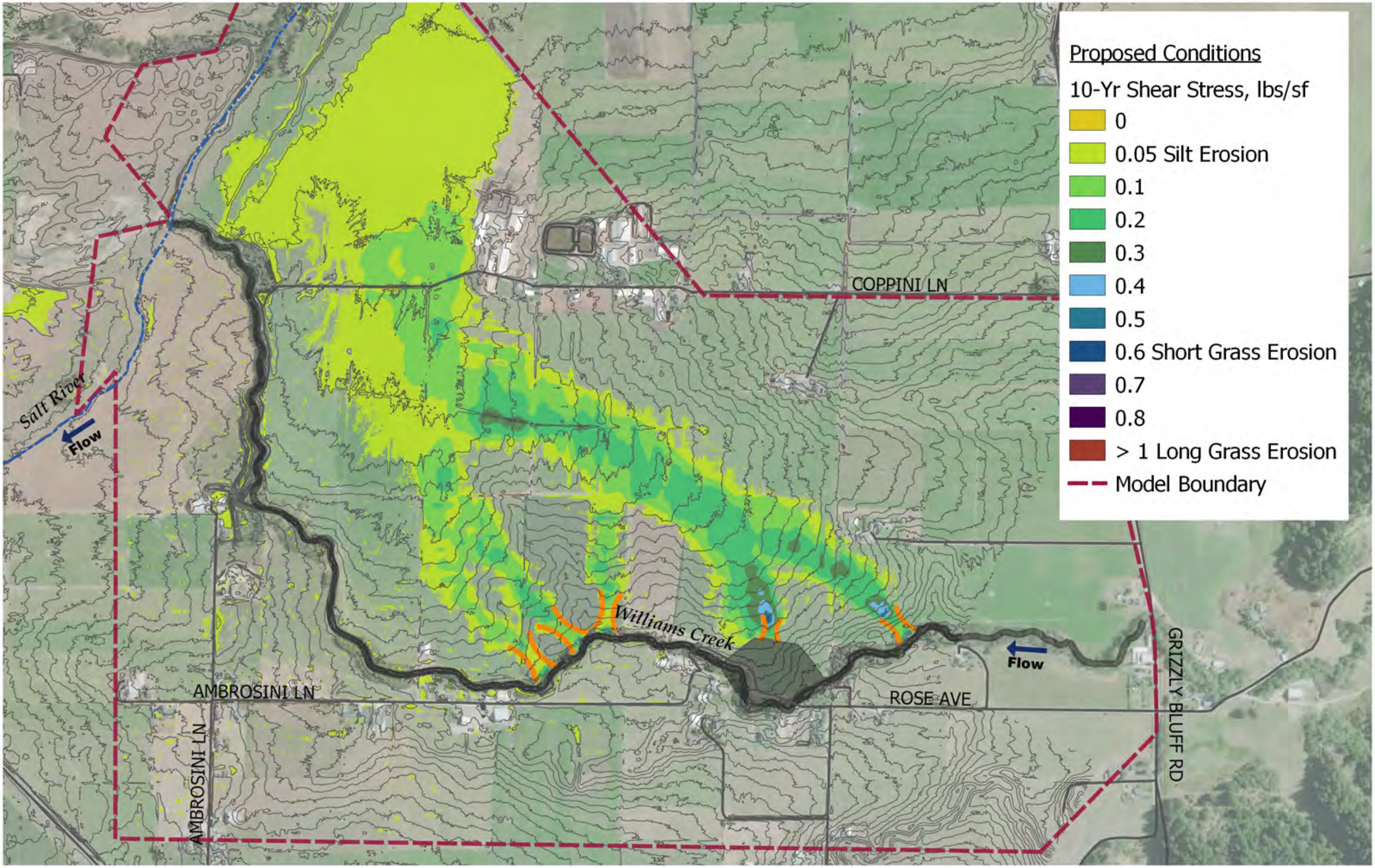

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Hydrologic Solutions

WILLIAMS CREEK
Alternative 2
10-Year Shear Stress

Filepath: Q:\Williams_C_Alternatives\7_CAD-GIS\QGIS\Projects\ALT 2_SHEAR.qgz

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Appendix G
Opinion of Probable Construction Cost

Williams Creek Restoration Project: Alternatives Analysis
Opinion of Probable Construction Cost
March 2020

Item Description	Unit	Unit Cost	Alternative 1		Alternative 2		Alternative 3	
			Quantity	Cost	Quantity	Cost	Quantity	Cost
Mobilization/Demobilization	LS	$ 200,000	1	$ 200,000	1	$ 200,000	1	$ 200,000
Water Management, Dust/Erosion Control, and Env. Protection	LS	$ 300,000	1	$ 300,000	1	$ 300,000	1	$ 300,000
Construction Surveying	LS	$ 75,000	1	$ 75,000	1	$ 75,000	1	$ 75,000
Clearing and Grubbing	AC	$ 20,000	15	$ 300,000	15	$ 300,000	17	$ 340,000
Sediment Excavation, Hauling and Application	CY	$ 20	120,000	$ 2,400,000	120,000	$ 2,400,000	120,000	$ 2,400,000
Instream Log Habitat Structures	LS	$ 250,000	1	$ 250,000	1	$ 250,000	1	$ 250,000
Rock Chute for Sediment Basins	LS	$ 300,000	1	$ 300,000	1	$ 300,000	1	$ 300,000
Misc. Access Roads for Sediment Basins and Agricultural Operations	LS	$ 200,000	1	$ 200,000	1	$ 200,000	1	$ 200,000
Bridge Replacement	EA	$ 150,000	4	$ 600,000	3	$ 450,000	3	$ 450,000
Biodegradable Mat	SY	$ 5	20,000	$ 100,000	20,000	$ 100,000	20,000	$ 100,000
Seed and Mulch	AC	$ 10,000	15	$ 150,000	15	$ 150,000	17	$ 170,000
Revegetation	AC	$ 30,000	15	$ 450,000	15	$ 450,000	17	$ 510,000
Exclusion Fence and Gates	LF	$ 5	19,000	$ 95,000	19,000	$ 95,000	21,000	$ 105,000
Sub-Total				$ 5,420,000		$ 5,270,000		$ 5,400,000
Estimating Contingency @ 30%	PER	30%		$ 1,626,000		$ 1,581,000		$ 1,620,000
TOTAL PLANNING LEVEL OPINION OF PROBABLE COST			**$ 7,050,000**		**$ 6,860,000**		**$ 7,020,000**	

NOTE: This opinion reflects probable construction costs obtainable for the project location on the date this estimate was prepared. Due to inflation of labor, material and equipment costs and nature of contruction cost volitility, prices may vary. Contingency of -10% to +30% commonly applies to planning-level estimating.

Appendix H
Baseline Biological Surveys

Technical Memorandum

February 7, 2020

To:	Humboldt County Resource Conservation District	Ref. No.:	11151140.03
From:	Elizabeth Meisman, Wildlife Biologist Genevieve Rozhon, Wildlife Biologist	Tel:	707-267-2298
CC:	Jeremy Svehla, Project Manager		

Subject: Reconnaissance Survey for Nesting Birds and Habitat Evaluation for the Little Willow Flycatcher and Evaluation of Potential to Occur for Marbled Murrelet and Northern Spotted Owl for Williams Creek, Humboldt County, CA

1. Introduction

This Technical Memorandum reports the results of a 2019 reconnaissance survey for special-status nesting birds and Little Willow Flycatcher (*Empidonax traillii brewsteri*) habitat along Williams Creek near the City of Ferndale, California (Figure 1, Attachment A). GHD Wildlife Biologists Genevieve Rozhon and Elizabeth Meisman performed the reconnaissance survey and habitat evaluation on behalf of the client on May 17, 2019. Elizabeth Meisman conducted a supplemental database search and likelihood determination of whether Marbled Murrelets *(Brachyramphus marmoratus)* and/or Northern Spotted Owls *(Strix occidentalis caurina)* could be present in the Project area. These were conducted to satisfy Section 3503 of the California Department of Fish and Wildlife (CDFW) Code, the Federal Migratory Bird Treaty Act, and to address protection to federally and state-listed species under the California Endangered Species Act (CESA) (California Code of Regulations, Title 14, Chapter 6, §§783.0-787.9) and the federal endangered species act. The survey was also conducted to address potential project impacts to nesting birds. This memo describes the methods and results of the survey and database search.

1.1 Purpose

Sediment deposition and overbank flooding on Williams Creek is a recurring problem that has resulted in ecological and land use degradation. In its present configuration, Williams Creek is unable to transport its sediment load within its banks and is largely disconnected from the Salt River. While the Salt River Ecosystem Restoration Project (SRERP) proposes to connect Williams Creek at its confluence with Salt River, the SRERP did not include any restoration of Williams Creek upstream of the confluence. In 2013, initial work was completed to develop conceptual strategies for streamflow and sediment management on Williams Creek (USACE 2013). Concepts were identified as part of that work to increase stream function and allow sediment to deposit in controlled areas.

The restoration of Williams Creek ("Project") is critical to further enhance ecosystem function of the greater Salt River Ecosystem Restoration Project. The purpose of this reconnaissance survey was to evaluate the potential for special-status nesting birds and avian habitat to occur within the Williams Creek Project area. The results may be used for planning, design, to avoid or mitigate impacts associated with project construction, and/or to guide future management decisions.

1.2 Location

The Project area is a section of Williams Creek near the City of Ferndale in Humboldt County, California. The Project area includes a section of William's Creek from the confluence with Salt River, upstream to private property south of Grizzly Bluff Road. The extent of the Project area is shown in Figure 2 (Attachment A). The parcel north of Grizzly Bluff Road was excluded from the survey as access was not granted.

2. Regulatory Setting

2.1 Federal Jurisdiction

2.1.1 Endangered Species Act (ESA)

The ESA of 1973 (16 USC 1531 et seq.) establishes a national policy that all federal departments and agencies provide for the conservation of threatened and endangered species and their ecosystems. The Secretary of the Interior and the Secretary of Commerce are designated in the ESA as responsible for: (1) maintaining a list of species likely to become endangered within the foreseeable future throughout all or a significant portion of its range (threatened) and that are currently in danger of extinction throughout all or a significant portion of its range (endangered); (2) carrying out programs for the conservation of these species; and (3) rendering opinions regarding the impact of proposed federal actions on listed species. The ESA also outlines what constitutes unlawful taking, importation, sale, and possession of listed species and specifies civil and criminal penalties for unlawful activities.

Pursuant to the requirements of the ESA, an agency reviewing a proposed project within its jurisdiction must determine whether any federally listed or proposed species may be present in the project region, and whether the proposed project would result in a "take" of such species. The ESA prohibits "take" of a single threatened and endangered species except under certain circumstances and only with authorization from the USFWS or the National Oceanic and Atmospheric Administration (NOAA) Fisheries through a permit under Section 7 (for federal entities or federal actions) or 10(a) (for non-federal entities) of the Act. "Take" under the ESA includes activities such as "harass, harm, pursue, hunt shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." USFWS regulations define harm to include "significant habitat modification or degradation" (64 FR 60727). On June 29, 1995, a U.S. Supreme Court ruling further defined harm to include habitat modification "…where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering".

In addition, the agency is required to determine whether the project is likely to jeopardize the continued existence of any species proposed to be listed under the ESA, or result in the destruction or adverse modification of critical habitat for such species (16 USC 1536[3][4]). If it is determined that a project may result in the "take" of a federally-listed species, a permit would be required under Section 7 or Section 10 of the ESA.

Critical Habitat is defined by the ESA as a specific geographic area containing features essential for the conservation of an endangered or threatened species. Under Section 7 of the ESA, critical habitat should be evaluated if designated for federally listed species that may be present in the project Action Area. The Action Area serves as the “study area” for the purposes of a Section 7 Biological Assessment.

The Project area may support federally-listed bird species, such as the Western Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*). Williams Creek is not designated as Critical Habitat for any avian species. However, Williams Creek is designated as Critical Habitat for the Southern Oregon/Northern California Coasts (SONCC) Coho Salmon (64 FR 24049).

2.1.2 Migratory Bird Treaty Act (MBTA)

The MBTA of 1918 (16 USC 703-711) as amended established federal responsibilities for the protection of nearly all species of birds, their eggs, and nests. A migratory bird is defined as any species or family of birds that live, reproduce or migrate within or across international borders at some point during their annual life cycle. The MBTA prohibits the take, possession, buying, selling, purchasing, or bartering of any migratory bird listed in 50 CFR Part 10, including feathers or other parts, nests, eggs, or products, except as allowed by implementing regulations (50 CFR 21). Only exotic species such as Rock Pigeons (*Columba livia*), House Sparrows (*Passer domesticus*), and European Starlings (*Sturnus vulgaris*) are exempt from protection.

In 2001, President Clinton defined “take” in Executive Order 13186 to include both “intentional” and “unintentional.” However, in 2017, the Department of the Interior’s (DOI) Office of Solicitor argued via Opinion M-37050 that incidental take was not prohibited under the Migratory Bird Treaty Act. Opinion M-37050 is currently the subject of a lawsuit between eight U.S. states and the U.S. DOI. Many avian species likely to occur in the Project area are protected under the MBTA.

2.2 State Jurisdiction

2.2.1 California Environmental Quality Act (CEQA)

CEQA applies to certain activities of state and local public agencies. A public agency must comply with CEQA when it undertakes an activity defined by CEQA as a "project." A project is an activity undertaken by a public agency or a private activity which must receive some discretionary approval. The Proposed Project is a project under CEQA; therefore, CEQA compliance is required. Under CEQA, a variety of technical studies including biological, cultural, traffic, and air quality studies as well as research and professional knowledge are considered to determine whether the project may have an “adverse effect” on the environment. Lead agencies are charged with evaluating the best available data when determining what specifically should be considered an “adverse effect” to the environment. Impacts to many avian species likely to occur in the Project area may require mitigation under CEQA.

2.2.2 California Endangered Species Act (CESA)

The CESA (California Code of Regulations, Title 14, Chapter 6, §§783.0-787.9) includes provisions for the protection and management of species listed by the State of California as endangered, threatened, or designated as candidates for such listing (California Fish and Game Code (FGC) Sections 2050 through 2085). The CESA generally parallels the main provisions of the ESA and is administered by the CDFW, who maintains a list of state threatened and endangered species as well as candidate and species of special concern. The CESA prohibits the "take" of any species listed as threatened or endangered unless authorized by the CDFW in the form of an Incidental Take Permit. Under FGC, "take" is defined as to "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." CESA-listed avian species may occur within the Project area, including the Western Yellow-billed Cuckoo and Little Willow Flycatcher.

2.2.3 California Fish and Game Code (FGC)

Lake or Streambed Alteration Agreement (LSAA)

Streams, lakes, and riparian vegetation that serve as habitat for fish and other wildlife species are subject to jurisdiction by the CDFW under Sections 1600-1616 of the FGC. Any activity that will do one or more of the following: 1) substantially obstruct or divert the natural flow of a river, stream, or lake; 2) substantially change or use any material from the bed, channel, or bank of a river, stream, or lake; or 3) deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it can pass into a river, stream, or lake; generally require a 1602 Lake and Streambed Alteration Agreement (LSAA). The term "stream," which includes creeks and rivers, is defined in the California Code of Regulations (CCR) as follows: "a body of water that flows at least periodically or intermittently through a bed or channel having banks and supports fish or other aquatic life. This includes watercourses having a surface or subsurface flow that supports or has supported riparian vegetation" (14 CCR 1.72). In addition, the term stream can include ephemeral streams, dry washes, watercourses with subsurface flows, canals, aqueducts, irrigation ditches, and other means of water conveyance if they support aquatic life, riparian vegetation, or stream-dependent terrestrial wildlife. Riparian is defined as, "on, or pertaining to, the banks of a stream;" therefore, riparian vegetation is defined as, "vegetation which occurs in and/or adjacent to a stream and is dependent on, and occurs because of, the stream itself." Removal of riparian vegetation also requires a Section 1602 Lake and Streambed Alteration Agreement from the CDFW. As this Project will involve in-water work, in is likely that a LSAA will be required. LSAA's frequently include conservation measures for nesting birds.

Birds of Prey and Native Nesting Birds

Section 3503 of the FGC prohibits the take, possession, or needless destruction of the nest or eggs of any bird. Subsection 3503.5 specifically prohibits the take, possession, or destruction of any birds in the orders *Falconiformes* (hawks and eagles) or *Strigiformes* (owls) and their eggs or nests. These provisions, along with the federal MBTA, essentially serve to protect nesting native birds. Non-native species, including the European Starling, Rock Dove, and House Sparrow, are not afforded protection under the MBTA or FGC.

Fully Protected Species

The CDFW enforces the FGC, which provides protection for "fully protected birds" (Section 3511), "fully protected mammals" (Section 4700), "fully protected reptiles and amphibians" (Section 5050), and "fully protected fish" (Section 5515). As fully protected species, the CDFW cannot authorize any project or action that would result in "take" of these species even with an incidental take permit. Many avian species likely to occur in the Project area are protected under the FGC.

2.2.4 CDFW Special Animals List

According to the CDFW, the Special Animals List encompasses "all the animal taxa tracked by the Department of Fish and Wildlife's California Natural Diversity Database (CNDDB), regardless of their legal or protection status. This list is also referred to as the list of "species at risk" or "special status species". The Special Animals List includes species, subspecies, or Evolutionarily Significant Units (ESU) where at least one of the following conditions applies:

- Officially listed or proposed for listing under the State and/or Federal Endangered Species Acts;
- Taxa considered by the Department to be a Species of Special Concern (SSC);
- Taxa which meet the criteria for listing, even if not currently included on any list, as described in Section 15380 of the California Environmental Quality Act Guidelines (more information on CEQA is available at: http://resources.ca.gov/ceqa/guidelines);
- Taxa that are biologically rare, very restricted in distribution, or declining throughout their range but not currently threatened with extirpation;
- Population(s) in California that may be peripheral to the major portion of a taxon's range but are threatened with extirpation in California;
- Taxa closely associated with a habitat that is declining in California at a significant rate (e.g. wetlands, riparian, vernal pools, old growth forests, desert aquatic systems, native grasslands, valley shrubland habitats, etc.);
- Taxa designated as a special status, sensitive, or declining species by other state or federal agencies, or a non-governmental organization (NGO) and determined by the CNDDB to be rare, restricted, declining, or threatened across their range in California" (CDFW 2019).

Species on the Special Animals List must be considered in CEQA.

3. Methods

3.1 Special-status Nesting Bird Survey

The survey area included the Project site and accessible areas within 500 feet of the project's disturbance area. To the degree feasible, inaccessible areas within 500 feet of the project's disturbance area were surveyed with binoculars. The survey was completed in one day within the first four hours after sunrise to coincide with the period of high bird activity. The survey was conducted by Genevieve Rozhon (GHD Wildlife Biologist). Weather on the survey day was partly cloudy, without any precipitation, high winds (< 5 miles per hour), or other conditions that could negatively impact bird activities. The avian survey occurred prior to the scheduled start of project construction.

The survey methods were intended to identify confirmed or probable avian nesting activity. Where the habitat allowed the surveyor to walk without risk of damaging nests and surrounding vegetation, the survey included a physical search of the area. This included inspecting the ground, shrubs, and trees for the presence of active nests (cup nests, stick nests, mud nests, and cavities) and avian species within them. Additionally, the bark of vegetation and the ground layer under vegetation were inspected for evidence of avian species, such as feathers, pellets, or whitewash. Where the habitat was dense or otherwise impenetrable/inaccessible (i.e. in the case of no property access on certain parcels), observations were made from fixed locations. The foliage was viewed with binoculars and behavioral observations of adult birds were made to infer the locations of nests.

A list of all avian species heard or observed on site was completed after the survey. Each detected species was also associated with a code representing the highest breeding evidence observed during the day (Table 3.1). High-powered binoculars were used during the survey (10x42 magnification).

Table 3.1 List of avian breeding codes, associated behavior, and breeding status*

Breeding Rank	Breeding Code	Description	Breeding Status
1	N	Active nest	Breeding
2	M	Carrying nesting material	Breeding
3	F	Carrying food or fecal sac	Breeding
4	D	Distraction display/feigning	Breeding
5	L	Local young fed by parents	Breeding
6	Y	Local young incapable of sustained flight	Breeding
7	C	Copulation or courtship observed	Breeding
8	T	Territorial behavior	Unconfirmed
9	S	Territorial song or drumming heard	Unconfirmed
10	E	Encountered in study area	Unconfirmed
11	O	Encountered flying over the study area	Unconfirmed

* The highest ranking code was recorded for each species during the survey.

3.2 Little Willow Flycatcher Habitat Evaluation

The Little Willow Flycatcher is a long-distance neotropical migrant that breeds west of the Cascades in the Sierra Nevada mountains up to southwestern British Columbia. The California Department of Fish and Wildlife listed the species as state endangered in 1990 (CDFG 1991). The species winters in southern Mexico and northern South America. In California, known breeding locations are from Shasta, Kern, Alpine, Inyo, Mono, Santa Barbara, Riverside, and San Diego counties. Willow Flycatchers are late spring migrants with abbreviated breeding seasons of only 70-90 days (Sedgwick 2000). They arrive on their breeding ranges in California in mid-May (Small 1994).

Optimal habitat requirements of Willow Flycatcher include dense willow (*Salix* sp.) thickets with low, exposed branches usually near slow moving water, and seeps or standing water typically between 600-2,500 meters in the Sierra Nevada and Cascade Range (Sedgwick 2000, Gaines 2005). The Little Willow Flycatcher in particular prefers shrubby riparian vegetation (willow, alder, etc.) with adjacent areas of saturated soils (Bombay et al. 2003). Riparian habitat occupied by the Brown-headed Cowbird (*Molothrus ater*) or areas where heavy grazing of willows has occurred from livestock may greatly reduce habitat quality for Willow Flycatchers (Gaines 2005).

On their breeding range, territory size may range from roughly 3 to 5 km (Prescot 1986). Cup nests are created out of twigs, grass, and bark and lined with hair, grass, and feathers. Nest are typically located low to the ground in willow shrubs and bushes. Willow Flycatchers primarily capture insects on the wing (Sedgwick 2000). The species was formerly widespread in California and has declined significantly as a result of riparian habitat loss and degradation (e.g. livestock overgrazing) and cowbird nest parasitism (Gaines 2005).

The Project site was evaluated based on Willow Flycatcher preferred habitat characteristics, as described above. Vegetation species, riparian corridor width, creek flow, intensity of grazing, the presence of nest predators, and the presence of brood parasite species were all documented and considered in the habitat evaluation. No protocol-level surveys were required or conducted at this time.

3.3 Marbled Murrelet and Northern Spotted Owl Database Searches

A database search of the California Natural Diversity Database (CNDDB; CDFW 2020a), using the Marbled Murrelet data layer in Biogeographic Information and Observation System (BIOS) Viewer, and the CDFW Spotted Owl Observations Database (CDFW 2020b) was conducted by GHD on January 28, 2020. The search encompassed the USGS Ferndale quadrangles (quad) centered on the project area.

Based on these database results, habitat assessments made during vegetation community mapping, results from the avian survey, and professional expertise regarding the habitat and conditions surrounding the Project area, the likelihood of federal and state listed Marbled Murrelet and Northern Spotted Owl to be present in the project area were evaluated.

4. Results

4.1 Special-status Nesting Bird Survey

The majority of the bird species detected during the survey were common species and do not have any special federal or state regulatory status. Species that nest on bridges, barns, and other human-made structures were particularly common. Based on behavioral observations, Tree Swallows (*Tachycineta bicolor*), Barn Swallows (*Hirundo rustica*), Black Phoebes (*Sayornis nigricans*), Black-capped Chickadees (*Poecile atricapillus*), and Violet-green Swallows (*Tachycineta thalassina*) are likely nesting on site. Of these species, only the Black-capped Chickadee has a special regulatory status (CDFW Watch List). A total of thirty-six avian species were observed in or flying over the project site.

Table 4.1 Avian Species Detected During Reconnaissance Survey of Williams Creek*

AOU Alpha Code	Common Name	Latin Name	Special Regulatory Status	Breeding Status Code
ANHU	Anna's Hummingbird	*Calypte anna*	MBTA Protected	T
AMGO	American Goldfinch	*Spinus tristis*	MBTA Protected	O

Table 4.1 Avian Species Detected During Reconnaissance Survey of Williams Creek*

AOU Alpha Code	Common Name	Latin Name	Special Regulatory Status	Breeding Status Code
SWTH	Swainson's Thrush	*Catharus ustulatus*	MBTA Protected	S
EUCD	Eurasian Collared-dove	*Streptopelia decaocto*	None, non-native species	E
SOSP	Song Sparrow	*Melospiza melodia*	MBTA Protected	S
PSFL	Pacific-slope Flycatcher	*Empidonax difficilis*	MBTA Protected	S
BLPH	Black Phoebe	*Sayornis nigricans*	MBTA Protected	C
TRES	Tree Swallow	*Tachycineta bicolor*	MBTA Protected	C
WREN	Wrentit	*Chamaea fasciata*	MBTA Protected	S
DEJU	Dark-eyed Junco	*Junco hyemalis*	MBTA Protected	S
BRCR	Brown Creeper	*Certhia americana*	MBTA Protected	E
BARS	Barn Swallow	*Hirundo rustica*	MBTA Protected	C
AMRO	American Robin	*Turdus migratorius*	MBTA Protected	S
VGSW	Violet-green Swallow	*Tachycineta thalassina*	MBTA Protected	C
RCKI	Ruby-crowned Kinglet	*Regulus calendula*	MBTA Protected	S
CORA	Common Raven	*Corvus corax*	MBTA Protected	O
BCCH	Black-capped Chickadee	*Poecile atricapillus*	CDFW WL	C
BHGR	Black-headed Grosbeak	*Pheucticus melanocephalus*	MBTA Protected	S
NRWS	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	MBTA Protected	E
BRBL	Brewer's Blackbird	*Euphagus cyanocephalus*	MBTA Protected	E
SAVS	Savannah Sparrow	*Passerculus sandwichensis*	MBTA Protected	S
WEWP	Western Wood-Peewee	*Sturnella neglecta*	MBTA Protected	S
TUVU	Turkey Vulture	*Cathartes aura*	MBTA Protected	O
EUST	European Starling	*Sturnus vulgaris*	None, non-native species	E
BHCO	Brown-headed Cowbird	*Molothrus ater*	MBTA Protected	S
OCWA	Orange-crowned Warbler	*Oreothlypis celata*	MBTA Protected	S
WAVI	Warbling Vireo	*Vireo gilvus*	MBTA Protected	S
STJA	Steller's Jay	*Cyanocitta stelleri*	MBTA Protected	E

Table 4.1 Avian Species Detected During Reconnaissance Survey of Williams Creek*

AOU Alpha Code	Common Name	Latin Name	Special Regulatory Status	Breeding Status Code
PEFA	Peregrine Falcon	*Falco peregrinus*	CDFW FP, CDF S, USFWS BCC	O
CAVI	Cassin's Vireo	*Vireo cassinii*	MBTA Protected	S
COHA	Cooper's Hawk	*Accipiter cooperii*	CDFW WL (nesting)	O
WCSP	White-crowned Sparrow	*Zonotrichia leucophrys*	MBTA Protected	S
RTHA	Red-tailed Hawk	*Buteo jamaicensis*	MBTA Protected	O
DOWO	Downy Woodpecker	*Dryobates pubescens*	MBTA Protected	E
GREG	Great Egret	*Ardea alba*	CDF S	O
CBCH	Chestnut-backed Chickadee	*Poecile rufescens*	MBTA Protected	S

***Regulatory status descriptions reprinted from CDFW (2019).**

MBTA Protected: Protected under the federal Migratory Bird Treaty Act

CDF S (California Department of Forestry and Fire Protection Sensitive): those species that warrant special protection during timber operations.

CDFW FP (California Department of Fish and Wildlife Fully Protected): This classification was the State of California's initial effort to identify and provide additional protection to those animals that were rare or faced possible extinction. Lists were created for fish, amphibians and reptiles, birds and mammals. Most of the species on these lists have subsequently been listed under the state and/or federal endangered species acts.

CDFW WL (California Department of Fish and Wildlife Watch List): The CDFW maintains a list consisting of taxa that were previously designated as "Species of Special Concern" but no longer merit that status, or which do not yet meet SSC criteria, but for which there is concern and a need for additional information to clarify status.

USFWS BCC (U.S. Fish and Wildlife Service Birds of Conservation Concern): The goal of the Birds of Conservation Concern 2008 report is to accurately identify the migratory and non-migratory bird species (beyond those already designated as Federally Threatened or Endangered) that represent our highest conservation priorities and draw attention to species in need of conservation action. This report is available at: http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php.

4.2 Little Willow Flycatcher Habitat Evaluation

A GHD botanist documented two Natural Communities within the Project area: the arroyo willow shrubland association and the red alder/arroyo willow association, during May 2019 botanical surveys. Riparian vegetation conditions onsite are reprinted below (see full botany report for details; GHD 2019). Vegetation conditions are analyzed in the context of Willow Flycatcher habitat.

Throughout the survey area, the majority of arroyo willow (*Salix lasiolepis*) and red alder (*Alnus rubra*) had small diameters, primarily <12” diameter at breast height (DBH), and in many cases, much smaller. The shrub layer was very sparse. The riparian corridor is wider on the east side of the creek than the west side, and gaps occurs where no riparian vegetation occurs on either side (Figure 2, Attachment A). The width of the riparian corridor varies along the creek from zero to an average of 25 feet on each side of the creek bank. Two invasive species, Canada thistle (*Cirsium arvense*) and reed canary grass *(Phalaris arundinacea*) occur near the channel.

The section of William's Creek north of the arroyo willow shrubland association, to the confluence with Salt River contained more diverse riparian vegetation, with various ages and size classes of trees. Some large diameter red alder and Pacific willows (*Salix lucida*) occurred with diameters as large as 22" DBH, along with several medium sized trees (10-15" DBH), and smaller trees.

No physical sightings or auditory detections of Little Willow Flycatchers were made during the May 17th survey, although protocol-level surveys were not proposed or conducted. In addition, the survey date was earlier than Willow Flycatchers are expected to breed in this area (early to mid-June is recommended as the earliest survey time to detect singing males recently arrived from wintering grounds) (Bombay et al 2003). Overall, the habitat in and around the Project site may be sub-par for nesting Willow Flycatchers. Specifically, the riparian corridor was fairly narrow, with a very limited understory/shrub layer, and generally heavily grazed by cattle (corridor was not fenced off from cattle in several locations, and areas that were fenced did not appear to stop all cattle). No saturated soil or seeps were present in the survey area, although slow moving water in the creek may provide seasonal suitable aquatic habitat. In addition, a Willow Flycatcher nest parasite, the Brown-headed Cowbird, was observed in multiple locations in the survey area.

4.3 Marbled Murrelet, Federally and State Threatened, No Potential

The federally threatened Marbled Murrelet is a small seabird that nests in coastal, old-growth forests of North America. The species is a year-round resident along the coast from the Alaskan Aleutian islands to Big Sur in California. The northernmost populations of Marbled Murrelets are migratory, while more southern populations likely only engage in small-scale migration movements (Nelson 1997).

Marbled Murrelets spend the majority of their lives in the near-shore marine environments and prefer to forage along rocky coastal areas within 1.2 miles of shore (USFWS 1997). They feed by diving for small fish and invertebrates in coastal waters and bays, but may also forage on rivers and lakes. Murrelets nest in old-growth conifer forests with decadence features such as remnant trees or large branch platforms from normal tree growth, disease, damage, or mistletoe (structure used for nesting). Nest-building is typically initiated around early March with the breeding season spanning from March through September. Murrelets have a slow reproductive rate and produce only one egg per year (Nelson and Peck 1995, USFWS 1997).

Murrelets favor old-growth coniferous forests <50 miles from the coast. Trees with a dbh (diameter at breast height) greater than 19 in are preferred for nesting (81 FR 51348 51370). Stand size is also an important feature for nest site selection with stands greater than 500 acres preferred in California (57 FR 45328-45337). Nest site and nest tree fidelity is common (Nelson 1997). Proximity of nesting habitat to foraging habitat is an important factor in determining murrelet distribution (USFWS 1997).

Loss of habitat due to timber harvesting is a major contributor to the decline of the species. Further, edge effects resulting from clear-cuts adjacent to nest sites may contribute to increased predation rates, as forest edges are preferred by many murrelet predators including jays, crows, ravens, accipiters, squirrels, marten, and fisher. Marbled Murrelet populations are considered to be highly sensitive to forest fragmentation. Other threats include gill-net fishing, marine pollution, and disease (USFWS 1997).

This species was not detected during general avian surveys, although surveys did not target this species. The closest known Marbled Murrelet occurrence, and the only one along Bear River ridge, occurred on

Mattole Road between Francis and Williams Creeks, approximately 2.5 miles from the Project area (CDFW 2020). There is no evidence of use of the Project area or immediate vicinity by Marbled Murrelets (CDFW 2020). Based on this lack of evidence and required habitat, there is no likelihood that the species would occur in the Project area. No impacts are expected to occur to this species and, therefore, they are excluded from further consideration.

4.4 Northern Spotted Owl *(Strix occidentalis caurina)*, Federally and State Threatened, No Potential

The Northern Spotted Owl is the northwestern-most dwelling subspecies of the Spotted Owl (*Strix occidentalis*) in North America. It is a federally threatened species (55 FR 26114-26194). The range of the Northern Spotted Owl comprises mixed conifer forests from southern British Columbia to Marin County in northern California, with populations as far east as the Cascades. In terms of plumage, this subspecies is slightly darker in coloration and has smaller white spots than the other two *Strix occidentalis* subspecies, the California Spotted Owl and the Mexican Spotted Owl (Oberholser 1915). As with most owl species, males are smaller than females in terms of mass and wing chords (Blakesley et al. 1990).

As a non-migratory subspecies, spotted owls reside in their breeding habitat year-round (Allen and Brewer 1986). The Northern Spotted Owl is somewhat of a specialist species, primarily feeding on small to medium-sized rodents. However, the owls occasionally will also feed upon birds and invertebrates (Thomas et al. 1990). Northern Spotted Owls typically lay up to three eggs per breeding season. The breeding season spans from March through September (Forsman et al. 1984).

The preferred habitat type of the Northern Spotted Owl consists of old growth forests with moderate to high canopy closure, a multi-species canopy with large over-story trees, large trees with numerous decadence features (i.e. broken tops, cavities, and snags), and a significant amount of open space beneath the canopy (USFWS 2008).

Historically, threats to the Northern Spotted Owl included a loss of suitable habitat from logging as well as wildfires and disease. Current threats include timber harvesting and wildfires, as well as competition from Barred Owls and predation. Clear-cutting and even-aged stand forestry management practices in this region also have contributed to a decline in habitat (Thomas et al. 1990). New potential threats may come from West Nile virus, sudden oak death, and loss of genetic variation due to a recent genetic bottleneck (USFWS 2008).

Northern Spotted Owls have been documented nearby on private timberlands along Bear River Ridge, south of the Project area. There are 26 positive detection records and one activity center within a 1 mile radius of the Project area (CDFW 2020). However, there are no detections within a half mile radius of the Project area (CDFW 2020), which is the typical nest buffer size for Northern Spotted Owls. Additionally, the habitat within the Project area is a limited riparian zone, and the immediately surrounding areas are residential and agricultural. Thus, there is no nesting, roosting, or foraging habitat for Northern Spotted Owls within the Project area or immediate vicinity and there is no likelihood that the species would occur in the Project area. No impacts are expected to occur to this species and, therefore, they are excluded from further consideration.

5. Conclusion

Based on survey results, the Project area likely provides nesting habitat for many common avian species. The majority of species detected onsite that exhibited breeding behavior during the survey nest on human-made structures (bridges, barns, etc.) or in tree cavities. If tree removal or in-channel work is prosed during the avian breeding season (March 15-August 15), pre-construction nesting bird surveys are recommended.

Willow Flycatchers have been documented nearby along the Salt River, including a lone territorial male in now restored parts of the lower channel (near the Riverside Ranch Barn), although most recent breeding records are clustered around the Mad River Fish Hatchery or Wastewater Treatment Plant in Blue Lake (Winzler & Kelly 2010, Winzler & Kelly 2011, eBird 2019). In Humboldt County, Willow Flycatchers are most commonly documented in riparian areas that contain a significant shrub layer in the understory (K. Slauson, personal comm.). While Willow Flycatcher presence in the Project area cannot be completely ruled out, the Project site likely serves as sub-par nesting habitat for the species (based on vegetation structure, heavy grazing pressure, and the presence of nest parasites), but may provide temporary shelter/stop-over habitat for migrants.

Marbled Murrelets and/or Northern Spotted Owls have been documented in much of Humboldt County (CDFW 2020). However, both species are associated with mature forest habitats, which are not present within or immediately adjacent to the Project area. Based on database search results and on-site habitat evaluations, there is no potential for Marbled Murrelets and/or Northern Spotted Owls to be present within the Project area.

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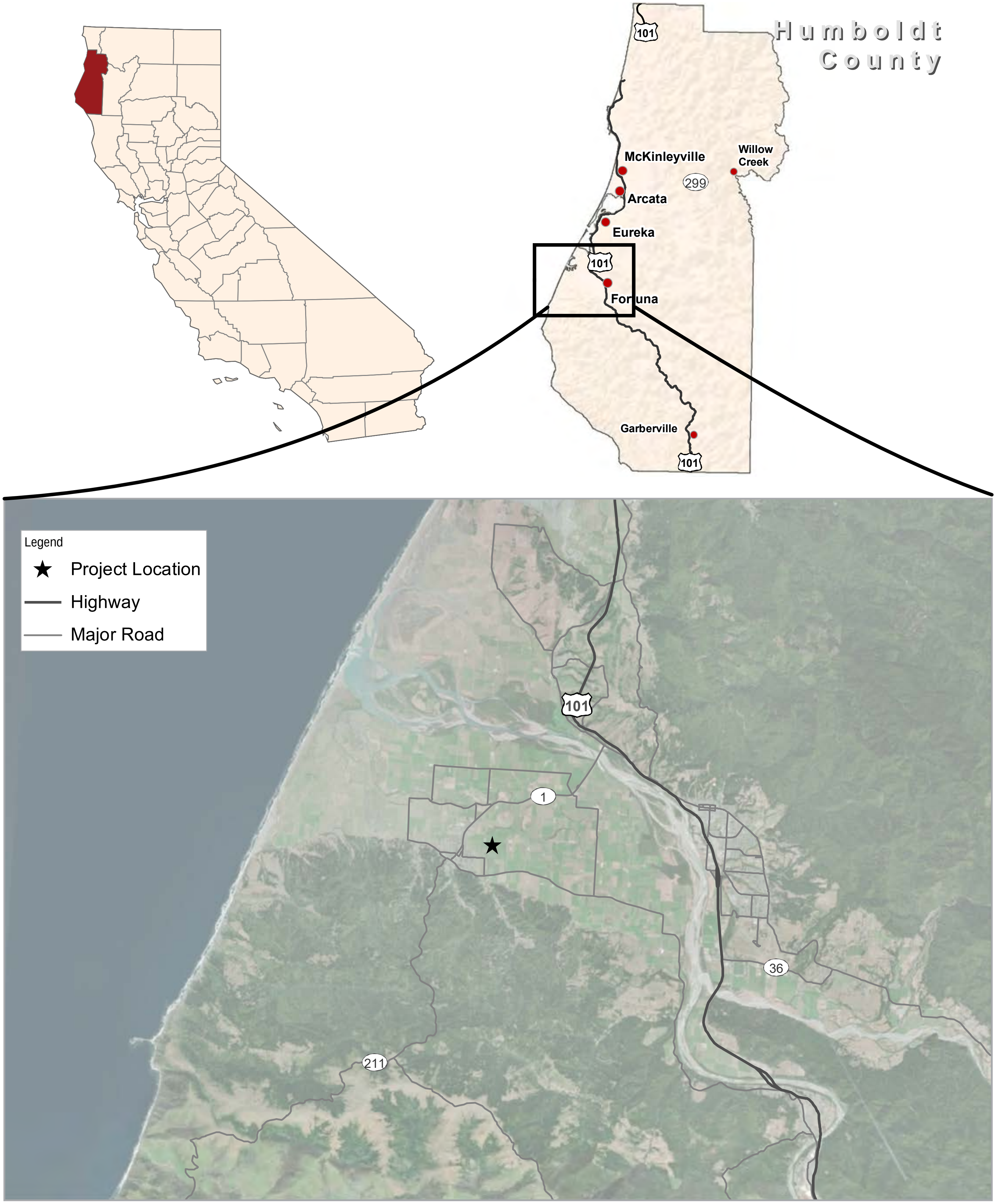
Attachment A. Figures



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GHD

Humboldt County Resource Conservation District
Williams Creek

Vicinity Map

Project No. 11151140
Revision No. -
Date 10/14/2019

FIGURE 1

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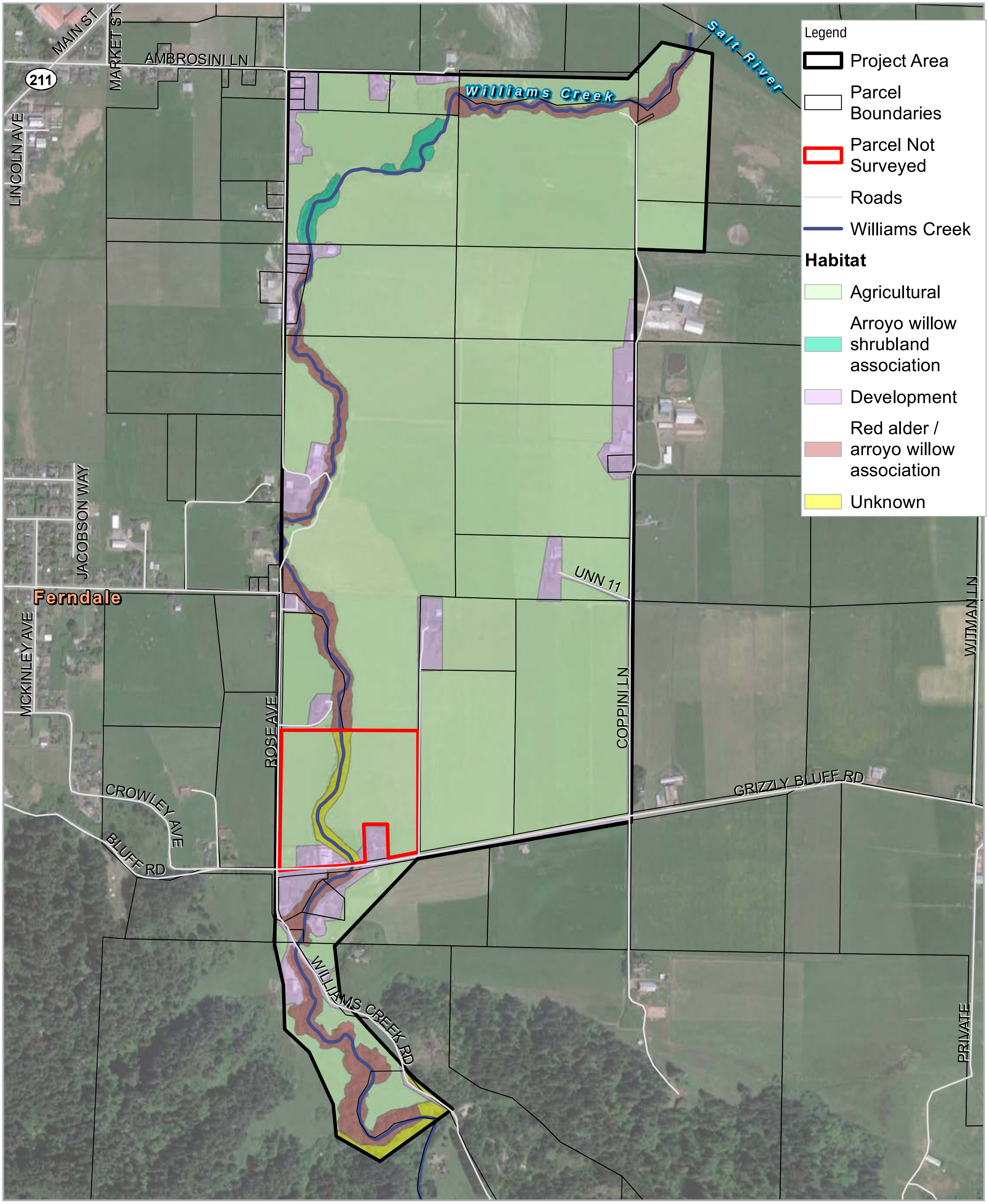

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GHD

Humboldt County Resource Conservation District
Williams Creek

Habitat Types

Project No. 11151140
Revision No. -
Date Feb 2020

FIGURE 2

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Memorandum

February 4, 2020

To:	Humboldt County Resource Conservation District	Ref. No.:	11151140
From:	Amy Livingston, Botanist; Andrea Hilton, Environmental Planner	Tel:	707-443-8326
CC:	Jeremy Svehla, Project Manager		
Subject:	**Special Status Plant Survey and Vegetation Community Mapping and Identification of Ordinary High Water Technical Memorandum for Williams Creek Alternatives Analysis, Humboldt County, CA.**		

1 Introduction

This Technical Memorandum summarizes results of the 2019 special status plant surveys along Williams Creek near the town of Ferndale, in Humboldt County, CA (Figure 1, Attachment 1). The area covered by the surveys is presented in Figure 2. The protocol level special status plant surveys and vegetation mapping were performed by GHD botanist Amy Livingston on behalf of the client on May 13 and May 17, 2019. Additionally, this Technical Memorandum documents Ordinary High Water (OHW), as determined for the study area.

2 Special Status Plant Survey and Vegetation Community Mapping

2.1 Purpose

The purpose of this evaluation was to conduct seasonally appropriate surveys for state, federal, and other sensitive listed plant species in the proposed study area. The surveys attempted to identify all vascular plants within the study area to the taxonomic level necessary to determine rarity and listing status, and to document the presence of special status plants within the project footprint and buffer areas, including immediate access roads. The results are intended to be used for planning, inclusion in the California Environmental Quality Act (CEQA) document, permitting, design, or to avoid or mitigate impacts associated with project construction, and to guide future management decisions.

2.2 Location

The study area is a section of William's Creek near the town of Ferndale in Humboldt County, California. The study area includes a section of William's Creek from the confluence with Salt River, upstream to private property south of Grizzly Bluff Road. The extent of the study area is shown in Figure 2. The parcel north of Grizzly Bluff Road was excluded from the survey as access permission was not granted.

The majority of William's Creek within the study area is located within the Appeals Zone of the California Coastal Zone, under primary jurisdiction of Humboldt County through the Local Coastal Program (Figure 3).

The Coastal Zone boundary corresponds roughly to the reach of William's Creek that is north of Grizzly Bluff Road. South of Grizzly Bluff Road William's Creek is mostly outside of the Coastal Zone.

2.3 Regulatory Setting

2.3.1 State Listed Species

Special status plant species under State jurisdiction include those listed as endangered, threatened, or as candidate species by the California Department of Fish and Wildlife (CDFW) under the California Endangered Species Act (CESA). Plant species on California Native Plant Society's (CNPS) California Rare Plant Ranking (CRPR) Lists 1A, 1B and 2 are considered eligible for state listing as Endangered or Threatened pursuant to the California Fish and Game Code and CDFW has oversite of these special status plant species as a trustee agency. As part of the CEQA process, such species should be considered as they meet the definition of Threatened or Endangered under Sections 2062 and 2067 of the California Fish and Game Code. CRPR List 3 and 4 plants do not have formal protection under CEQA. CDFW publishes and periodically updates lists of special status species which include, for the most part, the above categories. Additionally, there are 64 plant species designated as "rare" which is a special designation created before plants were rolled into CESA in the 1980s (CDFW 2019a). A project is required to have a "Scientific, Educational, or Management Permit" from CDFW for activities that would result in "take," possession, import, or export of state-listed plant species including research, seed banking, reintroduction efforts, habitat restoration, and other activities relating to any plant designated SE (State endangered), ST (State threatened), SR (State rare), or SC (State candidate for listing).

Sensitive Natural Communities

CDFW provides oversight of habitats (i.e. plant communities) listed as Sensitive in the California Natural Diversity Database (CNDDB) and on the California Sensitive Natural Communities List, based on global and state rarity rankings. Natural Communities are broken down to alliance and association level for vegetation types affiliated with ecological sections in California. The list coincides with A Manual of California Vegetation (Sawyer et al. 2009). CDFW considers Natural Communities with state ranks of a S1-S3 to be Sensitive Natural Communities (CDFW 2019b). Global and state ranking determinations for all associations have not been made at the time of the latest updated list of Sensitive Natural Communities (CDFW 2019b). According to CDFW associations are designated as Sensitive if the state rank is considered within the S1-S3 range (CDFW 2019b).

Environmentally Sensitive Habitat Areas

While there is not a specific list of habitats considered to be ESHA for the State or County, the Coastal Commission through the Coastal Act and counties or municipalities through the Local Coastal Program (LCP) are the jurisdictional agencies that exert authority in identifying and protecting ESHA in the course of project activities. In order for the Coastal Commission to determine if areas are to be classified as ESHA's, they often refer to CDFW's California Sensitive Natural Communities List. The global and state rarity ranking can be used to identify areas that may be considered ESHA and subject to protection by the Coastal Commission. CDFW does not use the term ESHA, but it has been inferred that CDFW terminology of "sensitive habitat" might be somewhat synonymous to Coastal Commission ESHA terminology.

2.3.2 Federal Jurisdiction

Federal Listed Species

Special status plant species under Federal jurisdiction include those listed as endangered, threatened, or as candidate species by the Fish and Wildlife Service (USFWS) under the U.S. Endangered Species Act (ESA).

Critical Habitat

Critical Habitat is defined by the ESA as a specific geographic area containing features essential for the conservation of an endangered or threatened species. The ESA requires consultation with USFWS by federal lead agencies for activities they carry out, authorize, or fund. Under Section 7 of the ESA, critical habitat federally designated for a listed or proposed species that may be present in the project Action Area should be evaluated.

2.4 Methods

2.4.1 Study Area and Survey Extent

Prior to conducting environmental fieldwork, the project scientist worked in coordination with the project manager and the applicant to develop the limits of the proposed study area. The extent of the proposed work on William's Creek is yet to be determined, so the entire stretch of William's Creek where property access had been secured was surveyed. As previously mentioned, one parcel within the survey reach of William's Creek was avoided as permission had not been granted. Likewise, no property access was granted on the north side of William's Creek along the section of creek that runs more or less east and then turns northeast to the confluence with Salt River (Figure 2). Along this reach, only the south and southeast side of the creek was surveyed. With the exception of the areas that were avoided, the survey included the riparian corridor on either side of William's Creek. As it was difficult to move around within the dense vegetation of the creek, the majority of the study area was surveyed either from within the creek channel, or primarily from the properties along the east side which contained pasture. The adjacent pastures were briefly assessed to confirm the assumption that no suitable habitat was present for special status plants.

2.4.2 Pre-Survey Investigations

Prior to field surveys, a scoping list of CRPR plant species and habitats with recorded occurrences in the project vicinity was compiled by consulting the *California Natural Diversity Database* (CNDDB) [CDFW 2019c], the CNPS *Inventory of Rare and Endangered Vascular Plants* (CNPS 2018), and the list of Federally listed plant species maintained by the U.S. Fish and Wildlife Service (USFWS 2019). The CNDDB database was consulted for rare plant occurrences documented in the project vicinity.

The scoping list includes special-status plants that occur in habitat similar to the study area with documented occurrences on the Ferndale USGS quadrangle or the adjacent quadrangles. CDFW and CNPS recommend the assessment area be a minimum of nine USGS quadrangles with the survey area located in the central quad. The scoping list also contains other taxa that may occur in the study area whose habitat is suitable if the project is within or near the known range of the species. Due to the location of the Ferndale quadrangle along the coastline, an assessment area of ten USGS 7.5' minute quadrangles was utilized. The assessment area included the following quadrangles: Cannibal Island, Fields Landing, McWhinney Creek, Ferndale, Fortuna, Hydesville, Cape Mendocino, Capetown, Taylor Peak, and Scotia.

The queries yielded 36 special status species previously documented in the assessment area. Of the 36 special status species, 31 have a CRPR rank of 1B or 2B. The query also yielded four species with a CRPR rank of 4. The complete scoping list was reviewed prior to the field survey. For simplicity, only species with a CRPR rank of 1 or 2 were included in the scoping table, along with the only one of the four species with a CRPR rank of 4 that had potential to occur within the study area. Of the species included in the scoping table only two had potential to occur within the study area (Table 1, Attachment 2). Scoping yielded three potential sensitive habitats tracked according to CNDDB (CDFW 2019c). None of the habitats tracked by CNDDB occur within the study area.

2.4.3 Special Status Plant Survey Procedures and Mapping Methodology

Surveys to determine the presence of special status plant species (listed as rare, threatened, endangered, or candidate under the State or Federal Endangered Species Acts, CNPS, or species of local importance) were timed to coordinate with the blooming period for the majority of the species thought to have potential to occur within the study area. The scoping list was reviewed to determine appropriate timing for botanical surveys. It was determined that an early season survey would be appropriate for this location.

The surveys were floristic in nature following *Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities* by the California Natural Resource Agency (CDFW 2018) and *General Rare Plant Survey Guidelines by the Endangered Species Recovery Program* (USFWS 2002). An intuitively controlled survey was conducted that sampled and identified potential habitat(s). Plants were identified to the lowest taxonomic level (genus or species) necessary for rare plant identification. Nomenclature follows *The Jepson Manual* (Baldwin et al 2012). Species surveys were conducted by walking the site looking for the presence of target species and habitats identified on the scoping list, as well as presence of any other incidental sensitive-listed plant species.

2.4.4 Vegetation Community Mapping

Per *Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities* by the California Natural Resource Agency (CDFW 2018), vegetation communities were assessed using the Combined Vegetation Rapid Assessment and Relevè Field Form (CDFW 2018) to classify communities as described in A Manual of California Vegetation at the alliance level and at the association level when possible (Sawyer et al. 2009).

2.5 Results

2.5.1 Special Status Plants

On May 13 and May 17, 2019, the study area was surveyed in an effort to identify if federal, state and/or CNPS listed plant species were present. No special status plants occurred within the study area. No critical habitat has been designated for plants within the study area. A list of all species observed within the study area is included in Table 2.

2.5.2 Vegetation Community Mapping

Per the Manual of California Vegetation, two Natural Communities occur within the study area. The CDFW Combined Rapid Assessment/Relevè forms used to document these communities are included in Attachment 3 along with photographs taken within the stands in the four cardinal directions. The Natural Communities are described in detail below. A brief description of the non-native pastureland occurring outside of the riparian corridor of William's Creek is also described.

Arroyo willow shrubland association

The Arroyo willow shrubland alliance is defined by The California Manual of Vegetation as having arroyo willow (*Salix lasiolepis*) as the dominant or co-dominant species in the shrub or tree canopy (Sawyer et al. 2009). This vegetation community occurs along a short section of the study area, shown on Figure 2. Young arroyo willow trees are the dominant vegetation. Due to the lack of other predominant shrub species, and the developed and diverse herbaceous layer, this community would best fit the Arroyo willow shrubland association, which is considered Sensitive by CDFW (CDFW 2019b).

Throughout this community, the majority of arroyo willow have small diameters, primarily in the 1-6" diameter at breast height (DBH) range. Some larger diameter willows occur within the 6-11" DBH range, but there are few larger trees. The shrub layer is very sparse. The riparian corridor is wider on the east side of the creek than the west side, and a gap occurs where no riparian vegetation occurs on either side (Figure 2). Some sections of this area have riparian vegetation on only one side of the creek. Two invasive species, Canada thistle (*Cirsium arvense*) and reed canary grass (*Phalaris arundinacea*) occur near the channel.

Red alder/arroyo willow association

The red alder/arroyo willow association is the dominant vegetation association throughout most of the study area. This alliance is defined by The California Manual of Vegetation as having > 50% relative cover of red alder (*Alnus rubra*) in the tree layer (Sawyer et al. 2009). Two Rapid Assessment plots were used to document this community (Attachment 3). The Rapid Assessment form labeled WC #1 describes vegetation along William's Creek south of Grizzly Bluff Road, and a description of this section is summarized below. The Rapid Assessment form labeled WC #2 described vegetation north or Grizzly Bluff Road, north of the parcel that was avoided, to the beginning of the arroyo willow shrubland association.

South of Grizzly Bluff Road, several mature red alder and arroyo willow trees occur. Throughout this reach, red alder was the dominant species in the overstory with arroyo willow, and an occasional red elderberry (*Sambucus racemosa*) tree was present in the understory. The shrub layer was sparse, and was composed of occasional young arroyo willows and native Rubus species (*Rubus* spp.), see Rapid Assessment Form WC#1, Attachment 3. A few patches of Himalayan blackberry (*Rubus armeniacus*) and English ivy (*Hedera helix*) occur but vegetation is composed primarily of native species. The riparian corridor was widest at the southern extent of the reach that was surveyed.

Between the north end of the property that was not surveyed and the area mapped as arroyo willow shrubland association, red alder, and dense arroyo willows are the dominant overstory species with an occasional Pacific willow (*Salix lasiandra* var. *lasiandra*). The majority of trees were small (<12") DBH, with some red alder or willows that were approximately 12" DBH. Several residential properties and a large barn occur on the west side of William's Creek and riparian vegetation was sparse in these locations. The riparian corridor was generally narrow in this reach and contained some gaps. Some Himalayan blackberry occurred.

The section of William's Creek north of the arroyo willow shrubland association, to the confluence with Salt River was not documented on a Rapid Assessment Form. Riparian vegetation was diverse in this area with various ages and size classes of trees. Some large diameter red alder and Pacific willows occurred with diameters as large as 22" DBH, along with several medium sized trees (10-15" DBH), and smaller trees. Gaps were present within the riparian corridor on the north side of the creek in this section. Reed canary grass was present in the channel of William's Creek in this section, and throughout much of the study area. The red alder/arroyo willow association has a state ranking of S3 and is considered Sensitive by CDFW.

Non-Native Pastureland

The pastures adjacent to William's Creek are actively grazed and do not contain suitable habitat for special status plant species. Dominant non-native species within the pasture observed included: Kentucky bluegrass (*Poa pratensis* ssp*. pratensis*), creeping buttercup (*Ranunculus repens*), tall orchard grass (*Dactylis glomerata*), tall fescue (*Festuca arundinacea*), white clover (*Trifolium repens*), velvet grass (*Holcus lanatus*), rye grass (*Festuca perennis*), low manna grass (*Glyceria declinata*), bristly ox-tounge (*Helminthotheca echioides*), and sheep sorrel (*Rumex acetosella*). The lawns/ruderal areas adjacent to William's Creek do not contain suitable habitat or special status species either.

2.6 Regulatory Summary

The vegetation communities that occur at William's Creek are presented in the table below.

Table 2.1 Vegetation Communities Present at William's Creek and their State Rank

Vegetation Community	Considered Sensitive?
Arroyo willow shrubland association	Assumed S-Rank of S1-S3 for association
Red alder/arroyo willow association	S3

Both the red alder/arroyo willow shrubland association and the arroyo willow shrubland association are considered Sensitive Natural Communities by CDFW and may be considered ESHA by the California Coastal Commission. In addition, under the Humboldt County Local Coastal Program, as defined in the Eel River Area Plan in Section 30240 (Eel River Area Plan 2007) rivers, creeks, and associated riparian habitats are considered Environmentally Sensitive Habitats. All riparian vegetation along William's creek is also regulated by the California Department of Fish and Wildlife through the Lake and Streambed Alteration permit process (California Department of Fish and Game Code Section 1602). Riparian vegetation outside of the Coastal Zone is regulated by Streamside Management Area protections under the Humboldt County General Plan (Humboldt County 2017).

2.7 Conclusion

The purpose of this survey was to identify any special status plants that might be present within the study area and to document the vegetation communities. No special status plants were observed within the study area. Two Sensitive Natural Communities occur, the arroyo willow shrubland association and the red alder/arroyo willow shrubland association. Both of these communities may be considered ESHA by the California Coastal Commission and the County of Humboldt through the Local Coastal Program. Outside of the Coastal Zone impacts to riparian vegetation are regulated by CDFW and the Humboldt County General Plan.

3 Ordinary High Water

Due to the limited period of record of streamflow data and the impacted condition of the Williams Creek channel, several approaches to determining OHW at the project site were considered. OWH indicators change during each storm event due to alteration of the downstream channel conditions and the variable rate of sediment delivery from the upstream watershed. As a result, aggradation and degradation vary significantly across reaches.

Measured streamflow and water surface elevation (WSE) data from water year (WY) 2017 and WY 2018 were modeled in HEC-RAS 5.07 to create a 1.01-year return period WSE. In un-altered stream systems that are in equilibrium, the ordinary high water is generally related to a 1-year recurrence interval and is often a lower flowrate relative to the bankfull discharge. As an initial screening, the modeled 1.01-year WSE was subsequently plotted along the channel corridor.

As a comparative approach and based on field observations, a depth of 2 feet was added to the measured channel thalweg and found to be lower than the 1.01-year return period WSE and more consistent with observed geomorphic indicators of scour and erosion of channel banks and change in riparian vegetation type. Given the consistency with observed field conditions, adding 2 feet to the channel thalweg was thus selected as the preferred approach to determining the OHW boundary for the Williams Creek throughout the project corridor (Figure 4).

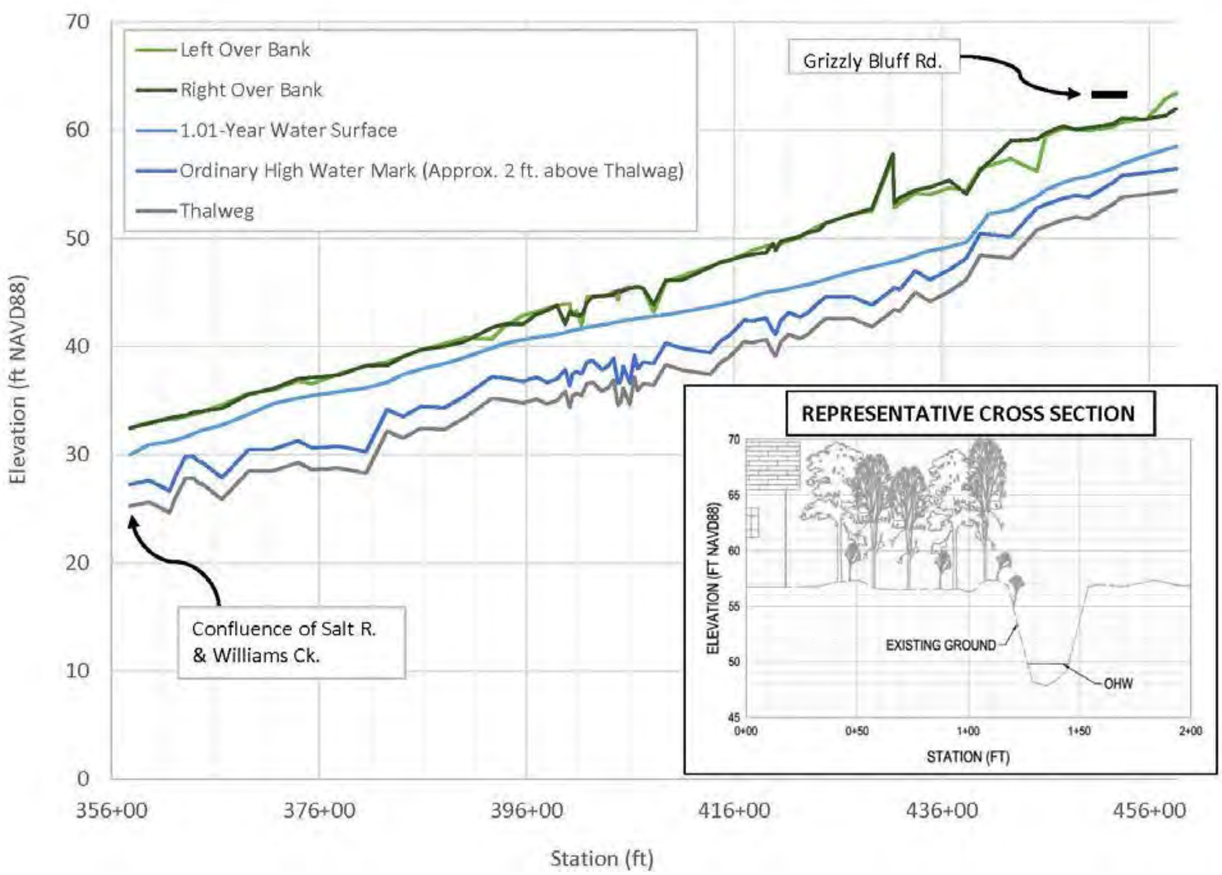

Figure 4. Williams Creek Ordinary High Water.

4 References

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Attachments

1. **Figures**

   Figure 1: Regional and Location Map

   Figure 2: Vegetation Communities

   Figure 3: Coastal Zone Jurisdictions

2. **Tables**

   Table 1: Special Status Plant Species with Potential to Occur in the PSB

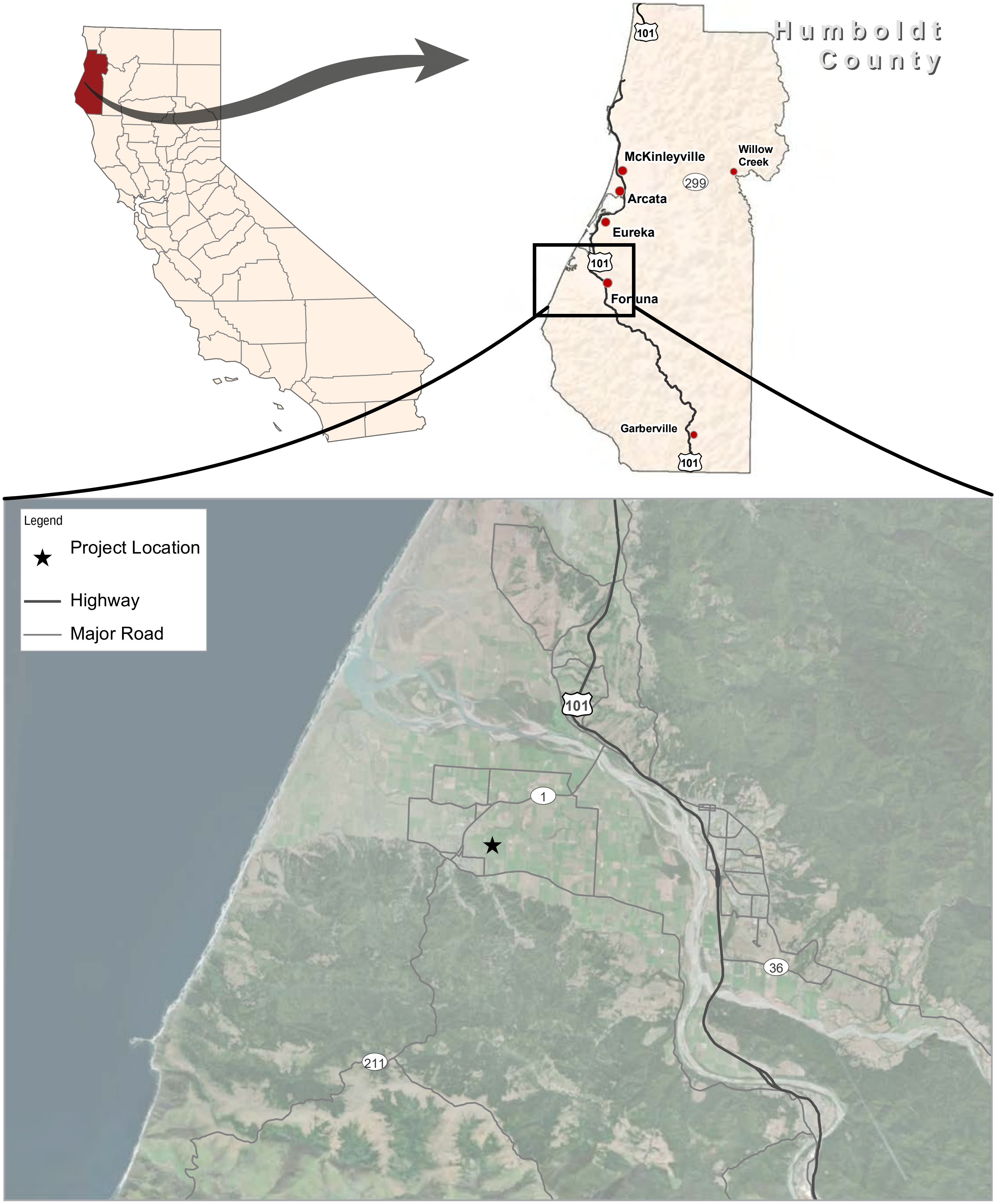
   Table 2: Plants Observed within the Study Area

3. **Combined Rapid Assessment/Relevé Field Forms and Photographs**

Table 2 Plants Observed within the Study Area on 5/13/19 and 5/17/19

Scientific Name	Common Name	Family
Alnus rubra	red alder	Betulaceae
Alopecurus geniculatus	water foxtail	Poaceae
Anthoxanthum odoratum	sweet vernal grass	Poaceae
Athyrium filix-femina	common ladyfern	Woodsiaceae
Avena sp.	oats	Poaceae
Bellis perennis	English daisey	Asteraceae
Brassica nigra	black mustard	Brassicaceae
Bromus carinatus	California brome	Poaceae
Cardamine oligosperma	bitter-cress	Brassicaceae
Carex leptopoda	slender-footed sedge	Cyperaceae
Cirsium arvense	canada thistle	Asteraceae
Claytonia sibirica	candy flower	Montiaceae
Conium maculatum	poison hemlock	Apiaceae
Crataegus monogyna	hawthorn	Rosaceae
Dactylis glomerata	orchard grass	Poaceae
Digitalis purpurea	foxglove	Plantaginaceae
Dipsacus fullonum	wild teasel	Dipsacaceae
Epilobium sp.	fireweed	Onagraceae
Equisetum hyemale subsp.affine	common scouring rush	Equisetaceae
Equisetum laevigatum	smooth scouring rush	Equisetaceae
Equisetum telmateia subsp. braunii	giant horsetail	Equisetaceae
Festuca arundinacea	tall fescue	Poaceae
Festuca perennis	meadow fescue	Poaceae
Frangula purshiana subsp. Purshiana	cascara	Rhamnaceae
Galium aparine	goose grass	Rubiaceae
Geranium dissectum		Geraniaceae
Glyceria declinata	low manna grass	Poaceae
Hedera helix	English ivy	Araliaceae
Helminthotheca echioides	bristly ox-tongue	Asteraceae
Holcus lanatus	velvet grass	Poaceae
Hydrophyllum tenuipes	Pacific waterleaf	Boraginaceae
Juncus bufonius	toad rush	Juncaceae
Juncus effusus	common rush	Juncaceae
Juncus patens	spreading rush	Juncaceae
Lysichiton americanus	yelllow skunk cabbage	Araceae

Lysimachia arvensis	scarlet pimpernel	Myrsinaceae
Marah oregana	coast manroot	Cucurbitaceae
Oenanthe sarmentosa		Apiaceae
Petasites frigidus var. palmatus	western sweet coltsfoot	Asteraceae
Phalaris arundinacea	reed canarygrass	Poaceae
Picea sitchensis	Sitka spruce	Pinaceae
Plantago lanceolata	English plantain	Plantaginaceae
Poa annua	annual blue grass	Poaceae
Poa pratensis ssp. pratensis	Kentucky blue grass	Poaceae
Polystichum munitum	western sword fern	Dryopteridaceae
Potentilla anserina	pacific silverweed	Rosaceae
Ranunculus parviflorus		Ranunculaceae
Ranunculus repens	creeping buttercup	Ranunculaceae
Raphanus sativus	radish	Brassicacae
Ribes bracteosum	stink currant	Grossulariaceae
Rubus parviflorus	thimbleberry	Rosaceae
Rubus ursinus	California blackberry	Rosaceae
Rumex acetosella	common sheep sorrel	Polygonaceae
Rumex sp.		Polygonaceae
Salix lasiandra var. lasiandra	Pacific willow	Salicaceae
Salix lasiolepis	arroyo willow	Salicaceae
Sambucus racemosa	red elderberry	Adoxaceae
Scirpus microcarpus	bulrush	Cyperaceae
Senecio jacobaea	tansy ragwort	Asteraceae
Sequoia sempervirens	redwood	Cupressaceae
Sonchus sp.	sow thistle	Asteraceae
Stachys chamissonis		Lamiaceae
Taraxacum officinale	common dandelion	Asteraceae
Thuja plicata	western red cedar	Cupressaceae
Tolmiea menziesii	pig a back plant	Saxifragaceae
Trifolium repens	white clover	Fabaceae
Urtica dioica	stinging nettle	Urticaceae
Verbascum thapsus	woolly mullein	Scrophulariaceae
Veronica americana	American brooklime	Plantaginaceae



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Map Projection: Lambert Conformal Conic
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GHD

Humboldt County Resource Conservation District
Williams Creek

Vicinity Map

Project No. 11151140
Revision No. -
Date 09/09/2019

FIGURE 1

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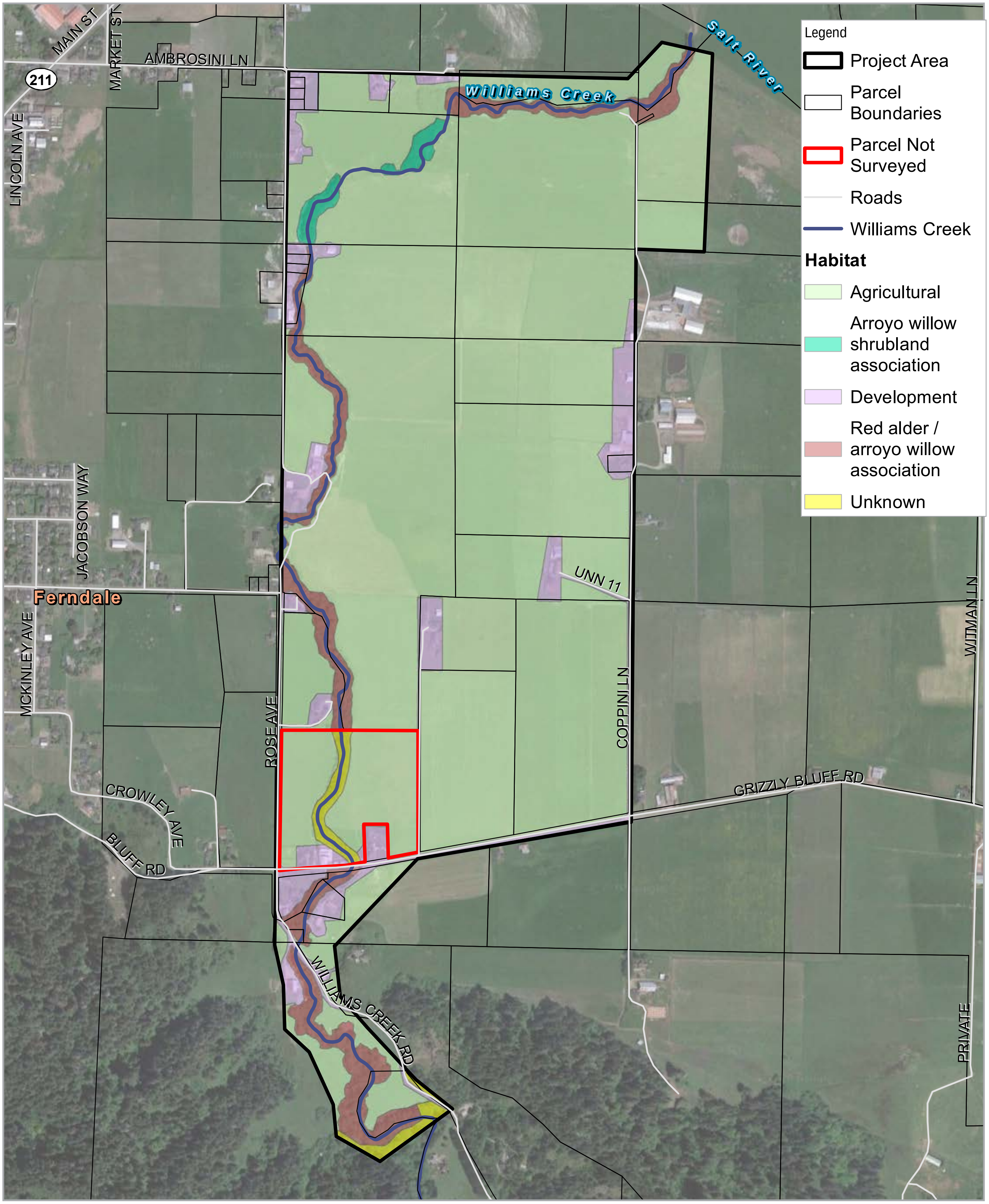
Data source: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, USGS, NOAA. Created by: jclark2



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Humboldt County Resource Conservation District
Williams Creek

Habitat Types

Project No. 11151140
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Date Feb 2020

FIGURE 2

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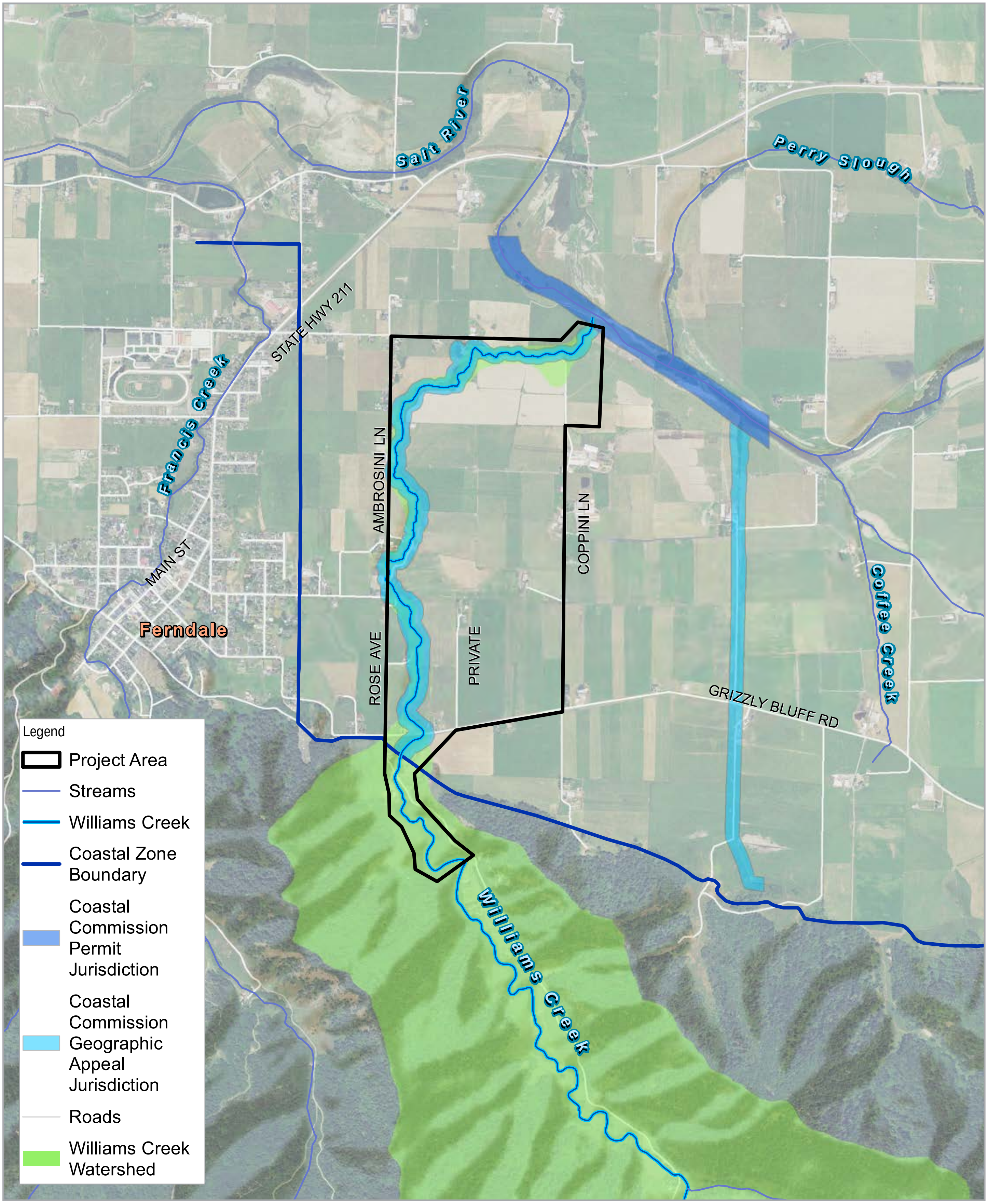
Data source: Google Earth Imagery; . Created by: jclark2



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Humboldt County Resource Conservation District
Williams Creek

Coastal Zone Jurisdictions

Project No. 11151140
Revision No. -
Date Feb 2020

FIGURE 3

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Data source: Sources: Esri, USGS, NOAA. Created by: jclark2

William's Creek 10 Quad Database Search of Ferndale, Cannibal Island, Fields Landing, McWhinney Creek, Fortuna, Hydesville, Cape Mendocino, Capetown, Taylor Peak, and Scotia on 4-17-19											
SciName	**ComName**	**FedList**	**CalList**	**GRank**	**SRank**	**RPlantRank**	**OtherStatus**	**Habitats**	**GenHab**	**MicroHab**	**Potential to Occur**
Abronia umbellata var. breviflora	pink sand-verbena	None	None	G4G5T2	S2	1B.1	BLM_S-Sensitive	Coastal dunes	Coastal dunes and coastal strand.	Foredunes and interdunes with sparse cover. A. umbellata var. breviflora is usually the plant closest to the ocean 0-75 m.	**No Potential.** No dune habitat occurs within the study area.
Astragalus pycnostachyus var. pycnostachyus	coastal marsh milk-vetch	None	None	G2T2	S2	1B.2	BLM_S-Sensitive | SB_SBBG-Santa Barbara Botanic Garden	Coastal dunes | Coastal scrub | Marsh & swamp | Wetland	Coastal dunes,marshes and swamps, coastal scrub.	Mesic sites in dunes or along streams or coastal salt marshes. 0-155 m.	**No Potential.** Coastal dune habitat is not present. Creek habitat is present but is not suitable or typical for this species.
Cardamine angulata	seaside bittercress	None	None	G4G5	S3	2B.1		Lower montane coniferous forest | North coast coniferous forest | Wetland	North coast coniferous forest, lower montane coniferous forest.	Wet areas, streambanks. 5-515 m.	**No Potential.** Neither lower montane coniferous forest nor north coast coniferous forest occurs within project area.

William's Creek 10 Quad Database Search of Ferndale, Cannibal Island, Fields Landing, McWhinney Creek, Fortuna, Hydesville, Cape Mendocino, Capetown, Taylor Peak, and Scotia on 4-17-19											
SciName	**ComName**	**FedList**	**CalList**	**GRank**	**SRank**	**RPlantRank**	**OtherStatus**	**Habitats**	**GenHab**	**MicroHab**	**Potential to Occur**
Carex leptalea	bristle-stalked sedge	None	None	G5	S1	2B.2		Bog & fen | Freshwater marsh | Marsh & swamp | Meadow & seep | Wetland	Bogs and fens, meadows and seeps, marshes and swamps.	Mostly known from bogs and wet meadows. 3-1395 m.	**No Potential.** Riparian habitat is present, but none of the specific wetland habitats where this species occurs is present.
Carex lyngbyei	Lyngbye's sedge	None	None	G5	S3	2B.2		Marsh & swamp | Wetland	Marshes and swamps (brackish or freshwater).	0-200 m.	**No Potential.** Species is known from Salt River; however, project area included fresh water within William's Creek with no marsh or swamp habitat.
Castilleja ambigua var. humboldtiensis	Humboldt Bay owl's-clover	None	None	G4T2	S2	1B.2	BLM_S-Sensitive	Marsh & swamp | Salt marsh | Wetland	Marshes and swamps.	In coastal saltmarsh with Spartina, Distichlis, Salicornia, Jaumea. 0-20 m.	**No Potential.** Coastal salt marsh habitat is not present in project area.

William's Creek 10 Quad Database Search of Ferndale, Cannibal Island, Fields Landing, McWhinney Creek, Fortuna, Hydesville, Cape Mendocino, Capetown, Taylor Peak, and Scotia on 4-17-19											
SciName	**ComName**	**FedList**	**CalList**	**GRank**	**SRank**	**RPlantRank**	**OtherStatus**	**Habitats**	**GenHab**	**MicroHab**	**Potential to Occur**
Castilleja litoralis	Oregon coast paintbrush	None	None	G3	S3	2B.2		Coastal bluff scrub | Coastal dunes | Coastal scrub	Coastal bluff scrub, coastal dunes, coastal scrub.	Sandy sites. 5-255 m.	**No Potential.** This species is known from nearby occurrences however no coastal bluff scrub, coastal dune, nor coastal scrub habitat occurs in project area.
Chloropyron maritimum ssp. palustre	Point Reyes salty bird's-beak	None	None	G4?T2	S2	1B.2	BLM_S-Sensitive	Marsh & swamp | Salt marsh | Wetland	Coastal salt marsh.	Usually in coastal salt marsh with Salicornia, Distichlis, Jaumea, Spartina, etc. 0-115 m.	**No Potential.** No salt marsh habitat is present within project area.
Clarkia amoena ssp. whitneyi	Whitney's farewell-to-spring	None	None	G5T1	S1	1B.1		Coastal bluff scrub | Coastal scrub	Coastal bluff scrub, coastal scrub.	5-125 m.	**No Potential.** No coastal bluff scrub or coastal scrub occurs within the project area.

William's Creek 10 Quad Database Search of Ferndale, Cannibal Island, Fields Landing, McWhinney Creek, Fortuna, Hydesville, Cape Mendocino, Capetown, Taylor Peak, and Scotia on 4-17-19											
SciName	**ComName**	**FedList**	**CalList**	**GRank**	**SRank**	**RPlantRank**	**OtherStatus**	**Habitats**	**GenHab**	**MicroHab**	**Potential to Occur**
Downingia willamettensis	Cascade downingia	None	None	G4	S2	2B.2		Cismontane woodland | Valley & foothill grassland | Vernal pool	Cismontane woodland, valley and foothill grasslands, vernal pools.	Lake margins. 15-1110 m.	**No Potential.** No cismontane woodland, valley or foothill grassland, or vernal pool habitat is present.
Erysimum menziesii	Menzies' wallflower	Endangered	Endangered	G1	S1	1B.1	SB_RSABG-Rancho Santa Ana Botanic Garden	Coastal dunes	Coastal dunes.	Localized on dunes and coastal strand. 1-25 m.	**No Potential.** No coastal dune habitat is present within project area.
Erythronium oregonum	giant fawn lily	None	None	G4G5	S2	2B.2		Cismontane woodland | Meadow & seep | Ultramafic	Cismontane woodland, meadows and seeps.	Openings. Sometimes on serpentine; rocky sites. 300-1435 m.	**No Potential.** No cismontane woodland, seeps, or ultramafic soil present. Project elevation is too low for this species.

William's Creek 10 Quad Database Search of Ferndale, Cannibal Island, Fields Landing, McWhinney Creek, Fortuna, Hydesville, Cape Mendocino, Capetown, Taylor Peak, and Scotia on 4-17-19											
SciName	**ComName**	**FedList**	**CalList**	**GRank**	**SRank**	**RPlantRank**	**OtherStatus**	**Habitats**	**GenHab**	**MicroHab**	**Potential to Occur**
Erythronium revolutum	coast fawn lily	None	None	G4G5	S3	2B.2		Bog & fen | Broadleaved upland forest | North coast coniferous forest | Wetland	Bogs and fens, broadleafed upland forest, north coast coniferous forest.	Mesic sites; streambanks. 60-1405 m.	**No Potential.** Neither broadleaved upland nor north coast coniferous forest is present. No bog or fen habitat is present.
Fissidens pauperculus	minute pocket moss	None	None	G3?	S2	1B.2	USFS_S-Sensitive	North coast coniferous forest | Redwood	North coast coniferous forest.	Moss growing on damp soil along the coast. In dry streambeds and on stream banks. 10-1024 m.	**No Potential.** No North coast coniferous redwood forest occurs within project area.
Gilia capitata ssp. pacifica	Pacific gilia	None	None	G5T3	S2	1B.2		Chaparral | Coastal bluff scrub | Coastal prairie | Valley & foothill grassland	Coastal bluff scrub, chaparral, coastal prairie, valley and foothill grassland.	5-1345 m.	**No Potential.** Grazed pasture and maintained lawns occur but no native grassland. Neither coastal bluff scrub nor coastal prairie is present.

William's Creek 10 Quad Database Search of Ferndale, Cannibal Island, Fields Landing, McWhinney Creek, Fortuna, Hydesville, Cape Mendocino, Capetown, Taylor Peak, and Scotia on 4-17-19

SciName	ComName	FedList	CalList	GRank	SRank	RPlantRank	OtherStatus	Habitats	GenHab	MicroHab	Potential to Occur
Gilia millefoliata	dark-eyed gilia	None	None	G2	S2	1B.2	BLM_S-Sensitive	Coastal dunes	Coastal dunes.	1-60 m.	**No Potential.** No coastal dune habitat occurs within project area.
Hesperevax sparsiflora var. brevifolia	short-leaved evax	None	None	G4T3	S2	1B.2	BLM_S-Sensitive	Coastal bluff scrub | Coastal dunes | Coastal prairie	Coastal bluff scrub, coastal dunes, coastal prairie.	Sandy bluffs and flats. 0-640 m.	**No Potential.** No coastal bluff scrub, coastal dune, or coastal prairie habitat is present.
Hesperolinon adenophyllum	glandular western flax	None	None	G2G3	S2S	1B.2		Chaparral, Cismontane woodland, Valley and foothill grassland		Usually serpentinite 150- 490 m.	**No Potential.** None of the habitats for this species are present. Project elevation is lower.
Layia carnosa	beach layia	Endangered	Endangered	G2	S2	1B.1	SB_RSABG-Rancho Santa Ana Botanic Garden	Coastal dunes | Coastal scrub	Coastal dunes, coastal scrub.	On sparsely vegetated, semi-stabilized dunes, usually behind foredunes. 0-30 m.	**No Potential.** No coastal dune or coastal scrub habitat is present.

Memorandum

February 6, 2020

To:	Humboldt County Resource Conservation District	Ref. No.:	11151140
From:	Misha Schwarz, Soil Scientist	Tel:	707-267-2279
CC:	Jeremy Svehla, Project Manager		

Subject: **Reconnaissance Uplands Determination Technical Memorandum for Williams Creek Alternatives Analysis, Humboldt County, CA.**

1 Introduction

This Technical Memorandum summarizes results of two reconnaissance-level upland determinations occurring in 2017 and 2020. The December 1, 2017 investigation was conducted by GHD Soil Scientist Misha Schwarz, GHD Project Manager Jeremy Svehla, P.E. and Humboldt County Resource Conservation District (RCD) technical representatives Frances Tjarnstrom and Summer Daugherty. The subsequent February 4, 2020 investigation was also conducted by GHD Soil Scientist Misha Schwarz and RCD technical representatives Frances Tjarnstrom and Summer Daugherty. The purpose of the reconnaissance was to determine presence/absence of wetlands to support future project planning, specifically for the beneficial reuse of excavated sediments.

Custom Soil Resource Reports were generated by the National Resources Conservation Service (NRCS) for the project area (USDA/NRCS 2020a, USDA/NCRC 2020b). Soils in the project area north of Grizzly Bluff Road are primarily mapped as 110 –Weott and designated as prime farmland (USDA/NRCS 2020a). A small area near the downstream reach of Williams Creek is mapped as 116 – Swainslough and not designated as prime farmland (USDA/NRCS 2020a). The Williams Creek channel itself is mapped as 131 – Typic Fluvaquents and is mapped as prime farmland if drained and either protected from flooding or not frequently flooded during the growing season (USDA/NRCS 2020a). South of Grizzly Bluff Road, soils in the upper watershed are mapped as 110 –Weott, designated as prime farmland, and 131 – Typic Fluvaquents, which is mapped as prime farmland if drained (USDA/NRCS 2020b).

2 Methods

A reconnaissance-level upland investigation occurred on December 1, 2017 throughout the portion of the project area north of Grizzly Bluff Road (Figure 1). The investigation evaluated the presence of wetlands and uplands along seven transects. A second field investigation occurred on February 4, 2020 focused on the portion of the project area located south of Grizzly Bluff Road, further upstream, and included additional transects to also evaluate the presence of wetlands and uplands (Figure 2).

Sampling locations were recorded with a GeoPro 6H global positioning system (GPS) receiver with sub-meter accuracy, connected to a Motion F5v Tablet running ArcPad geographic information system (GIS) software. Data was post-processed using GPS Pathfinder office which referenced UNAVCO base stations. The points were then connected using ArcGIS for map preparation.

2.1 **Soil Methodology**

Wetland presence was determined by shallow soil borings used to evaluate the presence or absence of hydric soils. Hydric soils were determined by the observed presence of redoximorphic features. The *Regional Supplement to the Corps of Engineers Wetland Delineation Manual (*USACE 2010) procedures were combined with the Natural Resources Conservation Service's (NRCS) definition of hydric soils presented in Field Indicators of Hydric Soils in the United States (USDA/NRCS 2018). Soil pits were dug to an approximate depth of 16 inches. Data on soil color, texture and redoximorphic features were observed. Any observed redoximorphic features (iron concentrations) were examined along with their percentage within the soil matrix, and care was taken to distinguish chromas of 1 and 2 indicative of an iron-depleted soil within 12 inches of the soil surface (USACE 2010, USDA/NRCS 2018). No soil, hydrology, or vegetation data sheets were completed.

Colors were described for the entire depth of the test pit and colors were determined on moist natural soil aggregate (ped) surfaces, which had not been crushed, using the Munsell Color Chart (Color 2000). Based on the Field Indicators of Hydric Soils in the United States (USDA/NRCS 2018), soils with low chromas and redoximorphic features were verified as being hydric; soils without redoximorphic features were classified as upland.

2.2 **Vegetation Methodology**

Vegetation data collection consisted of making visual observations of dominant pasture forage species at each plot. Pasture vegetation was recorded by species and by estimated percent cover at each plot. Wetland indicator status was assigned and the Dominance Test was calculated for each plot.

The location of the transects have received ongoing intensive pasture management practices, including regular farming and re-seeding with non-native coastal pasture forage seed mixtures. These types of practices are commonly used in support of agriculture in the Ferndale delta region. However, for the purposes of determining the presence or absence of wetlands, vegetation composition with associated Wetland Indicator Status ratings in intensively managed pastures can lead to inaccurate interpretations. If a hydrophytic vegetation determination had been made in the study area, the Coastal Commission and other regulatory agencies have previously reported, with respect to this project, that facultative vegetation present at a site is not necessarily indicative of wetland conditions as the sole parameter and are not growing as hydrophytes. Soils and/or hydrology have been previously used as primary indicators in areas where vegetation was predominantly facultative species.

3 Results

Results from the initial December 1, 2017 reconnaissance-level investigation north of Grizzly Bluff Road found sampling locations nearest Williams Creek were predominantly upland but transitioned to wetland with greater distance from the stream channel (Figure 1).

Results from the follow-up reconnaissance-level assessment south of Grizzly Bluff Road in the upstream reach of Williams Creek indicated predominantly upland soils across all transects (Figure 2). As an exception, three wetland detections occurred nearest the riparian drainage near Williams Creek.

Results from the December 1, 2017 investigation were similar to the National Wetlands Inventory (NWI) dataset, which classifies the entire project area outside the immediate channel as freshwater emergent wetland but does not include uplands parallel to the channel alignment (Figure 3). However, results from the February 4, 2020 investigation differed from the NWI dataset and indicated wetlands were not predominant south of Grizzly Bluff Road within the Williams Creek drainage.

The location of the transects have received ongoing intensive pasture management practices, including livestock grazing, irrigation, farming and re-seeding with non-native coastal pasture forage seed mixtures. These management techniques support the persistence of non-native grasses and forbs, and the degree of management appears to influence the vegetation composition and therefore is noted to be a disturbed condition with respect to this delineation Pasture vegetation was recorded by dominant species present at each plot and included species such as *Festuca (Lolium) perenne, Poa pratensis,Trifolium repens, Taraxacum officinale, Stellaria media, Ranunculus repens,* and *Senecio vulgaris*. The presence of these forage species on the parcel and their intensive management to support livestock indicate that land management techniques are controlling the plant community and influencing the determination for presence or absence of hydrophytic plant communities.

Findings of this investigation can be used for future project planning for sediment reuse. Results can also be used to help avoid wetland fill and/or determine locations for future wetland creation as part of future phases of project designs.

4 References

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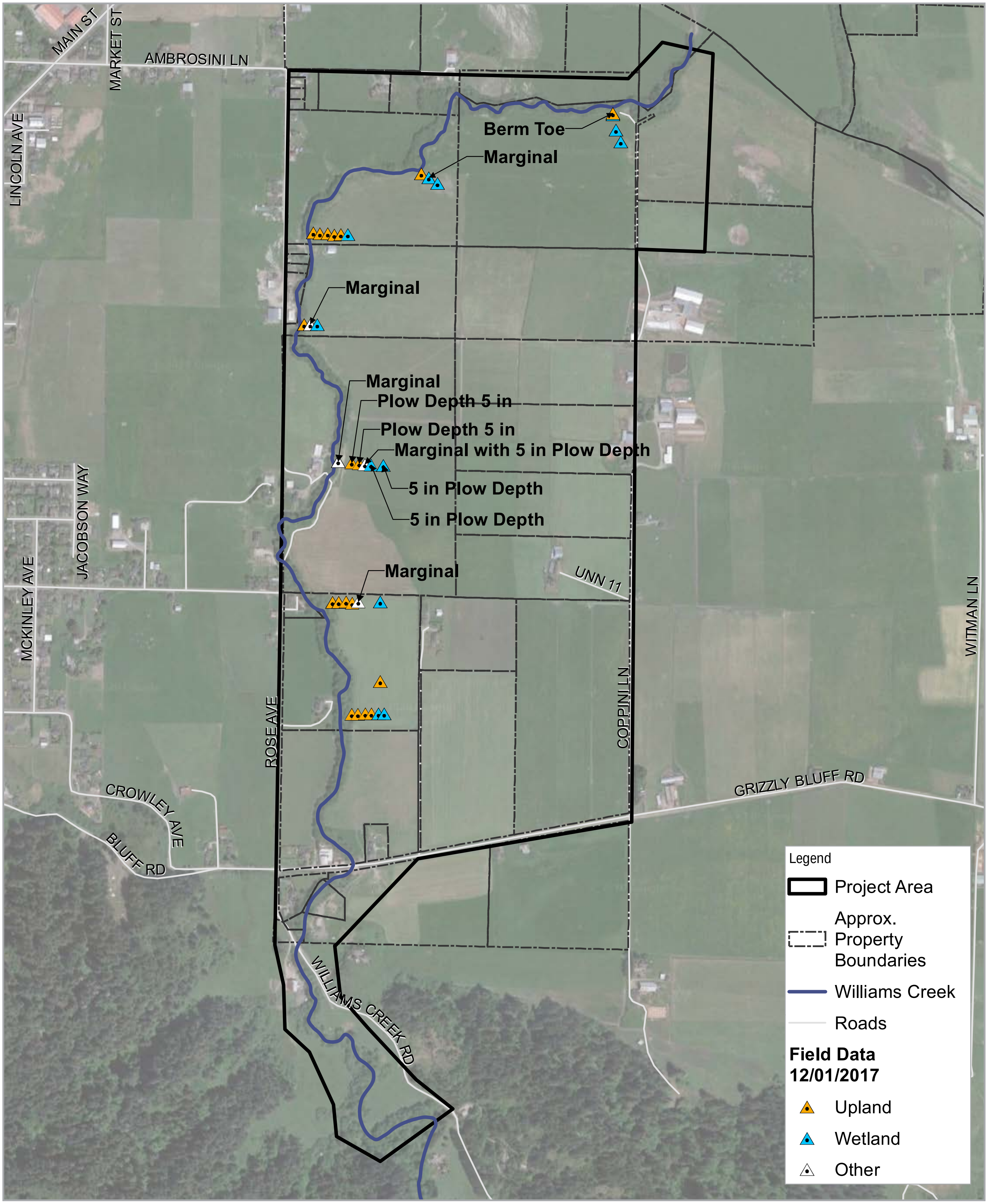
USDA/NRCS. 2020a. Custom Soil Resource Report for Humboldt County, Central Part, California, Williams-Coppini. January 24, 2020.

USDA/NRCS. 2020b. Custom Soil Resource Report for Humboldt County, Central Part, California, WC South of Grizzly Bluff. January 27, 2020.

Attachments

Figures



Paper Size ANSI A

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Feet

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Map Projection: Lambert Conformal Conic
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Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

GHD

Humboldt County Resource Conservation District
Williams Creek

Reconnaissance
Upland Determination North

Project No. 11151140
Revision No. -
Date Feb 2020

FIGURE 1

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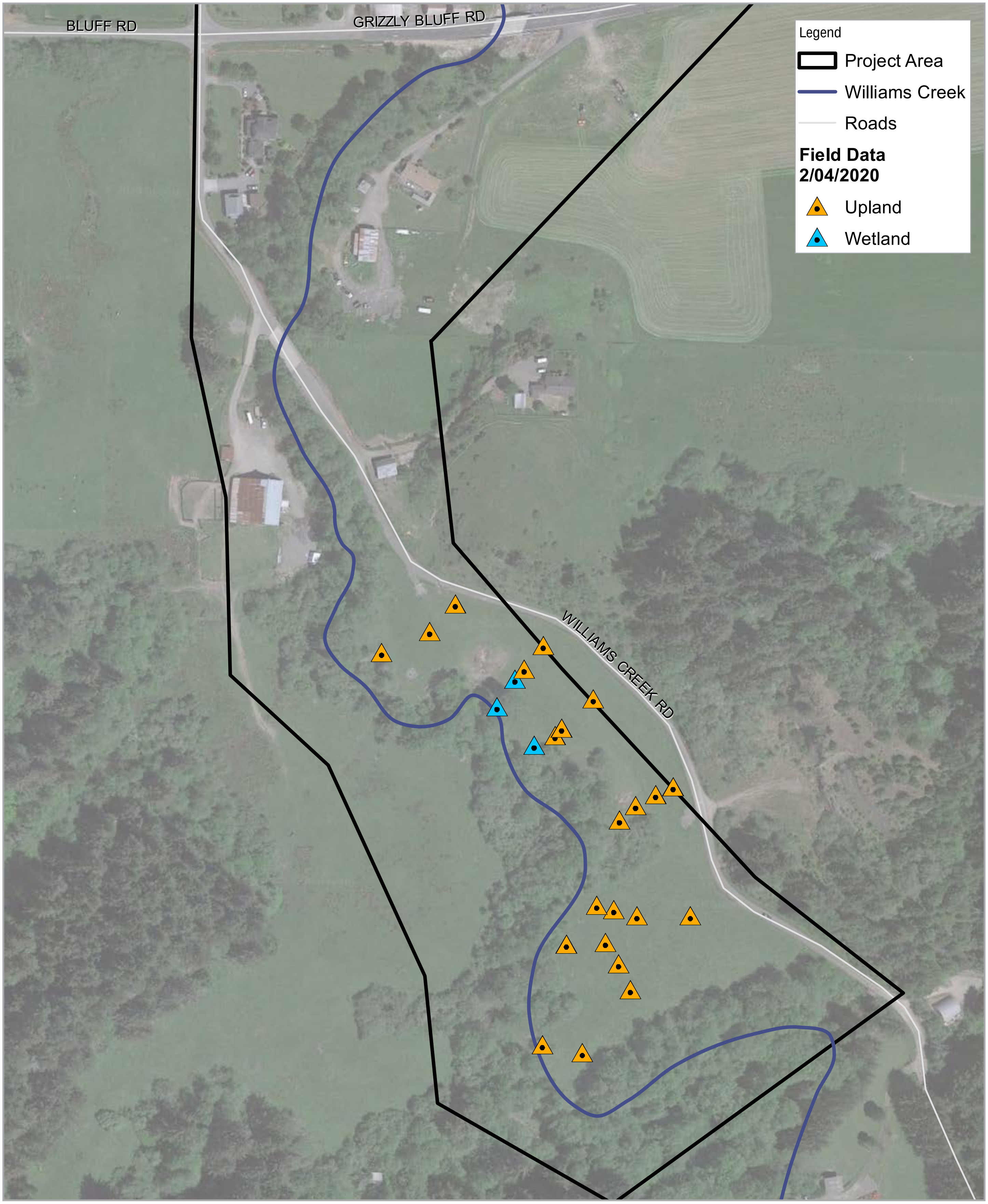

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Humboldt County Resource Conservation District
Williams Creek

Reconnaissance
Upland Determination South

Project No. 11151140
Revision No. -
Date Feb 2020

FIGURE 2

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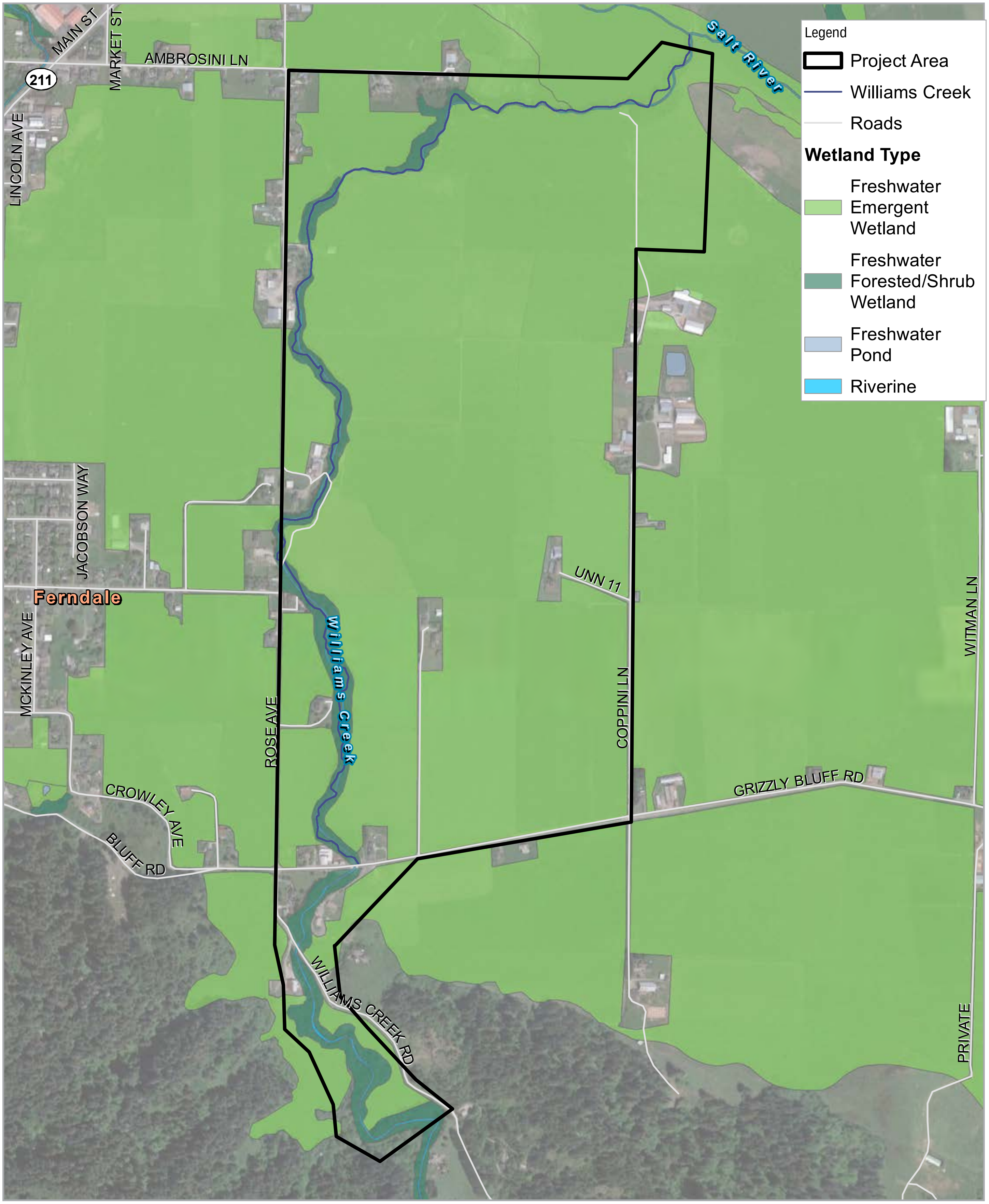

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Feet

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

GHD

Humboldt County Resource Conservation District
Williams Creek

Project No. 11151140
Revision No. -
Date Feb 2020

National Wetlands Inventory

FIGURE 3

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Data source: Google Earth Imagery; . Created by: jclark2